Sexual behaviour among people with HIV according to self-reported antiretroviral treatment and viral load status

Fiona C. Lampe, The Antiretrovirals, Sexual Transmission Risk and Attitudes (ASTRA) Study Group*

Objective: To assess, among people with HIV, the association of self-reported antiretroviral treatment (ART) and viral load status with condomless sex with an HIV-serodifferent partner (CLS-D).

Design: Cross-sectional study of 3258 HIV-diagnosed adults in the United Kingdom, 2011–2012.

Methods: CLS-D in the past 3 months and self-reported ART/viral load were ascertained by questionnaire. Clinic-recorded viral load was documented. HIV-transmission risk sex (CLS-D-HIV-risk) was defined as CLS-D together with either not on ART or clinic-recorded viral load more than 50 copies/ml.

Results: Of 3178 participants diagnosed more than 3 months ago, 2746 (87.9%) were on ART, of whom self-reported viral load was ‘50 copies/ml or less/undetectable’ for 78.4%; ‘more than 50 copies/ml/detectable’ for 8.3%; ‘do not know/missing’ for 13.3%. CLS-D prevalence was 14.9% (326/2189), 6.4% (23/360) and 10.7% (67/629) among men who have sex with men, heterosexual men and women, respectively. Among men who have sex with men, CLS-D prevalence was 18.8% among those not on ART; 15.2% among those on ART with undetectable self-reported viral load; 9.8% among those on ART without undetectable self-reported viral load. Compared with ‘on ART with undetectable self-reported viral load’, prevalence ratios (95% confidence interval) adjusted for demographic/HIV-related factors were: 0.66 (0.45, 0.95) for ‘on ART without undetectable self-reported viral load’, and 1.08 (0.78, 1.49) for ‘not on ART’ (global \( p = 0.021 \)). Among heterosexual men and women (combined), ART/self-reported viral load was not associated with CLS-D [corresponding adjusted prevalence ratios: 1.14 (0.73, 1.79) for ‘on ART without undetectable self-reported viral load’, and 1.08 (0.78, 1.49) for ‘not on ART’ (global \( p = 0.021 \)). Among all participants; 16.1% for ‘not on ART’; 0.6% for ‘on ART with undetectable self-reported viral load’; 4.2% for ‘on ART without undetectable self-reported viral load.’

Conclusion: Use of ART was not associated with increased prevalence of CLS-D, and was associated with greatly reduced prevalence of HIV-transmission risk sex.

Keywords: antiretroviral treatment, condomless sex, self-report, sexual behaviour, viral load
Introduction

Transmission of HIV in the United Kingdom continues to be high among men who have sex with men (MSM) [1–3]. Among heterosexual men and women, transmission within the United Kingdom is also ongoing, despite a decline in overall number of new diagnoses because of migration patterns [1]. Although it is estimated that most new HIV infections in the United Kingdom are transmissions from people unaware that they have HIV [3,4], a significant proportion (an estimated 18% among MSM [3]) are transmissions from people already diagnosed, indicating that prevention issues in this group remain important. Understanding patterns of sexual behaviour according to antiretroviral treatment (ART) use among people diagnosed with HIV has implications for clinical care and public health.

Recommendations on when (at what CD4+ cell count) an individual with HIV should start ART have shifted, over time, towards earlier initiation of ART. For some years, interest has focused on a strategy of offering ART to all people with HIV, from diagnosis, irrespective of CD4+ cell count [4,5], and such a policy was recommended in the United States in 2012 [6]. Until very recently, the main impetus for this strategy was the potential impact on transmission, based on compelling results regarding the profound reduction in infectiousness to sexual partners for HIV-positive people taking ART with suppressed viral load [7–13], in particular from the HPTN052 trial in 2011 [12], and the recent PARTNER study [13]. In May 2015, landmark results of the international START trial demonstrated that earlier ART also confers clinical prognostic benefit to the individual [14]. Consequently, treatment guidelines worldwide are being changed to recommend immediate ART for all people diagnosed with HIV [15,16]. Such a strategy should reduce HIV-related morbidity, and reduce HIV transmission.

A longstanding question is whether taking ART may influence an individual’s sexual behaviour. This question is becoming increasingly relevant, as knowledge about the protective effect of ART on HIV infectiousness becomes established and widespread. The ‘Swiss statement’ [17] in 2008 marked the first fundamental change in advice about ‘safe sex’ for HIV-positive people, asserting (with caveats) that an HIV-positive person on ART with viral suppression is not sexually infectious. Subsequent results from the Swiss HIV Cohort study suggested higher levels of condomless sex (CLS) with stable partners of HIV-negative/unknown status among participants who were virally suppressed [18]. However, most studies carried out before [19–29] and soon after [30–33] the Swiss Statement have not found higher prevalence of CLS among people on ART or those with viral load suppression. There have been few studies of sexual behaviour among people with HIV in the United Kingdom since the Swiss statement, and none that have examined associations of CLS with perceived (self-reported) viral load status – the crucial measure when considering impact on behaviour.

If ART use or perceived suppressed viral load was found to be associated with substantially higher levels of condomless sex (CLS), this could undermine the full impact of early ART on HIV transmission. This could occur if individuals on ART were not accurately assessing their viral load status (and therefore infectiousness to sexual partners) and modifying sexual behaviour accordingly. Also of importance is that lower condom use among people on ART may have an adverse effect on transmission of sexually transmitted infections other than HIV (STIs), the infectivity of which would not be lessened by ART use. Occurrence of STIs is high among HIV-diagnosed MSM [34,35].

The Antiretrovirals, Sexual Transmission Risk and Attitudes (ASTRA) study investigated sexual behaviour among people with HIV in the United Kingdom, and aimed to address the hypothesis that ART use and perceived undetectable viral load may be linked to CLS. This report assesses the association of self-reported ART/viral load status with CLS, in particular CLS with an HIV-serodifferent partner. In addition, as the protective effect of suppressed viral load on HIV infectiousness is now known with confidence, this report is the first to describe likely levels of CLS carrying an appreciable risk of HIV transmission (accounting for clinic-documented viral load level) according to self-reported ART/viral load. Although attitudes and behaviour in relation to condom use may be changing rapidly, as knowledge about transmission risk is disseminated and develops, the ASTRA results will also be important in establishing a baseline against which findings of future studies of HIV-positive people can be evaluated.

Methods

ASTRA recruited adults with diagnosed HIV attending eight hospital HIV outpatient clinics in the United Kingdom from February 2011 to December 2012. Full details have been described [36]. Participants self-completed a confidential sex-specific questionnaire on socio-demographic, HIV-related, health and lifestyle factors, and sexual behaviour. The latest documented viral load and CD4+ cell count results that the participant had been informed of were collected from medical records. The study was approved by North West London REC 2 research ethics committee (ref 10/H0720/70). At the time of the study, the British HIV Association guidelines recommended ART initiation for HIV-positive people with a CD4+ cell count of 350 cells/μl or less, unless special circumstances indicated earlier ART [37].
Self-reported antiretroviral treatment/viral load
Participants were asked about ever and current ART use. Those who ever started ART were asked their viral load at the last test, with three options: ‘50 copies/ml or less (undetectable or suppressed)’; ‘more than 50 copies/ml (detectable or raised)’ and ‘don’t know’. Self-reported ART/viral load was categorised into three groups: not on ART; on ART with undetectable self-reported viral load; on ART without undetectable self-reported viral load (including ‘do not know’ and missing self-reported viral load).

Sexual behaviour
The men’s questionnaire asked about sex with women, and sex with men; the women’s questionnaire asked about sex with men. Participants were asked whether, in the past 3 months, they had: anal or vaginal sex (and if so how many partners), sex without a condom (CLS), sex with an HIV-positive person, CLS with an HIV-serodifferent (negative or unknown status) partner (CLS-D). Those reporting CLS-D were asked: number and type (long-term or other) of CLS-D partner(s); number of times had CLS-D (in categories); whether they ever ejaculated inside a partner during CLS-D (men only); position for anal CLS-D for MSM (always insertive; always receptive; both); reasons for not using a condom at last CLS-D (11 options including: ‘I believe the risk of HIV transmission is very low’). Those who reported CLS, but did not indicate HIV status of partner(s), were classified as having ‘possible CLS-D’, but not included in the main definition. All participants were asked about group sex and new STI diagnoses in the past 3 months, and number of new sexual partners in the past year.

HIV-transmission risk sex
A variable was constructed to define sex with an appreciable risk of HIV transmission (CLS-D–HIV-risk). CLS-D–HIV-risk is a subset of CLS-D. An individual was positive for CLS-D–HIV-risk if, in addition to reporting CLS-D, they were either not on ART (self-reported) or had clinic-recorded viral load more than 50 copies/ml (using the single viral load documented for each participant). Individuals who reported CLS-D, but were on ART with clinic-recorded viral load 50 copies/ml or less were negative for CLS-D–HIV-risk.

