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ORIGINAL RESEARCH

Association between knowledge, risk behaviours, and testing for sexually transmitted infections among men who have sex with men: findings from a large online survey in the United Kingdom

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Objectives

In the UK, men who have sex with men (MSM) bear a disproportionate sexually transmitted infection (STI) burden. We investigated MSM's STI knowledge; whether their STI testing behaviour met national guidelines (annually if sexually active; 3-monthly if engaging in STI risk behaviours); and the relationship between STI testing in the last 3 months, STI knowledge and STI risk behaviours by HIV status.

Methods

Sexually active (in the last year) men aged > 15 years who were UK residents and were recruited from gay-orientated online dating platforms completed an anonymous online survey about STI knowledge, STI risk behaviours, and STI testing (March–May 2017). This included 11 true statements about STIs. Respondents scored 1 for each statement they 'knew', with those scoring < 6 overall treated as having 'poor' STI knowledge. Descriptive and multivariable analyses were conducted, separately by HIV status, to test our hypothesis and calculate adjusted odds ratios (AORs) with 95% confidence intervals (CIs).

Results

Compared to HIV-positive men (n = 489), the proportion of HIV-negative/unknown-status men (n = 3157) with 'poor' STI knowledge was significantly higher (46.4% versus 22.9% for HIV-positive men) and the proportion with STI testing in the last 12 months was lower (71.6% versus 87.2%, respectively). In the last 3 months, 56.9% of HIV-negative/unknown-status and 74.1% of HIV-positive men reported STI risk behaviours, of whom 45.8% and 55.1%, respectively, had been tested for STIs during this time. Among HIV-negative/unknown-status men, those reporting STI risk behaviours were more likely (AOR 1.52; 95% CI 1.26–1.84) and those with poor STI knowledge less likely (AOR 0.73; 95% CI 0.61–0.89) to have been tested during the last 3 months. However, neither factor was independently associated with 3-monthly testing among HIV-positive men.

Conclusions

Improving STI knowledge, especially among HIV-negative/unknown-status men, and promoting frequent STI testing among men engaging in STI risk behaviours are vital to address the poor sexual health of MSM.

Keywords: health knowledge, men who have sex with men, sexual behaviours, sexually transmitted infection, sexually transmitted infection testing

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Introduction

Globally, since the 1990s rates of curable bacterial sexually transmitted infections (STIs) have increased among gay, bisexual and other men who have sex with men (MSM), which has coincided with the use of antiretroviral treatment (ART) for HIV treatment and prevention [1,2]. In England, although a substantial decline in new HIV diagnoses in MSM has been observed since 2015 [3,4], STI diagnoses rates have increased. In 2017, over 50 000 new STI (excluding HIV) diagnoses were made among MSM, of which gonorrhoea (43%) was the most common [5]. Since 2008, there has been a 148% rise in syphilis diagnoses, mostly among MSM [5]. The rate of bacterial STIs diagnosed specifically among MSM with diagnosed HIV infection has also increased, with diagnoses being four times higher than among HIV-negative/undiagnosed MSM [6]. Increases since 2000 in the proportion of MSM engaging exclusively in seroadaptive behaviours, in the reported number of condomless anal sex (CAS) partners, and in CAS with HIV-serodifferent partners (CAS-D) [7] have been proposed as factors explaining observed increases in STIs. Dense sexual networks and chemsex (i.e. concurrent sex and recreational drug use) have also been shown to facilitate STI epidemics among MSM, including syphilis, hepatitis C and shigella [8–12].

Reflecting these epidemiological trends, the British Association for Sexual Health and HIV (BASHH) guidelines specifically for the sexual health care of gay, bisexual and other MSM, including cis and trans men, recommend annual STI testing (including HIV testing if negative/unknown status) for all sexually active MSM unless they have a long-term mutually exclusive partner [13]. The 2016 British HIV Association (BHIVA) guidelines for adults living with HIV also recommend screening annually for gonorrhoea, chlamydia and syphilis among patients with a CD4 cell count of > 500 cells/μL who report a partner change since the last test [14,15]. Additionally, these guidelines [13–16] recommend hepatitis B virus (HBV) and hepatitis C virus (HCV) serology 'at least annually'; and 3-monthly STI testing, including HBV and HCV testing, for MSM who engage in STI risk behaviours (see Appendix Table S1 for details of these behaviours).

