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Prevalence and frequency of heterosexual anal intercourse among young people: A systematic review and meta-analysis

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Abstract:	We aim to assess if heterosexual anal intercourse (AI) is commonly practiced and how frequently it is practiced by young people. We searched PubMed for articles published 1975 to July 2014 reporting data on the proportion of young people (mean age <25) practicing heterosexual AI (AI prevalence) and on number of AI acts (AI frequency). Stratified random-effects meta-analysis and meta-regression were used to produce summary estimates and assess the influence of participant and study characteristics on AI prevalence. Eighty-three and thirteen of the 136 included articles reported data on lifetime AI prevalence and monthly AI frequency, respectively. Estimates were heterogenous. Overall summary estimates of lifetime AI prevalence were 22% (95% confidence interval (CI) 20-24%) among sexually active young people, with no statistically significant differences by gender, continent or age. Prevalence increased significantly with confidentiality of interview method and, among males and in Europe, by survey year. Prevalence did not significantly differ by recall period. An estimated 3-24% of all reported sex acts were AI. Reported heterosexual AI is common but variable among young people worldwide. To fully understand its impact on STI spread, more and better quality data on frequency of unprotected AI, and trends over time are required.
Response to Reviewers:	

Prevalence and frequency of heterosexual anal intercourse among young people: A systematic review and meta-analysis

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Introduction

HIV is very effectively transmitted by both heterosexual and homosexual unprotected anal intercourse (UAI)[1,2]. However, the role of UAI as a determinant of heterosexual HIV epidemics has not been sufficiently examined[1–4].

A previous meta-analysis estimated the risk of HIV transmission in developed countries as 1.4% (95% confidence interval (CI) 0.2-2.5%) during a single receptive UAI act compared to 0.08% (CI:0.06-0.11%) during unprotected vaginal intercourse (UVI)[1]. This suggests that women may have an 18-fold higher HIV acquisition risk per UAI act compared to UVI. Even if a small fraction of all sex acts are UAI, AI may substantially contribute to HIV transmission and, at the population level, it may be as important as acute stage HIV (the first months following HIV infection, when infectivity is higher than during the asymptomatic stage)[5–7]. Intervention programmes that focus on reducing UAI may be easier to implement than those required to test and treat for recent infection, especially given the difficulties in identifying acute cases[5,7,8].

Understanding the patterns of heterosexual AI practice is also important for controlling other sexually transmitted infections (STIs), in particular human papilloma virus (HPV), especially given the reported increase in incidence of anal cancer in heterosexuals as well as homosexual men[9–11]. Due to the high infectivity of HPV, even infrequent practice of AI may impact patterns of anal infection and cancers, especially if initiated when young[12,13].

The practice of heterosexual AI has been reported in many articles. However, the extent to which it is practised and how often it is practised by age, risk population, country and over time have not been comprehensively described. It is particularly pertinent to examine these patterns among young people given their greater vulnerability to STI and HIV infection[14]. This review aims to address this gap and to systematically review and summarise published estimates from self-reported sexual behaviour data on the proportion of heterosexual young people who have had AI and the number of anal sex acts over various recall periods, and to understand the source of variation in AI practice by gender, risk group, region, mean age and interview method.

Methods

This systematic review was undertaken in accordance with MOOSE[15] and PRISMA guidelines[16].

Search strategy

The search was conducted in six steps. First, we searched PubMed from 1975 up to 30th September 2010 for peer-reviewed articles using the following terms in all fields ((anal AND (sex OR intercourse)) OR (HIV AND (sexual OR sexually transmitted infections)) AND behaviour AND (survey OR trial) AND heterosexual). Second, we screened the resulting titles and abstracts to identify all articles that reported on heterosexual sexual behaviour, even if AI was not mentioned in the abstract.

Third, we searched full text versions of articles for data on number of AI acts (i.e. AI frequency) and/or percentage of study participants reporting heterosexual AI, which

we refer to as AI prevalence, over different recall periods. We identified articles on heterosexual young people defined as articles reporting on participants with mean age <25 years (following the UN's definition of young people as aged 10-24 years[17]) and retained those on older adult populations for future analysis. We used mean age, rather than age range so as not to exclude samples containing small numbers of participants 25 years or older (typical in samples of university students). We included also articles which reported AI data on other age groups, extracting only data on young people. Fourth, we updated and extended the search from 1975 to 31st July 2014, expanding the search to Embase, PsycINFO and Medline in addition to PubMed, using the initial search terms as well as the following terms designed to identify articles on young people: Anal AND sex AND (adolescents OR young OR youth OR school OR university) AND (heterosexual OR females OR girls OR women). Searches included MeSH terms in PubMed and 'related terms' in the other databases.

Fifth, we scanned bibliographies of included articles as well as relevant review articles to identify other potentially eligible articles. Sixth, we applied the following inclusion and exclusion criteria:

Cross-sectional studies, cohort studies or randomised control trials (RCTs) that reported estimates or the relevant data from which it was possible to calculate the prevalence and/or frequency of heterosexual AI over any recall period among study participants with a mean age of less than 25 years were included. Articles were excluded if they reported no data on heterosexual AI, if data on heterosexual AI were indistinguishable from homosexual AI or from VI or other sexual acts, if the article

language was not English language, or if study participants were selected based on having AI experience.

Data extraction

We defined a priori the variables to be extracted. We used a standard procedure to extract data to a spreadsheet, with one reviewer extracting the data (BNO) and data extraction verified by one of two reviewers (ARB or PMB).

We extracted, or where necessary, calculated the numerator, denominator and proportion of respondents (equations available in supplementary material) reporting AI and VI over a given recall period. For AI frequency data, we extracted the number of AI and VI acts and extracted or calculated proportion of sex acts that were AI over a given recall period (equations available in supplementary material). Both frequency and prevalence data were extracted for all recall periods reported. In addition we extracted participant and study characteristics, including factors reflecting methodological quality (e.g. study design, sampling strategy, response rate).

Baseline data only were extracted from intervention studies and cohort studies. Where multiple articles reported on the same sample of participants (wholly or partially), the publication with the largest sample size or with the most information on AI (if the sample size was the same) was included. Authors of eligible articles were contacted if key variables of interest, (AI and VI recall period, study type, sampling method, interview method, mean age or survey year) were not reported. When we were not able to contact authors, or received no reply, we assumed the mid-range value for mean age.

Data synthesis and statistical methods

Our main outcome of analysis was lifetime AI prevalence (i.e. fraction reporting ever having practised AI), as this was the most commonly reported recall period. First, we calculated overall summary estimates and CI for lifetime AI and VI prevalence among all young people and among those sexually active (i.e. restricted to those who reported ever engaging in VI) by risk population. Populations were defined as "non-higher risk" to reflect samples from populations such as schools and the community, or "higher risk" to reflect samples from STI clinic patients or marginalised groups such as young, homeless people. Second, we produced forest plots and calculated separate summary estimates and CI for lifetime AI prevalence among sexually active young people in three subsets of study estimates: males, females and articles which provided only combined estimates for males and females (i.e. mixed gender). Third, we used sub-group analysis to examine the effect of interview method, survey year, mean age of sample and continent as well as variables related to methodological quality (study design, sampling method and response rate) on lifetime AI prevalence across articles by gender.

Additionally, an explanatory analysis examined condom use, age at first AI and VI, number of lifetime sex partners and alcohol use (both having drunk alcohol in lifetime and having sex under the influence of alcohol in lifetime) in the subsets of articles in which they were reported. Where explanatory variables were reported by a very small number of articles, their effect on lifetime AI prevalence was examined across gender groups, rather than stratifying by gender. Fourth, we used univariate random-effects meta-regression models to test whether these variables explained significant

amounts of variation in lifetime AI prevalence. All models were fitted and summary estimates derived using maximum-likelihood random-effects models based on inverse-variance [18–20] with the procedure 'Metafor'[21] in R version 2.14.1[22].

In addition to this analysis of lifetime AI prevalence, random-effects summary estimates of AI prevalence over shorter recall periods, as well as frequency of condom use during AI and VI, were compared. Data on the frequency of AI acts were tabulated but could not be analysed in detail due to the small number of included articles and the inconsistency of presentation of outcomes. To enable comparison across articles which reported AI acts by different recall periods, we calculated the number per month (e.g. divided number of sex acts reported over three months by three).

Dealing with Heterogeneity

Heterogeneity across study estimates was investigated using I^2 statistics, with <0.05 p-value used to determine significance[23,24]. As our review includes diverse populations of young people from different countries, we anticipated significant heterogeneity in prevalence estimates across articles. To account for this, we used random-effects models[25,26] for the meta-analysis and interpreted the results of sub-group analysis in conjunction with meta-regression results, as advocated by Ioannidis et al.[27].

Dealing with bias

The effect of different aspects of methodological quality (study type, sampling method and response rate), and thus the impact of various biases on lifetime AI were

explored through sub-group and univariate analysis as described above. Social-desirability bias was explored through assessing effect of interview method on reported AI prevalence. Selection bias was reduced by excluding articles which selected participants based on experience of AI.

We explored publication bias by funnel plot. Additionally, we examined the effect of section in the articles where AI was first mentioned: namely: title, abstract, main text or in tables, and examined the relationship with reported lifetime AI prevalence through sub-group and univariate analysis using methods described above, as it is possible that authors may be more likely to include or highlight AI data when prevalence is higher.

Results

Search results

Figure 1 summarises the study selection procedure and search results. Of the 13,016 abstracts initially identified, 136 unique articles were included. Most articles were identified from the database searches, with only eight (out of 23 initially identified) additional eligible articles identified through bibliography scanning. In total, additional information was obtained from 11 of the 32 authors contacted. A list of excluded articles is available on request.

