Community-level changes in condom use and uptake of HIV pre-exposure prophylaxis by gay and bisexual men in Melbourne and Sydney, Australia: results of repeated behavioural surveillance in 2013–17

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Summary

Background Pre-exposure prophylaxis (PrEP) has been rapidly rolled out in large, publicly funded implementation projects in Victoria and New South Wales, Australia. Using behavioural surveillance of gay and bisexual men, we analysed the uptake and effect of PrEP, particularly on condom use by gay and bisexual men not using PrEP.

Methods We collected data from the Melbourne and Sydney Gay Community Periodic Surveys (GCPS), cross-sectional surveys of adult gay and bisexual men in Melbourne, VIC, and Sydney, NSW. Recruitment occurred at gay venues or events and online. Eligible participants were 18 years or older (face-to-face recruitment) or 16 years or older (online recruitment), identified as male (including transgender participants who identified as male); and having had sex with a man in the past 5 years or identified as gay or bisexual, or both. Using multivariate logistic regression, we assessed trends in condom use, condomless anal intercourse with casual partners (CAIC), and PrEP use by gay and bisexual men, controlling for sample variation over time.

Findings Between Jan 1, 2013, and March 31, 2017, 27 011 participants completed questionnaires in the Melbourne (n=13 051) and Sydney (n=13 960) GCPS. 16 827 reported sex with casual male partners in the 6 months before survey and were included in these analyses. In 2013, 26 (1%) of 2692 men reported CAIC and were HIV-negative and using PrEP, compared with 167 (5%) of 3660 men in 2016 and 652 (16%) of 4018 men in 2017 (p<0·0001). Consistent condom use was reported by 1360 (46%) of 2692 men in 2013, 1523 (42%) of 3660 men in 2016, and 1229 (31%) of 4018 men in 2017 (p<0·0001). In 2013, 800 (30%) of 2692 men who were HIV-negative or untested and not on PrEP reported CAIC, compared with 1118 (31%) of 3660 men in 2016, and 1166 (29%) of 4018 in 2017 (non-significant trend).

Interpretation A rapid increase in PrEP use by gay and bisexual men in Melbourne and Sydney was accompanied by an equally rapid decrease in consistent condom use. Other jurisdictions should consider the potential for community-level increases in CAIC when modelling the introduction of PrEP and in monitoring its effect.

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Introduction

Regular use of antiretroviral drugs as pre-exposure prophylaxis (PrEP) is highly effective for the prevention of HIV infection.[1] WHO has recommended PrEP be made available to populations at high risk of HIV.[2]

In 2014–15, small demonstration projects were implemented in New South Wales and Victoria, Australia's most populous states, offering PrEP to people at high risk of HIV (predominantly gay and bisexual men).[3,4] Since March, 2016, large-scale implementation projects have enrolled more than 10 000 participants.

Concerns have been raised that risk compensation (decreased perceptions of HIV risk and less condom use) might undermine the effectiveness of PrEP.[5–7] In recent systematic reviews of randomised trials,[1,8] no evidence was found of increased condomless sex by PrEP users, but participants in these studies were unaware whether they were receiving PrEP or a placebo. In open-label and cohort studies of PrEP users,[9–12] condomless sex had become more frequent over time, but this does not seem to diminish the efficacy of PrEP if drug adherence is maintained. Less attention has been paid to the population-level effect of PrEP on community norms and behaviour. In particular, if people feel safer, the introduction of PrEP might lead to decreased condom use by those not using PrEP (so-called community-level risk compensation).[7] In San Francisco, CA, USA, condom use by gay and bisexual men, including those not using PrEP, decreased rapidly after PrEP was introduced.[13,14] The San Francisco researchers suggested that some men had given up consistent condom use under the assumption that other men will be using PrEP.[13]

Research in context

Evidence before this study

We searched PubMed for studies published in English before Dec 31, 2017, with the terms "HIV", "pre-exposure" or "preexposure", "prophylaxis", "men who have sex with men" or "MSM" or "gay" or "bisexual", "behaviour" or "behavior", "surveillance" or "impact" or "change", and "condom". In two systematic reviews, the sexual behaviour of men who used pre-exposure prophylaxis (PrEP) in trials did not change significantly. In three open label studies and one cohort study, PrEP users used condoms less often over time, and in five mathematical models, the effect of decreased condom use was considered for PrEP users but not for other men who have sex with men (MSM). In one study from San Francisco, condom use at a community level (ie, by MSM not using PrEP) decreased as PrEP use increased. Evidence suggesting that community-level changes in behaviour is related to PrEP was lacking from other jurisdictions.

