Understanding continuing high HIV incidence: trends in sexual behaviours, HIV testing and the proportion of men at risk of transmitting and acquiring HIV in London 2000-2013. A serial cross-sectional study.

Abstract

Background: HIV incidence among men who have sex with men (MSM) in the UK has remained unchanged over the last decade despite increases in HIV testing and antiretroviral (ARV) coverage. Here we examine trends in sexual behaviours and HIV testing among MSM, and explore risk of transmitting and acquiring HIV.

Methods: Ten cross-sectional surveys between 2000 and 2013 using self-administered questionnaires and oral HIV antibody testing among MSM in London gay social venues.

Findings: Of 11,876 MSM recruited, 12.7% (n=1512) were HIV positive with no significant trend over time. Of these, 35.3% (531/1505) had undiagnosed infection which over time declined from 34.4% (45/131) to 23.6% (25/106) (p=0.01) as recent HIV testing (in the last 12 months) increased from 26.4% (263/997) to 60.1% (467/777) (p<0.001). The increase in recent testing among the undiagnosed (from 28.6% to 66.7%, p<0.001) and negative (from 26.2% to 61.7%, p<0.001) suggests undiagnosed infection may be increasingly recently acquired infection.

Over the study period, the proportion reporting unprotected anal intercourse (UAI) during the previous year increased from 43.2% (513/1187) to 52.6% (394/749) (p<0.001) and serosorting (exclusively) increased from 18.3% (207/1132) to 27.7% (177/6369) (p<0.001). Overall, one in 43 (2.3%, 268/11570) had undiagnosed infection and reported UAI and were therefore at risk of transmitting HIV. A further one in 45 (2.2%, 259/11570) had diagnosed infection and reported UAI and not exclusively serosorting in the previous year. Whilst we did not collect data on ARV or viral load, surveillance data suggest that a small proportion of the latter group will have detectable viral load and hence be at risk of transmitting HIV. One in four HIV negative men (25.4%, 2633/10364) were at higher risk of acquiring HIV (defined as HIV negative MSM either reporting ≥1 casual UAI partner(s) in the previous year or not exclusively serosorting). The proportions of men at risk of transmission or acquisition changed little over time. Undiagnosed men reporting UAI and diagnosed men not exclusively serosorting had consistently higher partner numbers than other MSM over the period.

Interpretation: Undiagnosed HIV may be increasingly recently acquired infection, during which persons are most infectious. This coupled with the high partner numbers of a core group of MSM at risk of transmitting HIV, and the lack of decline in the proportion of men at higher risk of acquiring the infection, may explain the sustained HIV incidence.

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Introduction

Men who have sex with men (MSM) continue to be at highest risk of acquiring HIV in the UK. Since 2000, the annual number of new HIV diagnoses among MSM has increased from 1,830 to 3,270 in 2013.[1;2] Two studies have shown estimated HIV incidence over this period to have remained stable (increasing slightly), and is currently at a level similar to the annual number of new HIV diagnoses (in 2013, 2800 new infections estimated).[3;4] One of these studies uses a back-calculation approach based on CD4 cell count at diagnosis[3]; the second is a dynamic model of sexual behaviours[4]. Given the greatly increased uptake of HIV testing and antiretroviral (ARV) treatment in the last decade, which, by reducing viral load should reduce transmission, the sustained level of HIV incidence supports the notion that risk behaviours must have increased over this period.[5;6] Studies suggest, since the introduction of ARVs in the mid 1990's, the prevalence of high risk sexual behaviours among MSM is increasing (at least partly) due to 'treatment optimism', relating both to the dramatically reduced morbidity and mortality associated with the infection, and the reduced risk of transmission from a positive partner (the latter discovered in later years).[7-10] Few behavioural studies are able to explore trends in sexual behaviours in detail in particular examining seroadaptive behaviours in relation to a confirmed versus perceived HIV status. Current guidelines are for MSM to test annually and at least every three months if having UAI with new or casual partners.[1;11;12] Here we examine trends in both sexual risk and HIV testing behaviours against a background of targeted prevention and testing initiatives among MSM recruited from community venues in London over the last 14 years. With half of all new HIV diagnoses in the UK occurring in London, these trends can be used to understand the role of behaviour change and testing in driving continued HIV transmission.

Methods

Study population and data collection

The Gay Men's Sexual Health Survey is a regular community-based survey conducted since 1996. The survey methods have been described in detail elsewhere.[13-15] Briefly, from 2000 to 2013, for each survey, fieldworkers visited 38-58 bars, clubs and saunas across London over a three month period inviting MSM to self-complete a short, anonymous questionnaire on demographic and sexual behaviour characteristics, and provide oral fluid specimen for HIV antibody testing (OraSure Technologies, Inc., Bethlehem, Pennsylvania, USA). Recruitment was conducted between October and January for all survey years up to 2008; for 2011 and 2013 it was conducted between February and August. A barcode linked specimens to the corresponding questionnaire. Fieldworkers explained to participants that the specimens would be tested for research purposes only and results not returned to them. All participants were advised to attend a healthcare setting for a named HIV test if they wanted to know their status. All men aged 16 and

above in the study venues were eligible to take part and fieldworkers attempted to approach all and recorded refusal rates. Ethical approval was granted each year by the UCL research ethics committee (00/0158). Verbal consent for anonymous saliva samples and self-completion of questionnaires was obtained to ensure anonymity of all participants.

Statistical analysis

We defined undiagnosed infection when a participant had a positive Orasure specimen and reported either that they (i) had never had an HIV test, (ii) perceived themselves to be negative or didn't know, (iii) the result of their last test was negative. We defined a casual partner as a partner with whom unprotected (condomless) anal intercourse (UAI) was reported once only and a regular partner if more than once in the last year. Exclusively serosorting was defined as having UAI only with partners of presumed same HIV status in the last year. We refer to it as 'presumed' as the HIV status of partners was self-reported by respondents. This was established using the question '*In the past year, how many men that you had active/passive anal intercourse without a condom did you know had the same HIV status as you.*'

MSM potentially at risk of transmitting HIV were defined as either those with undiagnosed HIV reporting UAI in the previous year or with diagnosed HIV reporting UAI and not exclusively serosorting in the previous year. Among the latter group, most may have had undetectable viral load due to ARV treatment and may therefore not have been at risk of transmitting, but information on ARV treatment and viral load were not collected in this study. The implications of this for the interpretation of our findings are discussed later. MSM at higher risk of acquiring HIV were HIV negative who reported in the previous year either ≥1 casual UAI partner(s) or not exclusively serosorting.

