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Cost and anonymity as factors for the effective implementation of pre-exposure prophylaxis: an observational study among gay, bisexual and other men who have sex with men in Singapore

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Abstract. ***Background*:** HIV pre-exposure prophylaxis (PrEP) is currently offered by several public and private clinics at unsubsidised prices in Singapore, but to date, no information is available on the effect of these services. This study sought to assess the knowledge and uptake of, and willingness to use PrEP among gay, bisexual and other men who have sex with men (GBMSM) in Singapore. ***Methods*:** Recruitment was conducted through Grindr®, a geosocial networking application for GBMSM. Results were quantitatively analysed through descriptive statistics and multivariate Poisson regression models, while open-ended responses were qualitatively coded and categorised. ***Results*:** Of the 1339 participants who responded, 1098 participants who indicated their knowledge and use of PrEP were included in the analytic sample. Overall, 15.0% ($n = 154$) had taken PrEP, 66.2% ($n = 678$) had heard of but not taken PrEP, while 18.8% ($n = 193$) had never heard of PrEP. Of those who had ever taken PrEP, 59.6% ($n = 90$) had obtained PrEP from overseas or other unofficial sources. Of those who had heard of but never taken PrEP, 73.3% ($n = 486$) reported that they would consider taking PrEP. Those who had taken PrEP were older and had higher educational attainment. ***Conclusions*:** The gap between the willingness to use PrEP and its uptake may be attributed to the cost of PrEP and issues of anonymity at healthcare settings in Singapore. National financing schemes are needed to expand access to PrEP if it is to make a meaningful effect to the Singapore HIV/AIDS response.

Additional keywords: HIV, HIV prevention, primary prevention.

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Introduction

Gay, bisexual and other men who have sex with men (GBMSM) continue to be disproportionately affected by HIV across various settings.[1] HIV pre-exposure prophylaxis (PrEP) is a promising tool in the fight against HIV/AIDS among GBMSM and other key populations, with several large, randomised controlled trials underlining its efficacy in preventing HIV acquisition among at-risk populations.[2,3] In spite of its potential to reduce the incidence of HIV in key populations across the world, efforts to implement PrEP may be hindered by sociopolitical barriers that include, but are not limited to issues of cost, HIV care provider-related barriers and stigma against at-risk communities.[4,5]

As of the end of 2016, a total of 7548 Singapore citizens had been notified to Singapore's Ministry of Health to be infected with HIV, of whom 38.2% were GBMSM. In 2011, the number of newly diagnosed reported cases of HIV through male homosexual or bisexual transmission exceeded those via heterosexual transmission for the first time, and this trend has persisted since.[6] Despite the increasing burden of HIV in the local GBMSM community, there is a paucity of research on the factors contributing to the epidemic. This is likely due to social and legal barriers to conducting research among GBMSM in Singapore. A majority of Singaporeans hold negative attitudes towards GBMSM,[7,8] and Section 377A of the Singapore penal code criminalises sexual relations between men,[9] which makes open discussion of sex between men challenging.

The cost of antiretroviral (ARV) drugs in Singapore hence remains high due to drug licensing regulations in Singapore. Consequently, generic forms of co-formulated tenofovir disoproxil fumarate and emtricitabine (TDF/FTC) are not available in the country, whether for treatment or prevention,

such as with PrEP, and only brand-name ARVs can be sold in both government-run and private clinics and hospitals. Moreover, medication subsidies exist only for low-income individuals who qualify for means-tested, government-funded medical financial assistance schemes. Even though the cost of ARV drugs in Singapore remain prohibitive due to these said licensing regulations, health product importation regulations allow for the self-importation of personal medications (including ARV drugs) for up to 3 months' supply for individuals with valid prescriptions.[10] However, to our knowledge, little to no information on this scheme or the availability of online vendors is currently available or being disseminated in the local GBMSM community, and thus little is known about the effect of such online pharmaceutical vendors on access to ARV drugs among GBMSM in Singapore.

Pre-exposure prophylaxis is currently offered by several government-run clinics at unsubsidised prices of ~S$400.00 per month (approximately US$300.00), which are not allowed to be paid for using government-funded medical financial assistance schemes.[11] These prices may be as high as S$900.00 per month (approximately US$685.00) in private clinics.[12] Despite the availability of PrEP through these sources, no known information is available to date on the effect of such services on the local GBMSM community. In order to effectively implement PrEP services in Singapore, questions about whether GBMSM in Singapore are aware of PrEP and its efficacy, whether a demand for PrEP exists and what the barriers are to accessing PrEP in Singapore, need to be answered. This landmark survey hopes to address this gap in our understanding of PrEP, its role in HIV prevention and how to effectively implement it in Singapore.