Added value of this study

Using annual behavioural surveillance of gay and bisexual men in Australia's largest cities, Melbourne, VIC, and Sydney, NSW, we analysed the uptake and effect of PrEP on sexual behaviour in 2013–17. We found a rapid increase in PrEP use, particularly in 2016–17, and a reduction of a similar magnitude in consistent condom use at a population level (ie, consistent condom use with casual partners decreased in men not using PrEP). Despite the reduction in condom use, the overall level of protection in the population increased slightly and new HIV diagnoses in MSM decreased.

Implications of all the available evidence

The introduction of PrEP might be accompanied by a decrease in condom use by non-PrEP users. This potential change has not been consistently assessed or accounted for in routine monitoring of MSM or in mathematical modelling. The degree to which community-level risk compensation might impede the long-term, population-level effectiveness of PrEP is unknown. We recommend improved monitoring and evaluation to assess the effect of PrEP on sexual behaviour at a community or population level.

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Although decreased condom use by adherent PrEP users might have little effect on its efficacy in preventing HIV infection, decreased condom use by others could undermine the population-level effect of PrEP by increasing the number of unprotected sex acts during which transmission might occur. In San Francisco, annual HIV diagnoses in men who have sex with men (MSM) decreased by 55% between 2012 and 2016.[14] This suggests that the uptake of PrEP might outweigh the effect of community-level increases in condomless sex on new HIV diagnoses. Mathematical modelling has been done to assess the potential effect of PrEP on HIV epidemics in MSM.[15–19] However, although these models often assess scenarios in which PrEP users reduce condom use, they do not seem to consider the effect of non-PrEP-using MSM reducing condom use as PrEP uptake becomes more common.

In the context of rapidly increasing PrEP use in New South Wales and Victoria between 2016 and 2017, we adapted behavioural surveillance of gay and bisexual men to assess the effect of PrEP on condom use at a community level.[20] Our aim was to assess the degree of community-level risk compensation, if any, and the potential need to refine combination prevention responses in these jurisdictions.

Methods

Participants and procedures

Data were collected in the Melbourne and Sydney Gay Community Periodic Surveys (GCPS). These behavioural surveillance studies have been done annually for more than 20 years during Melbourne's Midsumma Festival and Sydney's Gay and Lesbian Mardi Gras. We included data from the period 2013–17 to compare periods before (2013–16) and after (2017) widespread PrEP use. The GCPS methods have been described previously.[20,21] In brief, the GCPS use time–location sampling at gay venues and events, during which trained recruitment staff approach men and ask them to self-complete a paper questionnaire. In each city, face-to-face recruitment occurs over two weekends, followed by a week of online recruitment driven by paid Facebook advertising. Online advertising is targeted at gay and bisexual men throughout Victoria and New South Wales. Online participants completed the questionnaire on the study website, and completing a questionnaire was taken as evidence of consent. The GCPS have been approved by the human research ethics committees of the University of New South Wales (reference HC13366), Victorian AIDS Council, and ACON (formerly the AIDS Council of New South Wales).

For the **study website** see http://gcpsonline.net

Participant eligibility criteria included: residing in Victoria or regularly participating in the Melbourne gay community (Melbourne GCPS); residing in New South Wales or regularly participating in the Sydney gay community (Sydney GCPS); aged 18 years or older (face-to-face recruitment) or 16 years or older (online recruitment); identifying as male (including transgender participants who identified as male); and having had sex with a man in the past 5 years or identifying as gay or bisexual, or both.

Measures

The questionnaire measures have been described previously.[20,21] The questionnaires are published in the survey reports and are accessible online. We included several variables in our analyses (table 1). We also reported HIV testing in the past 6 months and prescribed

For the **questionnaires** see https://csrh.arts.unsw.edu.au/research/publications/gcps/