Transmission risk beliefs
Participants rated their agreement (strongly agree, tend to agree, undecided/no opinion, tend to disagree and strongly disagree) with the following statements: ‘An undetectable HIV viral load makes someone less infectious to a sexual partner than if they had a high viral load’ and ‘When viral load is undetectable, a condom is not needed to prevent HIV transmission’.

Statistical analysis
Individuals who reported an HIV diagnosis date less than 3 months before the date of questionnaire issue were excluded, to ensure reported sexual behaviour related to a period after diagnosis. Men who self-identified as gay or bisexual or reported sex with a man in the past 3 months were classified as MSM. Characteristics and sexual behaviour were summarised for: MSM, heterosexual men, women. Subsequent analyses were conducted separately for MSM and all heterosexual individuals. The combined heterosexual category was used to increase power; there was no evidence that associations differed between men and women. Unadjusted associations of self-reported ART/viral load and other factors with CLS-D, and CLS overall, were assessed using χ² tests. Modified Poisson regression [38] was used to obtain unadjusted and adjusted prevalence ratios with 95% confidence intervals (CI), for association of self-reported ART/viral load with CLS-D. First, adjustment was made for socio-demographic and HIV-related factors: age group (<30 years; ≥30 years); black ethnicity (no/missing; yes); university education (no/missing; yes); identifying with a religion (no/missing; yes); time with diagnosed HIV (3 months to 1.9 years; 2–4.9 years; 5–9.9 years; 10–14.9 years; 15–19.9 years; ≥20 years) and partner status (HIV-positive; HIV-negative/unknown status; no stable partner). Age was used in two categories only because of collinearity with time with diagnosed HIV. In a second model, additional adjustment was made for higher alcohol intake (no/missing; yes, using score ≥6 on the first two WHO AUDIT-C [39] questions) and number of recreational drugs used in the past 3 months (none/missing; 1; 2–3; ≥4) [40]. In heterosexual models, categories were collapsed for some variables (see Table 4) and there was additional adjustment for sex. Model results were not materially altered by further adjustment for clinic, or when cases that had been excluded because of missing values in age, diagnosis date, partner status or self-reported ART/viral load were included using ‘missing’ categories. The prevalence of CLS-D–HIV-risk was described overall, and for MSM, and heterosexual men and women, according to self-reported ART/viral load.

Three sensitivity analyses were performed separately for MSM and heterosexual individuals. The association of self-reported ART/viral load with CLS-D was assessed:

(a) including ‘possible CLS-D’ cases;
(b) excluding participants who reported no sex in the past 3 months;
(c) separately among those diagnosed with HIV for less than 5 years and 5 years or more.

Results
Overall, 3258 people with diagnosed HIV participated in ASTRA (5112 invited: response rate 64%), of whom 80 are excluded as they had been diagnosed for less than 3 months. Table 1 shows characteristics for the 3178 included participants (2189 MSM, 360 heterosexual men...
| Characteristics                                      | MSM, N = 2189 | Heterosexual men, N = 360 | Women, N = 629 |
|-----------------------------------------------------|---------------|----------------------------|----------------|
| **Age group (years), N = 3112**                     |               |                            |                |
| <30                                                 | 96 (4.4)      | 9 (2.6)                    | 54 (9.1)       |
| 30–39                                               | 487 (22.5)    | 59 (16.9)                  | 174 (29.2)     |
| 40–49                                               | 929 (42.9)    | 160 (45.7)                 | 255 (42.9)     |
| 50–59                                               | 503 (23.2)    | 86 (24.6)                  | 88 (14.8)      |
| ≥60                                                 | 152 (7.0)     | 36 (10.3)                  | 24 (4.0)       |
| **Ethnicity, N = 3178**                             |               |                            |                |
| White                                               | 1931 (88.2)   | 113 (31.4)                 | 123 (19.6)     |
| Black African                                       | 21 (1.0)      | 179 (49.7)                 | 401 (63.8)     |
| Black other                                          | 54 (2.5)      | 25 (6.9)                   | 44 (7.0)       |
| Other/missing                                       | 183 (8.4)     | 43 (11.9)                  | 61 (9.7)       |
| UK birth, N = 3105                                  |               |                            |                |
| Yes                                                 | 1532 (70.9)   | 96 (27.7)                  | 112 (18.7)     |
| No                                                   | 629 (29.1)    | 250 (72.3)                 | 486 (81.3)     |
| **Education, N = 3178**                             |               |                            |                |
| University                                          | 954 (43.6)    | 129 (35.8)                 | 195 (31.0)     |
| Other/missing                                       | 1235 (56.4)   | 231 (64.2)                 | 434 (69.0)     |
| **Employment status, N = 3097**                     |               |                            |                |
| Employed (full or part time)                        | 1326 (61.6)   | 158 (46.1)                 | 282 (47.0)     |
| Unemployed                                          | 309 (14.3)    | 94 (27.4)                  | 160 (26.7)     |
| Not working because of sickness/disability          | 316 (14.7)    | 38 (11.1)                  | 62 (10.3)      |
| Other (student, looking after home, retired, other) | 203 (9.4)     | 53 (15.5)                  | 96 (16.0)      |
| **Money for basic needs? N = 3116**                  |               |                            |                |
| Always                                              | 1116 (51.6)   | 100 (28.8)                 | 130 (21.5)     |
| Mostly                                              | 597 (27.6)    | 79 (22.8)                  | 147 (24.3)     |
| Sometimes                                           | 277 (12.8)    | 101 (29.1)                 | 178 (29.4)     |
| No                                                   | 173 (8.0)     | 67 (19.3)                  | 151 (24.9)     |
| **Identifies with a religion, N = 3178**             |               |                            |                |
| Yes                                                 | 934 (42.7)    | 282 (78.3)                 | 551 (87.6)     |
| No/missing                                          | 1255 (57.3)   | 78 (21.7)                  | 78 (12.4)      |
| **Time with diagnosed HIV, N = 3150**                |               |                            |                |
| 3 months to 1.9 years                               | 184 (8.5)     | 45 (12.7)                  | 64 (10.4)      |
| 2–4.9 years                                         | 338 (15.5)    | 63 (17.7)                  | 97 (15.7)      |
| 5–9.9 years                                         | 550 (25.3)    | 111 (31.3)                 | 232 (37.5)     |
| 10–14.9 years                                       | 461 (21.2)    | 69 (19.4)                  | 117 (18.9)     |
| 15–19.9 years                                       | 376 (17.3)    | 45 (12.7)                  | 67 (10.8)      |
| ≥20 years                                           | 268 (12.3)    | 22 (6.2)                   | 41 (6.6)       |
| **Partner status, N = 3154**                        |               |                            |                |
| HIV+ stable partner                                 | 512 (23.6)    | 111 (31.1)                 | 123 (19.7)     |
| HIV− or HIV-unknown status stable partner           | 674 (31.0)    | 133 (37.3)                 | 220 (35.3)     |
| No stable partner                                    | 987 (45.4)    | 113 (31.7)                 | 281 (45.0)     |
| **Current smoker, N = 3178**                        |               |                            |                |
| No/missing                                          | 1377 (62.9)   | 252 (70.0)                 | 562 (89.4)     |
| Yes                                                 | 812 (37.1)    | 108 (30.0)                 | 67 (10.7)      |
| **Higher alcohol consumptiona, N = 3178**           |               |                            |                |
| No/missing                                          | 1821 (83.2)   | 317 (88.1)                 | 616 (97.9)     |
| Yes                                                 | 368 (16.8)    | 43 (11.9)                  | 13 (2.1)       |
| **Number of recreational drugs used in past 3 monthsb, N = 3178** |               |                            |                |
| None/missing                                        | 1078 (49.2)   | 303 (84.2)                 | 585 (93.0)     |
| 1                                                   | 364 (16.6)    | 36 (10.0)                  | 36 (5.7)       |
| 2–3                                                 | 403 (18.4)    | 21 (5.8)                   | 7 (1.1)        |
| ≥4                                                  | 344 (15.7)    | 0 (0)                      | 1 (0.2)        |
| **Self-reported ART status, N = 3125**               |               |                            |                |
| Never taken ART                                     | 253 (11.7)    | 19 (5.4)                   | 42 (6.9)       |
| Stopped ART                                         | 34 (1.6)      | 5 (1.4)                    | 26 (4.3)       |
| On ART                                              | 1876 (86.7)   | 327 (93.2)                 | 543 (88.9)     |
| **Self-reported viral load status, N = 2746 on ART only** |               |                            |                |
| 50 copies/ml or less (undetectable or suppressed)    | 1569 (83.6)   | 201 (61.5)                 | 384 (70.7)     |
| More than 50 copies/ml (detectable or raised)       | 153 (8.2)     | 32 (9.8)                   | 42 (7.7)       |
| Do not know                                         | 135 (7.2)     | 76 (23.2)                  | 90 (16.6)      |
| **Missing**                                         | 19 (1.0)      | 18 (5.5)                   | 27 (5.0)       |
| **Clinic-recorded viral loadc (copies/ml), N = 3157** |               |                            |                |
| ≤50                                                 | 1694 (77.9)   | 281 (78.7)                 | 486 (77.8)     |
| >50                                                 | 481 (22.1)    | 76 (21.3)                  | 139 (22.2)     |
and 629 women). The vast majority reported being on ART: 1876 (86.7%) MSM, 327 (93.2%) heterosexual men and 543 (88.9%) women, of whom 83.6, 61.5 and 70.7% respectively had undetectable self-reported viral load. These differences in self-reported viral load among participants on ART were primarily because of the higher proportion of heterosexual men (23.2%) and women (16.6%) than MSM (7.2%) who did not know their viral load status. A small proportion of participants (n = 65; 2.0%) reported having stopped ART. Overall 696 (22.1%) participants (12.4% of those on ART) had clinic-recorded viral load more than 50 copies/ml using the study-documented viral load.

