OPEN ACCESS

Trends in gonorrhoea testing and incidence among gay and bisexual men in Australia during PrEP implementation: an analysis of surveillance data (2012–2023)

Hein Htet Aung ,[1,2] Anna L Wilkinson,[1,2,3] Rebecca Guy,[4] Jason Asselin,[1,2] Htein Linn Aung ,[4] Eric P F Chow ,[2,5,6] Jason J Ong,[5,6] Rick Varma ,[4,7] Caroline Thng,[8] Marcus Shaw,[9] Frederick J Lee,[10,11] David J Templeton,[4,11,12] Fabian Yuh Shiong Kong ,[2] Nyssa Watson,[1] Vicent J Cornelisse,[4,6,13,14] Dash Heath-Paynter,[15] Margaret E Hellard,[1,3,14,16] Mark A Stoove,[1,2,3,17] Michael W Traeger[1,3]

► Additional supplemental material is published online only. To view, please visit the journal online (https://doi.org/10.1136/sextrans-2026-056909).

For numbered affiliations see end of article.

Correspondence to
Dr Hein Htet Aung; heinhteta@student.unimelb.edu.au

MAS and MWT are joint senior authors.

Received 10 January 2026
Accepted 21 August 2026

Check for updates

© Author(s) (or their employer(s)) 2026. Re-use permitted under CC BY. Published by BMJ Group.

To cite: Aung HH, Wilkinson AL, Guy R, *et al*. *Sex Transm Infect* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/sextrans-2026-056909

ABSTRACT

Objectives Gonorrhoea incidence is increasing globally, with gay and bisexual men (GBM) over-represented in notifications. Changes in behaviour, sexual networks and screening practices associated with HIV pre-exposure prophylaxis (PrEP) uptake and treatment-as-prevention may influence gonorrhoea transmission. We describe trends in gonorrhoea testing and incidence among GBM over 12 years spanning PrEP implementation in Australia.

Methods We conducted a retrospective study using surveillance data from 67 sexual health and general practice clinics between 1 January 2012 and 31 December 2023. For testing analyses, we included GBM with ≥1 visit and calculated annual test uptake (proportion of attendees tested at least once). For incidence analyses, we included GBM with ≥2 tests and calculated annual gonorrhoea incidence per 100 person-years (py). Test uptake and incidence were stratified by HIV status and PrEP use (ever vs never prescribed PrEP). Poisson regression explored factors associated with incident gonorrhoea, adjusted for calendar year and age.

Results A total of 193 053 GBM attended a clinic during the study period, of which 176 244 (91.3%) had ≥1 test. Annual test uptake increased from 58.7% in 2012 to 75.2% in 2023, largely driven by increased testing among ever-PrEP-users. Among 119 741 GBM in incidence analyses, there were 61 896 gonorrhoea infections over 542 949 py (incidence rate=11.4/100 py). From 2012 to 2023, incidence among HIV-negative ever-PrEP users increased from 6.2 to 19.6/100 py (p<0.001), and among GBM with HIV increased from 8.6 to 18.8/100 py (p<0.001). GBM with recurrent infections (n=13 620; 11.4%) accounted for 69.1% of all diagnoses. Ever being prescribed PrEP (adjusted incidence rate ratio (aIRR)=2.40, 95% CI: 2.35 to 2.45) and living with HIV (aIRR=3.05, 95% CI: 2.97 to 3.13) were associated with incident gonorrhoea.

Conclusions In this large cohort of GBM, gonorrhoea incidence significantly increased during PrEP implementation, although incidence was already rising before large-scale PrEP roll-out in 2016. GBM with HIV, PrEP users or those previously diagnosed with gonorrhoea should be prioritised for testing and prevention strategies.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Gonorrhoea notifications have steadily increased over the past decade among gay and bisexual men (GBM) in Australia, alongside widespread implementation of HIV pre-exposure prophylaxis (PrEP).

⇒ Longer-term epidemiological data are necessary to understand trends in gonorrhoea testing and incidence among all GBM following widespread PrEP uptake and help guide control measures.

WHAT THIS STUDY ADDS

⇒ From 2012 to 2023, gonorrhoea testing increased among GBM, particularly among PrEP users, but remained below the recommended screening frequency, while incidence increased around threefold.

⇒ The largest increases in incidence were observed at extragenital sites, and gonorrhoea diagnoses were concentrated among men experiencing reinfection.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ In the era of HIV PrEP, rates of gonorrhoea infection are similar among GBM using PrEP and GBM living with HIV, with those with previous infection most at risk.

⇒ Targeted screening and prevention strategies, alongside further research on the impact of asymptomatic screening on population-level transmission and antimicrobial resistance, are required to reduce the spread and burden of gonorrhoea among GBM.

INTRODUCTION

Gonorrhoea incidence has risen globally over the past decade and remains the second most prevalent bacterial sexually transmitted infection (STI).[1] In gay and bisexual men (GBM), up to 87% of urogenital gonorrhoea infections are symptomatic, whereas rectal and pharyngeal gonorrhoea are

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

predominantly asymptomatic.[2] The often-asymptomatic nature of gonorrhoea and increasing antimicrobial resistance (AMR) complicate efforts for effective treatment and control.[3] In Australia, gonorrhoea notifications have been steadily increasing, with notifications increasing by 155% from 15 671 in 2014 to 40 029 in 2023.[4]

GBM experience disproportionately high rates of gonorrhoea in Australia and globally.[5] Rapid scale-up of HIV pre-exposure prophylaxis (PrEP) in Australia from 2016 was associated with population-level reductions in condom use[6] and changes in sexual networks among GBM, including reduced HIV serosorting.[7] A previous analysis found gonorrhoea incidence among GBM currently using PrEP remained stable between 2016 and 2019 at approximately 37.8/100 person years (py).[8] However, longer-term trends in gonorrhoea incidence among PrEP users, and the broader impact of PrEP uptake and HIV treatment-as-prevention on gonorrhoea testing and incidence among GBM, are poorly described.[9]

Since 2016, PrEP guidelines recommend quarterly STI screening for all PrEP users, a recommendation which expanded to all sexually active GBM in 2019. Frequent asymptomatic screening for gonorrhoea may increase detection of asymptomatic infection, but also contribute to rising AMR through greater antibiotic consumption.[10] With limited antibiotic options to combat rising gonorrhoea, some have questioned whether the benefits of asymptomatic screening outweigh potential AMR-related harms.[10]

Longer-term epidemiological data are needed to understand trends in gonorrhoea testing and incidence among GBM using and not using PrEP, to inform targeted interventions and screening recommendations. Using sentinel surveillance data from sexual health and general practice services, we aimed to explore trends in gonorrhoea testing and incidence among GBM from 2012 to 2023, stratified by HIV status and PrEP use.