	All (N=16 827)	Melbourne (N=8165)	Sydney (N=8662)	p value
Age, years	36 (12)	36 (12)	37 (12)	0·0029
Recruitment source	..	..	..	<0·0001
Gay social venue or event	11 896 (71%)	6159 (75%)	5737 (66%)	..
Sex-on-premises venue	2356 (14%)	1069 (13%)	1287 (15%)	..
Sexual health or other clinic	927 (6%)	190 (2%)	737 (9%)	..
Online	1648 (10%)	747 (9%)	901 (10%)	..
Sexual identity	..	..	..	0·014
Gay	15 335 (91%)	7492 (92%)	7843 (91%)	..
Bisexual	1007 (6%)	446 (5%)	561 (6%)	..
Other	485 (3%)	227 (3%)	258 (3%)	..
Ethnicity	..	..	..	<0·0001
Anglo-Australian	10 809 (64%)	5509 (67%)	5300 (61%)	..
Aboriginal or Torres Strait Islander, or both	469 (3%)	180 (2%)	289 (3%)	..
Asian	1784 (11%)	749 (9%)	1035 (12%)	..
Other	3765 (22%)	1727 (21%)	2038 (24%)	..
Completed education	..	..	..	<0·0001
Below year 12 (high school)	1127 (7%)	538 (7%)	589 (7%)	..
Completed Year 12	2814 (17%)	1487 (18%)	1327 (15%)	..
Trade certificate	3384 (20%)	1660 (20%)	1724 (20%)	..
University degree	9420 (56%)	4437 (55%)	4983 (58%)	..
Employment status	..	..	..	<0·0001
Full-time employment	11 194 (67%)	5323 (65%)	5871 (68%)	..
Part-time employment	2115 (13%)	1131 (14%)	984 (11%)	..
Other	3518 (21%)	1711 (21%)	1807 (21%)	..
Number of gay friends	..	..	..	0·043
None, a few, or some	9040 (54%)	4452 (55%)	4588 (53%)	..
Most or all	7787 (46%)	3713 (45%)	4074 (47%)	..
Free time spent with gay men	..	..	..	0·0010
None, a little, or some	10 089 (60%)	4998 (61%)	5091 (59%)	..
A lot	6738 (40%)	3167 (39%)	3571 (41%)	..
HIV status	..	..	..	0·17
HIV-negative	13 596 (81%)	6550 (80%)	7046 (81%)	..
HIV-positive	1631 (10%)	811 (10%)	820 (9%)	..
Unknown or untested	1600 (10%)	804 (10%)	796 (9%)	..
Number of male sex partners in past 6 months	..	..	..	0·032
0–5	7332 (44%)	3505 (43%)	3827 (44%)	..
6–10	3610 (21%)	1725 (21%)	1885 (22%)	..
11–20	2742 (16%)	1339 (16%)	1403 (16%)	..
More than 20	3143 (19%)	1596 (20%)	1547 (18%)	..
Sex with regular male partners in past 6 months	..	..	..	0·12
No partner	5854 (35%)	2833 (35%)	3021 (35%)	..
No anal intercourse	2184 (13%)	1079 (13%)	1105 (13%)	..
Consistent condom use	2725 (16%)	1270 (16%)	1455 (17%)	..
Any CAI	6064 (36%)	2983 (37%)	3081 (36%)	..
HIV status of regular male partner	..	..	..	0·012
HIV-negative	6116 (36%)	2886 (35%)	3230 (37%)	..
HIV-positive	803 (5%)	406 (5%)	397 (5%)	..
Unknown or untested	4054 (24%)	2040 (25%)	2014 (23%)	..
No partner	5854 (35%)	2833 (35%)	3021 (35%)	..
Crystal methamphetamine use in past 6 months	2409 (14%)	1063 (13%)	1346 (16%)	<0·0001
Group sex during or after drug use in past 6 months	2818 (17%)	1296 (16%)	1522 (18%)	0·0030

(Table 1 continues on next page)

	All (N=16 827)	Melbourne (N=8165)	Sydney (N=8662)	p value
(Continued from previous page)				
Post-exposure prophylaxis use in past 6 months	1006 (6%)	487 (6%)	519 (6%)	0·94
Diagnosis with any sexually transmissible infection (other than HIV) in past 12 months	3807 (23%)	1878 (23%)	1929 (22%)	0·26

Data are mean (SD) or n (%). CAI=condomless anal intercourse.