Several studies in the UK have focused on HIV testing among MSM [7,17,18] and whether testing in MSM meets national HIV testing guidelines [18]; however, evidence in the context of STI testing among MSM in the UK is sparse [19,20]. Moreover, none of these STI testing studies have examined the frequency of STI testing among MSM who engage STI risk behaviours as defined by the BASHH and BHIVA STI testing guidelines [13–16]. Despite variation in STI diagnoses among MSM by HIV status, none of these studies [19,20] have examined if STI testing and factors associated with it vary by HIV status. Studies conducted in other Western industrialized countries have shown that MSM are less well informed about STIs than about HIV [21–23]. Lack of STI knowledge is a barrier for STI testing [19,21]. A qualitative study conducted in England among MSM has shown that their knowledge of STI transmission, severity and treatments is sparse [24].

To address these evidence gaps, we examined MSM's STI knowledge and whether their STI testing met recommended national guidelines for annual and 3-monthly testing. We also examined the hypothesis that STI knowledge and engagement in STI risk behaviours are independently associated with 3-monthly STI testing among MSM. As a consequence of the greater likelihood of HIV-positive men accessing sexual health services for routine HIV care and its potential impact on STI knowledge and testing, all analyses were stratified by HIV status.

Methods

We conducted an anonymous, self-completion online survey from March to May 2017, promoted on three geospatial social networking/dating platforms that are popular among MSM: Gaydar, Grindr and Scruff [25]. All men using Grindr and Gaydar in England encountered at least one interstitial message inviting them to participate in the study. Among Scruff users, only those living in Birmingham, London, Manchester or Leeds were shown a banner advertisement. Users of these dating apps/websites who clicked on the advert were taken to the online survey where they were asked initial questions about eligibility. Men aged > 15 years who were UK residents and who had had sex with at least one male partner in the last 12 months were eligible to participate. Online consent for study participation was obtained from eligible men. Ineligible men exited the survey. The London School of Hygiene and Tropical Medicine Observational/Interventions Research Ethics Committee approved the study (Ref: 11999).

The survey took 10–15 min to complete and covered a range of topics, including whether they had ever received HIV and other STI test results, and, if yes, when they had last been tested for HIV and for STIs, sexual behaviours (ever and within the last 12 and 3 months), and use of recreational drugs immediately prior to having sex in the last 12 months [crystal meth, mephedrone, Gamma-hydroxybutyrate/gamma-Butyrolactone (GHB/GBL) and ketamine]. Additionally, to measure STI-related awareness, participants were asked if they had heard of any of the following STIs: syphilis, gonorrhoea, chlamydia,

shigella, anal/genital warts, anal/genital herpes, hepatitis C and hepatitis B. Participants' STI knowledge was measured by presenting 11 true statements about transmission, symptoms, treatment and health consequences of these eight STIs (Appendix Table S2). Each question had five response options, where 1 indicated that they had previously known that the statement was true, and 2–5 indicated that they were unsure, were unaware of the subject addressed by the statement, did not understand the statement, or did not believe the statement to be true, respectively, suggesting a complete or partial lack of awareness about these statements, and were coded as 0. We calculated the total number of statements that participants 'knew' about, resulting in an STI knowledge score ranging from 0 to 11. A binary variable was derived, whereby participants who scored < 6 were considered to have 'poor' STI knowledge overall.

Men who reported that they had last tested negative/never received an HIV test result were treated as 'HIV-negative/unknown-status' men and those reporting a positive result as 'HIV positive'. Men who reported CAS with a serodiscordant HIV/unknown status partner were categorized as having discordant condomless anal sex CAS-D. Informed by national guidelines for 3-monthly STI testing among men reporting STI risk behaviours [13–16], a variable for 'engagement in STI risk behaviours' was created if reporting at least one of the following behaviours in the last 3 months (unless specified otherwise): (1) had > 10 sexual partners, (2) CAS, (3) CAS-D, (4) had more than one new sexual partner, and (5) use of recreational drugs immediately prior to having sex in the last 12 months. We did not collect data on 'unprotected' sexual contact with new partners, which is one of the indicators of engagement in STI risk behaviours as per BASHH guidelines [13]. Therefore, we considered reporting of 'any' sexual contact with more than one new sexual partner as one of the indicators to derive the variable of engagement in STI risk behaviours. However, this assumption is likely to overestimate the overall proportion of men engaging in STI risk behaviours because it is unlikely that sexual contact with all new partners was unprotected. We therefore conducted a sensitivity analysis using a 'conservative' variable of engagement in STI risk behaviours derived by excluding reporting of 'any' sexual contact with more than one new partner as one of its indicators.