Study and participant characteristics

Table I provides a summary of the characteristics of the included articles and details of individual articles are available in Table SI. AI and VI prevalence estimates were provided or could be derived from 133 and 114 articles, respectively. Only thirteen

articles provided data on frequency of AI. The most common study design was cross-sectional, with few RCTs or cohort studies (N=114, 13 and 8, respectively). The majority of studies used convenience sampling, (N=85), with only 23 and 21 employing cluster random sampling (CRS) and simple random sampling (SRS), respectively. Response rate was not reported by a majority of articles (N=71). Of the articles which did report it, 33 had a response rate ≥80%, with 32 reporting a rate of <80%. The majority of articles first mentioned AI in the abstract (N=92), followed by the in title (N=22), the text (N=19) and in tables (N=2).

More articles reported on females (N=101) than on males (N=49), partly reflecting the exclusion of male samples in articles that reported combined homosexual and heterosexual AI. Thirty articles reported only by mixed gender. More articles reported AI prevalence over a lifetime (N=83) than over shorter recall periods (N=45); with 'past three months' being the next most common (N=22). Eight articles reported over shorter periods in addition to lifetime prevalence. A sizable number (N=15) of articles failed to report a recall period and could not be analysed (they tended to be older articles with publication years ranging from 1978 to 2002). Self-administered questionnaire (SAQ) was the most common interview method employed (N=80) followed by face-to-face interview (FTFI) (N=29), audio computer assisted self-interview (ACASI) (N=25 and telephone interview (N=2).

More articles were published before 2004 (N=80), than after (N=57). Most articles were conducted in North America (N=94), followed by Europe (N=17), Africa (N=16), Asia (N=6) and Latin America (N=5). More articles reported on young people with mean age ≥18 years (N=86), than with mean age <18 years (N=52).

Twenty-seven articles reported on higher risk populations, defined as STI clinic patients or marginalised groups such as homeless young people. One-hundred and ten articles reported on non-higher risk populations of young people such as school and university students and representative samples from national surveys. One study reported on both higher- and non-higher risk young people.

Few articles reported on alcohol or condom use, number of sex partners, age at first AI or VI (Table I). Five articles were series cross-sectional, reporting prevalence among different samples of the same population over multiple time points[28–32], while two waves of two large national surveys were each reported in separate articles[33–36].

TABLE I

Meta-analysis: Lifetime AI and VI prevalence among all young people

Among all (both sexually active and inactive, higher- and non-higher risk) young people, 83 articles reported lifetime AI prevalence estimates. These displayed considerable heterogeneity, ranging from 0.0% to 57.1%. Summary estimates were similar between males at 17.1% (CI:12.7-21.5%) and females at 15.5% (CI:13.1-17.9%) (Table II). Lifetime AI prevalence was considerably higher, approximately doubled, among higher risk populations across all gender groups. Lifetime VI prevalence ranged from 0.0% to 100.0% across all articles, with a summary estimate of 71.3% (CI:63.0-79.7%) and 70.1% (CI:63.5-76.8%) among all males and females respectively (Table II).

Of the variables interview method, survey year, continent and mean age of sample explored in univariate regression analysis among articles of non-higher risk young people, only mean age was significantly, and positively, associated with lifetime prevalence of both AI and VI (Tables SIIa&b). However, non-significantly higher summary estimates were observed in Europe and North America than other continents.

Lifetime AI prevalence among sexually active non-higher risk young people

Given the strong positive association between lifetime AI and VI prevalence (R^2=44.4, p-value<0.0001, Fig. S1a) and the high proportion of sexually inactive respondents (i.e. reporting no VI), particularly in articles from Africa, Asia and Latin America, we examined AI prevalence among the sexually active proportion of each study sample in more detail (for the purpose of this analysis, defined as those reporting ever engaging in VI) otherwise most of the association would likely reflect only difference in the proportion sexually active.

Tables IIIa-c provide results for non-higher risk males, females and mixed gender. AI prevalence was heterogeneous and ranged from 4.6-61.7% (N=22), 1.7-48.1% (N=51) and 0.0-45.7% (N=16) in sexually active male, female and mixed samples respectively (Fig. 2a-c). Summary estimates were similar between males, at 22.7%, (CI:17.4-28.1%) and females at 21.5% (CI:18.7-24.3%) (Tables II).

Of the variables examined in order to assess the effect of methodological quality and bias; study design and response rate non-significantly explained little heterogeneity in AI prevalence, although in sub-group analysis, the summary estimate for cohort studies was significantly lower than for cross-sectional studies among females (Tables IIIa-c). Comparisons between study groups were not possible among males and mixed gender as all but one were cross-sectional. In univariate analysis, sampling method was borderline significant among males only. In sub-group analysis, summary estimates were non-significantly higher for CRS and SRS compared to convenience sampling among males and for SRS among females, but not mixed gender(Tables IIIa-c).

Interestingly, the place in article where AI was first mentioned significantly explained a fraction of the variation across study estimates for males (R^2=21.3) and females (R^2=10.1), but not mixed gender when examined in univariate analysis. Summary estimates tended to be higher the earlier AI is mentioned, although the difference was not significant in any gender group (e.g. title=27.7% CI:23.2-32.2%, abstract=21.6% CI:18.3-25.0%, text=16.2% 9.3-23.1% among females). Interview methods were significantly associated with variation among males and females, but not mixed gender, with summary estimates increasing with confidentiality of method (e.g. FTFI=13.7% CI:7.7-19.6%, SAQ=21.4% CI:18.5-24.7%, ACASI=31.1% CI:25.6-36.7% among females).

In univariate analysis, survey year significantly explained 15.4% of heterogeneity in prevalence among males, but none among females or mixed gender (Tables IIIa-c). In sub-group analysis, summary estimates increased substantially from pre-2004

and 2004 onwards among males and females, although not significantly. When time trends were examined by continent, all summary estimates for 2004 onwards were higher than pre-2004 summary estimates. This, however, was only statistically significant in Europe, where survey year explained 65.2% of variation in prevalence, with summary estimates nearly doubling between pre-2004 (18.2% (CI:14.2-22.3%) and 2004 onward (33.7%,CI:28.8-38.6%) (Table SIII). Four of the six time-series cross-sectional studies (i.e. studies repeated with different samples of the same population over time) found a significant increase in AI prevalence over time[28,32–36] (the two which did not were smaller and conducted before 1990[30,31]). Neither continent (Fig. 2a-c) nor mean age explained variation in AI prevalence among any gender group (Tables IIIa-c).

Explanatory analysis

The effect of number of lifetime sex partners, age at first VI and AI and alcohol use on lifetime AI prevalence were examined in the subsets of articles in which these variables were reported (listed in Table I). In univariate analysis, lifetime sex partners significantly explained 65.8% of heterogeneity in prevalence among females and 24.9% among mixed gender youth, although the latter was only borderline significant (Tables IIIa-c). In subgroup analysis among females, but not males, summary estimates increased with number of sex partners, but this was not significant (Table IIIb). Age at first VI was not associated with AI prevalence among males or females, but did significantly explain 47.1% of variability among mixed gender youth (Table IIIc).

When examined among the small subset of articles available independently of genders of the study participants, AI prevalence was not significantly associated with age at first AI (Table SIII). Lifetime prevalence of alcohol use (i.e. ever drank alcohol) was not associated with AI prevalence, but alcohol use with sex (i.e. ever had sex under the influence of alcohol) significantly accounted for substantial heterogeneity (R^2=83.1%, p-value=0.03), although this is from a very small number of articles (N=4) (Table SIII).

TABLE III a-c HERE

Condom use during AI and VI

Condom use during AI and VI was reported in 22 and 33 articles respectively. As condom use was reported over varied and often unclear periods, we analysed unprotected sex over the most frequent recall periods which were: frequent unprotected sex (i.e. proportion of respondents reporting 'never' or 'rarely' using condoms, N=8), any unprotected sex over past three months (N=6), and no condom use at last sex (N=11), (Table SIV). Given the small number of articles reporting for each recall period, we combined gender groups for the analysis.

The summary estimate for any AI that was unprotected was higher than for any VI over past three months and at last sex, although the difference between UAI and UVI was significant only at last sex (summary estimates 48.8% (CI:40.9-56.8%) for last VI, 70.1% (95% CI:64.2-76.0%) for last AI. This analysis was hindered, however, by the small sample sizes in each category (Table SIV).

Frequency of AI acts

Of the thirteen articles reporting monthly AI frequency data, all but two were conducted in the US (Table IV). Ten reported on non-higher risk and three on higher risk young people. Some articles reported frequency among the subset of participants who reported AI[37–41], whereas other articles reported among all study participants, including those who only practise VI or are sexually inactive[42–49]. Frequency recall period varied from one day to 12 months, with three months the most common (N=7). Number of sex acts per month was calculated to enable comparison across articles. Given the diversity of reporting methods and outcomes, we were not able to produce summary estimates for frequency data.

Across the articles which provided frequency data among those reporting AI, the number of AI acts per month ranged from 0.1 to 4.3 (N=4)[37–41] and the number of UAI acts 0.4-3.4 (N=2)[37,41]. The fraction of sex acts which were AI was 3.0-8.5% in females (N=3) and 3.0-24.7% in males (N=3)[38,39,41].