Table 1: **Participant characteristics**

	2013	2014	2015	2016	2017	β coefficient or crude OR (95% CI)	p value
Whole sample (gay and bisexual men with casual partners)	2962	2595	3592	3660	4018	..	..
Age, years	37·3 (12·0)	36·8 (11·7)	36·2 (12·2)	36·1 (11·6)	35·9 (11·9)	–0·34 (–0·47 to –0·22)*	<0·0001
Recruited at gay social venue or event	2246 (76%)	2012 (78%)	2274 (63%)	2554 (70%)	2810 (70%)	0·92 (0·90 to 0·94)†	<0·0001
Gay identity	2660 (90%)	2335 (91%)	3288 (92%)	3350 (92%)	3692 (92%)	1·05 (1·02 to 1·09)†	0·0060
University degree	1562 (53%)	1451 (56%)	1964 (55%)	2128 (58%)	2315 (58%)	1·05 (1·03 to 1·07)†	<0·0001
In full-time employment	1942 (66%)	1735 (67%)	2322 (65%)	2487 (68%)	2708 (67%)	1·02 (1·00 to 1·05)†	0·049
More than 20 male sex partners in past 6 months	532 (18%)	447 (17%)	645 (18%)	682 (19%)	837 (21%)	1·05 (1·03 to 1·08)†	<0·0001
Any CAI with regular male partners in past 6 months	873 (29%)	843 (32%)	1253 (35%)	1355 (37%)	1740 (43%)	1·15 (1·13 to 1·18)†	<0·0001
Crystal methamphetamine use in past 6 months	438 (15%)	415 (16%)	525 (15%)	472 (13%)	559 (14%)	0·96 (0·93 to 0·99)†	0·015
Group sex during or after drug use in past 6 months	457 (15%)	425 (16%)	589 (16%)	615 (17%)	732 (18%)	1·05 (1·02 to 1·08)†	0·0020
PEP use in past 6 months	131 (4%)	131 (5%)	170 (5%)	265 (7%)	309 (8%)	1·18 (1·12 to 1·23)†	<0·0001
Diagnosis with any sexually transmissible infection (other than HIV) in past 12 months	503 (17%)	477 (18%)	720 (20%)	860 (23%)	1247 (31%)	1·22 (1·19 to 1·26)†	<0·0001
HIV-negative men	2324	2030	2944	3008	3290	..	..
Tested for HIV in past 6 months	1371 (59%)	1326 (65%)	1955 (66%)	2163 (72%)	2517 (77%)	1·22 (1·18 to 1·25)†	<0·0001
Prescribed and used PrEP in past 6 months	44 (2%)	37 (2%)	59 (2%)	207 (7%)	783 (24%)	2·73 (2·54 to 2·94)†	<0·0001
HIV-positive men	290	290	346	325	380	..	..
On HIV treatment at time of the survey	230 (79%)	249 (86%)	302 (87%)	292 (90%)	358 (94%)	1·38 (1·24 to 1·53)†	<0·0001
Undetectable viral load (last test result)	222 (77%)	243 (84%)	305 (88%)	289 (89%)	357 (94%)	1·42 (1·28 to 1·58)†	<0·0001

Data are N, mean (SD), or n (%). OR=odds ratio. CAI=condomless anal intercourse. PEP=post-exposure prophylaxis. PrEP=pre-exposure prophylaxis. *Beta coefficient from linear regression with year as independent variable. †OR from logistic regression with year as independent variable.

Table 2: **Trends in selected participant characteristics**

PrEP use by HIV-negative men, and we reported HIV treatment use and undetectable viral load in HIV-positive men.

Our primary measure assessed HIV prevention practices used during casual sex (participants decided which of their partners were casual or regular partners). In Australia, most new HIV infections in gay and bisexual men happen through condomless anal intercourse with casual partners (CAIC).[22,23] From a series of questions about anal sex with casual male partners in the preceding 6 months,[21] we developed a mutually exclusive classification system to categorise the sexual practices of participants with casual partners.[20] Four categories were classified as safe sex: no anal intercourse with casual partners (participants of any HIV status; category 1); consistent condom use with casual partners (participants of any HIV status; category 2); any CAIC by HIV-positive men on HIV treatment and with an undetectable viral load (category 3); and any CAIC by HIV-negative men on PrEP (category 4). Three categories were classified as risky for HIV transmission or infection[20]: any CAIC by HIV-positive men not on HIV treatment or with a detectable viral load (category 5); insertive-only CAIC by HIV-negative or untested men not on PrEP (category 6); and any receptive CAIC by HIV-negative or untested men not on PrEP (category 7).

Statistical analysis

Statistical significance was set at $p<0·05$ (two-tailed). We compared the characteristics of participants in Melbourne, VIC, and Sydney, NSW, using χ^2 tests for categorical variables and *t* tests for continuous variables. We assessed change in sociodemographic and behavioural characteristics over time with linear regression for age (a continuous variable) and logistic regression for categorical variables, defining the sociodemographic or behavioural characteristic as the dependent (outcome) variable and

survey year as the independent (exposure) variable. Categorical variables were treated as binary dependent variables (eg, full-time employed *vs* not employed), with survey year as the independent variable. For the linear regression, we report the β coefficient and 95% CI. For the logistic regressions, we report crude odds ratio (OR) and 95% CI. We report trends over time for categories 1–7 and tested these trends using multivariate logistic regression, with each category treated as a binary dependent variable (eg, consistent condom use *vs* the other categories). Survey year and the sociodemographic and behavioural characteristics that had changed during 2013–17 were included as independent variables. We report adjusted odds ratios (aOR) and 95% CI for 1-year changes (2016–17) and 5-year trends (2013–17). We did analyses separately for each jurisdiction (Melbourne, VIC, and Sydney, NSW) to see if there were differences in outcomes for each jurisdiction. These differences are reported, where relevant. We used Stata version 13·1 for statistical analyses.