METHODS

Study design and participants

We conducted a retrospective analysis of electronic medical record data extracted from services participating in the Australian Collaboration for Coordinated Enhanced Sentinel Surveillance of STIs and Blood-Borne Viruses (ACCESS). The ACCESS protocol has previously been published.[11] The study period was from 1 January 2012 to 31 December 2023. We included linked data from 67 clinical services, including general practices (GPs), sexual health clinics (SHCs) and hospitals across Australia. Extracted data included demographics, STI pathology, HIV diagnoses and electronic PrEP prescriptions. Non-identified data were extracted and linked across services using probabilistic linkage based on deidentified keys generated from patient identifiers.[12] While follow-up was censored at 31 December 2023, we extracted data to December 31 2024, to minimise right-censoring bias.[13]

We included GBM aged ≥16 years attending ACCESS services during the study period. GBM status was determined using self-reported male sex partners and an algorithm incorporating rectal STI testing history as a marker of male-to-male sex.[14]

Follow-up and observation

For testing analyses, individuals contributed to the years in which they attended. Repeat gonorrhoea tests within 28 days were considered the same testing episode. For incidence analyses, individuals with at least two testing episodes were included, and repeat testing methods were used to calculate incidence.[8] Individuals contributed follow-up time from their first recorded test and were censored at their last recorded test during the study period or 31 December 2023, whichever came first. Gonorrhoea diagnoses were defined as positive cultures or nucleic acid amplification test results. Individuals could contribute multiple incident infections.

Statistical analysis

Trend analyses

Annual test uptake was defined as the proportion of attending GBM tested for gonorrhoea at least once during that year. Among those tested, we also calculated the mean number of tests per person per year.

Gonorrhoea incidence was defined as total number of diagnoses divided by total py and reported as per 100 py with 95% CIs. Positive first tests were excluded from incidence numerators. Overall, annual and anatomical site-specific incidence were reported.

To explore incidence trends over time, Poisson regression was used to estimate incidence rate ratios (IRRs) representing the mean annual change in incidence. The dependent variable was the count of new diagnoses per year, year was included as a continuous independent variable, and the offset was person-time at risk. We used robust variance estimators clustered by individual to account for multiple events per person. To assess the impact of the COVID-19 pandemic, we also calculated trends restricted to the pre-COVID-19 period (2012–2019).[15]

Subgroup analyses

For both testing and incidence analyses, we performed subgroup analyses stratified by HIV status and PrEP use. Individuals were classified as living with HIV from the date of their first HIV positive test result or record of HIV diagnosis date; HIV status was therefore time-varying. PrEP use was defined using electronic prescriptions for PrEP recorded within ACCESS clinics. Individuals were defined as ever-PrEP users if they had any electronic PrEP prescription during the study and were retrospectively categorised as ever-PrEP users for the whole study period. Ever versus never PrEP use was used, rather than modelling PrEP as a time-varying exposure, because previous analyses of ACCESS data[8] have demonstrated that changes in PrEP eligibility and uptake over time may introduce bias when using time-updated PrEP definitions (further information on PrEP classification is present in online supplemental appendix 1). Testing and incidence were calculated separately for GBM with HIV, ever-PrEP users without HIV and never-PrEP users without HIV. Analyses were also stratified by clinic setting (GPs vs SHCs) to observe variation in testing practices and gonorrhoea incidence.

Predictors of gonorrhoea diagnosis

Factors associated with gonorrhoea diagnosis were explored using Poisson regression. Covariates included age (per 5 year increase), Aboriginal or Torres Strait Islander status, clinic type, HIV/PrEP status and overseas birth. Covariates associated with gonorrhoea diagnosis at $p<0.1$ in bivariable analyses were included in a multivariable model using complete-case regression. To account for multiple observations per person, we used robust standard errors clustered by individual.

RESULTS

In total, 193 053 GBM had at least one visit between 2012 and 2023 and were included in testing analyses. Of these, 119 741

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

(62.0%) GBM had at least two gonorrhoea tests and were included in incidence analyses.

Gonorrhoea test uptake

Among 193 053 GBM included in testing analyses, the median age at study entry was 31 years (IQR=25–42). There were 17 144 (8.9%) GBM living with HIV included in testing analyses (of whom, 12 521 were living with HIV at study entry). By 2023, 54 655 (28.3%) had been prescribed PrEP at least once (table 1).

There were 984 451 gonorrhoea tests recorded during the study period. Overall, 91.3% of GBM tested for gonorrhoea at least once, 98.5% among HIV-negative ever-PrEP users, 87.7% among HIV-negative never-PrEP users and 85.4% among GBM living with HIV (see online supplemental appendix 2 for the number of included gonorrhoea tests and test uptake among subgroups). The median time between gonorrhoea test events was 112 days (IQR=78 226).

From 2012 to 2023, annual test uptake among all GBM increased from 58.7% to 75.2% (p-trend <0.001). There was a slight decline in annual test uptake during 2020–2021, likely due to COVID-19 restrictions.[15] The increase in annual test uptake was most prominent among ever-PrEP users (from 67.0% to 88.7%, p-trend <0.001); test uptake increased from 58.5% to 67.5% (p-trend <0.001) among never-PrEP users and from 48.1% to 52.3% (p-trend <0.001) among those with HIV (figure 1A).

Annual gonorrhoea test uptake increased across all age groups and remained highest among 16–29 year-olds (figure 1B). The mean number of tests per person per year increased from 1.5 to 1.9 from 2012 to 2023 (figure 1C) (see online supplemental appendix 3 for additional details on gonorrhoea test uptake, including the number of clinic attendees by HIV-PrEP subgroup and by age group). Similar testing patterns were observed across clinic settings (online supplemental appendix 4), with the highest testing uptake among ever-PrEP users.

Gonorrhoea incidence

Among 119 741 GBM included in incidence analyses, the median age at study entry was 31 years (IQR=25–41). There were 12 684 (10.6%) GBM living with HIV included in incidence analyses (of whom 9917 were living with HIV at study entry), and 49 606 (41.4%) were prescribed PrEP at least once during the study period (table 1).