Methods

Study design and setting

We conducted a cross-sectional, observational study through an online, web-based survey link hosted on SurveyMonkey (SurveyMonkey Inc., San Mateo, CA, USA) and disseminated by Grindr®. Grindr® is a popular application ('app') for smartphones and tablets that was designed to allow GBMSM to connect with other individuals through the geolocation capabilities of individual devices. Based on statistics provided by Grindr LLC, Grindr® has ~6.5 million monthly active users around the world, and 735 000 monthly active users in South-East Asia. With 50 000 monthly active users locally, Grindr® is the most popular geosocial networking app among GBMSM in Singapore.

Data collection

We sought to recruit a sample of Grindr®-using GBMSM, aged $\geq$18 years who were residing in Singapore at the point of the survey. From 14 January 14 to 11 February 2018, all users of Grindr® located in Singapore, as ascertained via global positioning system (GPS), received an invitation to participate in this survey. The invitation comprised a short paragraph that read: '*Have a few minutes to spare*? *Participate in our anonymous survey on PrEP in Singapore.*' The advertisement was in the form of a pop-up text box that Grindr® users received upon opening the app and was delivered twice a week (on one weekday and one weekend per week), and the language of the advertisement alternated between English and one of Singapore's three other official languages: Mandarin, Bahasa Melayu (Malay) and Tamil.

Upon accepting the invitation to participate, Grindr® users were directed to an external web page hosted by the online survey tool, SurveyMonkey®. Given that the law criminalises sexual relations between men in Singapore, an external site was used to assure participants that their Grindr® profiles would not be linked to their survey responses. Participants were provided with more details of the study through an informed consent form, which reiterated the anonymous and confidential nature of the survey, and gave their consent to participate by clicking on a button at the bottom of the page. Participants could choose from four languages to complete the survey, including: English, Mandarin, Bahasa Melayu (Malay) and Tamil. The average time taken to complete the survey was ~2 min, and 80% of respondents completed the survey. Multiple responses from the same device were not allowed. As we did not offer monetary incentives to participate in the survey, we kept the survey instrument as succinct as possible to achieve a high completion rate.

Variable measures

We collected information on the language that participants chose to take the survey in ('English', 'Mandarin', 'Bahasa Melayu' and 'Tamil') and their nationality (Singapore citizen, Singapore permanent resident or 'other'). Age was collected as a continuous variable and then recoded into a categorical variable ('18–29 years old', '30–39 years old', '40–49 years old' and '50 years old and above'). Ethnicity was collected as a categorical variable (Chinese, Malay, Indian and 'other'), as were educational attainment (recoded into 'secondary and below', 'pre-university', 'bachelor's degree' and 'postgraduate degree') and self-reported HIV status ('HIV-positive, undetectable', 'HIV-positive', 'HIV-negative' and 'don't know'). Respondents were asked if they had disclosed their sexual orientation to non-LGBTQ (Lesbian, Gay, Bisexual, Transgender, and Questioning) family members (yes vs no), non-LGBTQ friends (yes vs no), non-LGBTQ colleagues (yes vs no), other LGBTQ individuals (yes vs no), 'other' (yes vs no; participant was required to specify who they meant by 'other') and if they had never disclosed their sexual orientation to anyone (yes vs no).

Data on self-reported HIV testing behaviours were collected. Respondents were asked when they had their last voluntary HIV test ('never', 'in the last 6 months', '6–12 months ago', 'more than a year ago') and the location of testing ('government-run clinic or hospital', 'private clinic or hospital', 'anonymous test site - NGO', 'overseas', 'other'). Participants were asked specifically about voluntary HIV testing, as there are certain circumstances in which HIV tests are mandated in Singapore, such as before compulsory military service for Singapore men aged 18 years,[13] and for foreign nationals seeking employment in Singapore.[14] Anonymous HIV testing in Singapore is offered at several private clinics and NGOs to encourage testing among at-risk populations, as the Infectious Diseases Act mandates that all individuals who test positive at

non-anonymous public and private healthcare establishments are required to be registered with the Ministry of Health.[15]

All participants were asked if they had ever heard of or taken PrEP through a categorical response question ('yes, I have taken it', 'yes, I have heard of it but not taken it' and 'no, I have never heard of it'). Of those who had taken PrEP, respondents were asked for the sources from which they had obtained PrEP, either from government-run clinics of hospitals (yes vs no), private clinic or hospital (yes vs no), anonymous test sites situated at general practitioner practices (yes vs no), anonymous testing sites situated in NGOs (yes vs no), overseas (yes vs no) and 'other' (yes vs no; participant was required to specify what they meant by 'other'). Of those who have heard of PrEP but had not taken it, they were asked if they would consider taking PrEP (yes vs no). All participants who had taken PrEP were asked their reasons for taking PrEP through an open-ended text response field; while participants who said that they would consider or not consider PrEP were requested to elaborate further on their chosen response respectively.