Data were analysed using STATA version 13.0 (StataCorp, College Station, Texas, USA). Analyses were performed stratified by HIV status. We examined the significance of trends over time using linear, logistic and quantile regression, adjusted for age, with survey year modelled as a linear term. For trends in HIV testing, overall HIV positivity and undiagnosed HIV, we additionally adjusted for education, employment, and ethnicity, and assessed linearity using a likelihood ratio test relative to a model with survey year as a categorical variable. Characteristics of MSM at risk of transmitting and acquiring HIV were explored using a multivariable model controlling for the year of survey as a linear term (odds ratios for year not shown). Factors significant to $p<0.05$ in univariable analyses were included in the multivariable model.

Laboratory procedures

Oral fluid samples collected with the Orasure kit were tested for HIV antibody at Public Health England (PHE) using GACELISA HIV-1 and 2 (Abbott Laboratories, Maidenhead, UK). All samples were tested for total immunoglobulin (IgG) to check the specimen quality apart from those collected in 2011, when a two-stage approach was used, firstly by screening with a modified enzyme immunoassay, secondly by re-screening positive specimens with an enzyme immunoassay and a western blot (Genelabs HIV blot 2.2).

Role of the funding source

The sponsor contributed to the study design, data collection, data analysis, data interpretation and writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

A total of 13,861 questionnaires were collected between 2000 and 2013. Response rates ranged between 50% and 70% each year. Venue data were missing for 930 participants (two in 2002, three participants in 2008 and all 925 participants in 2013, however where data were available, 82% (n=10,578) were recruited from bars, 13% (n=1,636) from clubs, 6% (n=717) from saunas. We excluded 124 questionnaires from men who completed the survey previously or were heterosexual reporting no anal intercourse in the last year, leaving 13,737. In addition, 1,861 (13%) men were excluded as they did not provide samples for antibody testing leaving 11,876. Men who did and did not give samples were similar in age, education and employment status however differed slightly by ethnicity (5·7% (105/1856) vs. 3·2% (374/11841) black). Among the 11,876 included, the demographic characteristics of participants were similar over each of the ten surveys. Overall, the median age was 33 years and most (87%) were of white ethnicity.

When combining the study years, 12·7% (n=1512/11876) were HIV positive ranging between 8·5% (n=82/965) and 17·4% (200/1153) over the period (Table 1). A third of positive MSM (35.3%, n=531/1505, 4·5% of the entire sample) were undiagnosed which declined (non-linearly) over the period from 34·4% (45/131) in 2000 to 23·6% (25/106) in 2013 (p=0.01). Over this period, recent HIV testing (in the last 12 months) increased from 26·4% (263/997) to 60·1% (467/777) (p<0·001). Recent testing increased among the undiagnosed at a similar level (from 28·6% (10/35) to 66·7% (16/24), p<0.001). The proportion of MSM ever having had an HIV test increased from 63·1% (629/997) in 2000 to 91·3% (709/777) in 2013 (p=0·004). HIV positivity varied by recruitment venue type with a similar prevalence among MSM in bars (8·1% (740/9100) diagnosed, 4·3%, (387/9100) undiagnosed) and clubs (6·5% (89/1375) diagnosed, 4·5%,

(62/1375) undiagnosed) and highest prevalence in saunas (11·5% (71/617) diagnosed, 9·2%, (57/617) undiagnosed).

Over the 14 years, there was an increase in the proportion of MSM reporting UAI during the previous year from 43·2% (513/1187) in 2000 to 52·6% (394/749) in 2013 (p<0·001, Table 2, Figure 1.). This increase was significant among both negative and diagnosed MSM increasing from 42·3% (448/1058) to 50·9% (329/647, p<0·001) and 48·8% (41/84) to 63·8% (51/80, p=0·002), respectively. Among undiagnosed MSM, numbers were small and no clear trend was observed, the prevalence fluctuating between 42·9% (18/42) and 63·6% (14/22).

The proportion of MSM who exclusively serosorted increased overall from 18·3% (207/1132) in 2000 to 27·7% (177/639) in 2013; among negative men (with other presumed negative men) this increased, from 18·0% (181/1007) to 27·1% (150/554), among diagnosed men from 21·7% (18/83) to 30·4% (21/69) and among undiagnosed men (with presumed negative men) from 19·0% (8/42) to 37·5% (6/16). (To note, among men who perceived themselves to be negative, 2·8% (18/653) had undiagnosed HIV in 2013 with no significant trend overtime.)

Alongside this increase in men exclusively serosorting, the proportion of men reporting UAI with partners of unknown or discordant status declined from 22.3 % (253/1132) in 2000 to 16.7% (107/639) in 2013 (p<0·001) overall, and among negative men from 21.7% (218/1007) to 15.5% (86/554) (p<0·001), from 26.5% (22/83) to 27.5% (19/69) p=0·433) among diagnosed men and from 31.0% (13/42) to 12.5% (2/16) (p=0.012) among the undiagnosed, respectively.

Over the 14 years of study, the mean number of sexual partners in the last year was consistently higher in diagnosed positive MSM and increased significantly in this group from 4·7 (standard deviation (SD) 12·8) partners in 2000 to 9·7 (SD 22·5) in 2013 (p=0·008), after a peak of a mean of 13·5 (SD 36·8) in 2006.

Between 2000 and 2013, there were 259 diagnosed MSM who reported UAI and were not exclusively serosorting, some of whom may have been at risk of transmitting HIV. There were a further 268 undiagnosed HIV positive MSM who reported UAI. Together, they represented 4·6% (527/11570) of MSM overall (Table 3). The overall proportion of MSM potentially at risk of transmitting HIV remained stable over the period, as did the fraction of men in this group that were diagnosed and undiagnosed. Both diagnosed and undiagnosed MSM potentially at risk of transmitting HIV had consistently higher UAI

partners numbers compared to all other MSM, while the mean number of partners increased over time for all groups; in 2013 undiagnosed men at risk of transmitting reported a mean of 11·6 (SD 16·1) and median of 2·5 (interquartile range (IQR) 1, 20) UAI partners in the last year; diagnosed MSM, of whom some may be at risk of transmitting, reported a mean of 22·4 (SD 30) and median 10 (IQR 2,28) compared to other MSM with 2·2 (SD 13·1) and 1 (IQR 0, 1), respectively. This demonstrates the skewed distribution of partner numbers, with no increase over time for the majority (medians largely unchanged) but an increase in partners for the fraction in the upper end of the distribution so that the mean is increased. Multivariable analyses revealed that MSM were more likely to be at risk of transmitting HIV (compared to all other MSM) if they were older (Adjusted Odds Ratios (AOR) 35-44 years compared to 16-24 years 2·7 (95% confidence interval (C.I.) 1·8-3·9), of black ethnicity (AOR compared to white: 2·6 95% C.I. 1·7-3·9), had a higher number of casual UAI partners in the previous year (>10 compared to <2 AOR 21·8, 95% C.I. 16·2-29·2) or had attended a genitourinary medicine clinic (GUM) clinic during the previous year (AOR 1·8, 95% C.I. 1·5-2·3) (Table 4).