### Sexual behaviour and association with self-reported antiretroviral treatment/viral load among men who have sex with men

Table 2 shows sexual behaviour among 2189 MSM. In the past 3 months, 1392 (63.6%) MSM had anal/vaginal sex (1360 with men only, 12 with women only and 20 with both men and women), the majority of whom had more than one partner, with over a quarter having 5 partners or more. Overall, 836 (38.2%) MSM reported CLS; 326 (14.9%) reported CLS-D. When ‘possible CLS-D’ was included, prevalence rose to 16.3% (n = 357). Of MSM having CLS-D, most (57.5%) reported a single CLS-D partner, whereas approximately 14% had 5 or more CLS-D partners. For the majority (76.1%) of men reporting CLS-D, this was sex with partners other than, or in addition to, a long-term partner. Of men having CLS-D, less than a third reported insertive anal CLS-D with ejaculation inside a partner, and 40% reported receptive anal CLS-D only. MSM who reported CLS-D had higher prevalence of self-reported STI (22.4% vs. 8.7%) and group sex (45.1% vs. 16.4%) than those who did not, and CLS-D prevalence increased markedly with greater numbers of new sexual partners (Fig. 1).

Among 2163 MSM with information on self-reported ART/viral load, those on ART were less likely than those not on ART to report anal/vaginal sex (61.9% vs. 76.7%), CLS (36.9% vs. 48.4%) and CLS-D (14.3% vs. 18.8%) in the past three months, P < 0.05 for all ($\chi^2$ tests). MSM on ART were less likely than those not on ART to have: STI (9.9% vs. 16.7%) or group sex (19.6% vs. 28.6%) in the past three months, or 10 or more new partners in the past year (24.5% vs. 36.2%), P < 0.001 for all. Among MSM on ART, CLS-D prevalence was higher among those with undetectable self-reported viral load than without (15.2% vs. 9.8%, P = 0.014, Table 3a). However CLS-D prevalence among MSM not on ART (18.8%) was higher than for both ‘on ART’ groups. Table 3a also shows associations with other factors. Prevalence of CLS-D declined with older age, and with longer time since HIV diagnosis, and was higher among MSM without an HIV-positive stable partner. CLS-D was associated with higher alcohol consumption, and strongly with recreational drug use, but not with ethnicity, birth in the United Kingdom, education, employment status, financial hardship, religion, smoking status or CD4$^+$ cell count. Patterns of association were similar with all CLS.

After adjustment for socio-demographic and HIV-related factors, compared with MSM on ART with undetectable self-reported viral load, those on ART without undetectable self-reported viral load had significantly lower CLS-D prevalence [adjusted prevalence ratio (95% CI): 0.66 (0.45, 0.95)], whereas those not on ART had similar prevalence [1.08 (0.78, 1.49)] (Table 4a). Attenuation of this latter effect (‘not on ART’ vs. ‘ART with undetectable self-reported viral load’) was primarily because of adjustment for time with diagnosed HIV. The significant difference in CLS-D between the two ‘on ART’ groups persisted after additional adjustment for alcohol and recreational drug use (Table 4a).

### Sexual behaviour and association with self-reported antiretroviral treatment/viral load among heterosexual men and women

Table 2 shows sexual behaviour among heterosexual men and women. Of 360 heterosexual men, 226 (62.8%), 83 (23.1%) and 23 (6.4%) reported vaginal/anal sex, CLS and CLS-D respectively in the past 3 months. Among the 629 women, corresponding numbers were: 316 (50.2%), 133 (21.1%) and 67 (10.7%). Inclusion of ‘possible’ CLS-D made little difference to prevalence. Patterns of sexual behaviour among heterosexual participants differed from MSM: the vast majority had sex with a single partner,
Table 2. Sexual behaviour according to gender/sexual orientation, among 3178 individuals diagnosed with HIV more than 3 months ago.

| Sexual behaviour in past 3 months (N, denominator across all groups) | MSM N = 2189 | Heterosexual men N = 360 | Women N = 629 |
|-------------------------------------------------|----------------|----------------|--------------|
| Any anal or vaginal sex (N = 3178) | 1392 (63.6%)<sup>a</sup> | 226 (62.8%) | 316 (50.2%) |
| Number of anal/vaginal sexual partners (N = 1827<sup>c</sup>, who had sex) | | | |
| 1 | 594 (44.7%) | 194 (90.7%) | 279 (98.2%) |
| 2–4 | 379 (28.5%) | 19 (8.9%) | 5 (1.8%) |
| 5–9 | 171 (12.9%) | 1 (0.5%) | – |
| 10–19 | 106 (8.0%) | – | – |
| ≥20 | 79 (5.9%) | – | – |
| Number not given | 63 | 12 | 32 |
| Condomless sex (CLS) (N = 3178) | 836 (38.2%) | 83 (23.1%) | 133 (21.1%) |
| 95% confidence interval (CI) | 36.1%, 40.3% | 18.8%, 27.8% | 18.0%, 24.5% |
| CLS with HIV serodifferent partner (CLS-D) | 326 (14.9%) | 23 (6.4%) | 67 (10.7%) |
| 95% confidence interval (CI) | 13.4%, 16.5% | 4.1%, 9.4% | 8.4%, 13.3% |
| CLS-D including 'possible' cases<sup>b</sup> | 357 (16.3%) | 25 (6.9%) | 68 (10.8%) |
| 95% confidence interval (CI) | 14.8%, 17.9% | 4.5%, 10.1% | 8.5%, 13.5% |
| Number CLS-D partners, (N = 403<sup>d</sup>, who had CLS-D) | | | |
| 1 | 180 (57.5%) | 21 (91.3%) | 67 (100.0%) |
| 2–4 | 90 (28.8%) | 2 (8.7%) | – |
| 5–9 | 22 (7.0%) | – | – |
| ≥10 | 21 (6.7%) | – | – |
| Number not given | 13 | – | – |
| Total number times CLS-D, (N = 375<sup>e</sup>, who had CLS-D) | | | |
| Once | 95 (30.6%) | 1 (7.7%) | 14 (26.9%) |
| 2–10 times | 155 (50.0%) | 11 (48.6%) | 26 (50.0%) |
| ≥11 times | 60 (19.4%) | 1 (7.7%) | 12 (23.1%) |
| Number of times not given | 16 | 10 | 15 |
| Type CLS-D partner(s), (N = 408<sup>f</sup>, who had CLS-D) | | | |
| Long-term partner only | 76 (23.9%) | 18 (78.3%) | 63 (94.0%) |
| Long-term partner and other partner(s) | 19 (6.0%) | – | – |
| Other partner(s) | 223 (70.1%) | 5 (21.7%) | 4 (6.0%) |
| Missing partner type | 8 | – | – |
| Type CLS-D sex (for MSM only), (N = 314 MSM<sup>g</sup>, who had CLS-D) | | | |
| CLS-D anal sex with men | | | |
| Insertive anal sex with ejaculation | 88 (28.0%) | – | – |
| Insertive anal sex without ejaculation | 92 (29.3%) | – | – |
| Receptive anal sex | 126 (40.1%) | – | – |
| CLS-D with women only | 8 (2.5%) | – | – |
| CLS-D anal sex with men, missing type | 12 | – | – |
| Sexually transmitted infection diagnosed in past 3 months, (N = 3178) | 235 (10.7%) | 16 (4.4%) | 35 (5.6%) |
| Had group sex<sup>h</sup> in past 3 months, (N = 3178) | 453 (20.7%) | 2 (0.6%) | 5 (0.8%) |
| ≥10 new sexual partners in past year, (N = 2913) | 533 (23.5%) | 0 (0%) | 1 (0.2%) |
| Believe that HIV transmission risk very low indicated as reason for not using condom on last occasion of CLS-D, (N = 416 who had CLS-D) | 122 (37.4%) | 8 (34.8%) | 1 (2.5%) |
| Transmission risk belief score<sup>j</sup>, (N = 3129) | 99 (4.6%) | 35 (10.0%) | 47 (7.7%) |
| 2: If viral load undetectable, condom not needed to prevent HIV transmission | 1023 (47.3%) | 122 (34.8%) | 233 (38.0%) |
| 1: Less infectious if viral load undetectable (but does not agree with 2 above) | 1043 (48.2%) | 194 (55.3%) | 333 (54.3%) |
| 0: Does not agree with either of 1 or 2 above | | | |

<sup>a</sup>All variables relate to a 3-month recall period unless otherwise indicated.