Analytic plan

Quantitative data analysis was carried out using the statistical software, STATA version 15 (Stata Corp, College Station, TX, USA). The present study used descriptive statistics to elucidate patterns and trends in respondent characteristics, and in the responses relating to PrEP. Multivariate Poisson regression models with robust sandwich variances were used to compute the crude prevalence ratio (PR) and adjusted PR (aPR) for the outcome variables of interest, including the prevalence of those who have taken PrEP and for those who have never heard of PrEP. We controlled for key sociodemographic variables such as age, educational attainment, residence status and disclosure of sexual orientation, along with respondents' last HIV testing location, for all multivariate models.

Qualitative content analysis was conducted for three sets of open-ended responses: respondents' reasons for taking PrEP; and, if they had heard of PrEP but not taken it, reasons for considering taking PrEP; and reasons for not considering taking PrEP. Two coders (RKJ Tan and AKJ Teo) compiled each set of responses and conducted open-coding for each set to generate three sets of preliminary codes. Both coders met to discuss and group the preliminary codes to develop a coding frame that comprised broader categories. Intercoder reliability analysis was conducted for the use of each coding frame across the two designated coders; results indicated acceptable intercoder reliability across different sets of responses, with both Krippendorff's α and Cohen's kappa of 0.84, 0.83 and 0.88 calculated for the reasons for taking PrEP, considering PrEP and not considering PrEP respectively.

Results

Sample characteristics

Of the 1339 respondents who commenced the survey, 10 responses were excluded as they did not meet the age requirements for the survey. Another 167 respondents ceased participation immediately after choosing the language they preferred to take the survey in. Another 64 respondents ceased participation midway through the first few questions on demographic attributes. Of the remaining 1162 respondents, 1098 of those who indicated their knowledge and use of PrEP were included in the analytic sample. Figure 1 summarises the derivation of the analytic sample in a flowchart.

Table 1 summarises the demographic attributes and HIV testing patterns of the analytic sample ($n = 1098$). The demographics of the survey respondents are comparable with Singapore's national composition when comparing ethnicity (after accounting for foreigners in the sample) and residence status. However, the present sample has a higher proportion of

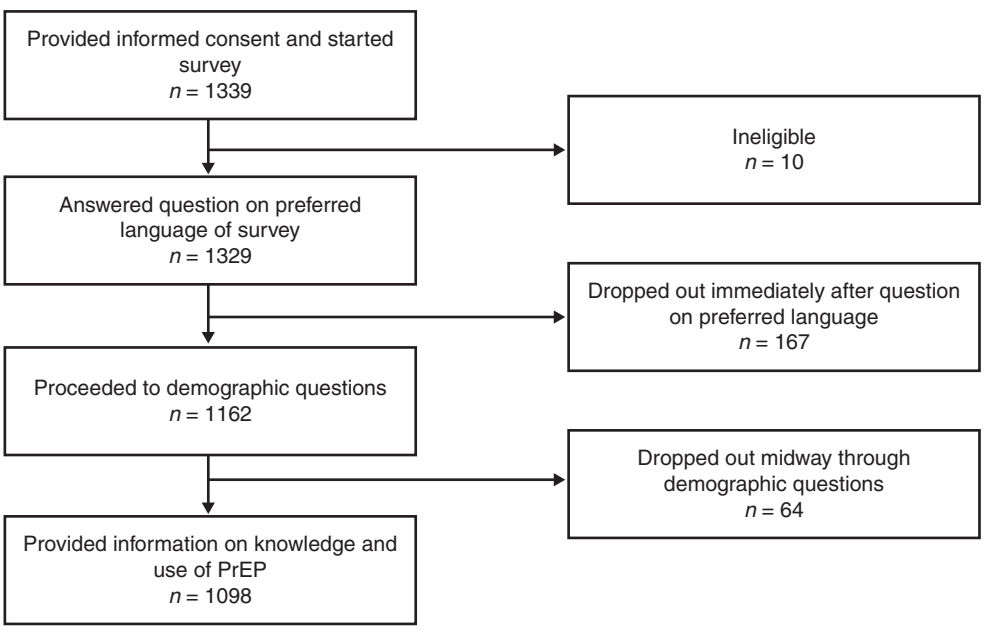

Fig. 1. Flowchart summarising the derivation of the analytic sample.