Role of the funding source

The Centre for Social Research in Health and the Kirby Institute are supported by the Australian Government Department of Health. Representatives of the department were not involved in this study. The Melbourne and Sydney GCPS are funded by the Victorian Department of Health and Human Services and New South Wales Ministry of Health, respectively. Representatives of these organisations participated in the study reference groups, guiding study design, data collection, and data interpretation and participated in the writing of this Article. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

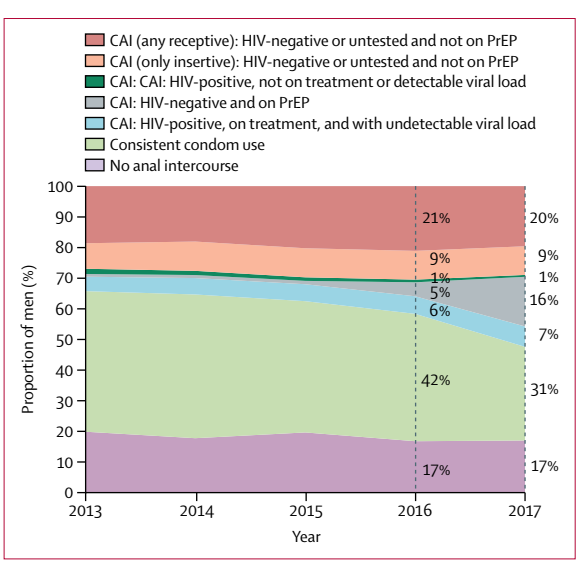

Figure 1: **Sex practices with casual male partners in the 6 months before survey in Melbourne and Sydney, 2013–17**
CAI=condomless anal intercourse. PrEP=pre-exposure prophylaxis.

Results

Between Jan 1, 2013, and March 31, 2017, 27 011 participants completed questionnaires in the Melbourne (n=13 051) and Sydney (n=13 960) GCPS, of whom 16 827 reported having had sex with casual male partners in the 6 months before survey. The following analyses are restricted to these 16 827 participants.

The mean age of participants was 36 years (table 1). Most participants were recruited from gay social venues and events, identified as gay, and were Anglo-Australian. Small proportions reported Aboriginal or Torres Strait Islander heritage (or both) or having an Asian background. Most of the sample were university educated and in full-time employment. Nearly half of the sample indicated that most or all of their friends were gay, and less than half of participants spent a lot of their free time with gay men. Most of the sample reported that they were HIV-negative. More than half of the sample reported six or more male sex partners in the previous 6 months, and most had had sex with regular male partners in the previous 6 months. More than 10% of men reported recent crystal methamphetamine use, and less than 20% of men reported recent group sex coincident with drug use. 1006 (6%) men had recently taken HIV post-exposure prophylaxis (PEP), and 3807 (23%) men had been diagnosed with a sexually transmissible infection other than HIV in the preceding year.

Of the 15 196 non-HIV-positive participants, 9485 (62%) men indicated that they had been tested for HIV in the 6 months before survey, 2199 (14%) had been tested in the previous 7–12 months, 1200 (8%) in the previous 1–2 years, 917 (6%) more than 2 years ago, and 1395 (9%) had never been tested. 1431 (88%) of the 1631 HIV-positive men in the sample reported being on HIV treatment at the time of the survey, and 1416 (87%) men reported that their last viral load test showed undetectable viral load.

Differences between the Melbourne and Sydney samples (table 1) were mostly small. Men were more likely to have been recruited at a gay social venue or event in Melbourne than in Sydney. We controlled for survey location (Melbourne or Sydney) in subsequent trend analyses.

Between 2013 and 2017, both the mean age of participants and the proportion of men recruited from gay social venues and events decreased (table 2). There was an increase in the proportion of participants who identified as gay, had a university degree, were in full-time employment, had more than 20 recent male sexual partners, had condomless anal intercourse with regular partners, had group sex during or after drug use, had recently taken PEP, or were diagnosed with a sexually transmitted infection in the previous year. There was a non-linear trend for recent crystal methamphetamine use. These changes in the sample were controlled for in the adjusted trend analyses.