AI frequency appeared to vary by both AI prevalence and frequency recall period, with higher monthly frequency reported when the original recall period was shorter. For example, among studies on non-higher risk populations from the US that reported frequency of AI acts across the whole sample, 20.5% of sex acts were AI in the two articles which reported over one day and 6.4% at last sex compared to 1.1% and 5.4% reported in the two studies with recall periods of three months [42,47]. These observation may, however, be confounded by AI prevalence recall period, which also seems to explain some variation in frequency. For example, among those reporting AI, the number of AI acts per month was higher among those reporting AI

in the past three months (4.3 acts/month) than AI during lifetime (0.1-2.2 acts/month). Comparatively, the monthly average of VI acts varied between 2.8-15.4 across both genders (N=9).

Based on the few data available, 3.0-24.7% (from the minimum and maximum frequencies reported by the relevant articles) of all sex acts may be AI among non-higher risk youth who report AI[38,39,41]. Similarly, 1.1-20.6% of all sex acts in a month may be AI among the whole sample[42–44,47–49] (N=6). (Table IV). Percentage of AI acts which were unprotected was high in the three articles in which it was possible to calculate it, ranging from 55-79% among non-higher risk [37,41,49]and 56-82% among higher risk youth[40].

TABLE IV HERE

Shorter recall periods among sexually active young people

AI prevalence estimates over recall periods shorter than lifetime prevalence were reported in a smaller subset of articles, with past three-month the most frequent (N=22). Three-month prevalence was very similar to that of lifetime prevalence among both non-higher and higher risk young people (Table V). For example, three-month summary estimates among non-higher risk were 23.9% (CI:10.8-37.0%) for males and 21.2% (CI:12.5-29.8%) for females compared to 22.7%, (CI:17.4-28.1%) for males and 21.5% (CI:18.7-24.3%) for females for lifetime prevalence (Table SV). Summary estimates for each of the other, less frequently reported recall periods were not statistically different to lifetime prevalence, with the exception of first sex act among males, although the numbers of estimates were too small to be conclusive.

Discussion

Heterosexual AI is common among young people worldwide, although patterns appear to vary substantially both within and between groups and regions. While it is clear that many young people experience AI, it is unclear how regularly it is practised. The available data suggest that condoms are used less frequently during heterosexual AI than during VI.

Lifetime AI prevalence increases with age among all young people (including some sexually inactive), but not among the sexually active, which may suggest that those who are sexually active at younger ages (<16 years) engage disproportionally in AI (Fig. S1b). This finding is corroborated by a study in Zambia, which found that AI was the first sex act of 9% of primary school girls, and 0% of secondary school girls[50].

AI prevalence did not vary by recall period, which may indicate that individuals who initiate AI continue to practise it. Alternatively, differences may be obscured by reporting bias, with more accurate reporting of behaviours over shorter recall periods. The latter conjecture is supported by a meta-analysis examining reported sexual behaviour over different recall periods, which found greater accuracy in reporting of AI over 30 days compared to six months[51].

AI is a highly stigmatised behaviour in many populations and thus its reporting is likely subject to social desirability bias. Therefore, it may be more accurately

reported using more confidential interviewing methods[52]. Our review found significantly higher prevalence reported using ACASI, followed by SAQ and FTFI, although as articles using ACASI tended to be more recent (all after 2002); this finding may be confounded by increasing AI prevalence over time. Studies conducted in South Africa provide a good illustration of the substantial heterogeneity found in reported AI prevalence, some of which is likely a result of bias in reporting this stigmatised behaviour. In Cape Town alone, the two estimates of lifetime AI prevalence among sexually active school students (14-15 years) vary widely: from 56% in one study of randomly selected young people throughout the city using ACASI[53], to 6% and 15% using SAQ and ACASI methods respectively, in a smaller study of a single school year of the same age[54]. Studies employing FTFI reported the lowest lifetime AI prevalence in the country, with a national survey reporting 5% among the sexually active[55], while two vaginal microbicide trials found <2% prevalence[56,57].

Only one study in our review directly compared AI prevalence using different interview methods, but their findings of higher reported prevalence using more confidential methods are supported by other studies[54]. For example, 3.5% of married men in Cotonou, Benin reported lifetime AI in a FTFI, but 17.5% using the more anonymous polling booth survey (PBS) method[58]. Discrepancies in reporting between more and less confidential interview methods imply that effort should be made to develop and utilise more reliable tools to gather data on stigmatised behaviours.

There is a popular opinion that heterosexual AI is on the increase[59]. Anecdotally, general practitioners at US universities have reported an increasing number of female students presenting with anal fissures caused by AI[60]. Some authors have linked recorded increases in AI practice to increased exposure to pornography at young ages, arguing that it causes a de-stigmatisation of anal sexual behaviour[28,61]. Higher AI prevalence has been found among Swedish and US adolescents exposed to online pornography[62,63]. Participants in a qualitative study on AI among 16-18 year olds in England frequently cited pornography as a main reason for young people practising AI, although the authors argue that this explanation is simplistic[64].

We found some evidence in this review to support the argument that AI prevalence is increasing, but it is difficult to separate an actual change in prevalence from a possible lessening in social stigma and thus a reduction in social desirability bias. Although our meta-analysis found a significant increase in AI prevalence over time only in males and among European youth, an increase was reported by series cross-sectional studies. Prevalence among Swedish female university students was found to increase by 12.1 percentage points over 10 years, and national surveys from the US and Croatia reported increases of 2.2% points over 4 years and 8.3% points over 5 years respectively among sexually active females, with similar increases among males[28,33,34,61]. This discrepancy between our meta-analysis findings and the findings of the series cross-sectional studies may be explained by the comparatively greater diversity in study populations and survey methods seen across the articles in this review, introducing greater heterogeneity and making it more difficult to conclusively identify trends.

This study has a number of limitations. We searched for published studies through established databases and through reference scanning and, did not include non-English language articles, and thus may have missed some eligible articles. This criteria, however, is unlikely to have influenced results much given the large number of articles included and the small number of eligible articles that were excluded on the basis of language (N=3). Where the survey year and mean age of the sample was not reported and attempts to contact authors were unsuccessful, we approximated it from available information in order to carry out the analysis. Our use of mean age, rather than maximum age as the upper cut-off, meant that small numbers of older adults are also included in some of the articles in this review, particularly from samples of university students. However, given that lifetime prevalence among the sexually active did not differ significantly by study sample (data not shown) or by age, it is unlikely that this has affected our findings. As a significant amount of heterogeneity remains unexplained, it is possible that we may have failed to identify possible explanatory variables due to inconsistency of reporting.

Other than the previously discussed social-desirability bias, other biases could have affected the results of this meta-analysis. Selection bias may have been introduced if study populations were chosen a priori for their perceived higher risk. Our use of engagement in VI as the definition of sexual activity may mask the practice of AI by those who hadn't initiated VI, however this may be small since two US studies indicate may be 1% and a study in Zambia with small sample size indicates may be approximately 4%[50,65,66].

Many articles reported incompletely on sexual behaviour, which in turn limited the scope of this review. Data on males from several articles were excluded for failing to report homosexual and heterosexual AI separately, while other articles were excluded for compiling AI practice together with other sexual activities. Of the 136 included articles, 30 failed to report separately by gender and 15 failed to report the recall period of AI prevalence. The dearth of data from Asia and Latin America hindered examination of trends by continent. Most of the included articles had small sample sizes, with a paucity of data from larger population-based studies. Our estimates for AI frequency are based only on the handful of articles which reported it. We focused our analysis on lifetime prevalence of AI as this was overwhelmingly the most common recall period. Shorter recall periods are, however, more epidemiologically relevant and useful.

This review has a number of strengths and makes a valuable contribution to understanding this neglected sexual risk behaviour. We have included a large number of studies, including also those which did not report AI data in the abstract, thus minimising reporting bias. Had we searched for and included only articles which referred to AI in the title or abstract our summary estimates would likely have been higher (Fig. S3).

Directions for future research

To assess the contribution of AI to transmission within heterosexual HIV and STI epidemics, information is required on frequency of heterosexual AI, with whom it is practised and whether it is condom protected[7]. Unfortunately, only 22 of 136 articles reported on condom use during AI and fewer still (N=13) reported on

frequency of AI, which is vital to understanding AI's contribution to HIV and other STI epidemics.

Given the ubiquity of AI across diverse heterosexual populations, we recommend that questions on its practice be routinely included in surveys on sexual behaviour, particularly in repeated national surveys. In order to obtain more reliable estimates, more confidential methods should be employed, thus reducing social-desirability bias. In order to obtain more epidemiologically useful estimates, surveys should report AI prevalence over shorter recall periods such as past three months as well as data on the frequency of protected and unprotected AI acts.

Such data could powerfully inform the extent to which AI impacts on HIV, HPV and other STI epidemics. Better monitoring AI practice would enable increases in risk over time to be identified and would identify populations requiring intervention.