Overall, 32 767 (27.4%) were diagnosed with gonorrhoea at least once. There were 61 896 gonorrhoea diagnoses over a total of 542 949.1 py (median follow-up per person=3.9 years, IQR=1.4–7.1). The overall gonorrhoea incidence was 11.4/100 py (95% CI 11.3 to 11.5). Gonorrhoea incidence was similar among HIV-negative ever-PrEP users (14.6/100 py) and GBM living with HIV (14.7/100 py); incidence among HIV-negative never-PrEP users was lowest at 6.1/100 py (online supplemental appendix 5a). Overall gonorrhoea incidence and numbers of included individuals by clinic setting are presented in online supplemental appendix 5b,c.

From 2012 to 2023, annual gonorrhoea incidence among all GBM increased from 5.9 to 16.7/100 py (IRR for mean increase per year=1.05, 95% CI 1.05 to 1.06, p<0.001). Among GBM with HIV, incidence increased from 8.6 to 18.8/100 py (IRR=1.03, 95% CI 1.02 to 1.04, p<0.001). Annual gonorrhoea incidence among ever-PrEP users increased from 6.3/100 py to 19.6/100 py (IRR=1.05, 95% CI 1.04 to 1.05, p<0.001) and among never-PrEP users fluctuated between 4.2/100 py and 9.3/100 py (figure 2A) (see online supplemental appendix 6 for

Table 1 Characteristics of individuals included in testing and incidence analyses

	Included in testing analyses (had at least one visit), n=193 053, n (%)	Included in incidence analyses (had at least two gonorrhoea tests), n=119 741, n (%)
Age at cohort entry, years, median (IQR)	31 (25, 42)	31 (25, 41)
16–29	84 343 (43.7)	52 785 (44.1)
30–39	52 613 (27.3)	33 169 (27.7)
40–49	29 951 (15.5)	18 441 (15.4)
≥50	26 146 (13.5)	15 346 (12.8)
Year of entry (first visit/first test)		
2012	42 530 (22.0)	20 884 (17.4)
2013	17 045 (8.8)	11 808 (9.9)
2014	16 996 (8.8)	10 637 (8.9)
2015	16 741 (8.7)	10 542 (8.8)
2016	16 864 (8.7)	13 966 (10.8)
2017	16 386 (8.5)	12 001 (10.0)
2018	15 357 (8.0)	10 380 (8.7)
2019	14 083 (7.3)	8933 (7.5)
2020	9485 (4.9)	5654 (4.7)
2021	7855 (4.1)	4922 (4.1)
2022	8864 (4.6)	5347 (4.5)
2023	10 847 (5.6)	5667 (4.7)
Aboriginal or Torres Strait Islander		
Yes	4154 (2.2)	2467 (2.1)
No	170 250 (88.2)	107 625 (90.0)
Not stated/missing	18 649 (9.7)	9649 (8.1)
PrEP usage during observation period		
Ever use	54 655 (28.3)	49 606 (41.4)
Never use	138 398 (71.7	70 135 (58.6)
HIV status at entry		
Yes	12 521 (6.5)	9917 (8.3)
No	180 532 (93.5)	109 824 (91.7)
Clinic type at cohort entry		
General practice	57 458 (29.8)	38 094 (31.81)
Sexual health clinic	134 472 (69.7)	80 991 (67.6)
Hospital	1123 (0.6)	656 (0.6)
Clinic state		
ACT	5430 (2.8)	2607 (2.2)
NSW	91 283 (47.3)	54 654 (45.6)
NT	1387 (0.7)	104 (0.1)
QLD	17 552 (9.1)	9462 (7.9)
SA	8356 (4.3)	5381 (4.5)
TAS	2004 (1.0)	1582 (1.3)
VIC	52 388 (27.1)	36 806 (30.7)
	14 653 (7.6)	9145 (7.6)
Region of birth		
Australia	98 573 (51.1)	62 560 (52.2)
Oceania (excluding Australia)	6023 (3.1)	3786 (3.2)
North-West Europe	17 085 (8.9)	9184 (7.7)
Southern and Eastern Europe	4011 (2.1)	2271 (1.9)
North Africa and Middle East	2809 (1.5)	1744 (1.5)
South-East Asia	13 819 (7.2)	9295 (7.8)
North-East Asia	10 536 (5.5)	6405 (5.4)
Southern and Central Asia	4504 (2.3)	2875 (2.4)
Americas	11 868 (6.2)	7091 (5.9)
Sub-Saharan Africa	2472 (1.3)	1568 (1.3)

Continued

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 1 Continued

	Included in testing analyses (had at least one visit), n=193 053, n (%)	Included in incidence analyses (had at least two gonorrhoea tests), n=119 741, n (%)
Not stated/missing	21 353 (11.1)	12 962 (10.8)

ACT, Australian Capital Territory; NSW, New South Wales; NT, Northern Territory; PrEP, pre-exposure prophylaxis; QLD, Queensland; SA, South Australia; TAS, Tasmania; VIC, Victoria; WA, Western Australia.

annual incidence changes by HIV-PrEP subgroups prior to the COVID-19 pandemic). Gonorrhoea incidence increased across all age groups, with the highest incidence among 16–29 year-olds (8.3/100 py) and lowest among those aged ≥50 years (2.9/100 py) (figure 2B). Recurrent infections were common: 13 620 (11.4%) GBM with ≥2 infections accounted for 69.1% of diagnoses and 2085 (1.8%) GBM with ≥5 infections accounted for 21.7% of diagnoses.