<sup>b</sup>Includes those who reported CLS, but did not specify whether with HIV serodifferent or concordant status partner(s).

<sup>c</sup>Of all those reporting anal/vaginal sex; percentages are given of 1329, 214 and 284 non-missing values for MSM, heterosexual men, women.

<sup>d</sup>Of all those reporting CLS-D; percentages are given of 313 non-missing values for MSM.

<sup>e</sup>Of all those reporting CLS-D; percentages are given of 310, 13 and 52 all non-missing values for MSM, heterosexual men, women.

<sup>f</sup>Of all those reporting CLS-D; percentages are given of 318 non-missing values for MSM.

<sup>g</sup>Of all those reporting CLS-D; percentages are given of 314 non-missing values for MSM.

<sup>h</sup>Sex with more than one person on the same occasion.

<sup>i</sup>Had sex with both men and women, and 12 had sex with women only.

<sup>j</sup>Hierarchical classification.
CLS-D was usually with a long-term partner, recent STI transmission was less common and prevalence of group sex and multiple partners was very low.

Among 351 heterosexual men with information on self-reported ART/viral load, there were no significant differences between those on ART vs. not on ART in prevalence of vaginal/anal sex (63.6% vs. 70.8%), CLS (23.9% vs. 16.7%) and CSL-D (6.4% vs. 4.2%) in the past 3 months. Similarly, among 611 women, ART was not associated with vaginal/anal sex (50.6% vs. 54.4% for on versus not on ART), CLS (21.4% vs. 23.5%) or CSL-D (11.2% vs. 8.8%) (P > 0.3 for all, \( \chi^2/Fisher’s\) exact test). Table 3b shows associations for all heterosexual participants combined. Self-reported ART/viral load was not associated with CLS-D. CSL-D was associated with younger age, birth in the United Kingdom, non-black ethnicity, university education, not having a recent HIV diagnosis, higher CD4+ cell count and tended to be associated with greater financial security. CLS-D prevalence was much higher among the majority of individuals who identified with a religion than the minority who did not, and much higher among people with an HIV-negative/unknown status stable partner. CSL-D was associated with recreational drug use, but not with smoking or alcohol use. Patterns of association were broadly similar with all CLS. There remained no significant association of self-reported ART/viral load with CSL-D among heterosexual individuals in adjusted models (Table 4b).

Transmission risk beliefs

Table 2 shows that the vast majority of participants believed in the need for condoms, even with undetectable viral load, and approximately half did not agree that undetectable viral load reduced infectiousness. However, of all 416 participants who reported CSL-D, just over a third (37.7%) gave ‘belief that transmission risk is very low’ as one reason for not using a condom. This percentage was 41.9% among participants on ART with undetectable self-reported viral load, compared with 23.1% among those on ART without undetectable self-reported viral load, and 27.9% among those not on ART (\( P = 0.008, \chi^2 \)).

Self-reported antiretroviral treatment/viral load and HIV-transmission risk sex

Among 2142 participants on ART who reported undetectable viral load, the vast majority (96.5%; \( n = 2066 \)) had clinic-recorded viral load 50 copies/ml or less. Conversely, of all 2389 with clinic viral load 50 copies/ml or less, 86.5% had undetectable self-reported viral load. Prevalence of CSL-D-HIV-risk (CLS-D together with either ‘not on ART’ or clinic-recorded viral load >50 copies/ml) was 3.2% (101/3178) overall, 16.1% (61/379) among those not on ART (by definition equivalent to CSL-D), 0.6% (14/2154) among those on ART with undetectable self-reported viral load (the 14 cases because of CSL-D together with clinic viral load >50 copies/ml despite undetectable self-reported viral load), and 4.2% (25/592) among those on ART without undetectable self-reported viral load. Among MSM, these proportions were 3.9% (85/2189) overall, and 18.8% (54/287), 0.8% (12/1569) and 5.9% (18/307) respectively for the three self-reported ART/viral load categories. Among heterosexual individuals, corresponding proportions were 1.6% (16/989) overall; 7.6% (7/92), 0.3% (2/585) and 2.5% (7/285) for the self-reported ART/viral load categories. Therefore, prevalence of CSL-D-HIV-risk was much lower among people on ART, and extremely low (<1%) among those on ART with undetectable self-reported viral load.

Sensitivity analyses

Among MSM, when defining CSL-D to include possible CSL-D, adjusted prevalence ratios (95% CI) from model 2 were: 0.74 (0.53, 1.04) for ‘ART without undetectable self-reported viral load’ and 1.06 (0.78, 1.44) for ‘not on ART’, compared with ‘ART with undetectable self-reported viral load’ (global \( P = 0.11 \)). Including only MSM who had sex in the past 3 months, corresponding adjusted prevalence ratios (95% CI) were 0.68 (0.48, 0.96) and 0.98 (0.72, 1.33) (\( P = 0.042 \)). Among MSM diagnosed less than 5 years ago, adjusted prevalence ratios (95% CI) were 0.22 (0.08, 0.59) for ‘ART without undetectable self-reported viral load’, and 0.70 (0.46, 1.07) for ‘not on ART’, compared with ‘ART with undetectable self-reported viral load’. Among MSM diagnosed 5 years ago or more, corresponding adjusted prevalence ratios (95% CI) were 0.88 (0.59, 1.31) and 1.60 (1.10, 2.33); this interaction was significant (\( P = 0.001 \)). Among heterosexual individuals, there was no significant association between self-reported...
Table 3. Condomless sex with HIV-serodifferent partner (CLS-D), and all condomless sex (CLS), in the past three months, according to self-reported ART/viral load status and other factors, among 3178 individuals diagnosed with HIV more than 3 months ago: (a) 2189 MSM and (b) 989 heterosexual men and women.