χ^2 tests were used to identify differences in STI testing and reporting of engagement in STI risk behaviours between HIV-positive and HIV-negative/unknown status MSM. As a consequence of the relatively small proportion of men who identified as HIV positive compared to HIV negative/unknown status, a *P*-value of < 0.01 was considered statistically significant. Separate multivariable logistic regression models by HIV status were used to examine the hypothesis that STI knowledge and engagement in STI risk behaviours were independently associated with 3-monthly STI testing among MSM, adjusting for potential confounding factors (age, ethnicity, education, area of residence, reporting sex with women in last 12 months, and being in a steady partnership). Unadjusted odds ratios (ORs) and adjusted odds ratios (AORs) with 95% confidence intervals (CIs) were calculated. STATA v15 (StataCorpLLC, College station, TX, USA was used for data management and analysis. Men who had never received an STI test result were excluded from descriptive analysis of STI testing in the last 12 and 3 months and multivariate analysis.

Results

Three thousand six hundred and sixty-three eligible men participated in the online survey. Participants' median age was 45 years [interquartile range (IQR) 33–54 years; range 16–81 years]. The majority of men identified as white British or Irish (82.2%). Half of them reported having a degree/higher degree. One in ten men was resident in parts of the UK other than England. Totals of 47.5% and 9.3% of men reported having sex with women, ever and in the last 12 months, respectively. It was found that 42.2% of men had a steady partner(s), of whom 16.2% reported having only a female steady partner and 1.3% reported both male and female steady partners. Of the 3646 men who responded to the question on HIV testing, 14.1% had never received an HIV test result and 13.4% had tested HIV positive.

Awareness and knowledge of STIs

Almost all men (96.4%) had heard of at least one of the eight STIs we asked about (Table 1). Approximately 90% had heard of each of the STIs, except shigella, which only 26.6% of men had heard of. With regard to STI knowledge, 2.7% of men did not know about any of the 11 true statements and these men were predominantly HIV-negative/unknown-status men. Knowledge about shigella transmission and related morbidity was poor (16.5% and 16.3%, respectively), whereas a high proportion of men were aware of how chlamydia was transmitted (78.9%). Two-thirds were aware of the risk of bacterial STI transmission associated with oral sex without ejaculation, and half were aware that having STIs can increase the risk of HIV transmission during sex. Half of men knew of treatment methods for gonorrhoea, yet only 30.2% were aware that 'gonorrhoea is the most common STI among gay and other MSM in England.' A total of 56.8% were aware of treatment for

Table 1 Awareness and knowledge of sexually transmitted infections (STIs) among men who have sex with men (MSM) by HIV status

	All MSM (n = 3646)	HIV-negative/ unknown-status MSM (n = 3157)	HIV-positive MSM (n = 489)	P-value*
Reported that they had heard of any of the eight STIs[†]	96.4 (3531)	96.3 (3041)	96.9 (474)	0.502
Reported that they had heard of the following STIs[‡]				
Gonorrhoea	92.4 (3386)	92.6 (2923)	91.4 (447)	0.360
Chlamydia	91.9 (3367)	92.5 (2919)	88.6 (433)	0.003
Syphilis	92.0 (3371)	92.1 (2906)	91.8 (449)	0.862
Shigella	26.6 (975)	24.8 (782)	38.9 (190)	< 0.001
Hepatitis B	87.9 (3219)	88.4 (2791)	84.7 (414)	0.018
Hepatitis C	88.1 (3227)	88.4 (2791)	86.5 (423)	0.225
Anal/genital warts	86.3 (3162)	86.5 (2732)	85.3 (417)	0.449
Anal/genital herpes	83.8 (3071)	84.5 (2667)	80.4 (393)	0.021
'Knew' about the following statements[‡]				
Shigella is a severe and highly infectious stomach upset caused by bacteria in faeces. It's sometimes caused by food poisoning but can be passed on during sex	16.5 (598/3631)	15.0 (41/3131)	25.6 (124/484)	< 0.001
Shigella is spread easily. It only takes a tiny amount of bacteria to get into your mouth during sex	16.3 (588/3608)	14.8 (461/3111)	25.8 (124/481)	< 0.001
Chlamydia can be transmitted via semen or vaginal fluids during anal, oral, and vaginal sex	78.9 (2846/3605)	78.2 (2429/3106)	84.5 (408/483)	0.002
Even without ejaculation, oral sex carries a risk of chlamydia, syphilis and gonorrhoea infection	64.5 (2361/3633)	63.6 (1992/3134)	74.1 (358/483)	< 0.001
The chances of HIV being passed on during sex between men are greater if either man has certain STIs	54.4 (1987/3650)	52.1 (1637/3145)	69.9 (342/489)	< 0.001
Most cases of gonorrhoea can be treated with a single pill and injection	55.9 (2004/3584)	53.1 (1642/3092)	73.3 (349/47)	< 0.001
In England, gonorrhoea is the most common STI among gay men and other men who have sex with men	30.2 (1095/3627)	28.3 (886/3130)	41.8 (201/481)	< 0.001
Syphilis is usually treated and cured with a course of penicillin injections	56.8 (2049/3607)	53.9 (1678/3109)	74.7 (361/483)	< 0.001
If untreated, syphilis can cause damage to the heart and brain and this can lead to death	66.6 (2402/3607)	64.4 (2007/3115)	81.5 (388/476)	< 0.001
Hepatitis C is a virus that can infect the liver. If untreated over many years, it can cause serious and potentially life-threatening damage	75.3 (2723/3624)	73.1 (2285/3125)	89.9 (434/483)	< 0.001
An outbreak of herpes involves painful blisters or sores which affect the mouth, genitals or rectum	75.9 (2728/3590)	74.8 (2316/3096)	84.3 (403/478)	< 0.001
Overall STI knowledge score [median (IQR)][§]	6 (4–8)	6 (4–8)	7 (6–9)	< 0.001
Overall poor STI knowledge	43.3 (1577/3646)	46.4 (1465/3157)	22.9 (112/489)	< 0.001