During this same period, the proportion of HIV-negative men who tested for HIV in the 6 months

	2013 (N=2962)	2014 (N=2595)	2015 (N=3592)	2016 (N=3660)	2017 (N=4018)	Change from 2016 to 2017*		5-year trend*	
						AOR (95% CI)	p value	AOR (95% CI)	p value
No anal intercourse	586 (20%)	458 (18%)	702 (20%)	610 (17%)	679 (17%)	1·10 (0·97–1·24)	0·13	0·99 (0·97–1·02)	0·73
Consistent condom use	1360 (46%)	1218 (47%)	1540 (43%)	1523 (42%)	1229 (31%)	0·65 (0·59–0·72)	<0·0001	0·87 (0·85–0·89)	<0·0001
CAI by HIV-positive men on HIV treatment with an undetectable viral load	140 (5%)	140 (5%)	199 (6%)	210 (6%)	268 (7%)	1·01 (0·83–1·24)	0·91	1·04 (0·99–1·10)	0·13
CAI by HIV-negative men on PrEP	26 (1%)	25 (1%)	39 (1%)	167 (5%)	652 (16%)	4·19 (3·46–5·08)	<0·0001	2·90 (2·64–3·18)	<0·0001
CAI by HIV-positive men not on HIV treatment or with a detectable viral load	50 (2%)	36 (1%)	42 (1%)	32 (1%)	24 (0·6%)	0·58 (0·34–1·00)	0·052	0·73 (0·66–0·81)	<0·0001
Insertive-only CAI by HIV-negative or untested men not on PrEP	247 (8%)	248 (10%)	341 (9%)	344 (9%)	377 (9%)	0·99 (0·85–1·15)	0·89	1·01 (0·97–1·05)	0·52
Any receptive CAI by HIV-negative or untested men not on PrEP	553 (19%)	470 (18%)	729 (20%)	774 (21%)	789 (20%)	0·87 (0·77–0·97)	0·013	0·99 (0·96–1·02)	0·37

Data are n (%) unless indicated otherwise. AOR=adjusted odds ratio. CAI=condomless anal intercourse. PrEP=pre-exposure prophylaxis. PEP=post-exposure prophylaxis. *Independent variables: year, survey location (Melbourne, Sydney), recruitment source, age, sexual identity, education, employment status, number of male sexual partners (past 6 months), CAI with regular partners (past 6 months), crystal methamphetamine use (past 6 months), group sex during or after drug use (past 6 months), PEP use (past 6 months), and diagnosis of sexually transmitted disease (past 12 months).

Table 3: **Trends in sex practices with casual male partners in the 6 months before the survey, 2013–17**

before survey increased, as did prescribed PrEP use (table 2). HIV treatment use and the proportion of HIV-positive men with an undetectable viral load also increased. These trends did not vary by survey location. Similar proportions of HIV-negative men reported PrEP use in Melbourne and Sydney in 2017 (388 [25%] men *vs* 395 [23%] men, χ^2=1·78; p=0·18). The most common sources of PrEP in 2017 were trials or research studies (n=687 [86%]) or personal importation from overseas (n=49 [6%]). The large increase in diagnoses of sexually transmitted infection between 2016 and 2017 is likely to be partially due to the increase in the number of PrEP users in studies, which require quarterly screening for HIV and other sexually transmitted infections.[3,4]

The proportion of men reporting no anal intercourse with casual partners did not change significantly, nor did the proportion of men who reported CAIC and were HIV-positive, on treatment, and had an undetectable viral load (figure 1, table 3). The proportion of men with casual partners reporting consistent condom use decreased markedly, with most of the change (11%) occurring between 2016 and 2017. The proportion of men reporting CAIC who were HIV-negative and on PrEP increased, with most of the increase (12%) occurring between 2016 and 2017. All HIV-negative men on PrEP who had casual partners reported CAIC in 2013–17 (ie, no PrEP users reported consistent condom use with casual partners). The proportions of men who were HIV-negative or untested and not on PrEP and who reported insertive-only CAIC or any receptive CAIC did not change significantly during the 5 year period, but the proportion reporting receptive CAIC decreased slightly between 2016 and 2017.