Table 1. Description of the analytic sample by demographic attributes (n = 1098)

NGO, non-government organisation; s.d., standard deviation

Demographic variables	*n*	%
Language of survey		
English	960	87.4
Mandarin	101	9.2
Bahasa Melayu	28	2.6
Tamil	9	0.8
Residence status		
Singapore citizen or permanent resident	797	72.6
Foreigner	301	27.4
Ethnicity		
Chinese	718	65.4
Malay	127	11.6
Indian	86	7.8
Others	167	15.2
Educational attainment		
Secondary and below	124	11.3
Pre-university	308	28.1
Bachelor's degree	478	43.5
Postgraduate degree	188	17.1
Disclosure of sexual orientation		
Never disclosed to anyone	182	16.6
Ever disclosed to another person	916	83.4
HIV status		
HIV positive	73	6.6
HIV negative	821	74.8
Don't know	204	18.6
Last voluntary HIV test (n = 1025)[A]		
In the last 6 months	517	50.4
6–12 months ago	163	15.9
More than a year ago	175	17.1
Never tested voluntarily for HIV	170	16.6
Location of last voluntary HIV test (n = 855)[B]		
Anonymous testing site (NGO)	240	28.1
Privately run clinic or hospital	352	41.2
Government-run clinic or hospital	164	19.2
Overseas	84	9.8
Other (e.g. self-testing)	15	1.8
	Mean	s.d.
Age	33.2	9.78

[A]73 HIV-positive respondents were excluded.

[B]73 HIV-positive respondents and 170 HIV-negative respondents who have never tested for HIV were excluded.

individuals who had attained a higher level of education, compared with the general Singapore resident population. With regard to self-reported HIV status, 6.6% of respondents identified as HIV positive, 74.8% as HIV negative and 18.6% reported being unaware of their HIV status. As for self-reported disclosure of one's own sexual orientation, 16.6% of respondents reported that they had never disclosed their sexual orientation to any other person. Of the 1025 respondents who self-reported being HIV negative, 16.6% (n = 170) had never taken a voluntary HIV test, while 50.4% (n = 517) had taken a voluntary HIV test in the last 6 months. Of the 855 respondents who reported ever having had a voluntary HIV test, 28.1% (n = 240) were tested at anonymous testing sites run by NGOs, 41.2% (n = 352) were tested at privately run clinics or hospitals, 19.2% (n = 164) at government-run clinics or hospitals, while 11.6% (n = 99) were tested overseas or through self-testing (all 'other' responses comprised respondents who had self-tested for HIV).

PrEP knowledge, uptake and attitudes

Table 2 summarises the knowledge, uptake and demand for PrEP, and the associated reasons for respondents' chosen options. Of the 1025 HIV-negative respondents who answered the question, '*Have you heard of HIV pre-exposure prophylaxis (PrEP)*?', 15.0% (n = 154) reported that they had heard of PrEP and had ever taken it, 66.2% (n = 678) reported that they had heard of PrEP but not taken it, while 18.8% (n = 193) reported that they had never heard of PrEP.

Of the 154 respondents who had taken PrEP, 151 provided the sources from which they obtained PrEP. Of these, 59.6% (n = 90) obtained PrEP from overseas and other unofficial sources (including through friends or online PrEP stores), 25.8% (n = 39) from privately run clinics or hospitals, 13.2% (n = 20) from government-run clinics and hospitals and 6.0% (n = 9) from non-governmental organisations; however, NGOs in the present setting are currently unable to prescribe or supply PrEP, and these respondents may have obtained their PrEP from overseas NGOs or other unofficial sources. Figure 2 provides an overview of the various sources of PrEP among participants who had taken PrEP (n = 151), contrasted against the proportion of GBMSM surveyed who had their last voluntary HIV test (n = 855) at the respective locations.

Of the 154 respondents who had ever taken PrEP, 134 (87.0%) provided reasons as to why they started taking PrEP. Of these, 59.7% (n = 80) regarded PrEP as an effective means of preventing HIV acquisition, 14.9% (n = 20) regarded PrEP as a means of providing extra protection over current HIV prevention methods, 9.7% (n = 13) used PrEP to engage in sex without condoms, 8.2% (n = 11) perceived themselves to be at high risk for HIV acquisition and 3.0% (n = 4) were in HIV-serodiscordant relationships.

Among respondents who reported having heard about PrEP but had never taken it (n = 678), 663 (97.8%) provided responses to the question, '*if you have not taken PrEP, would you consider taking PrEP*?'; 73.3% (n = 486) reported that they would consider using PrEP, while 26.7% (n = 177) reported that they would not consider using PrEP.