Values are % (n) or % (n/total) unless otherwise stated. *P-value is for the Pearson χ^2 test for difference in variables of interest by HIV status. [†]The following eight STIs were listed: gonorrhoea, chlamydia, syphilis, shigella, hepatitis B, hepatitis C, anal/genital warts and anal/genital herpes. [‡]Total n varies because of missing values. [§]Participants could score in a range of 0–11 for the 11 statements about knowledge of STIs listed in the table. IQR, interquartile range.

syphilis, and two-thirds were aware of its health impact if untreated. With regard to viral infections, three-quarters were aware of their impact on health. The proportion of HIV-negative/unknown-status men who had a poor overall STI knowledge score was significantly higher than that of HIV-positive men (46.4% versus 22.9%, respectively).

Engagement in STI risk behaviours in the last 3 months

Overall, 14.0% and 65.0% of men reported more than 10 partners and more than one new partner, respectively (Table 2). Around 55.4% and 13.9% of men had engaged in CAS and CAS-D, respectively. One in ten men reported having used one or more recreational drugs immediately prior to having sex in the last 12 months. Overall, 59.2% of men had engaged in one or more of these STI risk behaviours. The proportion of HIV-positive men who had engaged in STI risk behaviours was significantly higher than that of HIV-negative/unknown-status men (74.1% versus 56.9%, respectively).

Engagement in individual indicators of STI risk behaviours varied by STI knowledge level. Among HIV-negative/unknown-status men, the proportion of men who reported > 10 sexual partners in the last 3 months and the proportion who had used recreational drugs prior to having sex in the last 12 months were significantly higher among

Table 2 Engagement in behaviours that can increase sexually transmitted infection (STI) risk as per national STI testing guidelines among men who have sex with men (MSM) by HIV status and STI knowledge*,†,‡

	All MSM	HIV status (n = 3638)			STI knowledge among HIV-negative/unknown-status MSM (n = 3149)			STI knowledge among HIV-positive MSM (n = 489)		
	% (n/total)	HIV negative/unknown status % (n/total)	HIV positive % (n/total)	P-value§	Poor knowledge % (n/total)	Good knowledge % (n/total)	P-value¶	Poor knowledge % (n/total)	Good knowledge % (n/total)	P-value#
> 10 partners in the last 3 months	14.0 (401/2866)	12.5 (309/2482)	23.1 (87/376)	< 0.001	9.9 (110/1113)	14.5 (199/1369)	< 0.001	20.0 (16/80)	23.9 (71/296)	0.453
> 1 new partner in the last 3 months	65.0 (2088/3212)	64.6 (21 793/2777)	67.5 (284/421)	0.246	62.4 (783/1255)	66.4 (1010/1522)	0.030	61.7 (58/94)	69.1 (226/327)	0.177
CAS in the last 3 months	55.4 (1663/3004)	53.2 (1580/2594)	66.2 (276/399)	< 0.001	55.9 (652/1163)	50.9 (728/1429)	0.011	60.2 (53/88)	71.7 (223/311)	0.040
Serodiscordant CAS in the last 3 months	13.9 (350/2520)	11.8 (255/2152)	25.8 (93/360)	< 0.001	12.9 (123/955)	11.0 (132/1197)	0.187	24.3 (18/74)	26.2 (75/286)	0.739
Any recreational drug use in the last 12 months before having sex††,‡‡	10.4 (381/3653)	8.3 (260/3149)	24.1 (118/489)	< 0.001	5.8 (85/1459)	10.4 (175/1690)	< 0.001	20.5 (23/112)	25.2 (95/377)	0.311
Engagement in ≥ 1 behaviours that increase risk of STIs in the last 3 months§§	84.9 (2729/3212)	84.2 (2337/2777)	90.0 (379/421)	0.002	83.7 (1050/1255)	84.6 (1287/1522)	0.521	82.9 (78/94)	92.1 (301/327)	0.010
Conservative indicator of engagement in ≥ 1 behaviours that increase risk of STIs in the last 3 months¶¶	59.2 (1901/3212)	56.9 (1579/2777)	74.1 (312/421)	< 0.001	57.6 (723/1255)	56.2 (856/1522)	0.469	68.1 (64/94)	75.8 (248/327)	0.130