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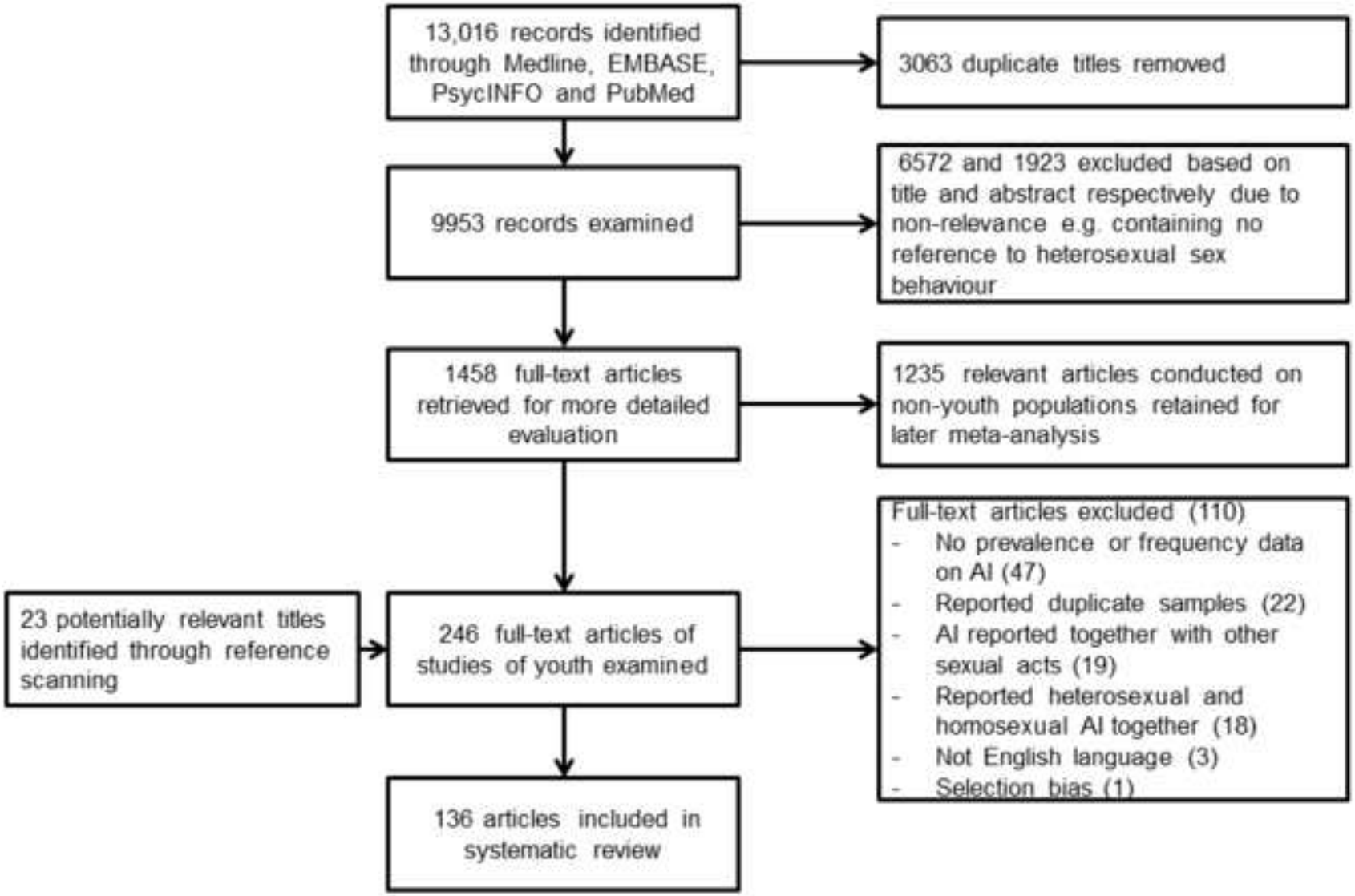

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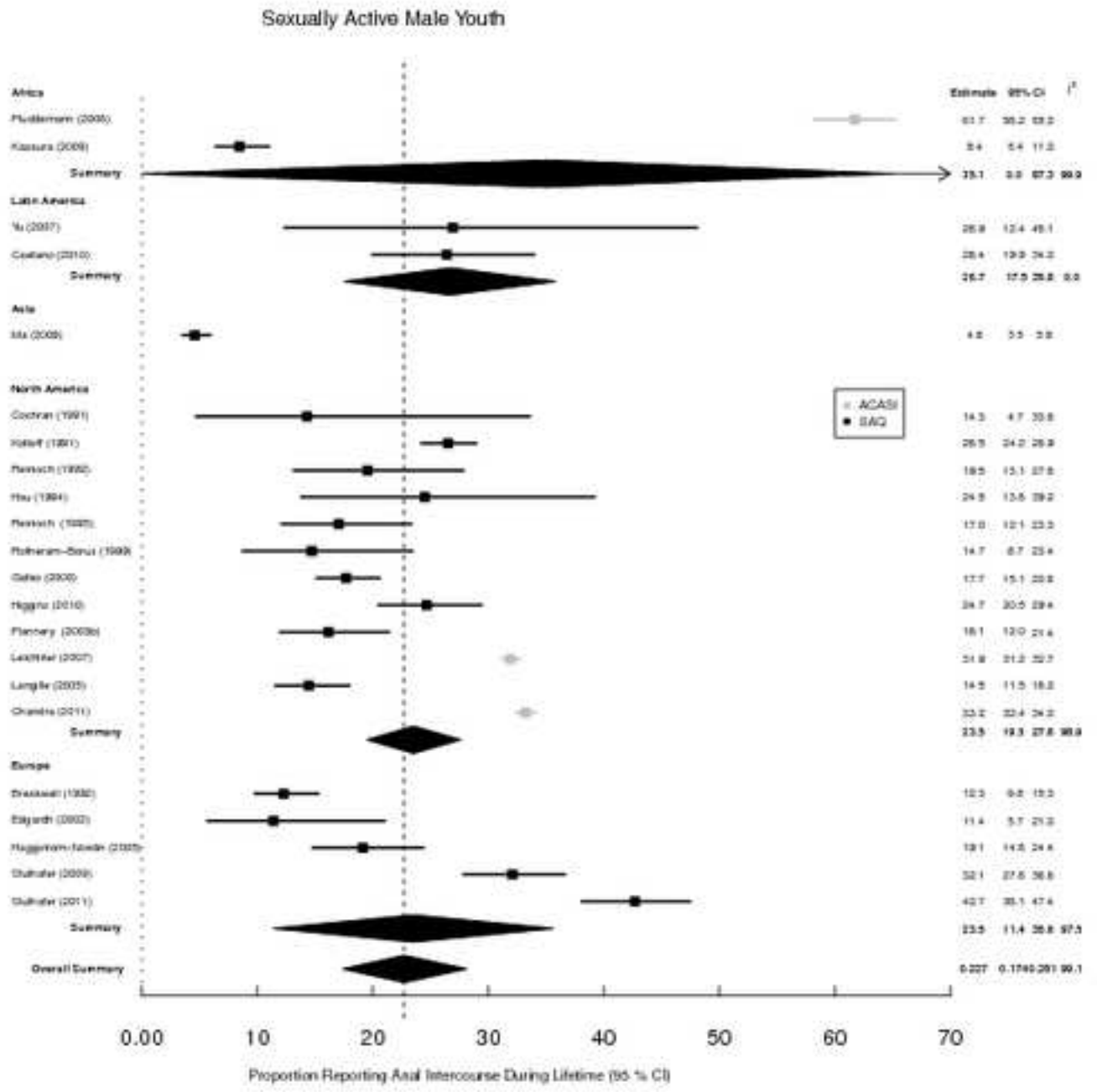

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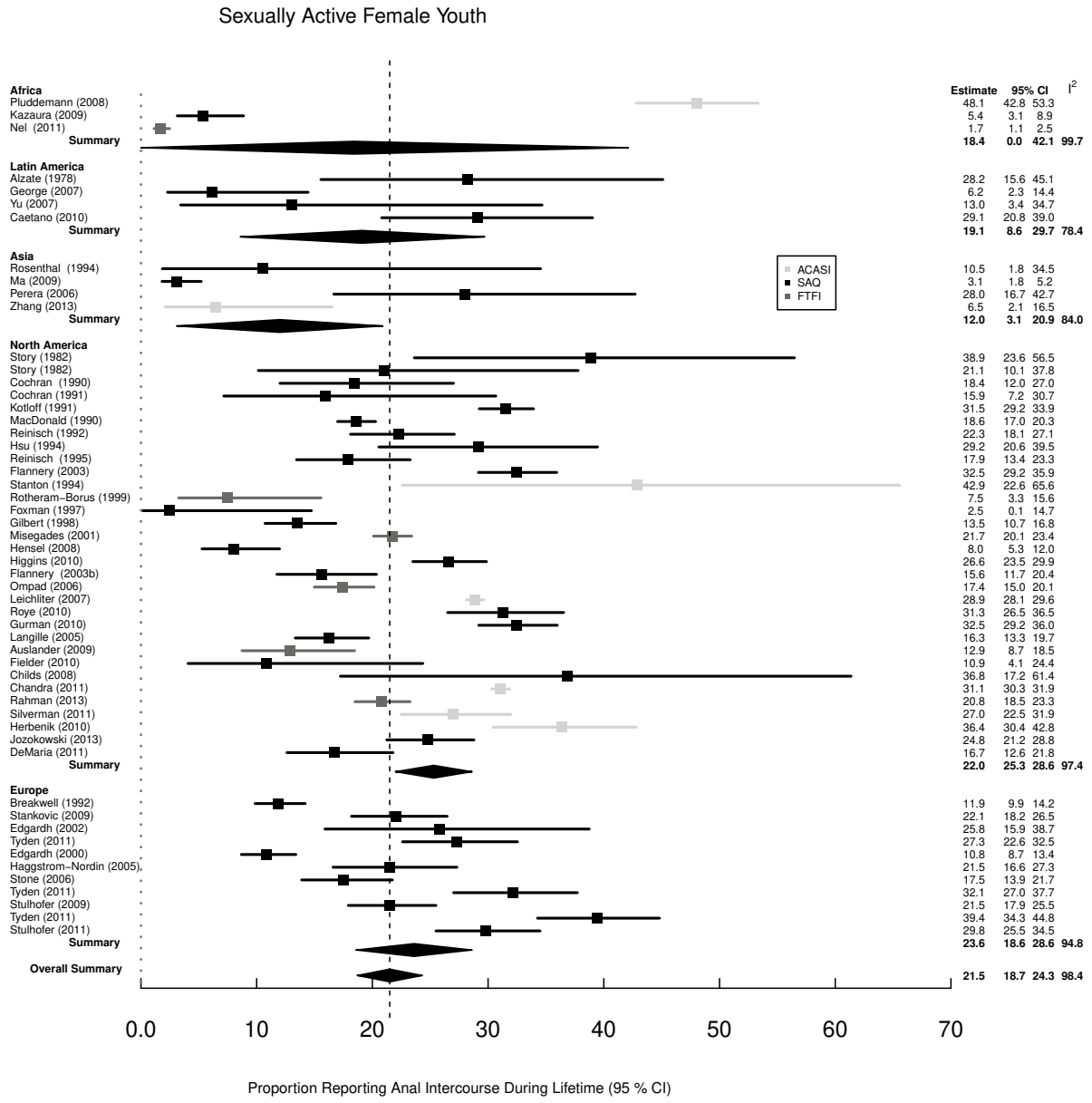