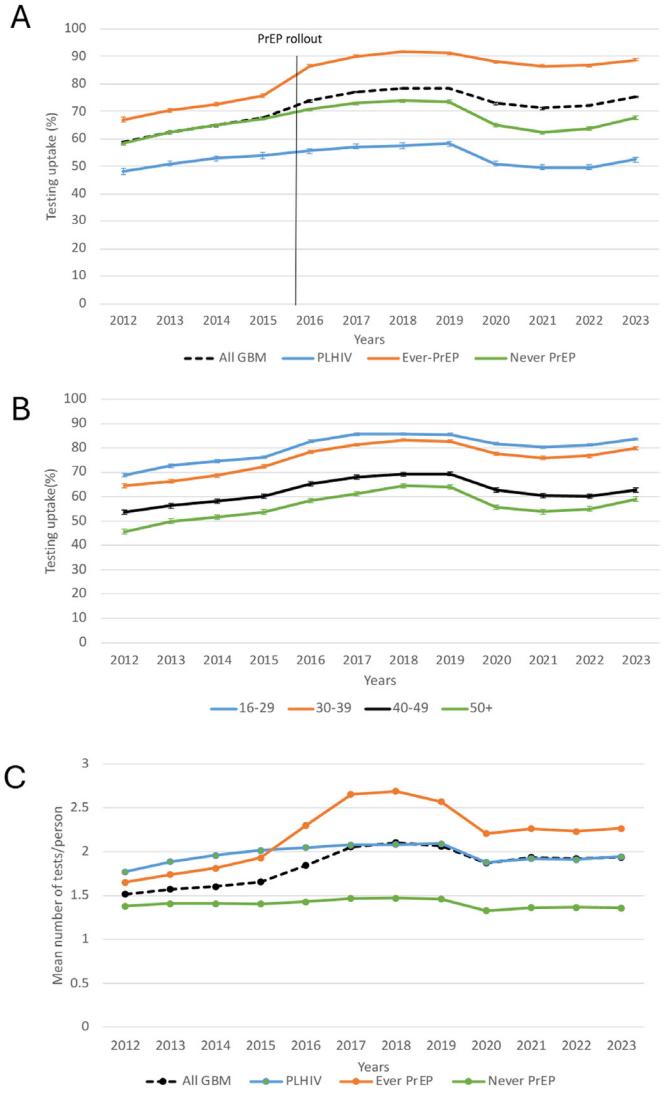


Figure 1 Annual gonorrhoea test uptake among gay and bisexual men (GBM) attending ACCESS clinics from 2012 to 2023, by (a) HIV status and PrEP use, (b) age group, and (c) Mean number of tests per person by HIV status and PrEP use. Error bars represent 95% CIs. Test uptake is defined as the proportion of GBM attendees tested at least once in a calendar year. PLHIV, Person living with HIV; PrEP, HIV pre-exposure prophylaxis. See Appendix 3 for the number of clinic attendees per year.

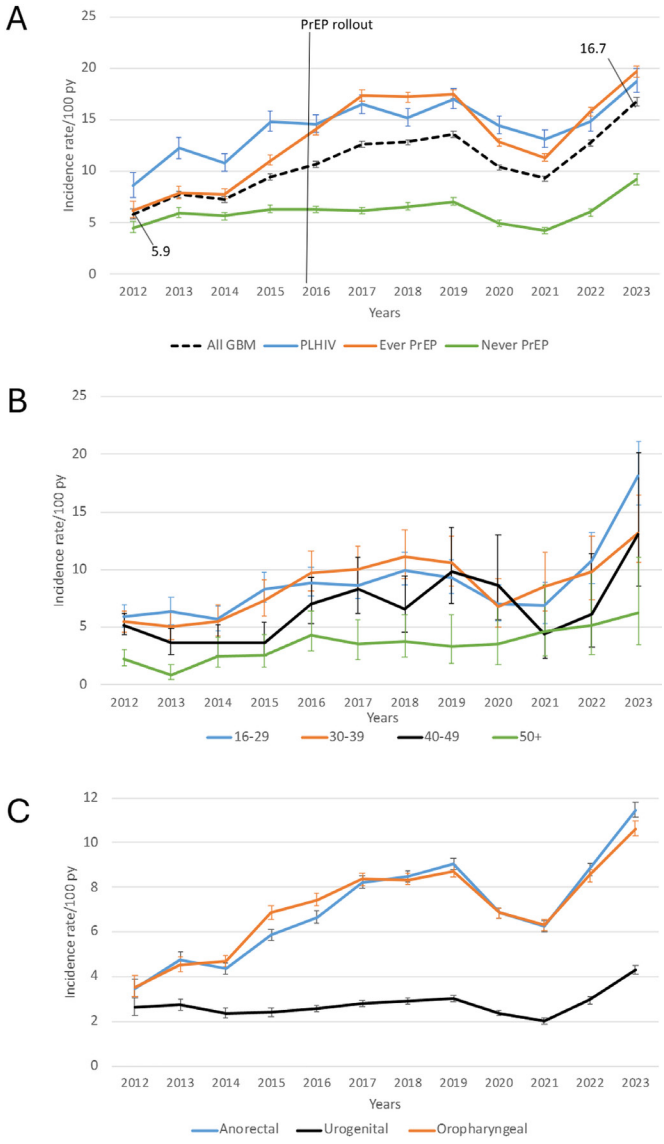


Figure 2 Annual gonorrhoea incidence per 100py among gay and bisexual men (GBM) attending ACCESS clinics from 2012 to 2023, by (a) HIV and PrEP use status, (b) age group and (c) anatomical site. Error bars represent 95% CIs. PLHIV, Person living with HIV; PrEP, HIV pre-exposure prophylaxis. See Appendix 7 for total person-years of follow-up per year.

During the study period, incidence was similar for rectal (7.5/100 py) and pharyngeal (7.6/100 py) gonorrhoea. Urogenital gonorrhoea incidence was lowest at 2.8/100 py (online supplemental appendix 5a). From 2012 to 2023, rectal gonorrhoea incidence increased from 3.5 to 11.5/100 py (IRR for increase per year=1.06, 95% CI 1.06 to 1.07, p<0.001), and pharyngeal gonorrhoea increased from 3.5 to 10.6/100 py (IRR=1.04, 95% CI 1.04 to 1.05, p<0.001). An increase in urogenital gonorrhoea incidence was also detected from 2012 to 2023 (IRR=1.03, 95% CI=1.02 to 1.04, p<0.001) (figure 2C) (see online supplemental appendix 6 for annual incidence changes by anatomical site before the COVID-19 pandemic). Additional details on gonorrhoea incidence, including person-years of

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Table 2 Unadjusted and adjusted incidence rate and rate ratios for factors associated with gonorrhoea infection among GBM attending ACCESS clinics (n=119 471)

Covariate	Gonorrhoea diagnoses	Total person-years	Gonorrhoea diagnosis/ 100 py (95% CI)	IRR (95% CI)	P value	aIRR (95% CI)	P value
Age at cohort entry (per 5-year increase)				0.88 (0.88 to 0.89)	<0.001	0.97 (0.97 to 0.98)	<0.001
HIV-PrEP subgroup							
Never PrEP uses	12 655	206 392.4	6.1 (6.0 to 6.2)	Reference			
Ever PrEP users	38 061	260 350.0	14.6 (14.5 to 14.8)	2.38 (2.34 to 2.43)	<0.001	2.27 (2.22 to 2.31)	<0.001
GBM with HIV	11 180	76 206.7	14.7 (14.4 to 14.9)	2.39 (2.33 to 2.45)	<0.001	2.82 (2.74 to 2.90)	<0.001
Aboriginal or Torres Strait Islander*							
No	57 211	491 057.2	11.7 (11.6 to 11.7)	Reference		-	
Yes	1397	11 714.6	11.9 (11.3 to 12.6)	1.02 (0.97 to 1.08)	0.389		
Born outside Australia*							
No	34 051	305 944.9	11.1 (11.0 to 11.2)	Reference		Reference	
Yes	22 383	172 929.40	12.9 (12.8 to 13.1)	1.16 (1.14 to 1.18)	<0.001	1.17 (1.15 to 1.19)	<0.001
Clinic type							
General practice	24 706	226 724.5	10.9 (10.8 to 11.0)	Reference		-	
Sexual health	36 907	312 137.2	11.8 (11.7 to 11.9)	1.09 (1.07 to 1.10)	<0.001		<0.001
Hospital	283	4087.3	6.9 (6.2 to 7.8)	0.64 (0.57 to 0.71)	<0.001		<0.001