*Denominator includes all men who were sexually active in the last 3 months prior to the survey unless specified otherwise. †Total number varies because of missing values. ‡All men irrespective of whether or not they had heard about STIs were included in this analysis. §P-values were derived from Pearson's χ^2 test used to compare behaviours that can increase STI risk by HIV status. ¶P-values were derived from Pearson's χ^2 test used to compare HIV-negative men's engagement in behaviours that can increase their STI risk by their STI knowledge scores. #P-values were derived from Pearson's χ^2 test used to compare HIV-positive men's engagement in behaviours that can increase their STI risk by their STI knowledge scores. ††Denominator includes all men who were sexually active in the last 12 months prior to the survey. ‡‡Crystal, meth, mephedrone, Gamma-hydroxybutyrate/gamma-Butyrolactone or ketamine. §§Indicator of engaging in behaviours that increase STI risk (i.e., men who reported atleast one or more of the following behaviours in the last 3months): more thank 10 sexual partners, more than one new partners, CAS, discordant CAS; and had used recreational drugs prior to having sex in the last 12 months. ¶¶The conservative indicator excluded reporting of more than one new partner in the last 3 months as a marker of being at risk for reasons explained in the Methods section.CAS, condomless anal sex.

men with good (14.5% and 10.4%, respectively) than among men with poor (9.9% and 5.8%, respectively) STI knowledge. In contrast, the proportion of HIV-negative/unknown-status men reporting any CAS in the last 3 months was significantly lower among men with good (50.9%) than among men with poor (55.9%) STI knowledge. Among HIV-positive men, the proportion of men who had engaged in CAS was significantly higher among men with good (71.7%) than among men with poor (60.2%) STI knowledge. However, the conservative indicator of engagement in STI risk behaviours in the last 3 months did not vary by STI knowledge score among either HIV-negative/unknown-status or HIV-positive men.

Testing for STIs

Of the 3316 men who responded, 24.5% (n = 813) had never received an STI test result. The proportion of HIV-negative/unknown-status men who had never received an STI test result was higher than that of HIV-positive men (26.3% versus 13.3%, respectively). Of the men who had ever received STI test results, 2420 responded to the question about when they had been tested for STIs. Overall, 74.1% and 43.4% of these men had been tested for STIs in the last 12 and last 3 months, respectively. Compared to HIV-positive men, the proportions of HIV-negative/unknown-status men who had been tested were significantly lower (71.6% versus 87.2% for HIV-positive men in the last 12 months and 41.4% versus 53.2% for HIV-positive men in the last 3 months). Among HIV-negative/unknown-status men who had engaged in STI risk behaviours in the last 3 months, STI testing in the last 3 months was lower than in HIV-positive men who had engaged in these behaviours (45.8% versus 55.1%, respectively).

Factors associated with STI testing in the last 3 months

Among HIV-negative/unknown-status men, STI knowledge and engagement in STI risk behaviours in the last 3 months were independently associated with STI testing during this time (Table 3). Compared to men with good STI knowledge, HIV-negative/unknown-status men with poor knowledge were less likely to have been tested for STIs in the last 3 months (AOR 0.73; 95% CI 0.61–0.89). Men who reported engaging in STI risk behaviours were more likely to report STI testing than men who did not do so (AOR 1.52; 95% CI 1.26–1.84). Of the HIV-negative/unknown-status men who reported engaging in STI risk behaviours and had not been tested for STIs in the last 3 months (n = 625), 43.8% also had poor STI knowledge.

Among HIV-positive men, neither engagement in STI risk behaviours (AOR 1.49; 95% CI 0.89–2.49) nor STI knowledge (AOR 0.67; 95% CI 0.40–1.21) was independently associated with STI testing in the last 3 months (Table 3). Among HIV-positive men who reported engaging in STI risk behaviours and had not been tested for STIs in the last 3 months (n = 158), 24.0% also had poor STI knowledge. Education was associated with testing in the last 3 months, and those with degree-level education were less likely to have been tested for STIs in the last 3 months, but the upper 95% CI was close to 1 (AOR 0.63; 95% CI 0.41–0.99). None of the other sociodemographic and behavioural factors were associated with STI testing in the last 3 months.