|                         | (a) MSM (N = 2189) | (b) Heterosexual men and women (N = 989) |
|-------------------------|--------------------|----------------------------------------|
|                         | n (%)              | n (%)                                  |
|                         | CLS-D              | CLS                                    |
|                         | N                  | n (%)                                  |
|                         | n (%)              | CLS-D                                  | CLS                                    |
| Self-reported ART status (1) |                    |                                        |
| Not on ART              | 287                | 54 (18.8)                              | 29 (12.3)                              |
| On ART                  | 1876               | 268 (14.3)                             | 233 (78.3)                             |
|                         |                    | 692 (36.9)                             | 216 (76.2)                             |
| P = 0.0045              |                    | P < 0.001                              | P = 0.047                              |
| Self-reported ART status (2) |                    |                                        |
| Never taken ART         | 253                | 42 (16.6)                              | 21 (7.6)                               |
| Ever taken ART          | 1910               | 280 (14.7)                             | 180 (62.3)                             |
|                         |                    | 708 (37.1)                             | 210 (70.7)                             |
| P = 0.42               |                    | P < 0.001                              | P = 0.44                               |
| Self-reported ART status (3) |                    |                                        |
| Never taken ART         | 253                | 42 (16.6)                              | 21 (7.6)                               |
| Stopped ART             | 34                 | 12 (35.3)                              | 16 (51.6)                              |
| On ART                  | 1876               | 268 (14.3)                             | 233 (78.3)                             |
|                         |                    | 692 (36.9)                             | 216 (76.2)                             |
| P = 0.002              |                    | P < 0.001                              | P = 0.050                              |
| Self-reported ART and viral load status |        |                                        |
| Not on ART              | 287                | 54 (18.8)                              | 216 (71.3)                             |
| On ART, viral load 50 copies/ml | 1569             | 238 (15.2)                             | 216 (71.3)                             |
| On ART, viral load >50 copies/ml or unknown<sup>a</sup> | 307               | 30 (9.8)                               | 285 (22.7)                             |
|                         |                    | 98 (31.9)                              | 57 (20.0)                              |
| P = 0.007              |                    | P < 0.001                              | P = 0.41                               |
| Age group (years)       |                    |                                        |
| <30                     | 96                 | 23 (24.0)                              | 29 (30.2)                              |
| 30–39                   | 487                | 75 (15.4)                              | 233 (47.8)                             |
|                         |                    | 233 (47.8)                             | 216 (71.3)                             |
| P = 0.008<sup>#</sup>  |                    | P < 0.001                              | P = 0.026<sup>#</sup>                 |
| Ethnicity               |                    |                                        |
| White                   | 1931               | 282 (14.6)                             | 236 (24.0)                             |
| Black African           | 21                 | 3 (14.3)                               | 4 (19.1)                               |
| Black other             | 54                 | 8 (14.8)                               | 23 (42.6)                              |
| Other/missing           | 183                | 33 (18.0)                              | 104 (56.7)                             |
|                         |                    | P = 0.67                               | P = 0.090                              |
| UK birth                |                    |                                        |
| Yes                     | 1532               | 226 (14.8)                             | 208 (13.0)                             |
| No                      | 629                | 96 (15.3)                              | 736 (12.3)                             |
|                         |                    | P = 0.76                               | P = 0.023                              |
| Education               |                    |                                        |
| University              | 954                | 149 (15.6)                             | 324 (11.7)                             |
| Other/missing           | 1235               | 177 (14.3)                             | 665 (52.8)                             |
|                         |                    | P = 0.40                               | P = 0.018                              |
| Employment status       |                    |                                        |
| Employed (full or part time) | 1326            | 211 (15.9)                             | 440 (11.9)                             |
| Unemployed              | 309                | 46 (14.9)                              | 254 (7.5)                              |
| Not working: sick or disabled | 316            | 42 (13.3)                              | 104 (32.9)                             |
| Other (student, looking after home, retired, other) | 203               | 22 (10.8)                              | 149 (7.4)                              |
|                         |                    | P = 0.23                               | P = 0.025                              |
| Money for basic needs?  |                    |                                        |
| Always                  | 1116               | 164 (14.7)                             | 230 (26.3)                             |
| Mostly                  | 597                | 85 (14.2)                              | 226 (41.1)                             |
| Sometimes               | 277                | 40 (14.4)                              | 279 (17.6)                             |
| No                      | 173                | 32 (18.5)                              | 218 (18.3)                             |
|                         |                    | P = 0.40<sup>f</sup>                   | P = 0.083<sup>f</sup>                  |
| Identify with a religion? |                    |                                        |
| Yes                     | 934                | 144 (15.4)                             | 833 (61.7)                             |
| No/missing              | 1255               | 182 (14.5)                             | 156 (29.8)                             |
|                         |                    | P = 0.55                               | P = 0.001                              |
| Time since HIV diagnosis |                    |                                        |
| 3 months to 1.9 years   | 184                | 29 (15.8)                              | 109 (5.3)                              |
| 2–4.9 years            | 338                | 57 (16.9)                              | 160 (4.7)                              |
| 5–9.9 years            | 550                | 96 (17.5)                              | 186 (8.5)                              |
| 10–14.9 years          | 461                | 69 (15.0)                              | 112 (11.8)                             |
| 15–19.9 years          | 376                | 47 (12.5)                              | 63 (9.4)                               |
| ≥20 years              | 268                | 26 (9.7)                               | 39 (14.3)                              |
|                         |                    | P = 0.005<sup>g</sup>                  | P = 0.11<sup>g</sup>                   |

<sup>a</sup> P = 0.001; <sup>#</sup> P = 0.001; <sup>f</sup> P = 0.001
ART and sexual behaviour  Lampe  1753

Table 3 (continued)

(a) MSM (N = 2189) (b) Heterosexual men and women (N = 989)

| Partner status                  | N  | n (%) | n (%) | N  | n (%) | n (%) |
|---------------------------------|----|-------|-------|----|-------|-------|
| HIV- stable partner             | 512| 47 (9.2) | 309 (60.4)| 234| 2 (0.9) | 106 (45.3) |
| HIV- or HIV-unknown status stable partner | 674| 141 (20.9) | 198 (29.4)| 353| 78 (22.1) | 95 (26.9) |
| No stable partner               | 987| 136 (13.8) | 326 (33.0)| 394| 10 (2.5) | 15 (3.8) |
| Current smoker                  |    |       |       |    |       |       |
| No/missing                      | 1377| 218 (15.8) | 506 (36.8) | 814| 73 (9.0) | 172 (21.1) |
| Yes                             | 812| 108 (13.3) | 330 (40.8) | 175| 17 (9.7) | 44 (25.1) |
| Higher alcohol consumptionb     |    |       |       |    |       |       |
| No/missing                      | 1821| 251 (13.8) | 684 (37.7) | 933| 86 (9.2) | 201 (21.5) |
| Yes                             | 368| 75 (20.4) | 152 (41.6) | 56| 4 (7.1) | 15 (26.8) |
| Number of recreational drugs used in past 3 months |    |       |       |    |       |       |
| None/missing                    | 1078| 103 (9.6) | 259 (24.0) | 888| 73 (8.2) | 183 (20.6) |
| 1                               | 364| 51 (14.0) | 119 (32.7) | 72| 13 (18.1) | 26 (36.1) |
| 2–3                             | 403| 84 (20.8) | 204 (50.6) | 26| 4 (14.3) | 7 (25.0) |
| ≥4                              | 344| 88 (25.6) | 254 (73.8) | 1| 0 (0) | 0 (0) |
| Clinic-recorded CD4<sup>c</sup> cell count (cells/μl)<sup>d</sup> |    |       |       |    |       |       |
| <200                            | 77| 11 (14.3) | 21 (27.3) | 72| 1 (1.4) | 9 (12.5) |
| 200–349                         | 240| 32 (13.3) | 80 (33.3) | 166| 12 (7.2) | 32 (19.3) |
| 250–499                         | 538| 79 (14.7) | 215 (40.0) | 234| 19 (8.1) | 51 (21.8) |
| ≥500                            | 1320| 201 (15.2) | 516 (39.1) | 508| 57 (11.2) | 121 (23.8) |
| Clinic-recorded viral load (copies/ml)<sup>d</sup> |    |       |       |    |       |       |
| ≤50                             | 1694| 243 (14.3) | 617 (36.4) | 767| 77 (10.0) | 173 (22.6) |
| >50                             | 481| 82 (17.1) | 217 (45.1) | 215| 13 (6.1) | 42 (19.5) |

Denominators vary because of missing values. Self-reported ART status missing for 53 participants (26 MSM, nine heterosexual men and 18 women). Prevalence of CLS-D and CLS among participants with missing current ART status: 15.4 and 19.2% for 26 MSM; 3.7 and 7.4% for 27 heterosexual men and women. Univariate P values by χ² tests.

*χ² tests for trend. 

<sup>a</sup>Includes ‘do not know’ viral load level and missing response.

<sup>b</sup>Score of 6 or more on modified WHO AUDIT C questionnaire (using first two questions only).

<sup>c</sup>Latest clinic-recorded value that participant had been informed of.

<sup>d</sup>Among heterosexuals, for time with diagnosed HIV, P value corresponds to comparison of ‘3 months to 1.9 years’ with ‘2 years or more’, using χ² test. For recreational drug use, P value corresponds to comparison of ‘no drug use’ with ‘drug use’, using χ² test.

Discussion

In this large multicentre study of people attending HIV clinics in the United Kingdom in 2011/12, use of ART was not associated with higher prevalence of CLS-D. Among MSM, those on ART had moderately lower prevalence of CLS-D than those not on ART, although this association was not independent of time since HIV diagnosis. Among MSM on ART, those who reported undetectable viral load had higher levels of CLS-D than those who did not, but CLS-D prevalence in both ‘on ART’ groups was lower than for MSM not on ART. Among heterosexual men and women, self-reported ART/viral load was not significantly associated with CLS-D. Patterns were similar for CLS overall. The prevalence of CLS-D-HIV-risk was low in the study population overall, and extremely low among those on ART with undetectable self-reported viral load.