Among those who would consider using PrEP (n = 486), 176 (36.2%) provided reasons as to why they would do so. Of these, 69.3% (n = 122) regarded PrEP as an effective means of preventing HIV acquisition, 12.5% (n = 22) regarded PrEP as a means of providing extra protection over current HIV prevention methods, 6.8% (n = 12) would use PrEP to engage in sex without condoms, 5.7% (n = 10) perceived themselves to be at high risk for HIV acquisition, 0.6% (n = 1) was in a serodiscordant relationship and 5.1% (n = 9) gave other reasons, such as the convenience of PrEP compared with condoms.

Among those who would not consider using PrEP (n = 177), 129 (72.9%) provided reasons as to why they would not

Table 2. Knowledge, uptake and demand for pre-exposure prophylaxis (PrEP) in the analytic sample

Variables	*n*	%
Have you heard of HIV pre-exposure prophylaxis (PrEP)? (*n* = 1025)		
Yes, I have taken it	154	15.0
Yes, I have heard of it but not taken it	678	66.2
No, I have never heard of it	193	18.8
Respondents who reported ever taking PrEP (*n* = 154)		
Sources where PrEP was obtained (*n* = *151*)[A]		
Government-run clinic or hospital	20	13.2
Privately run clinic or hospital	39	25.8
Non-governmental organisations	9	6.0
Overseas and other unofficial sources	90	59.6
Reasons for taking PrEP (*n* = *134*)[B]		
Effective in preventing HIV	80	59.7
Extra protection	20	14.9
Engages in sex without condoms	13	9.7
High HIV risk perception	11	8.2
Serodiscordant relationship	4	3.0
Others	6	4.5
Respondents who reported hearing of, but never taking PrEP (*n* = 678)		
If you have not taken PrEP, would you consider taking PrEP? (*n* = *663*)[C]		
Yes	486	73.3
No	177	26.7
Reasons for considering PrEP (*n* = *176*)[D]		
Effective in preventing HIV	122	69.3
Extra protection	22	12.5
Engages in sex without condoms	12	6.8
High HIV risk perception	10	5.7
Serodiscordant relationship	1	0.6
Others	9	5.1
Reasons for not considering PrEP (*n* = *129*)[E]		
Low perceived susceptibility of HIV	37	28.7
Cost and accessibility of PrEP	23	17.8
Doubts on efficacy of PrEP	16	12.4
Concerns about risk compensation	16	12.4
Side-effects of PrEP	15	11.6
Lack of information on PrEP	7	5.4
Inconvenience of PrEP	7	5.4
Others	8	6.2

[A]Three respondents did not answer this question; participants could choose more than one option for this question, and percentages reflect the number of respondents who obtained PrEP from the respective sources, out of 151 respondents who had taken PrEP.
[B]Fifteen respondents who were HIV positive were excluded from this question; 20 other respondents did not answer this question.
[C]Fifty-eight respondents who were HIV positive were excluded from this question; nine other respondents did not answer this question.
[D]Only 176 out of 486 respondents provided a response to this question.
[E]Only 130 out of 177 respondents provided a response to this question.

consider using PrEP. Of these, 28.7% (*n* = 37) perceived themselves to be at low risk of HIV acquisition, 17.8% (*n* = 23) cited barriers relating to cost and accessibility, 12.4% (*n* = 16) had doubts about the efficacy of PrEP, 12.4% (*n* = 16) had concerns over how PrEP would lead to risk compensation in the community, 11.6% (*n* = 15) had concerns over the side-effects of PrEP, 5.4% (*n* = 7) did not have enough information on PrEP, 5.4% (*n* = 7) regarded PrEP as inconvenient and 6.2% (*n* = 8) gave other reasons, such as preferring sex with condoms.

Table 3 summarises the multivariate Poisson regression models with robust sandwich variances estimating the PR and aPR for those who had ever taken PrEP, and those who had ever heard of PrEP, controlling for age, educational attainment, residence status and disclosure of sexual orientation. After adjusting for covariates, we found that increasing age and having higher educational attainment were significantly positively associated with ever taking PrEP in the sample. Specifically, those aged 30–39, 40–49 years and ≥50 years were 1.54-, 1.93- and 2.13-fold more likely than those ages 18–29 years to have taken PrEP respectively. Those who had a postgraduate degree were 2.40-fold more likely than those with secondary school education and below to had ever taken PrEP.