Discussion

Our study offers unique insights into MSM's knowledge of STIs and their engagement in STI risk behaviours by HIV status, and how these relate to STI testing. The majority of MSM had heard about the STIs we asked about. However, despite high and increasing prevalences of gonorrhoea and syphilis, and shigella outbreaks among MSM in England, knowledge about these infections was poor, especially among HIV-negative/unknown-status men. Despite good knowledge of STIs, engagement in STI risk behaviours was higher among HIV-positive men than HIV-negative/untested men. However, among HIV-negative/unknown-status men, engagement in STI risk behaviours varied by STI knowledge, with men with good STI knowledge reporting more sexual partners and recreational drug use prior to sex, and those with poor knowledge more likely to report engaging in CAS. These data highlight that, in addition to knowledge, behaviours are determined by a complex range of psychological and ecosocial factors [26,27].

A quarter of men, mainly HIV-negative/unknown-status men, had never received an STI test result, which is slightly higher than the 18% reported in a Glasgow community-based survey among MSM [19], highlighting the need to continue promoting STI testing among MSM. STI testing in the last 12 months was also higher in our survey (74%) compared to that reported by MSM in the UK (44%) in the European MSM Internet Survey (EMIS) [20] and the above-mentioned Glasgow survey (54%) [19]. However, both these surveys were conducted far earlier (2010) than our survey, and it is possible that, among those testing for STIs, the proportion testing annually may have increased over time. STI testing was higher in HIV-positive than HIV-negative/unknown-status men, potentially because they are more likely to access clinics for routine HIV care. The BHIVA national 2015 audit showed that 72.7% of HIV-positive men were offered an annual sexual health screen [28]. This is lower than STI testing among HIV-positive men in the last 12 months in

Table 3 Factors associated with sexually transmitted infection (STI) testing in the last 3 months by HIV status among men who have sex with men (MSM)*

	All MSM (n = 2420)† % (n) or median (IQR; range)	STI testing among HIV-negative/unknown-status MSM					STI testing among HIV-positive MSM				
		% (n/total) or median (IQR; range)	Unadjusted OR and 95% CI	P-value for ORs	AOR and 95% CI	P-value for AORs	% (n/total)	Unadjusted OR and 95% CI	P-value for ORs	AOR and 95% CI	P-value for AORs
Tested for STIs in the last 3 months	43.4 (1049)	41.4 (843/2038)	–	–	–	–	53.2 (199/374)	–	–	–	
Age											
Median (IQR; range)	44 (33–53; 16–81)	43 (32–52; 16–81)	–	–	–	–	48 (38–54; 16–78)	–	–	–	–
16–24 years	7.4 (179)	57.9 (99/171)	1	< 0.0001	1	< 0.001	75.0 (6/8)‡	1	0.440	1	0.808
25–34 years	20.3 (490)	44.2 (191/432)	0.57 (0.40–0.82)		0.54 (0.37–0.79)						
35–44 years	23.5 (569)	45.4 (222/489)	0.60 (0.43–0.86)		0.59 (0.41–0.86)		58.2 (46/79)	1.08 (0.56–2.11)		1.21 (0.59–2.48)	
> 44 years	48.8 (1182)	34.9 (331/946)	0.39 (0.28–0.55)		0.43 (0.30–0.61)		50.7 (117/231)	0.79 (0.46–1.39)		1.02 (0.56–1.88)	
Ethnicity											
White British /Irish	80.9 (1936)	39.1 (634/1621)	1	< 0.0001	1	0.008	50.3 (156/310)	1	0.092	1	0.107
White other	10.6 (254)	50.2 (106/211)	1.57 (1.18–2.09)		1.41 (1.04–1.91)		68.3 (28/41)	2.12 (1.06–4.26)		2.23 (1.06–4.68)	
Nonwhite	8.4 (202)	51.7 (94/182)	1.66 (1.22–2.26)		1.51 (1.09–2.08)		57.9 (11/19)	1.36 (0.53–3.47)		1.14 (0.41–3.14)	
Education											
No academic qualification/below degree level	45.0 (1071)	41.6 (372/895)	1	0.833	1	0.417	56.9 (98/172)	1	0.139	1	0.044
Degree level	54.9 (1308)	41.1 (457/1112)	0.98 (0.82–1.17)		0.94 (0.77–1.13)		49.2 (95/193)	0.73 (0.48–1.11)		0.63 (0.41–0.99)	
Area of residence											
Outside England§	8.7 (207)	29.6 (53/179)	1	0.001	1	0.005	46.4 (13/28)	1	0.506	1	0.654
England	91.3 (2171)	42.6 (779/1827)	1.76 (1.27–2.47)		1.64 (1.16–2.33)		52.9 (178/336)	1.29 (0.60–2.82)		1.20 (0.54–2.67)	
Had sex with women in the last 12 months											
No	90.5 (2182)	41.5 (755/1818)	1	0.540	1	0.775	52.8 (188/356)	1	0.493	1	0.500
Yes	9.5 (229)	39.3 (83/211)	0.91 (0.68–1.22)		1.04 (0.77–1.43)		61.1 (11/18)	1.40 (0.53–3.71)		1.41 (0.52–2.67)	
Steady partner¶											
No	58.7 (1421)	45.3 (546/1205)	–	–	–	–	56.1 (118/210)	–	–	–	–
Only men	35.4 (857)	36.9 (261/706)	–		–		48.9 (73/149)	–		–	
Only women	5.6 (136)	27.9 (34/122)	–		–		50.0 (7/14)	–		–	
Both men and women	0.3 (6)	40.0 (2/5)	–		–		100 (1/1)	–		–	
Steady partner (binary)											
No	58.7 (1421)	45.3 (546/1205)	1	< 0.001	1	< 0.001	56.2 (118/210)	1	0.191	1	0.313
Yes	41.3 (999)	35.7 (297/833)	0.67 (0.56–0.80)		0.69 (0.56–0.83)		49.4 (81/164)	0.76 (0.51–1.14)		0.79 (0.52–1.24)	
STI knowledge											
Good	63.4 (1534)	43.6 (535/1228)	1	0.013	1	0.002	54.8 (165/301)	1	0.207	1	0.199
Poor	36.6 (886)	38.0 (308/810)	0.79 (0.66–0.95)		0.73 (0.61–0.89)		46.6 (34/73)	0.72 (0.43–1.20)		0.67 (0.40–1.21)	
Engagement in ≥ 1 behaviours that increase STI risk in the last 3 months#											
No	40.3 (974)	35.7 (316/886)	1	< 0.001	1	< 0.001	47.1 (41/87)	1	0.195	1	0.132
Yes	59.8 (1446)	45.8 (527/1152)	1.52 (1.27–1.82)		1.52 (1.26–1.84)		55.1 (158/287)	1.37 (0.85–2.22)		1.49 (0.89–2.49)	