With few exceptions [18,21,23], previous epidemiological studies [19,20,22–26,28–33] have found either no association of CLS-D with ART use and/or suppressed viral load, or that people on ART had somewhat lower levels of CLS-D. Similarly, a randomized comparison within the SMART trial (2002–2006) found that starting ART led to a reduction in CLS-D in the short term [27]. The most recent observational study used data from 2009, a few years prior to ASTRA. Interview-assessed sexual behaviour was linked to recorded viral load among a large sample of United States’ HIV outpatients (Medical Monitoring Project) [33]. Self-reported viral load was not assessed. Similar to ASTRA results comparing ‘on ART’ with ‘not on ART’, the United States’ study found...
Table 4. Unadjusted and adjusted associations of self-reported ART/viral load status with condomless sex with HIV-serodifferent partner (CLS-D), in the past three months, among 3178 individuals diagnosed with HIV more than 3 months ago: (a) 2189 MSM and (b) 989 heterosexual men and women.

| Associations with CLS-D | (a) MSM (N = 2189) | (b) Heterosexual men and women (N = 989) |
|------------------------|---------------------|----------------------------------------|
|                        | Unadjusted prevalence ratio (95% CI) | Adjusted (1) prevalence ratio (95% CI) | Unadjusted prevalence ratio (95% CI) | Adjusted (2) prevalence ratio (95% CI) |
| Gender                 |                                   |                                        |                                  |                                        |
| Male                   | 1                                 | 1.67 (1.06, 2.63)                     | 2.02 (1.29, 3.17)                | 2.11 (1.34, 3.33)                      |
| Female                 |                                   |                                        |                                  |                                        |
| Self-reported ART/viral load status |                      |                                        |                                  |                                        |
| Not on ART             | 1.24 (0.95, 1.62)                  | 1.01 (0.74, 1.39)                     | 0.74 (0.35, 1.57)                | 0.88 (0.44, 1.77)                      |
| On ART, viral load ≤ 50 copies/ml | 0.64 (0.45, 0.92)                  | 0.64 (0.44, 0.92)                     | 0.75 (0.47, 1.20)                | 1.14 (0.73, 1.79)                      |
| On ART, viral load > 50 copies/ml or unknown | 0.64 (0.45, 0.92)                  | 0.64 (0.44, 0.92)                     | 0.75 (0.47, 1.20)                | 1.14 (0.73, 1.79)                      |
| Age                    |                                   |                                        |                                  |                                        |
| <30 years              | 0.60 (0.42, 0.87)                  | 0.76 (0.51, 1.13)                     | 0.71 (0.36, 1.39)                | 1.14 (0.61, 2.11)                      |
| ≥30 years              |                                   |                                        |                                  |                                        |
| Black ethnicity        |                                   |                                        |                                  |                                        |
| No/missing             | 0.98 (0.56, 1.72)                  | 0.97 (0.56, 1.68)                     | 0.63 (0.42, 0.93)                | 0.94 (0.60, 1.46)                      |
| Yes                    |                                   |                                        |                                  |                                        |
| University education   |                                   |                                        |                                  |                                        |
| No/missing             | 1.09 (0.89, 1.33)                  | 1.04 (0.85, 1.28)                     | 1.50 (1.01, 2.23)                | 1.12 (0.77, 1.64)                      |
| Yes                    |                                   |                                        |                                  |                                        |
| Identifies with a religion |                                |                                        |                                  |                                        |
| No/missing             | 1.06 (0.87, 1.30)                  | 1.22 (1.00, 1.49)                     | 0.39 (0.26, 0.59)                | 0.41 (0.26, 0.65)                      |
| Yes                    |                                   |                                        |                                  |                                        |
| Time with diagnosed HIV|                                   |                                        |                                  |                                        |
| 3 months to 1.9 years  | 1.07 (0.71, 1.61)                  | 1.12 (0.74, 1.70)                     | 2.71 (1.02, 7.25)                | 2.16 (0.88, 5.30)                      |
| 2–4.9 years            | 1.11 (0.70, 1.62)                  | 1.18 (0.77, 1.79)                     | 1.23 (0.82, 1.85)                | 2.16 (0.91, 5.15)                      |
| 5–9.9 years            | 0.95 (0.64, 1.41)                  | 1.06 (0.66, 1.65)                     | 1.11 (0.72, 1.71)                | 2.16 (0.91, 5.15)                      |
| 10–14.9 years          | 0.79 (0.52, 1.22)                  | 0.84 (0.52, 1.35)                     | 0.86 (0.54, 1.37)                | 2.16 (0.91, 5.15)                      |
| 15–19.9 years          | 0.62 (0.38, 1.01)                  | 0.71 (0.42, 1.21)                     | 0.81 (0.48, 1.35)                | 2.16 (0.91, 5.15)                      |
| Partner status         |                                   |                                        |                                  |                                        |
| HIV+ stable partner    | 2.28 (1.67, 3.11)                  | 2.34 (1.71, 3.19)                     | 2.63 (1.93, 3.57)                | 25.8 (6.4, 104.2)                      |
| HIV- or HIV-unknown stable partner | 1.50 (1.10, 2.05)                  | 1.54 (1.12, 2.21)                     | 1.63 (1.19, 2.24)                | 2.97 (0.66, 13.4)                      |
| No stable partner      | P < 0.001                         | P < 0.001                             | P < 0.001                        | P < 0.001                             |
| Higher alcohol consumption |                           |                                        |                                  |                                        |
| No/missing             | 1.48 (1.17, 1.87)                  | 1.34 (1.06, 1.68)                     | 0.77 (0.30, 2.04)                | 0.74 (0.25, 2.14)                      |
| Yes                    |                                   |                                        |                                  |                                        |
that individuals with viral load suppression had lower levels of sex, CLS, and CLS-D than those without; the association was significant only for MSM.

For MSM on ART in ASTRA, the prevalence of CLS-D was higher among those who reported undetectable viral load than among those who did not. This modest difference remained after adjustment for other factors, and among the subgroup of MSM who had recent sex (sensitivity analysis b), therefore was not due to those on ART being less likely to be sexually active. The difference was particularly marked among those more recently diagnosed (sensitivity analysis c). Although there may be other differences between the two ‘on ART’ groups, one plausible explanation is that some MSM were choosing not to use a condom with HIV-serodifferent partners because of knowledge of very low infectiousness based on their perceived viral load. Consistent with this, of all participants who reported CLS-D, belief that transmission risk was low was more frequently a reason for not using condoms among those with undetectable self-reported viral load than those without. However, if knowledge of viral load was influencing sexual behaviour among MSM, the effect appeared modest, because levels of CLS-D among those on ART with undetectable self-reported viral load did not exceed those for men not on ART.

Prevalence estimates of CLS-D among MSM (15%) and heterosexual men (6%) and women (11%) with HIV in ASTRA are similar to those from two clinic-based studies in the United Kingdom in 2004–2005 using an identical definition (20 and 15% among 758 [22] and 451 [29] MSM, respectively; less than 10% among heterosexual men and women [22,29]), and from the European START trial participants at baseline: 15, 3 and 10% in the past 2 months for 1518 MSM, 207 heterosexual men and 138 women with HIV not taking ART (recently diagnosed participants were included) [41]. The START analysis found no significant trend in baseline CLS-D prevalence over the recruitment period (2009–2013). Taken together these results suggest levels of CLS-D among people with HIV have remained fairly stable in the past decade, emphasising further that any change related to new messages about ‘safe sex’ has not been significant. Comparison with other studies is complicated by different recall periods and sampling frames: internet and venue-based studies tend to yield higher CLS-D estimates among HIV-positive MSM [42,43], which may be because of selection bias. Consistent with other studies [41,44–46], ASTRA suggests that perceived risk-reduction strategies (withdrawal before ejaculation and being the receptive partner) are commonly used among HIV-positive MSM having CLS-D.

Among MSM in ASTRA, CLS-D prevalence was lower with longer time since diagnosis, and higher among younger men, those without an HIV-positive stable partner, and those with higher alcohol and drug use, but
CLS-D was not linked to socio-economic status. Similarly, among MSM in START, CLS-D was not associated with education level [41]. We have previously described the strong link between polydrug use and CLS/CLS-D among MSM [40], in part reflecting use of ‘chemsex’ [47]. Among heterosexual individuals in ASTRA, factors associated with CLS-D included white ethnicity, and higher socio-economic status in unadjusted analysis. In contrast, among heterosexual individuals in START, CLS-D tended to be associated with non-white ethnicity and lower education in unadjusted analysis [41]. START had a diverse international population; socio-demographic effects on sexual behaviour may vary across cultural settings. Among heterosexuals in ASTRA, female sex, not having a recent HIV diagnosis, not identifying with a religion and recreational drug use were independent correlates of CLS-D, but the dominant association was with having an HIV-negative stable partner – this was the context of CLS-D for most heterosexual men and women who reported it. There may be specific issues relating to CLS-D in this context, such as desire for conception, or mutuality of decision making about condom use.

ASTRA is the largest questionnaire study of sexual behaviour among people living with HIV in the United Kingdom; although power to assess associations among heterosexual men and women separately was limited. Participants were reassured that questionnaire responses were confidential and would not be seen by clinic staff. Nevertheless, self-reported behaviour and attitudes may be subject to errors and social desirability bias.

What are the implications of these results for HIV-transmission? The prevalence of ‘HIV-transmission risk sex’ was much lower among those on ART vs. not on ART (1.4% vs 16.1%), and less than 1% among those on ART with undetectable self-reported viral load. Even if the ASTRA results do indicate the start of a trend of increasingly higher levels of CLS-D with perceived undetectable viral load (among MSM or the HIV-diagnosed population overall), prevalence of CLS-D-HIV-risk will likely continue to remain far lower among those on ART with undetectable self-reported viral load than among those not on ART. This is because of the effectiveness of ART and the apparent high accuracy of self-reported undetectable viral load status in this population. These results highlight the importance, as ART use expands, of promoting sustained high adherence, regular viral load testing, and on-going awareness of personal viral load level. It is also important to note that the definition of CLS-D-HIV-risk used here is based on the single clinic viral load measurement collected for all ASTRA participants, assumes elimination of risk with viral suppression on ART (as assumed with condom use), and does not incorporate factors such as self-reported ART non-adherence or presence of other STIs, the additional impact of which are uncertain [13,48].