HIV negative MSM were considered at higher risk of acquiring HIV if they reported UAI with ≥1 casual partners or reported not to have exclusively serosorted in the previous year. Overall, this applied to 25·4% (2633/10364) of negative men fluctuating between 23·0% (n=203/883) and 28·8% (n=377/1308) over the ten surveys with no significant trend. The mean and median numbers of UAI partners in the previous year among those at higher risk of acquiring HIV fluctuated between 2·8 and 6·1, and 1 and 2, respectively with no trend. There was a marked increase in HIV testing in the last year among MSM in this group from 33·8% (79/234) to 72·5% (111/153) (p<0·001) (Table 3.). Compared to other HIV negative MSM, those at higher risk of acquiring HIV were more likely to have had a high number of casual UAI partners (>10 compared to <2 AOR 69·8, 95% C.I. 35·3-138·2, p<0·001) or have been diagnosed with a sexually transmitted infection (STI) in the previous year (AOR 1·4, 95% C.I. 1·2-1·7) (Table 4).

Discussion

We have shown in a 14 year time series of large-scale surveys amongst MSM in London that HIV prevalence remains high at around 13%, and that there have been substantial increases in the uptake of HIV testing and the concomitant decline in the fraction of HIV which remains undiagnosed. Despite these changes, which may have been expected, combined with improved uptake of treatment to reduce transmission, HIV incidence remains high and unchanged.[3;4] Our data show that irrespective of the positive changes in testing uptake, risk behaviour has increased over this period characterised by increased UAI and increasing numbers of sexual partners, particularly among HIV positive men and those who remain at risk of transmission. We have shown that serosorting, which has increased substantially over the last 14 years, is a risky practice, particularly amongst negative men since 3% (in 2013) of those

who perceive themselves to be negative are positive and inadvertently putting others at risk. We have identified and characterised a subgroup at risk of transmitting infection, in particular undiagnosed men reporting UAI (one in 43 MSM) and a larger group at risk of acquiring infection (one in five negative MSM) in whom maintenance of the epidemic may be occurring. As not all diagnosed MSM are on treatment (69% in 2000 (personal communication Zheng Yin), 90% in 2013[2]) and of those on treatment, not all have undetectable viral loads (94% in 2013)[2], a fraction of those diagnosed reporting UAI and not exclusively serosorting are also likely to be at risk of transmission. Furthermore, increased uptake of recent testing, combined with evidence of undiagnosed HIV positives amongst those who have recently tested negative, suggest that an increasing proportion of the undiagnosed fraction may be recent infections posing high risk of transmission.

This study examined long term trends in undiagnosed HIV, testing, UAI, serosorting and partner numbers by HIV status among MSM in London. It sheds light on the changes in behaviours and testing alongside other current available information on testing[1;16] and ARV treatment uptake[1;17]. It is known that some HIV positive individuals change their behaviour shortly after diagnosis[18] and here we are able to present differences by HIV infection status and further explore a large group of undiagnosed MSM. In addition, we were able to identify HIV positive (particularly undiagnosed) MSM reporting behaviours conducive to transmission. These data will be of value to modelling studies, as we are able to provide key parameters such as rate of partner change and the proportion of the population at risk.

A limitation of the study is that for MSM at risk of transmitting HIV, we had no information on the timing of infection in relation to contact with sexual partners, or how many diagnosed individuals were on treatment and had undetectable viral load. Among HIV diagnosed men potentially at risk of transmitting, the proportion diagnosed with an STI in the last year was double that compared to other MSM (39% vs. 17%) which may have increased their risk of transmission. Secondly, the increase in recent testing among the undiagnosed is only suggestive of undiagnosed infection being increasingly recently acquired, as we cannot know length of infection among men that did not test.

Thirdly, the surveys were convenience samples and may lack generalisability and/or comparability over time which may partially explain the lack of some observed trends. Response rates varied between 50% and 70% and we are unable to say how non-responders differed in risk. Among the 13% that refused a test, the demographic characteristics were broadly the same as those that did test, although we are unable to infer differences in HIV status. Also, the self-reported behaviour and testing data may be subject to recall bias. Further, new web- or app-based methods to meet partners have become increasingly popular[19] and MSM who use these may differ from those visiting bars, clubs and saunas; a

study comparing MSM recruited to online and offline behavioural surveillance studies showed that those using web-based methods were younger, less gay identified, less likely to use condoms with casual partners and less likely to test for HIV.[20] In addition, London-based MSM may not be representative of MSM in the UK; in the capital the estimated HIV prevalence is one in 11 MSM compared to one in 28 in England and Wales outside London.[21] However, due to the low MSM population prevalence, it is not feasible to obtain a true probability sample. Unlike many convenience samples or internet samples, we did have a clear sampling frame and calculated a response rate. Data from the National Survey of Sexual Attitudes and Lifestyles (NATSAL) show that in 2000, 61.6% (95% CI: 52.8-69.7) of MSM had attended a gay club or bar in the last year and in 2010 this was 55% (95% CI: 44.7-64.9) (personal communication Catherine Mercer). Among gay-identifying MSM, 77.5% (95% C.I. 64.3-86.8) had attended such venues in the last year. Comparison of data from MSM in convenience sample surveys and NATSAL (2010) show that the former are likely to overestimate rates of STI diagnoses and HIV testing but that these differences are smaller among gay-identifying MSM[22], suggesting our findings may be generalizable to gay-identifying MSM. By obtaining trends from similar venues over an extended time frame, we were able to make comparisons over time. Lastly, some participants may not have accurately disclosed their status potentially inflating our estimate of the undiagnosed. However, we believe nondisclosure was kept to a minimum as the self-completed survey was entirely anonymous.

To our knowledge, few UK studies exist which examine trends in sexual behaviours among MSM in the community by HIV status and none that have reported trends in MSM partner numbers in detail by HIV transmission risk. Most are cross-sectional data from earlier rounds of surveys included in this study.[14;15;23;24] A study by Lattimore et al. which examined the sexual behaviour of gay men in London using gyms between 1998 and 2008 found a lower proportion of MSM reporting UAI than in our study (36·6% vs. 50% in our study in 2008) but also an increase in UAI with partners of the same status particularly among HIV negative MSM from 12·4% in 1998 to 21·1% in 2008.[25] A study by McDaid et al. on both serosorting and strategic positioning during UAI among MSM in Scotland found that, although these were occurring (among 11% of HIV positive and 13% of negative MSM in 2008), they were performed inconsistently.[26] Both of these studies also found increased HIV testing (ever and recent) among MSM. Continuing high levels of undiagnosed infection among MSM in the community has been reported also in Scotland (25·4% in 2011).[27] To note is that HIV epidemics among MSM in numerous other countries are similar to that in the UK. For example, reports show that in France and the United States, also despite increases in ARV coverage and testing, transmission is sustained at a high level,[28;29] likely due to increased risk behaviours similar to those shown here.