*Total number varies because of missing values. †All MSM for whom STI testing data were available. ‡Age categories 16–24 and 25–34 years were combined for analysis of HIV-positive men because of the small number of HIV-positive men aged 16–24 years who participated in this study. §Men who were residing in Scotland, Wales, Northern Ireland, or British overseas territories and crown were combined to form a category 'outside England'. ¶Not included in the regression model because of the small number of cases in some categories; however, a binary variable indicating whether a person was in a steady partnership was included in the model. #Conservative indicator of engaging in behaviours that increase STI risk (i.e., men who reported ≥ 1 of the following behaviours in the last 3 months: > 10 sexual partners), CAS, CAS-discordant; had used recreational drugs in the last 12 months prior to sex (i.e., crystal meth, mephedrone, GHB/GBL or ketamine). The conservative indicator excluded reporting of more than one new partner in the last 3 months as a marker of being at risk for reasons explained in the Methods section.
AOR, adjusted odds ratio; CI, confidence interval; IQR, interquartile range; OR, odds ratio.

our study, which was conducted 2 years after this audit, suggesting a potential increase over time in annual sexual health screening in this population. However, a significant minority of HIV-positive men and one-third of HIV-negative/unknown-status men had not been tested for STIs in the last 12 months. Furthermore, approximately half of HIV-positive and HIV-negative/unknown-status men who had engaged in STI risk behaviours during this time had also not been tested for STIs in the last 3 months. These data highlight the need to develop effective interventions to implement national guidelines recommending at least annual STI testing among all sexually active MSM and 3-monthly STI testing among men who engage in STI risk behaviours [13–15] to reduce STI transmission. STI knowledge and engagement in STI risk behaviours in the last 3 months were associated with STI testing during this time period among HIV-negative/unknown-status men, whereas these factors were not associated with STI testing in the last 3 months in HIV-positive men.

Our study has the following limitations. Our sample may not be representative of men who do not use the geospatial social networking dating platforms we used for recruitment, or of men who do not use such dating platforms in general. However, the dating platforms we used for recruitment are commonly used among MSM in the UK [25]. Moreover, recruitment of our sample online as opposed to from sexual health clinics has enabled us to assess STI knowledge and testing behaviours among men who may not necessarily engage with sexual health services. Recruitment through these dating platforms probably reflects the demographic characteristics of their users; for example, the median age of our sample was 45 years. Thus, our study findings may not be reflective of STI knowledge and testing behaviours of younger MSM. Our online survey was administered in English, and therefore men with poor English language capability and/or a lack of access to the internet may have been unlikely to participate in our study. All data were self-reported and therefore ensuring reliability is challenging. Our findings regarding associations between STI knowledge, behaviours and testing should be interpreted with caution because causality cannot be inferred as a consequence of the cross-sectional nature of our data. The BHIVA guidelines also recommend STI testing among people with HIV infection who have an *a prior* STI diagnosis and/or report anonymous partners [15]; however, we did not collect data about this in our survey.