After adjusting for covariates, we found that individuals who were aged 30–39 years, had higher levels of educational attainment, were Singaporean citizens or permanent residents and had disclosed their sexual orientation were more likely to had ever heard of PrEP. Specifically, those aged 30–39 years were 1.07-fold more likely than those aged 18–29 years, while those who had attended pre-university, or obtained a bachelor's degree and postgraduate degree were 1.27-, 1.52- and 1.59-fold more likely than those with secondary school education and below to had ever heard of PrEP respectively. Non-Singaporeans were 0.81-fold as likely as Singaporean residents to had ever heard of PrEP, and respondents who had never disclosed their sexual orientation to anyone were 0.76-fold as likely as those who had disclosed their sexual orientation to had ever heard of PrEP.

Discussion

In this survey among GBMSM Grindr® users residing in Singapore, we explored HIV testing patterns and service preferences, as well as knowledge and uptake of, and attitudes towards PrEP. We draw on these findings to highlight existing trends in the context of PrEP, potential barriers to the implementation of PrEP and recommendations for the scaling up of PrEP in the present setting.

Knowledge of PrEP

Our study found that 15.0% of HIV-negative GBMSM in the analytic sample had taken PrEP, while 66.2% of HIV-negative GBMSM had heard of but never taken PrEP. Only 18.8% of GBMSM surveyed indicated that they had never heard of PrEP. The prevalence of PrEP use among HIV-negative GBMSM in the sample was comparable to that of GBMSM in other urban settings, such as Sydney (15.4% had used PrEP in the last 6 months), San Francisco (14.5% had used PrEP in the last 12 months) and in New York (14.8% had used PrEP in the last 6 months).[16–18]

While they exist in the minority, it is important to note that those who had never heard of PrEP were more likely to be less educated, non-Singapore citizens or permanent residents and had never disclosed their sexual orientation to anyone. These findings indicate existing gaps in the dissemination of knowledge on PrEP, which may currently be via word of mouth,

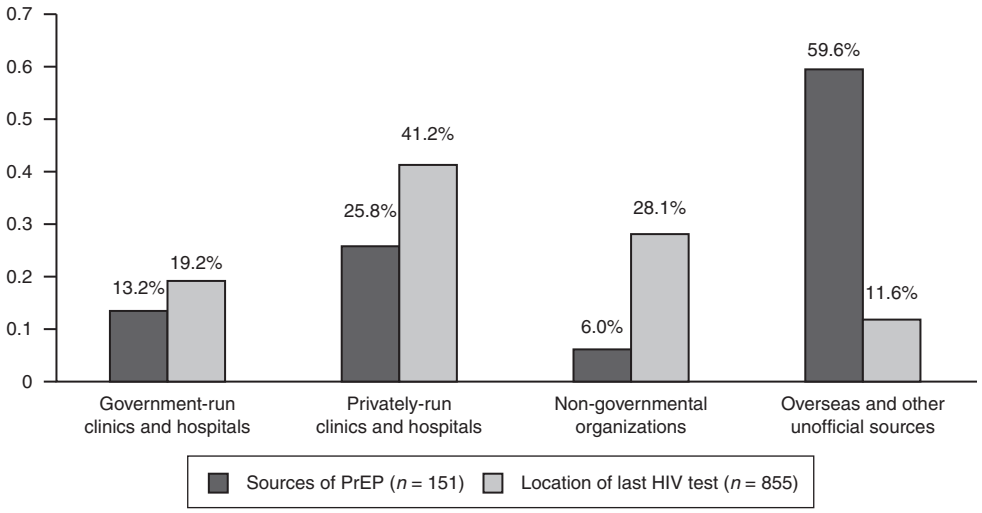

Fig. 2. Comparison of trends in last HIV testing location and sources of pre-exposure prophylaxis (PrEP).

social media within the local GBMSM community or health promotion efforts by NGOs that promote GBMSM sexual health. This precludes GBMSM who are not local, or who are not 'out' with their sexual orientation, and consequently are less likely to assimilate and pick up information from GBMSM-specific venues or campaigns. The association between educational attainment and knowledge of PrEP is consistent with the extant literature that establishes a positive association between education and PrEP knowledge, as well as general sexual health-seeking among GBMSM.[19–22]

Uptake and willingness to use PrEP: issues of cost

Our results provide insight into the barriers to accessing to PrEP among GBMSM in Singapore. Results of multivariate Poisson regression indicate that those who were older and had higher levels of educational attainment were more likely to have taken PrEP. As PrEP is only available at unsubsidised prices in Singapore, these findings may be reflective of how respondents who are older or more educated may be better able to afford PrEP. Furthermore, the finding that a large proportion of GBMSM had obtained PrEP overseas may be attributed to the lower cost of generic PrEP that is available in other neighbouring countries.