*n=9649 individuals had missing data for Aboriginal or Torres Strait Islander status and n=12 962 individuals had missing data for country of birth. Age, HIV-PrEP subgroup and being born outside Australia were included in the adjusted model (clinic type excluded).
ACCESS, Australian Collaboration for Coordinated Enhanced Sentinel Surveillance of STIs and Blood-Borne Viruses; aIRR, adjusted incidence rate ratio; GBM, gay and bisexual men; PrEP, pre-exposure prophylaxis.

follow-up by HIV-PrEP subgroup, age group and anatomical site of infection, are presented in online supplemental appendix 7. Stratified analyses by clinic setting showed similar trends across subgroups, although overall incidence was higher at SHCs (online supplemental appendix 8).

Risk factors for gonorrhoea

Unadjusted and adjusted IRRs from Poisson regression analyses are presented in table 2. In bivariable analyses, the strongest predictors of gonorrhoea diagnosis were living with HIV and ever being prescribed PrEP during the study period. Increasing age was associated with lower rates of gonorrhoea diagnosis. Being born outside Australia was positively associated with gonorrhoea diagnosis.

In multivariate analysis, living with HIV (adjusted incidence rate ratio (aIRR)=2.82, 95% CI 2.74 to 2.90, p<0.001) was the strongest predictor of gonorrhoea diagnosis, followed by ever being prescribed PrEP (aIRR=2.27, 95% CI 2.22 to 2.31, p<0.001). Associations with being born outside Australia (aIRR=1.17, 95% CI 1.15 to 1.19, p<0.001) and a 5-year increase in age (aIRR=0.97, 95% CI 0.97 to 0.98, p<0.001) did not change significantly (table 2).

DISCUSSION

In this large cohort of GBM attending Australian SHCs, GPs and hospitals, gonorrhoea incidence nearly tripled from 2012 to 2023, with the greatest increases among GBM with evidence of PrEP use, followed by GBM with HIV. Prior to the PrEP introduction in 2016, gonorrhoea incidence was highest among GBM with HIV, with rates among GBM with HIV and with evidence of PrEP use comparable from 2016 onwards. Both testing and incidence decreased between 2020 and 2021, likely indicative of changes in sexual activity and service access due to COVID-19-related restrictions.[15] The greatest increases occurred in pharyngeal and rectal gonorrhoea, suggesting increased screening may partially explain the increase in gonorrhoea incidence. However, urogenital gonorrhoea, a mostly symptomatic infection,[2] also increased, supporting a concurrent rise in transmission. In Australia, increasing incidence among GBM has also been observed for syphilis, with ACCESS data showing an increase from 2.2/100 py to 4.6/100 py from 2012 to 2022,[16] and for chlamydia, with national surveillance data indicating similar increases over the same time.[4] These trends likely reflect, in part, more frequent testing among PrEP users and GBM more broadly. However, in our study, gonorrhoea incidence increased disproportionately relative to testing, suggesting that increased population-level transmission is also contributing.

PrEP rollout in Australia began through large demonstration studies from 2016, which collectively enrolled more than 10 000 individuals and targeted individuals at higher risk of STIs,[17 18] prior to broader PrEP access via public subsidy in 2018. Consistent with this, gonorrhoea incidence among ever-PrEP users was already increasing prior to PrEP introduction.[19 20] Higher testing uptake among ever-PrEP users likely reflects national guidelines recommending 3-monthly testing.[21]

In our cohort, GBM living with HIV consistently had the lowest gonorrhoea test uptake, likely reflecting less frequent HIV care visits (typically 6-monthly) and the absence of mandatory STI screening during HIV care. However, gonorrhoea incidence among GBM with HIV was similar to that among those prescribed PrEP, and a similar increasing trend was observed across the study period. Converging trends among people with HIV and those with evidence of PrEP use may partly reflect a decline in serosorting (ie, a risk-reduction strategy where individuals choose partners based on their HIV status) following PrEP implementation and increasing acceptance of 'undetectable=untransmissible' (U=U). In annual behavioural surveillance surveys of GBM in Australia, the proportion of GBM with HIV who practised serosorting with casual partners decreased from 32.1% in 2019 to 26.6% in 2023.[22] National surveys also indicated that comfort in having condomless sex with PrEP users increased.[23]

An earlier study using data from a subset of the SHCs participating in ACCESS demonstrated a 1.74-fold increase

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

in gonorrhoea incidence from 14.1 to 24.6/100 py from 2010 to 2017 among 46 904 GBM.[5] Our study, which also included GP and tertiary hospital clinics, found gonorrhoea incidence has continued to increase since 2017, and incidence recovered substantially after COVID-19 restrictions. Increasing trends in gonorrhoea in recent years have also been observed internationally. The European Centre for Disease Prevention and Control reported increasing annual gonorrhoea cases between 2013 and 2022, most commonly among GBM, with GBM comprising 60% of all reported gonorrhoea cases in 2022 and cases among GBM increasing by 65% between 2018 and 2022.[24] In the UK, where the timing of PrEP rollout was similar to Australia, gonorrhoea diagnoses among GBM increased by 51% from 2015 to 2019, and 44% of new STI diagnoses in 2019 were gonorrhoea cases.[25] In Ireland, where PrEP was rolled out in 2019,[24] the gonorrhoea notification rate among GBM increased almost twofold from 2019 to 2023.[26]

Our observation that increases in gonorrhoea incidence were most prominent for infections at anatomical sites typically associated with asymptomatic infection suggests that increased screening is likely influencing detection. To date, screening recommendations have been made despite limited evidence that high-frequency, extragenital screening reduces population-level gonorrhoea among GBM. Further, the individual-level benefit of screening for asymptomatic gonorrhoea at these anatomical sites has also not been established.[10] In the era of growing AMR in gonorrhoea and emergence of multidrug-resistant gonorrhoea strains in Australia,[27] further research is needed to understand the impact of screening recommendations on population-level transmission and rising AMR. Ongoing surveillance and systematic monitoring of treatment failures will be important for gonorrhoea control strategies.