This study emphasises the importance of core groups in the epidemiology and control of HIV infection among the UK MSM community. The data show changes in sexual risk behaviours of MSM in London over the last 14 years with more reporting UAI and using serosorting as a risk reduction strategy. As may be expected, there are distinct differences in risk behaviours of MSM by HIV status with positive men describing the highest risk. A subgroup of these are infectious, particularly the undiagnosed and, coupled with high partner numbers, and the one in five negative men at risk of acquisition, they are likely to disproportionately be the drivers of the sustained incidence over the last decade. The benefits of serosorting may be outweighed by increased partner numbers, inconsistent practice and incorrect perceived serostatus as demonstrated by the high proportion of undiagnosed men who incorrectly perceive their status as negative. In addition, the rise in testing rates among the undiagnosed suggests these infections are increasingly recently acquired, when persons may be most infectious.

Modelling studies have shown that reducing the number of undiagnosed infections and subsequently treating them will have the greatest impact on HIV incidence.[30;31] There is a high level of undiagnosed HIV infection in the community, particularly in saunas where nearly one in 10 men were undiagnosed. Community–level interventions in settings such as bars, clubs and saunas have been shown to be successful[32] and not to deter clientele[33]. Further, self-sampling and self-testing is acceptable to MSM[34] and now available in the UK, which could promote testing at more regular intervals, and would be important in earlier detection of infection to reduce transmission, in particular among those less likely to frequent sexual health clinics. Anecdotal evidence suggests the recent increase in new diagnoses and infections in London[1] may also partly been attributable to other behaviours not studied here such as an increase in recreational drug use.[35] As Kirby et al report, MSM attending the central London CODE clinic (a clinic which specialises in sexual health for men who use drugs for sex referred to as chemsex) prefer to use internet sites which specialise in 'barebacking' (UAI) to find partners, with an average of five partners per episode reported.[35] Further work is needed to design interventions which also reach the users of these sites.

Whilst HIV testing is increasing[1], and the coverage of ARV is high among people diagnosed, the prevalence of high risk behaviours among MSM visiting gay social venues remains high. It has been demonstrated that treatment as prevention strategies are unlikely to have a significant impact on HIV incidence in the UK, due to transmission from men with primary infection and undiagnosed cases.[36] We have shown here that a large fraction of undiagnosed infection is now recently acquired infection and a proportion of these are likely primary infections. In addition, modelling studies have found the epidemiological effect of earlier diagnosis and treatment to be offset by increases in risk behaviours.[37;38] Pre-exposure prophylaxis

(PreP) may help prevent outbreaks among those with early infection, however it relies on MSM perceiving themselves at risk and choosing to test; in our study a third of undiagnosed MSM had not tested within the last year. Finally, it must be emphasised that serosorting, where the status of the partner is presumed, is unsafe due incorrect perception of serostatus. Thus, there is an urgent need for public health authorities to put more focus on behaviour change interventions alongside other possible biomedical interventions currently being evaluated, such as test and treat and PreP programmes, targeting in particular the core group of 'potential transmitters', as well as those negative with behavioural patterns putting themselves at high-risk of acquisition. The social and cultural mixing between these groups will need to be considered as part of the design of risk reduction strategies, e.g. targeting in particular younger MSM who may be less aware of the risks and/or less able to protect themselves. These findings are an important contribution to the growing evidence that testing and treat strategies alone are not sufficient to reduce HIV incidence at population level. Combination prevention working closely with affected communities, to reduce communitywide risk by both behavioural and biological interventions, is critical if we are to move towards eradication of HIV.

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Panel: Research in context

Evidence before this study

We conducted a systematic review searching PubMed for articles published in English up until 14th June 2015 using the terms: "sexual behaviour", "MSM", "homosexuality or male" "trends", "HIV", "HIV infections" or "HIV antibodies" or "HIV seropositivity" or "saliva" or "incidence" or "prevalence," "UK", "Great Britain". There has only been one other study examining trends in sexual behaviours among UK MSM (recruited from gyms across London) between 1998-2008, which found lower rates of MSM reporting unprotected anal intercourse (UAI) overall, but also an increase in the proportion of men reporting UAI and to serosort. There are no studies showing trends in sexual behaviours in the UK in more recent years and none showing trends in numbers of sexual partners in this population. One recent cross-sectional study among HIV positive MSM recruited from HIV clinics between 2011 and 2012 showed a lower prevalence of UAI (38%) and serosorting (28%). Another cross-sectional study in 2008 also found a lower prevalence of serosorting and strategic positioning during UAI among MSM in Scotland with 11% among HIV positive and 13% among negative MSM. Three modelling studies which used multiple national surveillance databases show trends in undiagnosed HIV infection to not have declined and HIV testing to

have increased. In addition, similar patterns were found in community-based surveys conducted in Scotland, and England.

Added value of this study

Our data indicate changes in sexual risk behaviours with increasing rates of UAI and serosorting, the latter considered to be a risk reduction strategy. Our findings emphasise the importance of core groups in the epidemiology and control of HIV infection in MSM in the UK, with one in 20 identified as being potentially at risk of transmitting and one in four at risk of acquiring HIV. Undiagnosed HIV infection may be increasingly recently acquired infection, during which persons are most infectious. This coupled with the high partner numbers of a core group of MSM potentially at risk of transmitting HIV, and the lack of decline in the proportion at men at risk of acquiring the infection, may explain the sustained HIV incidence in the UK, despite increases in HIV testing and ARV coverage.

Implications of all the available evidence

There is growing evidence that test and treat interventions alone are not sufficient to reduce HIV incidence at population level. Combination prevention interventions will be critical for countries with similar epidemics among MSM.