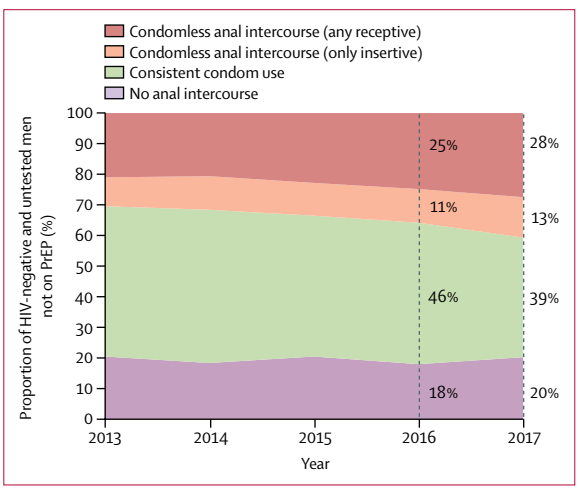

Figure 2: **Sex practices with casual male partners in the 6 months before survey in HIV-negative and untested men not on PrEP, 2013–17**
PrEP=pre-exposure prophylaxis.

These trends did not vary between jurisdictions. To confirm the changes in condom use and CAIC in non-PrEP users, we stratified by PrEP use and HIV status (figure 2). Of 14022 HIV-negative and untested men not on PrEP with casual partners (excluding PrEP users and HIV-positive men), the number of men with consistent condom use decreased from 1288 (49%) of 2624 in 2013, to 1108 (39%) of 2836 in 2017 (aOR 0·91, 95% CI 0·89–0·93; p<0·0001), and the number of men engaging in CAIC increased from 798 (30%) of 2624 in 2013, to 1152 (41%) of 2836 in 2017 (aOR 1·10, 95% CI 1·07–1·13; p<0·0001).

We also examined the use of antiretroviral-based prevention (PrEP or treatment as prevention) in

6922 participants who reported engaging in CAIC (excluding men who did not have condomless sex). The number of men who were HIV-negative and on PrEP increased from 26 (3%) of 1016 men in 2013, to 167 (11%) of 1527 men in 2016, and 652 (31%) of 2110 men in 2017 (aOR 2·74, 95% CI 2·50–3·02; p<0·0001). 140 (14%) of 1016 men were HIV-positive with undetectable viral loads in 2013, compared with 268 (13%) of 2110 men in 2017 (aOR 0·97, 95% CI 0·92–1·02; p=0·24). Overall, the number of men who had CAIC and used antiretroviral-based prevention increased from 166 (16%) of 1016 men in 2013, to 377 (25%) of 1527 men in 2016, and 920 (44%) of 2110 men in 2017 (aOR 1·53, 95% CI 1·46–1·60; p<0·0001).

Discussion

By use of repeated behavioural surveillance in Australia's most populated metropolitan areas, we found a large increase in PrEP use from 2013 to 2017 (up to 24% of HIV-negative men) and an increase in men using PrEP who reported condomless sex with casual partners (increasing to 16% of men with casual partners in 2017). A similar magnitude reduction in consistent condom use with casual sex partners occurred during the same period. This change was concentrated in non-PrEP users because no PrEP users reported consistent use of condoms with casual partners. The net effect of these changes was that the proportion of HIV-negative and untested men who engaged in condomless sex and were unprotected by taking PrEP remained relatively unchanged (at 29% of men with casual partners in 2017). We believe the increase in PrEP use is the largest and most rapid recorded so far in any large jurisdiction.[13,24,25] The magnitude of the reduction in consistent condom use is similar to that in San Francisco between 2011 and 2014, when PrEP use by HIV-negative men increased from 0% to 9·6% and consistent condom use decreased from 30·5% to 17·5%.[13,14] Despite what seems to be community-level risk compensation (decreasing condom use coincident with increasing PrEP use),[7] the overall level of safe sex by gay and bisexual men in Melbourne and Sydney was sustained at around 70% (the proportion of men with casual partners engaging in practices that pose a minimal risk of HIV transmission). Focusing only on men who had condomless sex with casual partners, the rapid uptake of PrEP use, combined with high levels of viral suppression in HIV-positive men, meant that by 2017, more than 40% of men who had condomless sex with casual partners were using antiretroviral-based prevention (compared with only 16% in 2013).

The increase in PrEP uptake and decrease in condom use coincided with a reduction in new HIV diagnoses in MSM of 16% in Victoria and 11% in New South Wales between 2016 and 2017.[26,27] These were the largest annual reductions in diagnoses during 2013–17 in each jurisdiction, during which there were substantial but gradual increases in HIV testing, HIV treatment, and viral suppression. This suggests that rapidly increasing PrEP use was effective in preventing new HIV infections and catalysed or built upon improvements in HIV testing and treatment (which had not previously resulted in large reductions in new diagnoses). The rapid increase in PrEP use seems to have outweighed the rapid decrease in condom use in this early phase of PrEP implementation. However, it is too early to tell the long-term effect of increasing PrEP use (and decreasing condom use) on new HIV diagnoses in Victoria and New South Wales.