Recently, there has been interest in biomedical invention strategies. Although large clinical trials[28 29] have demonstrated that taking 200 mg of doxycycline within 72 hours after sex can reduce the incidence of syphilis and chlamydia by over 70% in GBM, the evidence for the effectiveness for preventing gonorrhoea has varied, with some studies suggesting doxyPEP may reduce gonorrhoea incidence by 50%.[30] Given the high prevalence of tetracycline resistance in *Neisseria gonorrhoeae* in many settings, the effectiveness of doxyPEP for gonorrhoea prevention may be limited. In addition, there are concerns that widespread use of doxyPEP could contribute to further selection of resistant strains, with potential implications for growing AMR.[31] Vaccination against gonorrhoea is also being explored, with emerging evidence of potential cross-protection from the 4CMenB meningococcal vaccine, originally developed for *Neisseria meningitidis*.[32] This vaccine is now recommended for GBM in the UK.[33] Our data suggest that GBM with HIV and those using PrEP would benefit most from vaccination in Australia, if shown to be sufficiently effective. Further, reinfection was common, with 11.4% of GBM experiencing ≥2 infections. This suggests that targeting prevention strategies, such as vaccination, to individuals with prior infection may improve efficiency in reducing population-level transmission.

Strengths and limitations

Strengths of this study include the large longitudinal cohort of GBM with and without HIV before and after PrEP introduction, inclusion of multiple healthcare settings across Australia, and the linked nature of ACCESS data, which enabled analysis of testing and incidence trends over prolonged follow-up. The linked sentinel design also enabled measurement of incidence among repeat testers at increased risk of gonorrhoea, providing insights beyond passive surveillance data.

Our analysis also has several limitations. First, gonorrhoea cases diagnosed outside of ACCESS services were not captured, potentially leading to an underestimated incidence. However, the median time between tests was relatively short, suggesting testing outside the network was minimal. Second, we did not explore the recency of PrEP use. A previous study of current PrEP users (censoring those who stopped PrEP after 4 months) reported a gonorrhoea incidence of 37.8 per 100 py (95% CI 37.0 to 38.5).[8] Our study reported a lower incidence among ever-PrEP users, likely reflecting differences in exposure definition and the inclusion of a broader range of clinical services. Third, behavioural factors such as condom use and the number of sexual partners were unavailable from all services. Fourth, symptomatic data were unavailable. As such, we were unable to directly distinguish symptomatic from asymptomatic infection, and instead inferred changes in asymptomatic infection based on the anatomical site of diagnosis. Finally, as we relied on testing data from electronic medical records, the exact date of infection is unknown. However, given that participants were being tested twice per year on average, this probably has minimal impact on our trend analysis.

CONCLUSION

In this large cohort of GBM in Australia, gonorrhoea incidence increased almost threefold, with incidence among GBM with HIV and GBM with evidence of PrEP use converging over the past 12 years. While testing for gonorrhoea increased, testing frequency remained below recommended guidelines. Targeted screening and prevention strategies, alongside further research on the impact of asymptomatic screening on population-level transmission and AMR, are required to reduce the spread and burden of gonorrhoea among GBM.

Author affiliations
[1]Burnet Institute, Melbourne, Victoria, Australia
[2]Centre of Epidemiology and Biostatistics, The University of Melbourne School of Population and Global Health, Melbourne, Victoria, Australia
[3]School of Public Health and Preventive Medicine, Monash University, Melbourne, Victoria, Australia
[4]UNSW Sydney, The Kirby Institute, Kensington, New South Wales, Australia
[5]Melbourne Sexual Health Centre, Alfred Health, Melbourne, Victoria, Australia
[6]School of Translational Medicine, Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, Victoria, Australia
[7]Sydney Sexual Health Centre, Sydney, New South Wales, Australia
[8]Gold Coast Sexual Health Service, Gold Coast, Queensland, Australia
[9]M Clinic, Perth, Western Australia, Australia
[10]New South Wales Health Pathology, Newcastle, New South Wales, Australia
[11]The University of Sydney Central Clinical School, Sydney, New South Wales, Australia
[12]Department of Sexual Health Medicine, Sydney Local Health District, Sydney, New South Wales, Australia
[13]North Coast HIV and Sexual Health Services, Sydney, New South Wales, Australia
[14]Department of Infectious Diseases, University of Melbourne, at the Peter Doherty Institute for Infection and Immunity, Melbourne, Victoria, Australia
[15]Health Equity Matters, Sydney, New South Wales, Australia
[16]Department of Infectious Diseases, The Alfred and Monash University, Melbourne, Victoria, Australia
[17]Australian Research Centre in Sex, Health and Society, La Trobe University, Melbourne, Victoria, Australia

Handling editor Stefano Rusconi

Acknowledgements The authors acknowledge the contribution of the ACCESS Team members who are not coauthors of this article including: Basil Donovan, Kirby Institute, UNSW Sydney; Allison Carter, Kirby Institute, UNSW Sydney; Wayne Dimech, NRL Quality; Alexis Apostolellis, Australasian Society for HIV Medicine; Aaron Cogle, National Association of People with HIV Australia; Cameron Taylor, Derbarl Yerrigan Health Service; Rani West, ATLAS; Daniel Coase, Federation of Ethnic Communities'

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

Councils of Australia (FECCA); David Lewis, Western Sydney Sexual Health Centre; David Nolan, Royal Perth Hospital; Edward Huddy, Ministry of Health; Emma Sanguineti, Queensland Ministry of Health; Florin Douglas, Deakin University; Janaki Amin, NSW Ministry of Health; Jane Davies, Menzies School of Health Research; Jane Hocking, University of Melbourne; John Didlick, Hepatitis Australia; John G, Australian Injecting and Illicit Drug Users League (AIVL); Jess Doumany, Australian Injecting and Illicit Drug Users League; Lien Tran, Hepatitis B Voices; Lisa Bastian, WA Department of Health; Mandy Charleton, Ministry of Health; Manoji Gunathilake, Royal Darwin Hospital; Megan Campbell, National Aboriginal Community Controlled Health Organisation (NAACHO); Mish Pony, Scarlet Alliance; Nathan Ryder, Hunter New England LHD; Norm Roth, Prahran Market Clinic; Philip Cunningham, SydPath; Phillip Read, Kirkton Road Centre; Stella Pendle, Australian Clinical Laboratories; Tom Rees, SA Ministry of Health; Stella Lintzeris, Kirby Institute, UNSW Sydney; Brendan Quinn, Burnet Institute; Thi Nguyen, Burnet Institute; Victoria Polkinghorne, Burnet Institute. The authors also acknowledge all clinics participating in ACCESS. ACCESS is a partnership between the Burnet Institute, Kirby Institute and NRL Quality. Preliminary findings from this study were previously presented at the STI & HIV 2025 World Congress in Montreal, Canada (abstract number OA03.05),[34] and at the Australasian Sexual & Reproductive Health Conference 2025 in Adelaide, Australia.[35]

Collaborators Not applicable.