Table 1 Trends in HIV positivity and HIV testing among MSM in London[a, d], 2001-2013

			Year										
		Total % (n)	**2000 % (n)**	**2001 % (n)**	**2002 % (n)**	**2003 % (n)**	**2004 % (n)**	**2005 % (n)**	**2006 % (n)**	**2008 % (n)**	**2011 % (n)**	**2013 % (n)**	**p-value[b]**
% HIV positive	All MSM	**12.7 (1512/11876)**	**11.0 (132/1206)**	**11.5 (150/1309)**	**12.1 (126/1043)**	**12.2 (177/1432)**	**12.8 (177/1377)**	**12.9 (195/1503)**	**17.4 (200/1153)**	**15.0 (167/1106)**	**8.5 (82/965)**	**13.6 (106/782)**	**p<0.001[c]**
% undiagnosed	HIV + MSM	**35.3 (531/1505)**	**34.4 (45/131)**	**49.3 (74/150)**	**33.9 (42/126)**	**44.1 (78/177)**	**41.2 (73/177)**	**29.0 (56/193)**	**34.9 (68/197)**	**28.1 (46/166)**	**29.3 (24/82)**	**23.6 (25/106)**	**p=0.01[c]**
% ever tested for HIV	All MSM	**79.4 (9184/11568)**	**63.1 (629/997)**	**69.3 (900/1297)**	**75.9 (788/1035)**	**78.0 (112/1240)**	**78.1 (1065/1363)**	**80.4 (1195/1487)**	**83.4 (952/1142)**	**89.1 (972/1092)**	**89.9 (862/958)**	**91.3 (709/777)**	**p<0.004**
	HIV-	**77.6 (7886/10161)**	**61.6 (567/920)**	**66.9 (770/1150)**	**74.9 (683/912)**	**76.5 (955/1288)**	**76.0 (904/1189)**	**78.6 (1024/1303)**	**81.1 (770/950)**	**87.5 (818/935)**	**89.4 (787/880)**	**90.1 (608/674)**	**p<0.001**
	HIV + undiag	**78.9 (408/517)**	**57.1 (20/35)**	**77.0 (57/74)**	**57.1 (24/42)**	**80.3 (61/76)**	**82.1 (60/73)**	**76.8 (43/56)**	**85.3 (58/68)**	**93.3 (42/45)**	**87.5 (21/24)**	**91.7 (22/24)**	**p<0.001**
% tested for HIV in the past year	All MSM	**42.3 (4891/11568)**	**26.4 (263/997)**	**32.4 (421/1297)**	**36.2 (375/1035)**	**38.6 (550/1420)**	**42.3 (576/1363)**	**43.1 (634/1487)**	**44.0 (504/1142)**	**51.4 (560/1092)**	**55.5 (532/958)**	**60.1 (467/777)**	**p<0.001**
	HIV-	**42.2 (4312/10161)**	26.2 (241/920)	32.1 (370/1150)	36.6 (334/912)	38.6 (482/1248)	41.58 (498/1198)	43.2 (563/1303)	44.4 (422/950)	51.9 (485/935)	56.9 (501/880)	61.7 (416/674)	**p<0.001**
	HIV + undiag	**43.3 (224/517)**	**28.6 (10/35)**	**29.7 (22/74)**	**21.4 (9/42)**	**46.1 (35/76)**	**49.3 (36/73)**	**39.3 (22/56)**	**55.1 (38/68)**	**53.3 (24/45)**	**50.0 (12/24)**	**66.7 (16/24)**	**p<0.001**

[a] Determined by Orasure oral fluid specimen
[b] Adjusted for age, education , ethnicity and employment
[c] p-value for association between outcome and survey year (categorical) as data showed evidence of departure from linearity
[d] Denominators vary due to incomplete data on all variables

Table 2 Trends in sexual behaviours among MSM by HIV status [a,c], 2000-2013

			Year									
		Total % (n)	**2000 % (n)**	**2001 % (n)**	**2002 % (n)**	**2003 % (n)**	**2004 % (n)**	**2005 % (n)**	**2006 % (n)**	**2008 % (n)**	**2011 % (n)**	**2013 % (n)**	**p-value[b]**
% had UAI in the last year	HIV -	**45.9 (4651/10139)**	**42.3 (448/1058)**	**44.8 (510/1138)**	**41.7 (378/907)**	**45.9 (567/1235)**	**42.8 (502/1173)**	**49.0 (633/1291)**	**46.5 (431/927)**	**46.7 (430/920)**	**50.2 (423/843)**	**50.9 (329/647)**	**p<0.001**
	HIV+ diag	**59.5 (556/934)**	**48.8 (41/84)**	**47.3 (35/74)**	**58.2 (46/79)**	**61.7 (58/94)**	**66.3 (65/98)**	**54.3 (70/129)**	**65.6 (82/125)**	**63.8 (74/116)**	**61.8 (34/55)**	**63.8 (51/80)**	**p=0.002**