Our results suggest that introducing PrEP at scale can reduce consistent condom use at a population level (ie, by those not using PrEP). As in other high-income countries,[28] consistent condom use by gay and bisexual men in Melbourne and Sydney has been gradually decreasing for more than 15 years, since before the introduction of PrEP and coincident with increases in HIV testing, reliance on serosorting, and HIV treatment and viral suppression.[20] However, the rate of reduction in consistent condom use since PrEP was introduced has been striking and happened very quickly between 2016 and 2017. We therefore think this recent reduction in condom use is most likely a result of the introduction of PrEP. We and other researchers have suggested that non-PrEP users might use condoms less often because they perceive that condomless sex in general has become less risky as PrEP use increases (indirect prwotection) and that they have the opportunity to have condomless sex with a growing cohort of partners who are on PrEP (direct protection).[7,13,20] Existing research about risk compensation has primarily considered changes in behaviour by PrEP users and not considered changes in behaviour at a community level.[1,7,8] In mathematical models, the beneficial effect of PrEP on HIV epidemics might have been overestimated, particularly in settings in which it was assumed that condom use would be sustained in MSM not using PrEP.[15–19]

Our results suggest that jurisdictions should monitor the behavioural effect of PrEP at a community or population level (not only in PrEP users) and update modelling to consider community-level risk compensation. We also think it would be prudent for jurisdictions to consider community education campaigns that support condom use and combination prevention as PrEP is introduced, particularly if an aim during PrEP roll-out is to maintain existing levels of condom use. In New South Wales, for example, community education campaigns aimed at gay and bisexual men have jointly promoted condoms, PrEP, and having an undetectable viral load as effective HIV prevention strategies. Our results show that introducing PrEP at scale can disrupt existing prevention practices at a community or population level, and jurisdictions should anticipate that when considering implementation. The disruptive effects of PrEP (such as community-level risk compensation) are, however, likely to be highly dependent on local epidemic contexts.[7] For contexts in which the level of condom use is

low, there might be fewer concerns about introducing PrEP if the aim is to increase the overall level of protection from HIV. In settings with high levels of condom use, introducing PrEP might result in lower levels of condom use and increased rates of diagnosis and treatment of sexually transmitted infections, posing an extra burden for sexual health services.[1]

We acknowledge the limitations of our analysis. Repeated, cross-sectional surveys cannot be used to track the behaviour of individuals over time. Focusing on aggregated behaviour within the past 6–12 months (rather than event-level data) might lead to overestimations of the level of HIV risk by classifying men who had any condomless sex as potentially at risk. Consistent with guidelines for behavioural surveillance,[29] the GCPS target gay and bisexual men in metropolitan areas because they are most affected by HIV. Online recruitment, incorporated in 2015, broadened the reach of recruitment but only accounted for 10% of the sample reported here. A representative sample of Australian gay and bisexual men would feature a broader age range, more men who identified as bisexual, and more men from regional areas.[30] However, these are the largest, regular surveys of gay and bisexual men in Australia, and the consistency of our approach and adjustment for sampling variation over time (including controlling for offline *vs* online recruitment) means that we have confidence in the trends we have identified.

In conclusion, rapid uptake of PrEP by gay and bisexual men in Melbourne and Sydney during its early implementation has been accompanied by an equally rapid decrease in consistent condom use. The reduction in condom use might reduce the beneficial, population-level effect of PrEP, although it will, to some extent, be counterbalanced by herd immunity (eg, a growing proportion of the population that cannot acquire or pass on HIV). The long-term consequences of this shift in community practice are unknown (eg, the potential for HIV transmission to rebound in HIV-negative and untested men not using PrEP). We think it would be prudent for other jurisdictions to actively consider the potential for community-level compensation when modelling the introduction of PrEP and monitoring its effect. This would help in more realistically anticipating the population-level effect of PrEP and in considering how education programmes can guide and respond to the diversification of HIV prevention practices in the PrEP era.

Contributors

All authors contributed to the study design, data collection, and data interpretation. MH did the literature search and prepared the figures. TL and MH analysed the data with input from the other authors. MH wrote the report with support from the other authors.

Declaration of interests

MH, TL, and JDW report grants from the Australian Government Department of Health, the Victorian Department of Health and Human Services, and the New South Wales Ministry of Health, enabling the conduct of the reported study. AG and IZ report non-financial support from Gilead Sciences, outside of the submitted work. All other authors declare no competing interests.

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