Contributors HHA conceived the study, conducted the analyses, interpreted the findings and drafted the manuscript. MWT supervised the study, contributed to study design, interpretation of findings and critical revision of the manuscript. Other authors contributed to the interpretation of findings. All authors reviewed and approved the final manuscript. HHA is the guarantor of this work.

Funding The Australian Collaboration for Coordinated Enhanced Sentinel Surveillance (ACCESS) is supported by core funding from the Australian Department of Health to monitor national progress in the control of blood-borne viruses and sexually transmitted infections. Additional funding for state-level outcomes is provided by the Governments of Victoria and Western Australia. Funding for specific components of ACCESS is provided by the Blood Borne Viruses and Sexually Transmitted Infections Research, Intervention and Strategic Evaluation (BRISE) Program; a National Health and Medical Research Council (NHMRC) project grant (APP1082336); an NHMRC partnership grant (GNT1092852); and the Prevention Research Support Program funded by the New South Wales Ministry of Health. MWT is supported by a National Health and Medical Research Investigator Grant (GNT2027235).

Competing interests MWT has received consulting fees from Gilead Sciences Ltd. RG has received research support funding from Cepheid and SpeeDx. MEH has received investigator-initiated research grant support from Gilead Sciences and AbbVie. MAS has received investigator-initiated grants from AbbVie and Gilead and consultancy from Gilead. EPFC is supported by an Australian National Health and Medical Research Council (NHMRC) Emerging Leadership Investigator Grant (GNT1172873), and has received speakers' honoraria from Gilead Sciences, MSD and CSL Seqirus. EPFC and MWT are members of the Editorial Board of Sexually Transmitted Infections as Associate Editors. FYSK is also a member of the Editorial Board. They were not involved in the peer review or editorial decision-making for this manuscript.

Patient consent for publication Not applicable.

Ethics approval Ethics approval for ACCESS was provided by the Human Research Ethics Committees at Alfred Hospital (248/17), Central Australia (CA-19-3355), Northern Territory Department of Health and Menzies School of Health (08/47), University of Tasmania (H0016971), Aboriginal Health and Medical Research Council (1099/15), ACON (2015/14), Victorian AIDS Council/Thorne Harbour Health (VAC REP 15/003) and St. Vincent's Hospital (08/051). As our study analyses non-identified data collected under the auspices of public health surveillance, individual patient consent was not required. Individuals were able to opt-out of the surveillance system if they wish.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. Deidentified individual participant data used in this study are not publicly available because of the sensitive nature of the data and restrictions imposed by participating clinical services and ethics approvals. Access to deidentified data may be available via the Burnet Institute, subject to approval from the relevant Human Research Ethics Committee and data governance requirements, for researchers who meet the criteria for access to confidential data. The ACCESS study protocol has been published previously.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution 4.0 Unported (CC BY 4.0) license, which permits others to copy, redistribute, remix, transform and build upon this work for any purpose, provided the original work is properly cited, a link to the licence is given, and indication of whether changes were made. See: https://creativecommons.org/licenses/by/4.0/.

ORCID iDs
Hein Htet Aung https://orcid.org/0009-0004-7055-1243
Htein Linn Aung https://orcid.org/0000-0002-8867-3220
Eric P F Chow https://orcid.org/0000-0003-1766-0657
Rick Varma https://orcid.org/0000-0002-0402-0506
Fabian Yuh Shiong Kong https://orcid.org/0000-0002-9349-3080

REFERENCES

1 Springer C, Salen P. Gonorrhea. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing, 2024. Available: http://www.ncbi.nlm.nih.gov/books/NBK558903/
2 Donovan LC, Fairley CK, Aung ET, *et al*. The Presence or Absence of Symptoms Among Cases of Urethral Gonorrhoea Occurring in a Cohort of Men Taking Human Immunodeficiency Virus Pre-exposure Prophylaxis in the PrEPX Study. *Open Forum Infect Dis* 2021;8:ofab263.
3 Williamson DA, Fairley CK, Howden BP, *et al*. Trends and Risk Factors for Antimicrobial-Resistant *Neisseria gonorrhoeae*, Melbourne, Australia, 2007 to 2018. *Antimicrob Agents Chemother* 2019;63:e01221-19.
4 Kirby Institute. HIV, viral hepatitis and sexually transmissible infections in Australia: annual surveillance report 2024: sexually transmissible infections. 2025.
5 Callander D, Guy R, Fairley CK, *et al*. Gonorrhoea gone wild: rising incidence of gonorrhoea and associated risk factors among gay and bisexual men attending Australian sexual health clinics. *Sex Health* 2019;16:457–63.
6 Holt M, Lea T, Mao L, *et al*. 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. *Lancet HIV* 2018;5:e448–56.
7 Chow EPF, Phillips TR, Bradshaw CS, *et al*. Brief Report: Sexual Mixing Patterns by HIV Status and PrEP Use Among Men Who Have Sex With Men Partnerships in Melbourne, 2011–2018. *J Acquir Immune Defic Syndr* 2020;83:99–102.
8 Traeger MW, Guy R, Asselin J, *et al*. Real-world trends in incidence of bacterial sexually transmissible infections among gay and bisexual men using HIV pre-exposure prophylaxis (PrEP) in Australia following nationwide PrEP implementation: an analysis of sentinel surveillance data. *Lancet Infect Dis* 2022;22:1231–41.
9 Goddard SL, Poynten IM, Petoumenous K, *et al*. Prevalence, incidence and predictors of anal *Chlamydia trachomatis*, anal *Neisseria gonorrhoeae* and syphilis among older gay and bisexual men in the longitudinal Study for the Prevention of Anal Cancer (SPANC). *Sex Transm Infect* 2019;95:477–83.
10 Williams E, Williamson DA, Hocking JS. Frequent screening for asymptomatic chlamydia and gonorrhoea infections in men who have sex with men: time to re-evaluate? *Lancet Infect Dis* 2023;23:e558–66.
11 Callander D, Moreira C, El-Hayek C, *et al*. Monitoring the Control of Sexually Transmissible Infections and Blood-Borne Viruses: Protocol for the Australian Collaboration for Coordinated Enhanced Sentinel Surveillance (ACCESS). *JMIR Res Protoc* 2018;7:e11028.
12 Nguyen L, Stoové M, Boyle D, *et al*. Privacy-Preserving Record Linkage of Deidentified Records Within a Public Health Surveillance System: Evaluation Study. *J Med Internet Res* 2020;22:e16757.
13 Barrajon E, Barrajon L. Effect of right censoring bias on survival analysis. *J Clin Oncol* 2019;37:e18188.
14 Ampt FH, El Hayek C, Agius PA, *et al*. Anorectal swabs as a marker of male-to-male sexual exposure in STI surveillance systems. *Epidemiol Infect* 2017;145:2530–5.
15 Chow EPF, Hocking JS, Ong JJ, *et al*. Sexually Transmitted Infection Diagnoses and Access to a Sexual Health Service Before and After the National Lockdown for COVID-19 in Melbourne, Australia. *Open Forum Infect Dis* 2021;8:ofaa536.
16 Traeger MW, Guy R, Taunton C, *et al*. Syphilis testing, incidence, and reinfection among gay and bisexual men in Australia over a decade spanning HIV PrEP implementation: an analysis of surveillance data from 2012 to 2022. *Lancet Reg Health West Pac* 2024;51:101175.
17 Traeger MW, Cornelisse VJ, Asselin J, *et al*. Association of HIV Preexposure Prophylaxis With Incidence of Sexually Transmitted Infections Among Individuals at High Risk of HIV Infection. *JAMA* 2019;321:1380–90.
18 Grulich AE, Guy R, Amin J, *et al*. Population-level effectiveness of rapid, targeted, high-coverage roll-out of HIV pre-exposure prophylaxis in men who have sex with men: the EPIC-NSW prospective cohort study. *Lancet HIV* 2018;5:e629–37.
19 Grulich A, Bavinton B, Stoove M, *et al*. Agenda 2025 ending HIV transmission in Australia: technical paper on science, trends and targets June 2021 [report]. 2021. Available: http://hdl.handle.net/1959.4/unsworks_76500