Similar to other studies [19,21–23], our findings highlight poor knowledge of STIs, especially among HIV-negative/unknown-status MSM. Compared to knowledge about HIV among MSM, the EMIS survey also reported relatively poor knowledge about other STIs, especially among HIV-negative/unknown-status MSM [20]. However, it is important to bear in mind that the measures of STI knowledge used in all these surveys varied considerably from those used in our survey. Education about STI transmission, symptoms and treatment among HIV-negative/unknown-status men should be prioritized given the high levels of never testing for STIs, STI testing below recommended national standards among those who had previously tested, and the association between poor STI knowledge and testing observed among them. Interactive digital interventions (IDIs) are effective in enhancing sexual health knowledge [29] and may be acceptable to MSM who are more likely to use the internet. However, further research is needed to explore the acceptability of such innovative approaches for sexual health promotion and to assess their effectiveness in promoting sexual health knowledge among MSM in the UK.

Alongside enhancing STI knowledge, our results highlight the need for effective interventions to promote STI testing among HIV-positive and HIV-negative/unknown-status MSM. In order to implement the BHIVA recommendation [15] of at least annual STI testing among HIV-positive men, 'opt-out' STI testing should be offered to all sexually active men attending for routine HIV care to maximize the impact of clinic contact time. Reminders for offering opt-out testing to HIV-positive patients attending clinics can be facilitated by using prompts incorporated within electronic patient records [30]. However, the extent to which this is possible needs consideration, given the fragmentation of sexual health service provision in England, with HIV services being provided by the National Health Service, while STI testing is commissioned by the local authorities [31,32]. Nevertheless, the change in sexual health service configuration by way of shifting away from clinic-based testing to offering self-sampling kits for STI testing online presents opportunities for improving testing uptake in this population. Online STI testing services could be advertised via dating platforms commonly used by MSM, although evidence of acceptability and its impact on STI testing uptake is needed.

Given the high levels of engagement in STI risk behaviours, the frequency of STI testing among these men needs to be improved by recall of MSM who report engagement in such behaviours, via text messages, for 3-monthly retesting [33,34]. Recall could be especially useful among HIV-negative/unknown-status men as they are less likely to attend clinics regularly, and among HIV-positive MSM with a CD4 cell count > 500 cells/μL and/or on ART with stable undetectable viral load as they may not engage with HIV clinics more than 6-monthly to once a year for routine HIV monitoring [15]. The use of

pre-exposure prophylaxis (PrEP) by HIV-negative/unknown-status MSM for HIV prevention could improve 3-monthly STI testing as it is recommended for PrEP users [13], but it could also potentially increase engagement in STI risk behaviours as a consequence of risk compensation. Therefore, research investigating trends in sexual behaviours of MSM [7] remains pivotal. Moreover, interventions promoting STI testing should make efforts to provide friendly, professional, discreet, knowledgeable and nonjudgemental services [35] to address barriers to STI testing caused by the stigma associated with men having sex with men and being diagnosed with STIs [21,35]. In addition to promoting STI testing, robust pathways for offering partner notification to MSM diagnosed with STIs should be in place to prevent reinfection, because a high proportion of these men reported steady partners. Collection of the gender of sexual partners during sexual history taking [36] remains key because a significant minority of these men reported having sex with women in the last 12 months. Moreover, recent evidence has highlighted diagnosis of congenital syphilis cases potentially facilitated by behaviourally bisexual MSM bridging between sexual networks [37]. In conclusion, our findings emphasize that primary and secondary STI prevention and control interventions among MSM, regardless of their HIV status, remain vital [2,38,39].

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Author contributions

DR set up the study with advice and support from PW, SW, GH and CM. DR secured ethics approval and coordinated and managed the implementation of the survey. SF and PB conducted the data cleaning and management. SW undertook all the analysis and wrote the first and subsequent drafts of the manuscript. All authors contributed to the drafting of the paper and approved the final version. CM and GW secured funding from the National Institute for Health Research for the Health Research Health Protection Research Unit (NIHR HPRU) in Blood Borne and Sexually Transmitted Infections at University College London in partnership with Public Health England [PHE, in collaboration with the London School of Hygiene and Tropical Medicine (LSHTM)].

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Table S1. UK national guidelines for STI testing among HIV negative and positive MSM.

Table S2. Statements presented to participants to measure knowledge related to STIs.