We found that most respondents who had heard of PrEP were willing to consider using PrEP. Of the 66.2% of HIV-negative GBMSM who had heard of but never taken PrEP, 73.3% had indicated that they would consider using PrEP, citing the effectiveness of PrEP in preventing HIV and as extra protection over and above existing methods, as the most important reasons for their willingness to use PrEP. Among respondents who said that they would not consider using PrEP (26.7%), a low perceived susceptibility of HIV, as well as the cost and accessibility of PrEP, were the most important reasons for not being willing to use PrEP. As responses that were coded as a 'low perceived susceptibility of HIV' included reasons relating to the self-perceived lack of risk or sexual activity by respondents ('I don't engage in casual sex') or the preference to only practice safe sex ('I only do protected sex'), cost and accessibility of PrEP would thus be the main barrier cited for not considering the use of PrEP in this group. Assuming full uptake and lowered barriers to access PrEP, a total of 62.4% ($n = 640$) of GBMSM surveyed, comprising those who had taken PrEP (15.0%; $n = 154$) and those who had heard of PrEP and are willing to use it (47.4%; $n = 486$), would utilise PrEP.

HIV testing service preferences: issues of anonymity

We found that most GBMSM, when asked for the location of their last voluntary HIV test ($n = 855$), reported that they tested for HIV outside of government-run healthcare institutions. Only 19.2% of GBMSM sampled had had their last voluntary HIV test at a government-run clinic or hospital. When asked about the source from which they had obtained PrEP, more GBMSM reported getting PrEP from privately run PrEP providers than government-run PrEP providers, despite the much higher prices charged for PrEP at the former. Given that sex between men is criminalised in Singapore and that society largely holds negative views towards GBMSM in the present setting, these findings are unsurprising. Opinion leaders in the GBMSM community have highlighted the detrimental effect of Section 377A of the Penal Code on HIV prevention efforts in Singapore, specifically by making GBMSM unwilling to test or seeking early treatment for HIV out of fear of being identified as homosexual by the authorities.[23,24] Globally, public health practitioners and academics have also recognised the negative effect of stigma, discrimination and the criminalisation of GBMSM in driving concentrated epidemics of HIV among marginalised communities around the world, and have called for more comprehensive services that serve the GBMSM community.[25]

Strengths and limitations

We identified several limitations relating to the selection of GBMSM sample in our study in Singapore. The study population – geosocial networking app users – limits the generalisability of the findings to the general population of

Table 3. Multivariate Poisson regression with crude prevalence ratios and adjusted prevalence ratios (95%CI) for having ever taken PrEP and hearing of PrEP

PrEP, pre-exposure prophylaxis; CI, confidence interval; PR, prevalence ratio; aPR, adjusted prevalence ratio

	Ever taken PrEP							Ever heard of PrEP					
	Model 1			Model 2		Model 3			Model 4				
	PR	95% CI	*P*-value	aPR	95% CI	*P*-value	PR	95% CI	*P*-value	aPR	95% CI	*P*-value
Age (years; ref = 18 –29 years)												
30–39	1.71	(1.18 – 2.48)	0.005	1.54	(1.05 – 2.28)	0.029	1.19	(1.11 – 1.27)	<0.001	1.07	(1.00 – 1.15)	0.045
40–49	2.14	(1.40 – 3.26)	<0.001	1.93	(1.24 – 2.99)	0.003	1.17	(1.08 – 1.28)	<0.001	1.07	(0.98 – 1.16)	0.125
≥50	2.31	(1.42 – 3.75)	0.001	2.13	(1.29 – 3.51)	0.003	1.09	(0.97 – 1.22)	0.161	1.00	(0.89 – 1.13)	0.960
Educational attainment (ref = secondary and below)												
Pre-University	1.74	(0.87 – 3.49)	0.116	1.64	(0.82 – 3.29)	0.163	1.36	(1.13 – 1.64)	0.001	1.27	(1.06 – 1.52)	0.008
Bachelor's degree	1.87	(0.96 – 3.66)	0.066	1.63	(0.83 – 3.19)	0.157	1.63	(1.37 – 1.95)	<0.001	1.52	(1.28 – 1.80)	<0.001
Postgraduate degree	3.00	(1.51 – 5.96)	0.002	2.40	(1.2 – 4.77)	0.013	1.71	(1.43 – 2.04)	<0.001	1.59	(1.34 – 1.88)	<0.001
Non-Singaporean citizen or permanent resident	0.87	(0.62 – 1.22)	0.414	0.97	(0.69 – 1.37)	0.873	0.79	(0.73 – 0.86)	<0.001	0.81	(0.75 – 0.87)	<0.001
Never disclosed sexual orientation to anyone	0.58	(0.36 – 0.96)	0.032	0.61	(0.38 – 1.00)	0.050	0.73	(0.65 – 0.83)	<0.001	0.76	(0.68 – 0.85)	<0.001