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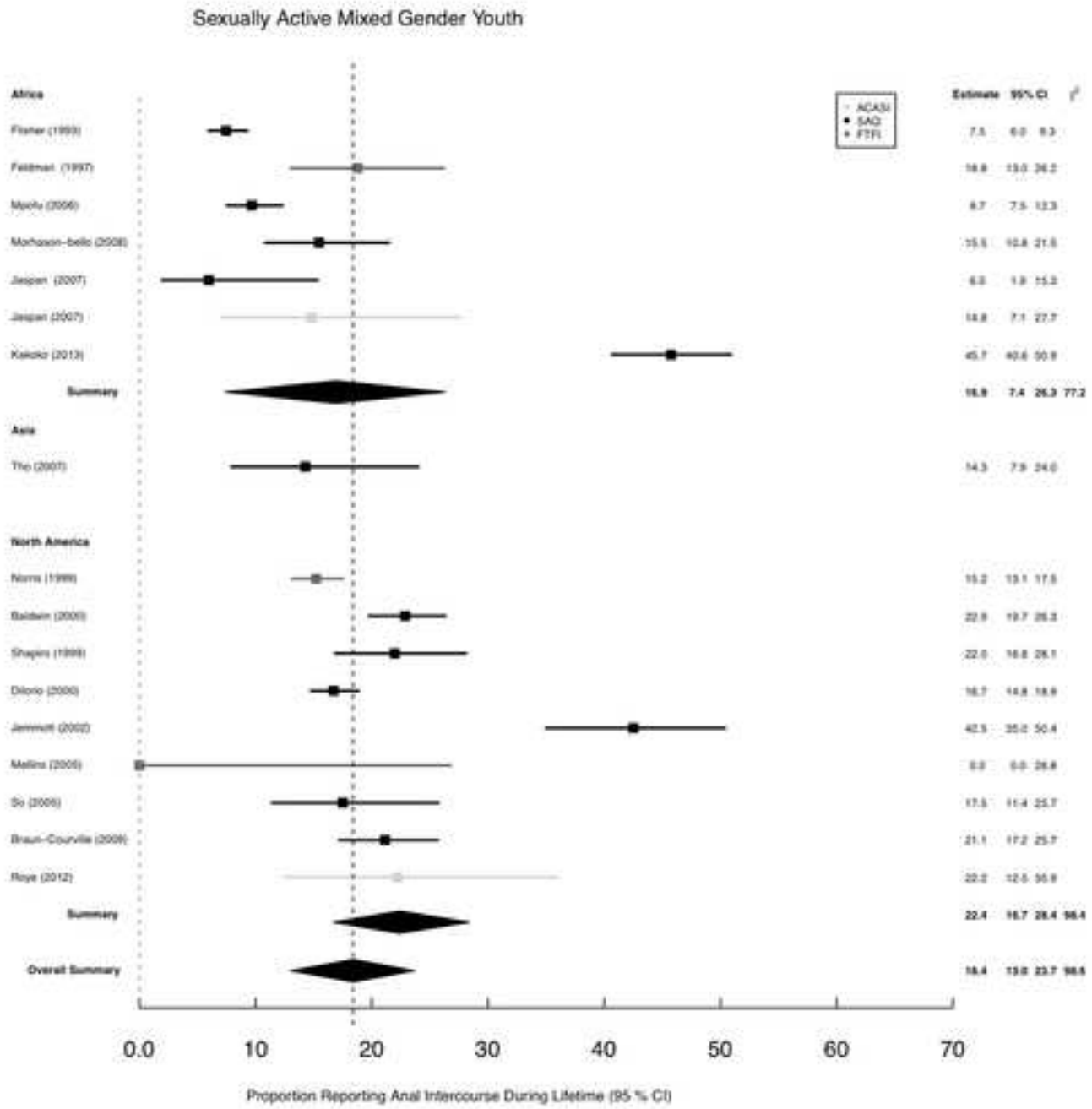

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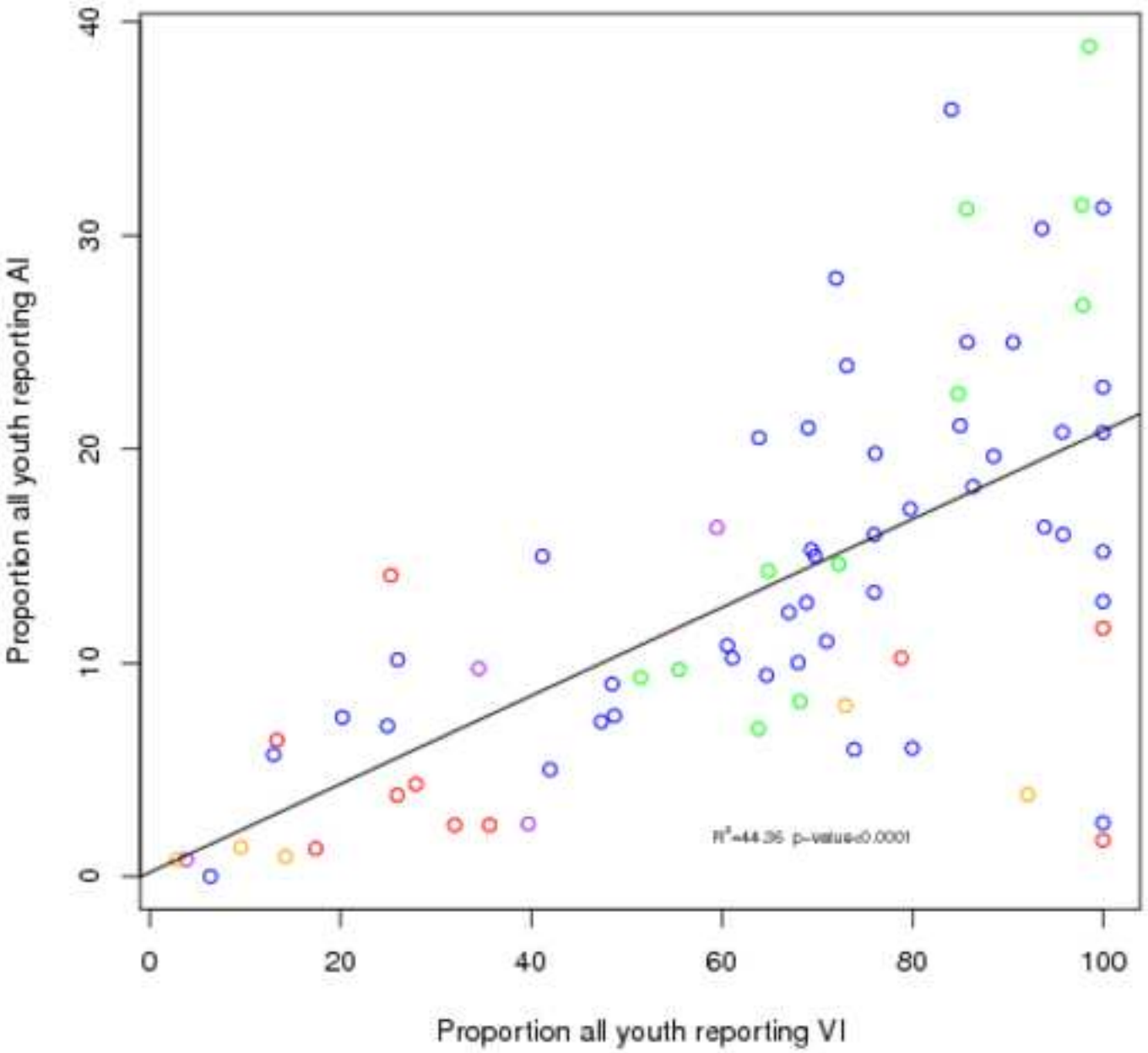