In terms of transmission of other STIs, CLS overall is the most relevant measure. Similar to CLS-D, CLS prevalence among MSM was highest for those not on ART with no significant difference by ART use among heterosexual individuals. Therefore these data give little suggestion that expansion of ART use will have a negative impact on STI transmission. Nevertheless, the high prevalence of CLS compared with CLS-D-HIV risk, and the possibility that levels of CLS among those with undetectable self-reported viral load may continue to increase, emphasise the importance of ongoing promotion of condom use, STI prevention and testing among people with HIV.

The ASTRA study was planned in the period following the Swiss statement, which was then hugely controversial [49]. During recruitment, results were released from HPTN 052 [12]; PARTNER results were first presented after completion of ASTRA [13]. During this period United Kingdom [37] and other [50,51] treatment guidelines were changed to recommend discussing with HIV-positive people the beneficial effect of ART on infectiousness. The extent to which, and the rapidity with which, these findings and recommendations may influence the sexual behaviour of people with HIV [52], or change the long-standing culture of condom use [3], is unclear. With increasing use of early ART, it will be important to continue monitoring the association between ART and CLS, not only to understand the impact on HIV transmission, but also to assess implications for transmission of hepatitis C and other STIs.

In conclusion, among people with HIV in the United Kingdom, use of ART was not associated with increased prevalence of CLS or CLS-D, and was associated with greatly reduced prevalence of HIV-transmission risk sex. Although there was evidence that perceived undetectable viral load may influence condom use among MSM, any such effect was modest at the time of the study, and would not undermine the effect of early ART on HIV/STI transmission. These results support the prevention role of ART offered to all people with HIV, and emphasise the need to focus on HIV/STI prevention among those not on ART.

Acknowledgements

Funding: The ASTRA study presents independent research funded by the National Institute for Health Research (NIHR) under its Programme Grants for Applied Research funding scheme (RP-PG-0608–10142). The views expressed in this presentation are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health. The ASTRA Study Group acknowledges the support of the NIHR, through the Comprehensive Clinical Research Network.
We thank all study participants for their time and effort, and gratefully acknowledge the contributions of all the ASTRA clinic teams in recruitment and data collection.

ASTRA clinic teams: Royal Free Hospital: Alison Rodger; Margaret Johnson; Jeffrey McDonnell; Ademokun Adebiyi, Mortimer Market Centre: Richard Gilson; Simon Edwards; Lewis Hadlow; Simon Gilson; Christina Brousard; Robert Pralat; Sonali Wayal. Brighton and Sussex University Hospital: Martin Fisher; Nicky Perry; Alex Pollard; Serge Fedele; Louise Kerr; Lisa Heald; Wendy Hadley; Kelly Hobs; Julia Williams; Elaney Youssef; Celia Richardson; Sean Groth. North Manchester General Hospital: Ed Wilkins; Yvonne Clowes; Jennifer Cullie; Cynthia Murphy; Christina Martin; Valerie George; Andrew Thompson. Homerton University Hospital: Jane Anderson; Sitiso Mguni; Damilola Awoiska; Rosalind Scourse. East Sussex Sexual Health Clinic: Kazem Aderoga; Caron Osborne; Sue Cross; Jacqueline Whinney; Martin Jones. Newham University Hospital: Rebecca O’Connell; Cheryl Tawana. Whipps Cross University Hospital: Monica Lascar; Zandile Maseko; Gemma Townsend; Vera Theodore; Jas Sagoo. ASTRA core team: Fiona Lampe; Alison Rodger; Andrew Speakman; Andrew Phillips. ASTRA data management: Andrew Speakman; Marina Daskalopoulou; Fiona Cullie. ASTRA advisory group: Lorraine Sherr; Simon Collins; Jonathan Elford; Alec Miners; Anne Johnson; Graham Hart; Anna-Maria Geretti; Bill Burman. CAPRA grant Advisory Board: Nick Partridge; Kay Orton; Anthony Nardone; Ann Sullivan.

Writing committee: Fiona C. Lampe, Marina Daskalopoulou, Andrew N. Phillips, Andrew Speakman, Margaret A. Johnson, Richard Gilson, Martin Fisher, Ed Wilkins, Jane Anderson, Rebecca O’Connell, Monica Lascar, Kazem Aderoga, Jeffrey McDonnell, Jonathan Elford, Simon Collins, Simon Edwards, Nicky Perry, Lorraine Sherr, Anna Maria Geretti, Graham Hart, Anne M. Johnson, Alec Miners, William J. Burman, Alison J. Rodger.

1. Department of Infection and Population Health, University College London, London, UK.
2. Royal Free London NHS Foundation Trust, London, UK.
3. Brighton and Sussex University Hospitals NHS Trust, Brighton, UK.
4. Pennine Acute Hospitals NHS Trust, Manchester, UK.
5. Centre for the study of Sexual Health and HIV, Homerton University Hospital NHS Foundation Trust, London, UK.
6. Barts Health NHS Trust, London, UK.
7. East Sussex Healthcare NHS Trust, Eastbourne, UK.
8. School of Health Sciences, City University London, London, UK.
9. HIV i-Base, London, UK.
10. Mortimer Market Centre, Central and North West London NHS Foundation Trust, London, UK.
11. Institute of Infection and Global Health, University of Liverpool, Liverpool, UK.
12. London School of Hygiene and Tropical Medicine, London, UK.
13. Denver Public Health, Denver, Colorado, USA.

Professor Martin Fisher died in April 2015.

References

1. Yin Z, Brown A, Hughes G, Nardone A, Gill ON, Delpech VC, et al. HIV in the United Kingdom 2014 Report: data to end 2013. November 2014. London: Public Health England.
et al.

49. Behavioural surveillance study: sexual risk taking among men who have sex with men in the UK: is transmission controlled by universal access to HIV treatment and care? HIV Med 2013; 14:563–570.

50. Granich RM, Gilks CF, Dye C, De Cock KM, Williams BG. Universal voluntary HIV testing with immediate antiretroviral therapy as a strategy for elimination of HIV transmission: a mathematical model. Lancet 2009; 373:456–57.

51. US Department of Health and Human Services. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. 2012. http://aidsinfo.nih.gov/guidelines.

52. Quinn TC, Wawer MJ, Serwadda D, Li C, Walbire-Mangen F, et al. Viral load and heterosexual transmission of human immunodeficiency virus type 1 in Africa. AIDS Res Hum Retroviruses 2001; 17:901–910.

53. Tovanabutra S, Robison V, Wongtrakul J, Sennum S, Suriyawan V, Kingkeow D, et al. Male viral load and heterosexual transmission of HIV-1 subtype E in northern Thailand. J Acquir Immune Defic Syndr 2002; 29:273–283.

54. Atta S, Egger M, Müller M, Zwahlen M, Low N. Sexual transmission of HIV according to viral load and antiretroviral therapy: systematic review and meta-analysis. AIDS 2009; 23:1307–1404.

55. Donnell D, Baeten JM, Kiarie J, Thomas KK, Stevens W, Cohen CR, et al. Heterosexual HIV-1 transmission after initiation of antiretroviral therapy: a prospective cohort analysis. Lancet 2010; 376:2092–2098.

56. Cohen MS, Chen YQ, McCauley M, Gamble T, Hosseinipour MC, Kumarasamy N, et al. Prevention of HIV-1 infection with early antiretroviral therapy. N Engl J Med 2011; 365:493–505.

57. Rodger AJ, Cambiano V, Bruun T, Vernazza P, Collins S, Van Lunzen J, et al. Association between sexual activity without condoms and risk of HIV transmission in serodifferent couples when the HIV-positive partner is using suppressive antiretroviral therapy: The PARTNER STUDY. JAMA in press.

58. The INSIGHT START Study Group. Initiation of antiretroviral therapy in early asymptomatic HIV infection. New Eng J Med 2015; 373:795–807.

59. World Health Organization. Guideline on when to start antiretroviral therapy and on preexposure prophylaxis for HIV. 2015. http://www.who.int/hiv/pub/guidelines/earlyrelease-av/en/ [Accessed March 2016].

60. British HIV Association guidelines for the treatment of HIV-1-positive adults with antiretroviral therapy. 2015. http://www.bhiva.org/HIV-1-treatment-guidelines.aspx [Accessed March 2016].