	HIV + undiag	53.9 (268/497)	53.3 (24/45)	59.2 (42/71)	53.8 (21/39)	44.0 (33/75)	56.7 (38/67)	61.5 (32/52)	55.6 (35/63)	42.9 (18/42)	52.4 (11/21)	63.6 (14/22)	p=0.93
	All	**47.3 (5475/11570)**	**43.2 (513/1187)**	**45.8 (587/1283)**	**43.4 (445/1025)**	**46.9 (658/1404)**	**45.2 (605/1338)**	**49.9 (735/1472)**	**49.2 (548/1115)**	**48.4 (522/1078)**	**50.9 (468/919)**	**52.6 (394/749)**	**p<0.001**
% exclusively serosorted in the last year	HIV -	**21.2 (1942/9166)**	**18.0 (181/1007)**	**17.5 (178/1015)**	**16.9 (143/844)**	**21.2 (242/1144)**	**18.6 (198/1067)**	**23.5 (271/1155)**	**22.8 (186/817)**	**23.9 (200/838)**	**26.6 (193/725)**	**27.1 (150/554)**	**p<0.001**
	HIV+ diag	**26.1 (225/862)**	**21.7 (18/83)**	**19.1 (13/68)**	**20.8 (15/72)**	**29.5 (26/88)**	**30.4 (28/92)**	**24.2 (30/124)**	**27.2 (31/114)**	**30.5 (32/105)**	**23.4 (11/47)**	**30.4 (21/69)**	p=0.06
	HIV + undiag	**14.6 (64/438)**	**19.0 (8/42)**	**9.4 (6/64)**	**8.8 (3/34)**	**11.9 (8/67)**	**10.0 (6/60)**	**19.6 (9/46)**	**13.2 (7/53)**	**20.5 (8/39)**	**17.7 (3/17)**	**37.5 (6/16)**	**p=0.033**
	All	**21.3 (2231/10466)**	**18.3 (207/1132)**	**17.2 (197/1147)**	**17.0 (161/950)**	**20.6 (267/1299)**	**19.0 (232/1219)**	**23.4 (310/1325)**	**22.7 (224/984)**	**24.4 (240/982)**	**26.4 (207/789)**	**27.7 (177/639)**	**p<0.001**
% reported UAI with partners of unknown/discordant HIV status in the last year	HIV -	**19.1 (1748/9166)**	**21.7 (218/1007)**	**20.8 (211/1015)**	**20.5 (173/844)**	**20.5 (235/1114)**	**18.7 (200/1067)**	**19.8 (229/1155)**	**16.7 (136/817)**	**17.7 (148/838)**	**15.5 (112/725)**	**15.5 (86/554)**	**p<0.001**
	HIV+ diag	30.1 (259/862)	26.5 (22/83)	23.5 (16/68)	33.3 (24/72)	29.6 (26/88)	33.7 (31/92)	28.2 (35/124)	35.1 (40/114)	29.5 (31/105)	31.9 (15/47)	27.5 (19/69)	p=0.433
	HIV + undiag	**33.3 (146/438)**	**31.0 (13/42)**	**45.3 (29/64)**	**38.0 (13/34)**	**25.4 (17/67)**	**43.3 (26/60)**	**37.0 (17/46)**	**34.0 (18/53)**	**18.0 (7/39)**	**23.5 (4/17)**	**12.5 (2/16)**	**p=0.012**
	All	**20.6 (2153/10466)**	**22.3 (253/1132)**	**22.3 (256/1147)**	**22.1 (210/950)**	**21.4 (278/1299)**	**21.1 (257/1219)**	**21.2 (281/1325)**	**19.7 (194/984)**	**18.9 (186/982)**	**16.6 (131/789)**	**16.7 (107/639)**	**p<0.001**
Number of UAI partners in the last year mean (SD); median(IQR)	HIV -	1.4 (6.8) 0 (0,1)	0.9 (3.2); 0 (0,1)	1.6 (5.9); 0 (0,1)	1.2 (5.0); 0 (0,1)	1.4 (4.9); 0 (0,1)	1.3 (7.1); 0 (0,1)	1.7 (11); 0 (0,1)	1.3 (4.3); 0 (0,1)	1.3 (4.6); 0 (0,1)	1.4 (3.6); 0 (0,1)	1.9 (12.5); 0 (0,1)	**p**=0.073
	HIV+ diag	**9.2 (30.7) 1 (0,5)**	**4.7 (12.8); 0 (0,2)**	**4.6 (14.7); 0 (0,2)**	**8.3 (24.9); 1 (0,7)**	**7.9 (22.5); 1 (0,4)**	**7.1 (15.6); 2 (0,5)**	**9.3 (45.0); 1 (0,5)**	**13.5 (36.8); 1 (0,5)**	**11.8 (42.1); 1 (0,5)**	**12.6 (31.8); 1 (0,11)**	**9.7 (22.5); 1 (0,10)**	**p=0.008**
	HIV + undiag	4.1 (17.5) 1 (0,2)	1.6 (3.5); 1 (0,1)	3.8 (6.5); 1 (0,3)	2.9 (8.4); 1 (0,1)	5.3 (34.6); 0 (0,2)	6.5 (22.4); 1 (0,2)	4.5 (7.8); 1 (0,4.5)	4.0 (13.9); 1,(0,2)	1.5 (3.3); 0,(0,2)	1.2 (2.2); 1(0,1)	7.4 (13.9) 1(0,5)	**p**=0.77
	All	**2.1 (11.6)** 0 (0,1)	**1.2 (4.7); 0 (0,1)**	**1.9 (6.9); 0 (0,1)**	**1.8 (8.7); 0 (0,1)**	**2.0 (11.0); 0 (0,1)**	**2.0 (9.5); 0 (0,1)**	**2.5 (17.0); 0 (0,1)**	**2.8 (13.8); 0 (0,1)**	**2.4 (14.8); 0 (0,1)**	**2.0 (8.9); 1(0,1)**	**2.9 (14.2); 1(0,1)**	**p=0.001**