GBMSM in Singapore. However, as the popularity of geosocial networking apps has grown in recent years, and there is evidence that app users are more likely to have ever tested for HIV and are more sexually active than non-app-users,[26] PrEP use may thus be particularly impactful in this subpopulation of GBMSM. Furthermore, our study population is younger than that of the general population, but they represent the demographics of the group most affected by HIV in 2016 in Singapore; specifically GBMSM aged between 20–39 years.[6]

Although sampling through Grindr® might have precluded individuals who might not have access to smartphones, we believe that such a bias is less plausible, given that Singapore's mobile penetration rate was 148.8% as at October 2017.[27] Due to the lack of monetary incentives to participate, the recruitment message '*Have a few minutes to spare*? *Participate in our anonymous survey on PrEP in Singapore*' was developed to highlight the topic of PrEP and the anonymous nature of the survey to improve the participation rate of the survey. However, this could have biased the sample towards individuals with prior knowledge or use of PrEP, thus underestimating the number of respondents who had never heard of PrEP. The sampling method of recruiting Grindr® users, who were relatively younger and potentially more technologically savvy and sexually active than the general GBMSM population, may have also caused an overestimation of those who had ever used or heard of PrEP.

Respondents who identified as non-Singaporeans were not asked if they were working in Singapore or were in Singapore for a short-term visit, which could have biased the results regarding the channels where respondents had accessed PrEP or had last tested for HIV, given that short-term visitors would have most likely accessed such HIV-related health services overseas. However, we found that only 17 (11.0%) out of 154 respondents who had reported ever taking PrEP were non-Singaporean citizens or permanent residents, and had obtained PrEP through overseas sources, thus reducing the effect of this potential bias. Furthermore, given the alignment of the sample's demographic breakdown by residence status with Singapore's national population, we believe that any effect that this would have on the results would be minimal.

We also identified several potential issues pertaining to information bias in the present study. Due to the lack of monetary incentive for participation in this survey, we devised a questionnaire of reasonable length to improve the survey completion rate; there are potentially several unmeasured confounders that might have affected the results from our multivariate models. Furthermore, only 36.2% of respondents who indicated that they had heard of PrEP but not taken it, and would consider it, provided reasons for why they would consider it. We believe that those who provided responses may represent a portion of GBMSM who might possess greater PrEP-related knowledge and may thus be able to articulate why PrEP may be useful for them. Consequently, the reasons for considering PrEP among respondents with lower PrEP knowledge may not be represented.

The brevity of the survey instrument also meant that several important questions that would have allowed us to better understand the barriers to accessing PrEP among GBMSM in Singapore were not included in the survey questionnaire. First,

as participants were asked if they had ever taken PrEP, we could not ascertain if participants had stopped taking PrEP, and their reasons for doing so. Second, as we were interested in the perceptions driving the potential demand for PrEP among GBMSM in Singapore, participants who indicated that they would consider PrEP, given that they had heard of PrEP but not taken it, were only asked about the reasons as to why they would consider using PrEP and not why they had not yet taken PrEP, given their willingness to do so. Finally, the open-ended text response questions soliciting respondents' reasons for taking PrEP and for considering or not considering PrEP given that they had heard of it but not yet taken it, could not capture the multiple and potentially complex nature of barriers to accessing PrEP among GBMSM in Singapore. Ultimately, the availability of such information would shed further light on the obstacles to the effective and sustained implementation of PrEP in the local GBMSM community, and warrants further research.

Conclusion and recommendations

The present study among GBMSM Grindr® users residing in Singapore identified the cost of PrEP and the relative lack of anonymity accorded to patients at healthcare institutions, as the main challenges to the wider implementation and roll-out of PrEP in Singapore. We recommend that policymakers should extend subsidies or other forms of national medical financing schemes to offset the high cost of PrEP. To address issues relating to anonymity, we suggest that PrEP prescribing and dispensing be made available through existing NGOs that provide anonymous HIV testing services, where anonymous HIV testing may also be carried out for those accessing their regular supply of PrEP. As this represents a significant change to conventional health services provision in Singapore, this will require a multipartite effort on the part of NGOs, government and healthcare institutions. Further efforts need to be undertaken by community organisations to provide more knowledge about PrEP among GBMSM who test for HIV at government and privately run sexual health clinics. These measures will help ensure that PrEP services are delivered in a sustainable way and can reach those who need it the most.

Conflicts of interest

The authors declare no conflicts of interest.

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