61. Vernazza P, Hirschel B, Bernaocchi E, Flepp M. Les personnes séropositives se ne suffisant d’autre autre MST et suivant un traitement antirétroviral efficace ne transmettent pas le VIH par voie sexuelle. Bull des Médecins Suisse 2008; 89(16):69.

62. Hesse B, Lodgergerber B, Hirschel B, Vernazza P, Glass TR, Jeanin A, et al. Frequency and determinants of unprotected sex among HIV-infected persons: the Swiss HIV cohort study. Clin Infect Dis 2010; 51:1314–1322.

63. Crepez N, Hart TA, Marks G. Highly active antiretroviral therapy and sexual risk behaviour: a meta-analytic review. JAMA 2004; 292:224–236.

64. Koziol JA, Attie AR, Chiarella J, Schreibman T, Conman D, Fisher W, et al. Antiretroviral resistance and high-risk transmission behavior among HIV-positive patients in clinical care. AIDS 2004; 18:2185–2189.

65. Van de Ven P, Mao L, Fogarty A, Rawstone P, Crawford J, Prestage G, et al. Immediate viral load and sexual risk behavior is associated with sexual risk taking in HIV serodiscordant gay couples in Sydney. AIDS 2005; 19:179–184.

66. Elford J, Ibrahim F, Bukatu C, Anderson J. Sexual behaviour of people living with HIV in London: implications for HIV transmission. AIDS 2007; 21 (Suppl 1):S63–S70.

67. Seng R, Rolland M, Beck-Wirth G, Souala F, Deveau C, Dellfrassey JF, et al. Trends in unsafe sex and influence of viral load among patients followed since primary HIV-infection. 2000–2009. AIDS 2011; 25:977–988.

68. Stephenson JM, Imrie J, Davis MM, Mercer C, Black S, Copas AJ, et al. Is use of antiretroviral therapy among homosexual men associated with increased risk of transmission of HIV infection? Sex Transm Infect 2003; 79:7–10.

69. Glass TR, Young J, Vernazza PL, Rickenbach M, Weber R, Cavasinni M, et al. Is unsafe sexual behaviour increasing among HIV-infected individuals? AIDS 2004; 18:1707–1714.

70. Morin SF, Myers JJ, Shade SB, Koester K, Maiorana A, Dawson Rose C. Predicting HIV transmission risk among HIV-infected patients seen in clinical settings. AIDS Behav 2007; 11 (Suppl 5): S6–S16.

71. Burman W, Grund B, Neuhaus J, Douglas J Jr, Friedland G, Telzak E, et al. Epidemic antiretroviral therapy increases HIV transmission risk compared with continuous therapy: results of a randomized controlled trial. J Acquir Immune Defic Syndr 2008; 49:142–150.

72. Golin C, Marks G, Wright J, Gerovich M, Tien H, Patel SN, et al. Psychosocial characteristics and sexual behaviours of people in care for HIV infection: an examination of men who have sex with men, heterosexual men and women. AIDS Behav 2009; 13:1129–1142.

73. Harding R, Clucas I, Lampe FC, Norwood S, Leake-Dade H, Fisher M, et al. Behavioural surveillance study: sexual risk taking behaviour in UK HIV outpatient attendees. AIDS Behav 2012; 16:1708–1715.

74. Kalichman SC, Cherry C, White D, Jones M, Grebler T, Kalichman MO, et al. Sexual HIV transmission and antiretroviral therapy: a prospective cohort study of behavioural risk factors among men and women living with HIV/AIDS. Ann Behav Med 2011; 42:111–119.

75. Cunha CB, De Boni RB, Guimarães MRC, Yanavich C, Veloso VC, Moreira RJ, et al. Unprotected sex among men who have sex with living with HIV in Brazil: a cross-sectional study in Rio de Janeiro. BMC Public Health 2014; 14:379.

76. Durham MD, Buchacz K, Richardson J, Huang P, Anderson J, et al. The Ambulatory Care Quality Improvement Project (ACQUIP). Sexual risk behaviour and viral suppression among HIV-infected adults receiving medical care in the United States. AIDS 2014; 28:1203–1211.

77. Malek R, Mitchell H, Furegato M, Simms I, Mohammed H, Nardone A, et al. Contribution of transmission in HIV-positive men who have sex with men to evolving epidemics of sexually transmitted infections in England: an analysis using multiple data sources, 2009–2013. Eurosurveillance 2015; 20:21093.

78. European Centre for Disease Prevention and Control. STI and HIV prevention in men who have sex with men in Europe. Stockholm: ECDC; 2013.

79. Speakman A, Rodger A, Phillips AN, Gilson R, Johnson M, Fisher M, et al. The ‘Antiretrovirals, Sexual Transmission Risk and Attitudes’ (ASTRA) Study. Design, methods and participant characteristics. PLoS ONE 2013; 8:e77730.

80. British HIV Association guidelines for the treatment of HIV-1-positive adults with antiretroviral therapy. 2012. http://www.bhiva.org/HIV-1-treatment-guidelines-2012.aspx.

81. Zou C. A modified Poisson regression approach to prospective studies with binary data. Am J Epidemiol 2004; 159:702–706.

82. Bush K, Kivlahan DR, McDonell MB, Fihn SD, Bradley KA for the Ambulatory Care Improvement Project (ACQUIP). The AUDIT alcohol consumption questions (AUDIT-C): an effective brief screening test for problem drinking. Arch Intern Med 1998; 158:1789–1795.
40. Daskalopoulou M, Rodger A, Phillips AN, Sherr L, Speakman A, Collins S, et al. Recreational drug use, polydrug use, and sexual behaviour in HIV-diagnosed men who have sex with men in the UK: results from the cross-sectional ASTRA study. Lancet HIV 2014; 1:e22–e32.

41. Rodger AJ, Lampe FC, Gaulich AE, Fisher M, Friedland G, Phanuphak N, et al. for the International Network for Strategic Initiatives in Global HIV Trials (INSIGHT) START Study Group. Transmission risk behaviour at enrolment in participants in the INSIGHT Strategic Timing of AntiRetroviral Treatment (START) trial. HIV Med 2015; 16 (Suppl 1):64–76.

42. Crepaz N, Marks G, Liau A, Mullins MM, Aupont LW, Marshall KJ, et al. for the HIV/AIDS Prevention Research Synthesis (PRS) Team. Prevalence of unprotected anal intercourse among HIV-diagnosed MSM in the United States: a meta-analysis. AIDS 2009; 23:1617–1629.

43. Hickson F, Bourne A, Weatherburn P, Reid D, Jessup K, Hammond G. Tactical dangers: findings from the United Kingdom Gay Men’s Sex Survey, 2008. London: Sigma Research; 2010.

44. c JT, Schrimshaw FW, Wolitski RJ, Halkitis PN, Purcell DW, Hoff CC, et al. Sexual harm reduction practices of HIV seropositive gay and bisexual men: serosorting, strategic positioning, and withdrawal before ejaculation. AIDS 2005; 19 (Suppl 1):S13–S25.

45. Jin F, Crawford J, Prestage GP, Zablotska I, Imrie I, Kippax SC, et al. Unprotected anal intercourse, risk reduction behaviours, and subsequent HIV infection in a cohort of homosexual men. AIDS 2009; 23:243–252.

46. Mao L, Kippax SC, Holt M, Prestage GP, Zablotska IB, de Wit JB. Rates of condom and noncondom-based anal intercourse practices among homosexually active men in Australia: deliberate HIV risk reduction? Sex Transm Infect 2011; 87:489–493.

47. Bourne A, Reid D, Hickson F, Torres Rueda S, Weatherburn P. The Chemsex study: drug use in sexual settings among gay & bisexual men in Lambeth, Southwark & Lewisham. London: Sigma Research; 2014, www.sigmaresearch.org.uk/chemsex [Accessed March 2016].

48. Kelley CF, Haaland RE, Patel P, Evans-Strickfaden T, Farshy C, Hanson D, et al. HIV-1 RNA rectal shedding is reduced in men with low plasma HIV-1 RNA viral loads and is not enhanced by sexually transmitted bacterial infections of the rectum. J Infect Dis 2011; 204:761–767.

49. The Swiss Statement and its repercussions. http://www.aidsmap.com/The-Swiss-Statement-and-its-repercussions/page/1746478/ [Accessed March 2016].

50. EACS European AIDS Clinical Society guidelines, version 7.1. 2014. http://www.eacsociety.org/guidelines/guidelines-archive/archive.html.

51. World Health Organization consolidated guidelines on the use of antiretroviral drugs for treating and preventing HIV infection. 2013. http://www.who.int/hiv/pub/guidelines/arv2013/en/ [Accessed March 2016].

52. Persson A. The world has changed: pharmaceutical citizenship and the reimagining of serodiscordant sexuality among couples with mixed HIV status in Australia. Social Health and Illness 2016; 38:380–395.