[a] Determined by Orasure oral fluid specimen

[b] Adjusted for age

[c] Denominators vary due to incomplete data on all variables

Table 3 Trends in the proportion of MSM potentially at risk of transmitting and acquiring HIV, their number of UAI partners in the previous year and recent testing among those at risk of acquiring HIV 2000-2013[a, b]

				Year										
			Total %(n)	**2000 % (n)**	**2001 % (n)**	**2002 % (n)**	**2003 % (n)**	**2004 % (n)**	**2005 % (n)**	**2006 % (n)**	**2008 % (n)**	**2011 % (n)**	**2013 % (n)**	**p-value[c]**
Potentially at risk of transmitting HIV[d]	**Undiagnosed MSM reporting UAI in the previous year**	**As a % of all MSM**	2.3 (268/11570)	2.0 (24/1187)	3.3 (42/1283)	2.1 (21/1025)	2.4 (33/1404)	2.8 (38/1338)	2.2 (32/1472)	3.1 (35/1115)	1.7 (18/1078)	1.2 (11/919)	1.9 (14/749)	0·09
		As a % of MSM having UAI	4.9 (568/5475)	4·7 (24/513)	7·2 (42/587)	4·7 (21/445)	5·0 (33/658)	6·3 (38/605)	4·4 (32/735)	6·4 (35/548)	3·5 (18/522)	2·4 (11/468)	3·6 (14/394)	0.005
		Mean (SD) number of UAI partners [g]	**7.6 (23.2)**	**3 (4.4)**	**6.5 (10.2)**	**5.5 (11.0)**	**12 (51.8)**	**11.4 (28.9)**	**7.4 (8.9)**	**7.1 (18.2)**	**3.5 4.4)**	**2.4 (2.7)**	**11.6 (16.1)**	**0·62**
		Median (IQR) of n UAI partners [g]	2 (1,5)	1 (1,2)	3 (1,10)	1 (1,5)	2 (1,4)	2 (1,3)	3 (1,10)	2 (1,4)	2 (1,4)	1 (1,3)	2.5 (1,20)	1.0
	Diagnosed MSM reporting UAI and not exclusively serosorting in the previous year[e]	**As a % of all MSM**	2.2 (259/11570)	1.9 (22/1187)	1.3 (16/1283)	2.3 (24/1025)	1.9 (26/1404)	2.3 (31/1338)	2.4 (35/1472)	3.6 (40/1115)	2.9 (31/1078)	1.6 (15/919)	2.5 (19/749)	0.07
		As a % of MSM having UAI	4.7 (259/5475)	4.3 (22/513)	2.7 (16/587)	5.4 (24/445)	4.0 (26/658)	5.1 (31/605)	4.8 (35/735)	7.3 (40/548)	5.9 (31/522)	3.2 (15/468)	4.8 (19/394)	0.47
		Mean (SD) number of UAI partners [g]	**17.8 (39.5)**	**13.4 (21.3)**	16.1 (27.6)	13.8 (17.4)	13.9 (23.4)	12 (23.0)	9.5 (11.5)	28.8 (56.0)	24.0 (71.5)	22.7 (51.6)	**22.4 (30.0)**	**0.05**
		Median (IQR) of n UAI partners [g]	5 (2,15)	7 (2,15)	4 (1,14)	7 (3,16)	3.5 (2,8)	4 (2,15)	5 (2,10)	5 (2,16)	5 (2,15)	2 (1,20)	10 (2, 28)	0.45
	Total	**As a % of all MSM**	4.6 (527/11570)	3·9 (46/1187)	4·5 (58/1283)	4·4 (45/1025)	4·2 (59/1404)	5·2 (69/1338)	4·6 (67/1472)	6·7 (75/1115)	4·6 (49/1078)	2·8 (26/919)	4·4 (33/749)	0·96
Not reporting risk of transmitting HIV [f]		**As a % of all MSM**	95·5 (11,043/11570)	96·1 (1141/1187)	95·5 (1225/128	95·6 (980/1025)	95·8 (1345/140	94·8 (1269/133	95·5 (1405/147	93·3 (1040/111	95·5 (1029/107	97·2 (893/919)	95·6 (716/749)	0·96
		As a % of MSM having UAI	90·4 (4948/5475)	91·0 (467/513)	90·1 (529/587)	89·9 (400/445)	91·0 (599/658)	88·6 (536/605)	90·9 (668/735)	86·3 (473/548)	90·6 (473/522)	94·4 (442/468)	91·6 (361/394)	0·13
		Mean (SD) number of UAI partners [g]	**1.6 (9.2)**	**1·0 (3·3)**	**1·5 (5·8)**	**1·4 (8·1)**	**1·5 (6·9)**	**1·5 (7·3)**	**2·2 (17·2)**	**1·7 (7·0)**	**1·7 (8·1)**	**1·7 (5·6)**	**2·2 (13·1)**	**0·004**
		Median (IQR) of n UAI partners [g]	0 (0,1)	0 (0,1)	0 (0,1)	0 (0,1)	0 (0,1)	0 (0,1)	0 (0,1)	0 (0,1)	0 (0,1)	0 (0,1)	1 (0,1)	1·0
At higher risk of acquiring HIV [gh]		**As a % of all MSM**	22.8 (2633/11570)	23·6 (280/1187)	23·3 (299/1283 \	23·0 (236/1025)	24·3 (341/1404 \	21·5 (288/1338 \	25·6 (377/1472 \	19·5 (217/1115 \	22·1 (238/1078 \	22·1 (203/919)	20·6 (154/749)	0·275
		As a % of all HIV negative MSM	25.4 (2633/10364)	26·1 (280/1074)	25·8 (299/1159 \	25·7 (236/917)	27·2 (341/1255 \	24·0 (288/1200 \	28·8 (377/1308 \	22·8 (217/953)	25·4 (238/939)	23·0 (203/883)	22·8 (154/676)	0·16
		Mean (SD) of n UAI partners [g]	4.2 (12.8)	2·8 (5·7)	5·1 (10·8)	3·4 (9·0)	3·8 (8·2)	4·5 (13·9)	4·8 (20·0)	4·2 (8·1)	3·7 (8·4)	3·8 (6·0)	6·1 (25·2)	0·252
		Median (IQR) of n UAI [g]	2 (1,3)	1·5 (1,2)	2 (1,4)	1 (1,3)	1 (1,3)	2 (1,3)	2 (1,4)	2 (1,3)	2 (1,3)	2 (1,3)	2 (1,4)	1·0