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.

20 Cornelisse VJ, Fairley CK, Stoove M, *et al*. Evaluation of Preexposure (PrEP) Eligibility Criteria, Using Sexually Transmissible Infections as Markers of Human Immunodeficiency Virus (HIV) Risk at Enrollment in PrEPX, a Large Australian HIV PrEP Trial. *Clin Infect Dis* 2018;67:1847–52.
21 Australian STI Management Guideline. Men who have sex with men. 2024. Available: https://sti.guidelines.org.au/populations-and-situations/men-who-have-sex-with-men/
22 MacGibbon J, Broady T, Chan C, *et al*. Gay community periodic survey: Melbourne 2023. 2023.
23 Holt M, Draper BL, Pedrana AE, *et al*. Comfort Relying on HIV Pre-exposure Prophylaxis and Treatment as Prevention for Condomless Sex: Results of an Online Survey of Australian Gay and Bisexual Men. *AIDS Behav* 2018;22:3617–26.
24 European Centre for Disease Prevention and Control. Gonorrhoea - annual epidemiological report for 2022. 2022. Available: https://www.ecdc.europa.eu/en/publications-data/gonorrhoea-annual-epidemiological-report-2022
25 Stroude W. Sharp rise in gonorrhoea and chlamydia cases among gay and bi men over last five years. 2020. Available: https://www.attitude.co.uk/news/world/sharp-rise-in-gonorrhoea-and-chlamydia-cases-among-gay-and-bi-men-over-last-five-years-301605/
26 Health Protection Surveillance Centre. Surveillance reports. 2024. Available: https://www.hpsc.ie/a-z/sexuallytransmittedinfections/gonorrhoea/surveillancereports/#d.en.24201
27 Lahra MM, Van Hal S, Hogan TR. Australian Gonococcal Surveillance Programme Annual Report, 2022. *Commun Dis Intell (2018)* 2023;47.
28 Luetkemeyer AF, Donnell D, Dombrowski JC, *et al*. Postexposure Doxycycline to Prevent Bacterial Sexually Transmitted Infections. *N Engl J Med* 2023;388:1296–306.
29 Molina J-M, Bercot B, Assoumou L, *et al*. Doxycycline prophylaxis and meningococcal group B vaccine to prevent bacterial sexually transmitted infections in France (ANRS 174 DOXYVAC): a multicentre, open-label, randomised trial with a 2 × 2 factorial design. *Lancet Infect Dis* 2024;24:1093–104.
30 Bachmann LH, Barbee LA, Chan P, *et al*. CDC Clinical Guidelines on the Use of Doxycycline Postexposure Prophylaxis for Bacterial Sexually Transmitted Infection Prevention, United States, 2024. *MMWR Recomm Rep* 2024;73:1–8.
31 Unemo M, Cole MJ, Kodmon C, *et al*. High tetracycline resistance percentages in *Neisseria gonorrhoeae* in Europe: is doxycycline post-exposure prophylaxis unlikely to reduce the incident gonorrhoea cases? *Lancet Reg Health Eur* 2024;38:100871.
32 World Health Organisation. Neisseria gonorrhoeae. 2025. Available: https://www.who.int/teams/immunization-vaccines-and-biologicals/diseases/neisseria-gonorrhoeae
33 GOV.UK. A guide to the Meningococcal B vaccine for protection against gonorrhoea. 2025. Available: https://www.gov.uk/government/publications/meningococcal-b-menb-vaccination-against-gonorrhoea-guide/a-guide-to-the-meningococcal-b-vaccine-for-protection-against-gonorrhoea
34 Aung HH, Guy R, Chow E, *et al*. OA03.05– Trends in gonorrhoea testing and incidence among gay and bisexual men in Australia over a decade spanning HIV PrEP implementation. *Sex Health* 2025;22:SHv22n4abs.
35 Aung HH, Guy R, Chow EPF, *et al*. Trends in gonorrhoea testing and incidence among gay and bisexual men in Australia during PrEP implementation: an analysis of a decade of surveillance data (2012–2023). Adelaide Convention Centre; 2012. Available: https://ashm.eventsair.com/QuickEventWebsitePortal/hivsrh2025/jointprogram/Agenda/AgendaItemDetail?id=dc04ca84-1dca-4ae4-8bd2-a5aecb8b188b

Sex Transm Infect: first published as 10.1136/sextrans-2026-056909 on 21 September 2026. Downloaded from http://sti.bmj.com/ on October 28, 2026 at Bayside Health - Alfred Health . Protected by copyright, including for uses related to text and data mining, AI training, and similar technologies.