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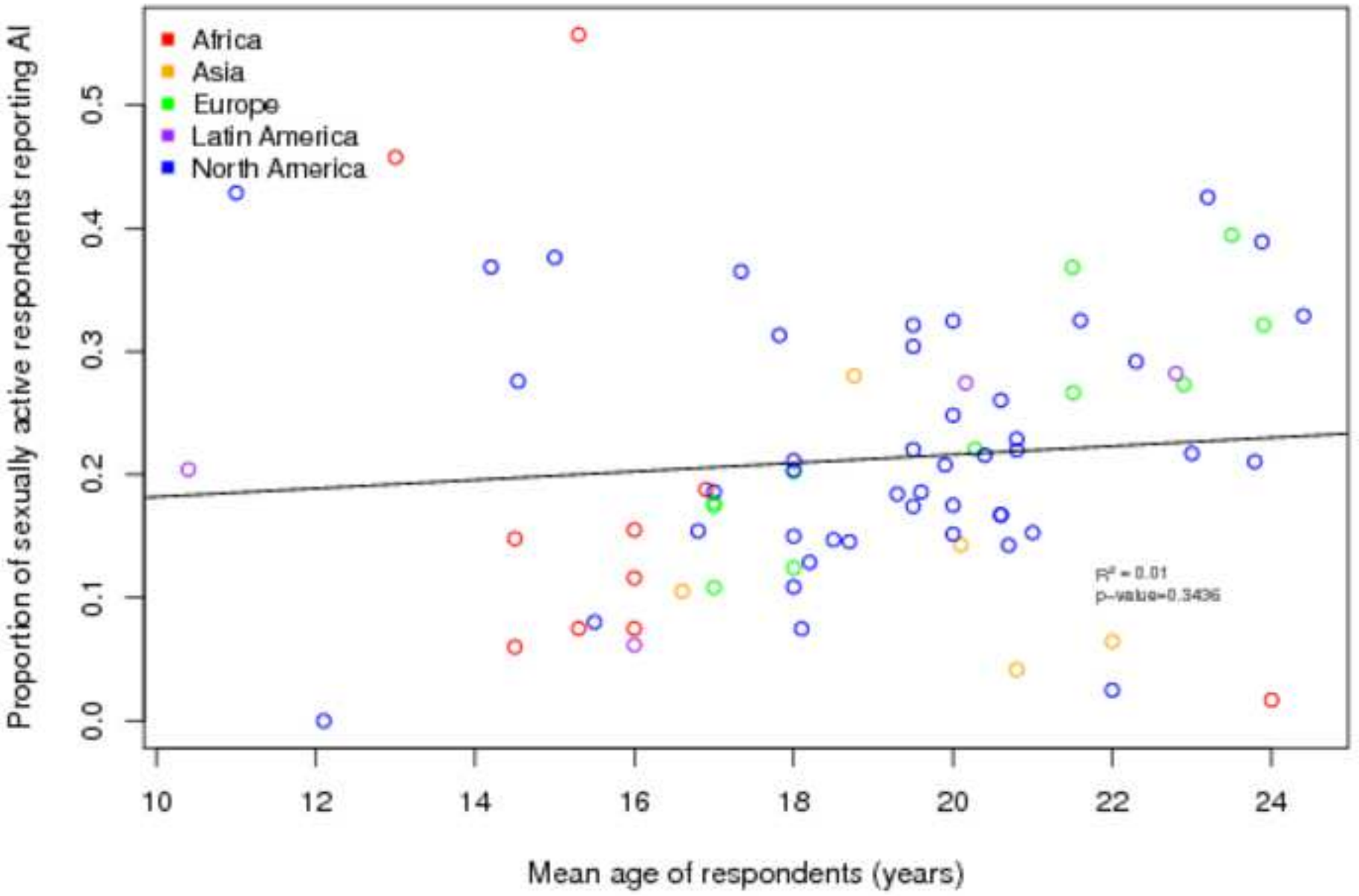

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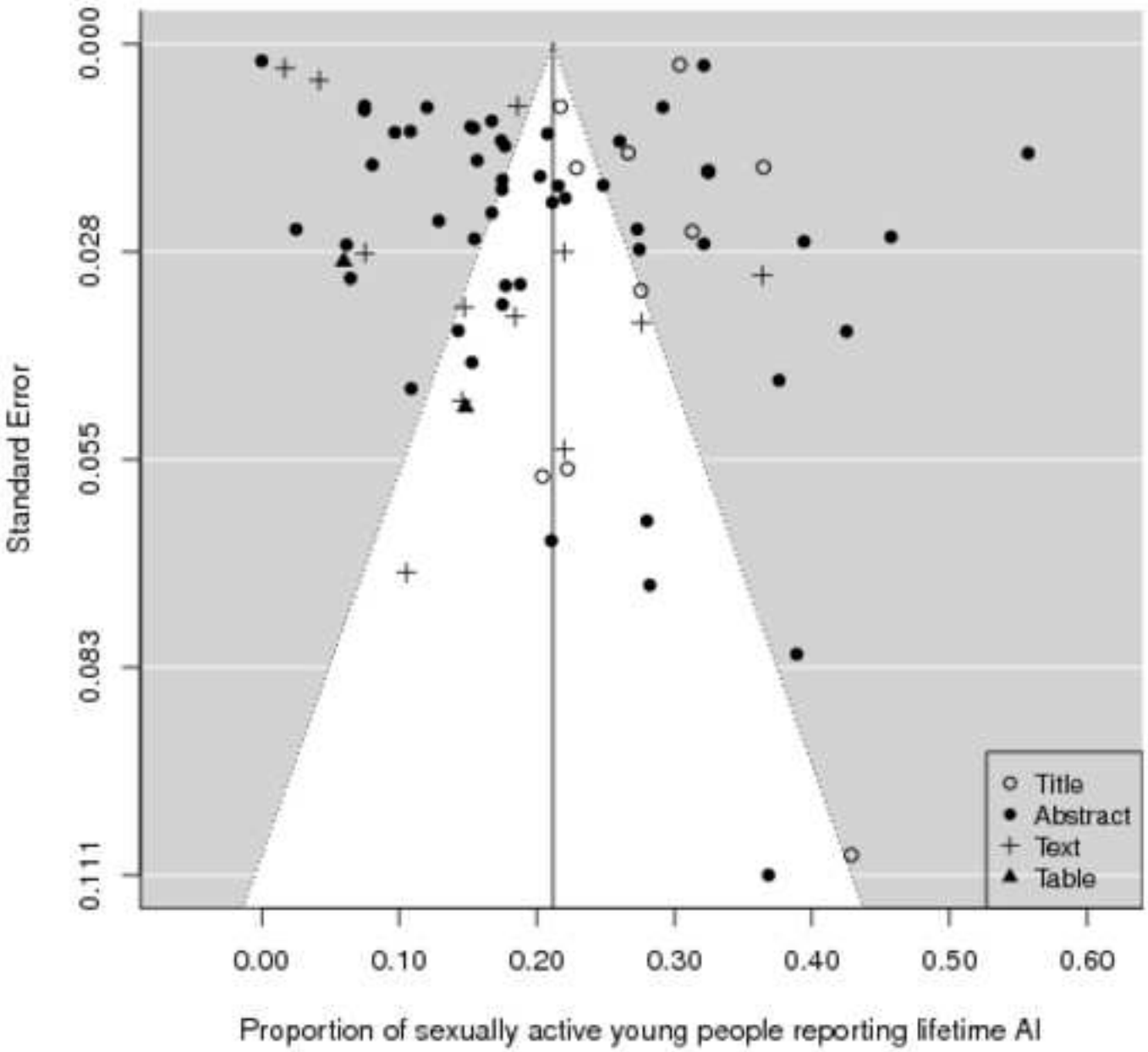

Table 1
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Table I: Summary of Study Characteristics

Outcomes and key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
		N	Sources	N	Sources	N
Outcomes reported	AI prevalence	108	[28,30,31,33–39,41–44,47,50,53–57,62,63,66–150]	26	[32,40,45,105,151–172]	133[a]
	VI prevalence	94	[28,30,31,33–39,41,42,44,50,53,54,56,62,63,67–79,81–83,85–108,110,112–121,123–132,134–141,144–146,148–150]	21	[40,45,105,151,152,154–161,163–166,169–172]	114[a]
	AI frequency	10	[37–39,41–44,47–49]	3	[40,45,46]	13
Study Design	Cross-sectional	94	[28,30,31,33,35,36,38,39,41–43,47–50,53–56,62,63,66–69,71,73–90,92,94–105,107–116,118,119,121–129,131–134,137–139,141–146,148–150]	21	[32,45,46,105,151–156,159–166,170–172]	114[a]
	RCT[c]	8	[57,70,106,117,120,130,135,140]	5	[40,157,167–169]	13
	Cohort	7	[37,44,72,91,93,136,147]	1	[158]	8
Sampling method	CRS	23	[50,53,55,62,67,70,75,76,90,102,104,111,114,115,117,120,132,134,135,137–139,141]	0	-	23
	SRS	20	[33–36,39,42,43,54,72,78,85,103,107,113,116,125,142,144,149,163]	1	[163]	21
	Convenience	61	[28,30,31,37,38,41,44,47–49,56,57,63,66,68,69,71,74,77,79–83,87–89,92–101,106,108,110,112,118,119,121–124,127–131,136,140,143,145–148,150]	25	[32,40,46,105,151–162,164–172]	85[a]
	RDS	1	[91]	1	[45]	2
	NS	5	[73,84,109,126,133]	0	-	5
Response	≥80%	23	[28,30,41,49,50,54,55,63,66,70,72,73,76,89,99,102,120,122,136,137,140,147,149]	10	[45,151,153,156,157,160,162,166,169,172]	33