% tested for HIV in the last year	**50.1 (1288/2573)**	**33•8 (79/234)**	**36•4 (108/297)**	**43•6 (102/234)**	**46•6 (157/337)**	**49•7 (141/284)**	**52•9 (199/376)**	**50•7 (110/217)**	**58•0 (138/238)**	**70•4 (143/203)**	**72•5 (111/153)**	**<0•001**

[a] Determined by Orasure oral fluid specimen

[b] Denominators vary due to incomplete data on all variables

[c] Adjusted for age

[d] MSM with undiagnosed HIV who reported UAI in the previous year or MSM with diagnosed HIV who reported UAI and to not have exclusively serosorted.

[e] no ART or VL data available so we were unable to ascertain if men in this group were on treatment and had undetectable viral loads and therefore not at risk of transmitting HIV.

[f] all MSM not included in [d] who provided information on number of UAI partners

[g] In the last year

[h] HIV- MSM reporting ≥ 1 casual UAI partner or not exclusively serosorting in the last year

413 **Table 4 Factors associated with potential risk of transmitting and higher risk of acquiring HIV in MSM, 2000-2013 combined**

414

	MSM potentially at risk of transmitting HIV [a]					MSM at higher risk of acquiring HIV[b]				
Characteristic	**% (n/N) [c]**	**OR (95 % C.I.) [d]**	**p-value**	**AOR (95 % C.I.) [e]**	**p-value**	**% (n/N)**	**OR (95 % C.I.)[d]**	**p-value**	**AOR (95 % C.I.) [e]**	**p-value**
Total	4·6 (527/11570)	N/A		N/A		25·4 (2633/10364)	N/A		N/A	
Age										
16-24	2·5 (40/1583)	1.0		1·0		30·2 (469/1554)	1.0		1·0	
25-34	4·6 (217/4735)	**1·85 (1·32-2·60)**		**2·11 (1·45-3·08)**		26·6 (1146/4317)	**0·84 (0·74-0·95)**		0·94 (0·79-1·12)	
35-44	5·4 (195/3635)	**2·19 (1·55-3·09)**	**0.0002**	**2·67 (1· 82-3·92)**	**<0·0001**	24·1 (745/3090)	**0·74 (0·64-0·85)**	**<0·0001**	0·83 (0.69-1.00)	**0·003**
45-64	4·8 (70/1455)	**1.94 (1·31-2·89)**		**2·55 (1·64-3·97)**		20·1 (250/1245)	**0·59 (0·49-0·70)**		**0·62 (0·49-0·80**)	
65+	1·2 (1/82)	0·48 (0·06-3·50)		0·89 (0·11-7·21)		11·3 (9/80)	**0·30 (14·6-59·6)**		0·39 (0·15-1·04)	
Ethnicity										
White	4·4 (434/9973)	1·0		1·0		25·5 (2269/8912)	1.0		--	
Black	11·5 (41/356)	**2·86 (2·04-4·01)**		**2·60 (1·73-3·90)**		26·5 (76/287)	1·06 (0.81-1.38)		--	
Asian	3·2 (10/314)	0·72 (0·38-1·37)	**<0·0001**	0·83 (0·43-1·64)	**0·0001**	23·6 (73/310)	0·90 (0.69-1.18)	0·14	--	--
South East Asian	2·5 (5/204)	0·55 (0·23-1·35)		0·71 (0·28-1·81)		18·3 (36/197)	**0·65 (0.45-0.94)**		--	
Mixed/other	5·2 (36/689)	1·21 (0·85-1·71)		1·21 (0·82-1·79)		26·8 (168/628)	1·09 (0.90-1.31)		--	
Years education post age 16										
None	5·2 (69/1325)	1·0		1.0		28·1 (314/1116)	1·0		1·0	
Up to 2 years	6·3 (119/1888)	1·22 (0·90-1·66)	**0·0002**	1·32 (0·94-1·85)	**0·03**	27·9 (459/1648)	0·99 (0·84-1·17)	**0·003**	0·91 (0·72-1·13)	0·18
3 years or more	4·1 (306/7459)	0·77 (0·59-1·01)		0·91 (0·68-1·23)		24·3 (1637/6741)	**0·83 (0·72-0·95)**		**0·82 (0·68-0·99)**	
Still in full time education	3·7 (30/820)	0·69 (0·44-1·06)		0·99 (0·60-1·63)		27·3 (213/779)	0·97 (0.79-1·19)		0·85 (0·64-1·14)	
Employed										
No	5·8 (87/1508)	1·0	**0·011**	1·0	0·81	27·4 (342/1247)	1·0	**0.09**	1·0	0·96
Yes	4·4 (437/10021)	**0·75 (0·59-0·95)**		0·97 (0·74-1·27)		25·2 (2289/9091)	**0·89 (0·78-1·02)**		1·02 (0·84-1·24)	
Age of first AI <16 years										
No	4·4 (410/9393)	1·0	**<0·0001**	1·0	0·054	25·8 (2176/8429)	1·0	**<0·0001**	1·0	0·42
Yes	7·5 (110/1463)	**1·78 (1·43-2·22)**		1·27 (1·00-1·63)		33.3 (406/1218)	**1·44 (1·26-1·64)**		1·11 (0·94-1·33)	
Casual UAI partners in the last year										
<2	1·8 (168/9264)	1·0		1·0		14·6 (1227/8380)	--		**1·0**	
2-5	11·0 (180/1633)	**6·73 (5·42-8·37)**	**<0·0001**	**5·50 (4·37-6·91)**	**<0·0001**	76·9 (1046/1360)	**19·7 (17·1-22·7)**	**<0·0001**	**17·9 (15·4-20·9)**	**<0·0001**
6-10	18·7 (64/343)	**12·5 (9·15-17·06)**		**9·83 (7·08-13·64)**		89.9 (218/245)	**48·0 (32·0-71·9)**		**54·4 (33·3-88·8)**	
>10	34·9 (115/330)	**29·3 (22·3-38·51)**		**21·77 (16·23-29·19)**		92.2 (142/154)	**70·2 (38·8-127·0)**		**69·8 (35·3-138·2)**	
STD in the last year										
No	3·.4 (321/9391)	1·0	**<0·0001**	1·0	0·058	22·5 (1938/8610)	1·0	**<0·0001**	1·0	**<0·001**
Yes	9.7 (202/2083)	**3·05 (2·54-3·67)**		1·24 (0·99-1·55)		40·4 (671/1661)	**2·32 (2·08-2·59)**		**1·43 (1·22-1·68)**	
Attended a GUM clinic in the last year										
No	2·5 (154/6199)	1·0	**<0·0001**	1·0	**<0·0001**	21·5 (1275/5537)	**1·0**	**<0·0001**	1·0	0·12
Yes	7·0 (367/5256)	**2·97(2·45-3·60)**		**1·81 (1·45-2·26)**		30·7 (1330/4327)	**1·65 (1·50-1·80)**		1·10 (0·97-1·25)	

415 [a] includes MSM with undiagnosed HIV who report UAI in the previous year and MSM with diagnosed HIV who report UAI and not to have exclusively serosorted in the last year; compared to all other MSM
416 [b] includes HIV negative MSM who either report 1+UAI casual partner or not exclusively serosorting in the last year; compared to all other HIV negative MSM
417 [c] denominators vary due to incomplete data on all variables
418 [d] adjusted for age and year of survey
419 [e] multivariable model includes variables that were p<0·05 in[d]
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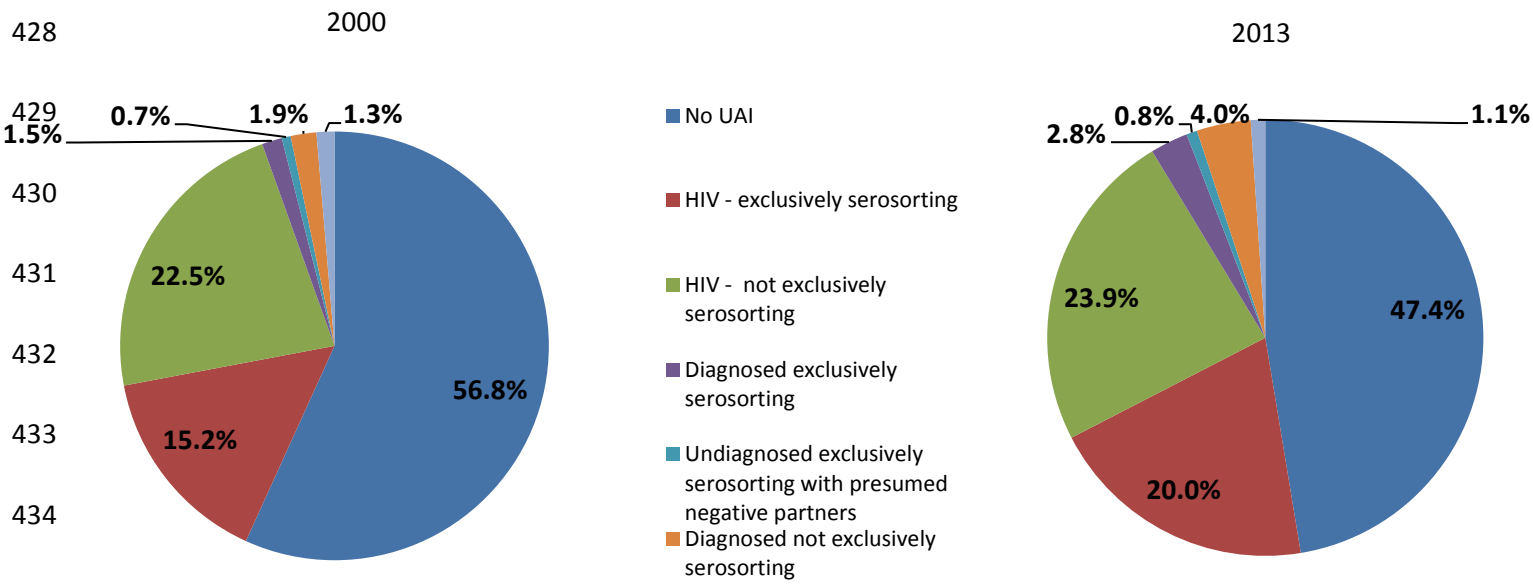
Figure 1 Prevalence of serosorting by HIV status among MSM in London in 2000 and 2013



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