Outcomes and key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
		N	Sources	N	Sources	N
rate	60-79%	14	[33,34,42,47,62,74,75,103,104,108,128,135,144,145]	3	[40,154,155]	17
	<60%	13	[36,39,78,81,84,85,107,121,124,125,139,142,146]	2	[167,168]	15
	NS	59	[31,37,38,43,44,48,53,56,57,67–69,71,77,79,80,82,83,86–88,90–98,100,101,105,106,109–119,123,126,127,129–134,138,141,143,148,150]	13	[32,46,105,152,158,159,161,163–165,170,171]	71[a]
First AI mention	Title	17	[33,36,37,70,75,76,88,94,96,104,106,111,125,130,142,143]	5	[32,40,151,167,170]	22
	Abstract	74	[28,30,31,34,38,39,43,44,48,50,53,62,63,66–68,71–74,77–82,84,86,87,89–93,95,97,99–101,108–110,113–124,126,127,129,131–141,144–149]	18	[45,152,153,155–158,160–166,168,169,171,172]	92
	Text	16	[41,42,47,49,55–57,69,83,85,98,102,103,105,112,128,150]	4	[46,105,154,159]	19[a]
	Table	2	[54,107]	0	-	2
Gender	Male & female	38	[33–36,38,39,41,49,50,53,55,62,63,67–88,139,142,150]	6	[40,46,151–154]	44
	Female only	44	[28,30,31,37,42,44,48,56,57,89–111,134–136,138,140,141,143–148]	14	[105,155–164,170–172]	57[a]
	Male only	2	[112,113]	3	[45,165,166]	5
	Mixed only	26	[43,47,54,66,114–133,137,149]	4	[32,167–169]	30
AI Recall Period[b]	Lifetime	73	[28,31,33–36,38,39,41,42,44,53,54,56,62,63,66–71,73,74,76,77,79,81–83,86,89–99,102,104–106,108,110,111,113–116,118,119,121,123–125,128,130,132,134–138,140,143–146,148,149]	11	[105,151,153–155,159,160,164,166,168,169]	83[a]

Outcomes and key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
		N	Sources	N	Sources	N
	Current partner	4	[88,112,129,142]	1	[151]	5
	12 Months	8	[55,85,101,103,107,111,131,139]	0	-	8
	6 Months	1	[127]	0	-	1
	3 Months	11	[37,43,72,75,78,83,117,120,124,147,148]	11	[40,45,158,161,163,165,167–169,171,172]	22
	2 Months	0	-	1	[157]	1
	1 Month	6	[42,47,57,119,134,141]	1	[152]	7
	First Sex Act	1	[50]	0		1
	NS	10	[30,80,84,87,100,109,122,126,133,150]	5	[32,46,154,156,162]	15
Interview methods[b]	ACASI	18	[33,34,37,42,48,53,54,71,75,78,106,117,120,130,139,140,145,146]	7	[40,151,157,167,169,171,172]	25
	SAQ	73	[28,30,31,35,36,38,39,43,44,49,50,54,62,63,66–70,73,74,76,77,79–87,89,90,92–99,101–103,105,107–110,113–116,119,121,122,124–129,131–134,137,138,141,147,148,150]	8	[105,153,155,156,158–160,166]	80[a]
	FTFI	17	[41,55–57,72,88,91,100,104,111,112,118,123,135,136,143,149]	12	[32,45,46,152,154,161–165,168,170]	29
	Telephone	2	[142,144]		-	2
Survey Year[b]	Pre-2004	64	[28,30,31,37–39,41,44,47,49,50,66,72–74,77,79–87,89,95,96,98–100,102–113,118,121–123,125–129,131–135,138,142–144,150,166]	17	[32,40,46,105,151–153,158–160,162–168]	80[a]
	2004 onwards	47	[28,33–36,42,43,48,53–57,62,63,67–71,75,76,78,88,90–94,97,101,114–117,119,120,130,136,137,139–141,145–	10	[32,45,155–157,161,169,171,172]	57

Outcomes and key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
		N	Sources	N	Sources	N
			148]			
Continent[b]	Africa	15	[49,50,53–57,67,112,114,115,123,132,137,150]	1	[155]	16
	Asia	6	[69,90,105,116,146,150]	1	[105]	6[a]
	Europe	13	[28,35,36,62,74,81,85,95,99,103,138,139,147]	4	[45,160,165,166]	17
	Latin America	4	[68,70,89,108]	1	[154]	5
	North America	73	[30,31,33,34,37–39,41–44,47,48,63,66,71–73,75–80,82–88,91–94,96–98,100–102,104,106,107,110,111,113,117–122,124–131,133–136,140–145,148,149]	21	[32,40,43,46,152,153,156–159,161–164,167–172]	94
Mean age[b]	<18 years	40	[33,34,37,42,44,48,50,53,54,66,67,70,71,73–76,78,89,92,94,99–101,105,106,113–115,117,118,120,122,123,132,137,138,140,145,147]	13	[105,153,154,156–159,161–163,167–169]	52[a]
	18-24	71	[28,30,31,33–36,38,39,41,43,47,49,55–57,62,63,68,69,72,77,79–88,90,91,93,95–98,102–104,108–112,116,119,121,124–131,133–136,139,141–144,146,148–150]	15	[32,40,43,45,46,151,152,155,160,164–167,171,172]	86
Study sample[b]	National representative surveys	14	[33–36,42,55,72,78,99,111,113,139,142,144],	-	-	14
	Community level surveys[d]	19	[37,41,48,49,54,56,67,71,81,88,92,94,104,106,116,118,123,135,149],			19
	Higher Education	43	[28,31,38,39,43,47,68,69,77,79,80,82–87,93,96–98,102,103,107–110,112,119,121,124–129,131,133,134,141,146,148,150]	-	-	43

Outcomes and key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
		N	Sources	N	Sources	N
	Schools	24	[50,53,62,66,70,73–76,89–91,95,101,105,114,115,117,120,122,132,137,138,147]	1	[105]	24[a]
	Clinics (non-STI)	10	[30,44,57,63,100,130,136,140,143,145]	-	-	10
	STI or family planning clinics	-	-	13	[32,46,151–153,157,160,166–168,170–172]	13
	Homeless	-	-	5	[105,154,161,162,164]	5
	Pregnant/teen mothers	-	-	2	[158,159]	2
	Roma young people	-	-	2	[45,165]	2
	'At Risk'[e]	-	-	3	[40,155,169]	3
	Prisoners	-	-	2	[156,163]	2
Number lifetime sex partners		29	[28,30,36–39,54,57,62,68,76,79,82,86,89,91,93,95,96,103,108,110,114,116,128,129,139–141]	7	[151,156,158–160,163,166]	36
Age at first VI		32	[28,36–39,48,53,54,57,62,63,67–69,77,85,86,91,92,94–96,98,103,107,124,125,130,132,133,135,149]	10	[40,45,102,152–154,158,160,163,164]	42
Age at first AI		10	[38,39,88,91,92,94,121,125,130,135]	1	[153]	11
Condom use	During AI	11	[37,41,75,92,96,100,117,125,131,136,141]	11	[40,45,151,153,160,161,163,164,166,169,171]	22

Outcomes and key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
		N	Sources	N	Sources	N
	During VI	25	[35–37,41,56,57,74,75,82,92–94,99,100,104,107,116–118,122,124,125,131,136,141]	8	[40,158,159,161,163,164,171]	33
Alcohol Use	General use[f]	8	[70,99,109,115,116,118,122,147]	3	[157,159,164]	11
	Use with sex[g]	5	[28,77,78,119,127]	5	[43,152–154,161]	10

ACASI – audio computer-assisted self-interview, AI – anal intercourse, CRS – cluster random sample, FTFI – face-to-face interview, NS – not specified, RCT – cluster randomised trial, RDS – respondent driven sampling, SAQ – self-administered questionnaire, SRS – simple random sample, VI – vaginal intercourse.

[a] The sum of total studies is less than expected as one article[105] reports on both higher and non-higher-risk populations. [b] The sum of some subgroups is greater than total number of included articles because several articles provided AI data in more than one category. [c]Includes both individual and cluster randomised control trials. [d]Refers to non-higher risk participants recruited locally through posters, advertisements, from home visits or community venues etc. [e]Three studies recruited 'at risk' young people, which were variously defined as: reporting recent unprotected sex [40,155], having recently been arrested [40], being a crack user, having had multiple sex partners in the past year. [f] Have drunk alcohol in lifetime. [g] Have had sex under influence of alcohol in lifetime.

Table 2
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Table I: Lifetime AI and VI prevalence among all young people and sexually active young people, stratified by gender and risk group

		Male				Female				Mixed gender[a]			
		N	Range %	Summary estimate (CI)	I^{2b} (p-value)	N	Range %	Summary estimate (CI)	I^{2b} (p-value)	N	Range %	Summary estimate (CI)	I^{2b} (p-value)
A) *All young people (i.e. sexually active and inactive)*													
AI	All	27	1.2-57.1	17.1 (12.7-21.5)	99.5 (<.0001)	49	0.4-57.1	15.5 (13.1-17.9)	99.4 (<.0001)	18	0.0-35.7	11.5 (7.2-15.7)	-
	Higher risk	3	27.0-57.1	37.4 (18.3-56.6)	95.7 (<.0001)	8	10.2-46.0	22.9 (14.3-31.5)	97.5 (<.0001)	1	-	24.8 (19.4-30.2)	-
	Non-higher risk	24	1.2-37.3	14.6 (11.0-18.1)	99.2 (<.0001)	55	0.0-38.9	14.5 (12.1-16.8)	99.3 (<.0001)	17	0.0-35.7	10.8 (6.6-14.9)	-
VI	All	27	4.3-100.0	71.3 (63.0-79.7)	99.9 (<.0001)	57	2.8-100.0	70.1 (63.5-76.8)	99.9 (<.0001)	17	0.0-100.0	56.0 (43.6-68.4)	99.6 (<.0001)
	Higher risk	4	63.9-99.3	87.6 (74.2-100.0)	99.3 (<.0001)	7	61.4-100.0	91.3 (82.2-100)	67.9 (<.0001)	3	31.8-80.1	54.3 (31.7-76.8)	97.8 (<.0001)
	Non-higher risk	23	4.3-100.0	68.5 (59.5-77.5)	99.9 (<.0001)	50	2.8-100.0	67.5 (60.5-74.6)	99.8 (<.0001)	22	4.4-100.0	56.2 (42.6-70.0)	99.8 (<.0001)

		Male				Female				Mixed gender[a]			
		N	Range %	Summary estimate (CI)	I^{2b} (p-value)	N	Range %	Summary estimate (CI)	I^{2b} (p-value)	N	Range %	Summary estimate (CI)	I^{2b} (p-value)
B) *Sexually active young people only (i.e. 100% VI prevalence)*													
AI	All	24	4.6-61.7	25.0 (19.2-30.8)	99.3 (<.0001)	57	1.7-48.1	21.9 (19.2-24.7)	98.4 (<.0001)	17	0.0-48.8	20.1 (14.1-26.0)	- (<.0001)
	Higher risk	2	44.1-55.5	49.8 (41.9-57.7)	66.5 (.014)	7	11.5-46.8	25.1 (15.3-34.9)	97.3 (<.0001)	1	-	48.8 (40.0-57.6)	-
	Non-higher risk	22	4.6-61.7	22.7 (17.4-28.1)	99.1 (<.0001)	51	1.7-48.1	21.5 (18.7-24.3)	98.4 (<.0001)	16	0.0-45.7	18.4 (13.0-23.7)	- (<.0001)

[a] Data available for mixed gender only. [b] I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity.

Table 3
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Table Ia: Lifetime prevalence of AI: subgroup analysis of sexually active, non-higher risk males

Sub-group	N	Range %	Sub-group analysis			Univariate analysis	
			Summary estimate (CI)	I^{2a} (%)	p-value[b]	R^2	p-value[c]
All	22	4.6-61.7	22.7 (17.4-28.1)	99.1	<.0001		
Study design						**0.0**	**.926**
Cross-sectional	21	4.6-61.7	23.8 (18.8-28.8)	99.5	<.0001		
Cohort	0	-	-	-	-		
RCT	1	-	26.9 (9.9-44.0)	-	-		
Sampling method						**15.4**	**.071**
CRS	4	8.4-61.7	29.1 (8.7-49.5)	99.0	<.0001		.107
SRS	6	17.0-42.7	29.7 (24.4-34.9)	99.4	<.0001		.052
Convenience	11	11.4-26.5	18.2 (14.1-22.4)	82.2	<.0001		-
NS	1	-	14.5 (11.4-17.6	-	-		-
Response rate						**3.7[d]**	**.533**
≥80%	3	14.5-26.9	18.7 (12.5-24.9)	0.4	.370		
60-79%	4	11.4-39.1	23.9 (15.2-32.6)	99.4	<.0001		
<60%	3	12.3-42.7	24.0 (8.9-39.1)	97.5	<.0001		
NS	11	4.6-61.7	22.2 (13.5-30.9)	99.0	<.0001		
AI first mentioned						**21.3[e]**	**.028**
Title	4	22.8-42.7	33.4 (27.2-39.7)	98.5	<.0001		.073
Abstract	14	8.4-61.7	21.7 (17.1-27.1)	99.2	<.0001		-
Text	3	4.6-24.5	14.6 (3.6-25.6)	83.2	.000		.347
Table	0	-	-	-	-		
Interview method						**32.1**	**.002**
FTFI	1	-	14.7 (7.8-21.6)	-	-		.616
SAQ	19	4.6-42.7	19.9 (15.5-24.3)	96.4	<.0001		-
ACASI	3	22.8-61.7	35.5 (26.6-44.5)	99.8	<.0001		.000

Survey year						**15.4[d]**	**.037**
<2004	15	11.4-26.5	18.4 (14.1-22.7)	88.7	<.0001		
≥2004	7	4.6-61.7	27.6 (19.5-35.7)	99.6	<.0001		
Continent						**.35**	**.728**
Africa	2	8.4-61.6	35.1 (0.0-87.3	99.9	.188		.106
Asia	1	-	4.6 (3.5-5.9)	-	-		.151
Europe	5	11.4-44.3	23.5 (11.4-35.6)	97.5	<.0001		.705
L. America	2	26.4-26.9	26.7 (17.5-35.8)	0.0	<.0001		.576
N. America	12	14.3-39.1	23.5 (19.5-27.6)	98.9	<.0001		-
Mean age						**1.5[d]**	**.601**
<18	9	8.4-61.7	23.3 (11.5-35.0)	99.6	<.0001		
18-24	13	4.6-42.7	24.2 (18.8-29.7)	99.4	<.0001		
Number of lifetime sex partners						**0[d]**	**.452**
<3	0	-	-	-	-		
3-6	3	15.0-32.1	24.9 (17.1-32.7)	85.8	<.0001		
>6	2	17.0-19.5	18.3 (13.8-22.8)	0.0	<.0001		
Age at first VI (years)						**1.5[d]**	**.696**
<16	2	8.4-26.4	17.4 (5.0-29.8)	91.8	<.0001		
≥16	7	4.6-32.1	18.3 (11.9-24.8)	94.0	<.0001		

ACASI – audio computer-assisted self-interview, AI – anal intercourse, CRS – cluster random sample, FTFI – face-to-face interview, NS – not specified, RCT – cluster randomised trial, SAQ – self-administered questionnaire, SRS – simple random sample.

[a]I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity. [b]P-value to test significance of heterogeneity (I^2).[c]p-value in bold test significance of R^2 value. P-values not in bold test difference between categorical variables which were compared in turn to the variable with the largest sample size. [d]Analysed as continuous variable in univariate analysis. [e]Place in article where AI is first mentioned was analysed as a ordered variable, in descending order from title, abstract, text to table.

Table IIIb: Lifetime prevalence of AI: subgroup analysis of sexually active, non-higher risk females

Sub-group	N	Range %	Sub-group analysis			Univariate analysis	
			Summary estimate (CI)	I^{2a} (%)	p-value[b]	R^2	p-value[c]
All	51	1.7-48.1	21.5 (18.7-24.3)	98.4	<.0001		
Study design						**3.6**	**.121**
Cross-sectional	46	1.7-48.1	23.1 (20.2-26.0)	98.9	<.0001		
Cohort	4	8.0-20.8	13.1 (7.7-18.6)	86.1	<.0001		
RCT[f]	3	13.0-42.9	26.2 (16.3-36.0)	85.3	<.0001		
Sampling method						**1.6**	**.485**
CRS	10	5.4-48.1	22.4 (15.3-29.4)	98.1	<.0001		.751
SRS	7	2.5-46.6	27.6 (22.4-32.9)	99.3	<.0001		.502
Convenience	32	1.7-42.9	21.5 (18.0-24.9)	96.7	<.0001		-
RDS	1	-	12.8 (8.3-17.5)	-	-		.421
NS	1	-	16.3 (13.2-19.4)	-	-		.534
Response rate						**0.1[d]**	**.837**
≥80%	8	6.2-39.4	19.2 (12.8-25.7)	97.3	<.0001		
60-79%	10	2.5-36.4	24.0 (18.3-29.8)	98.8	<.0001		
<60	4	6.4-29.8	16.5 (8.1-24.9)	94.2	<.0001		
NS	28	1.7-48.1	22.1 (18.0-26.1)	97.6	<.0001		
AI first mentioned						**10.1[e]**	**.023**
Title	8	13.0-42.9	27.7 (23.2-32.2)	91.8	<.0001		.137
Abstract	35	2.5-48.1	21.6 (18.3-25.0)	97.9	<.0001		-
Text	8	1.7-46.6	16.2 (9.3-23.2)	98.6	<.0001		.138
Table	0	-	-	-	-		
Interview method						**9.4**	**.017**
FTFI	6	1.7-21.7	13.7 (7.7-19.6)	98.2	<.0001		.048

SAQ	38	3.1-39.4	21.4 (18.5-24.7)	95.1	<.0001		-
ACASI	7	6.5-48.1	31.1 (25.6-36.7)	99.4	<.0001		.012
Telephone	1	-	2.5 (0.0-8.7)	-	-		.040
Survey year						**2.2[d]**	**.329**
<2004	33	2.5-42.9	20.7 (17.7-23.7)	97.8	<.0001		
≥2004	19	1.7-48.1	26.3 (21.3-31.4)	99.2	<.0001		
Continent						**2.4**	**.152**
Africa	3	1.7-48.1	18.4 (0.0-42.1)	99.7	<.0001		.479
Asia	4	3.1-28.0	12.0 (3.1-20.9)	84.0	.001		.063
Europe	9	10.8-39.4	23.6 (18.6-28.6)	94.8	.000		.747
L. America	4	6.2-29.1	19.1 (8.6-29.7)	78.4	<.0001		.562
N. America	32	8.0-46.6	25.3 (22.0-28.6)	97.4	<.0001		-
Mean age						**2.8[d]**	**.370**
<18 years	17	5.4-48.1	22.9 (17.3-28.5)	98.1	<.0001		
18-24 years	38	1.7-46.6	22.8 (19.6-25.6)	98.8	<.0001		
Number of lifetime sex partners						**65.8 [d]**	**.001**
<3	4	6.2-22.1	13.0 (6.8-19.2)	87.0	<.0001		
3-6	5	13.5-27.3	20.0 (15.7-24.4)	83.6	<.0001		
>6	3	17.9-39.4	30.5 (22.9-38.1)	91.2	<.0001		
Age at first VI						**0.0 [d]**	**.172**
<16	5	5.4-36.8	20.8 (11.1-30.5)	96.0	<.0001		
≥16	11	3.1-39.4	23.5 (18.5-28.5)	95.4	<.0001		

ACASI – audio computer-assisted self-interview, AI – anal intercourse, CRS – cluster random sample, FTFI – face-to-face interview, NS – not specified, RCT – randomised control trial, SAQ – self-administered questionnaire, SRS – simple random sample, VI – vaginal intercourse

[a]I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity. [b]P-value to test significance of heterogeneity (I^2). [c]P-value in bold test significance of R^2 value. P-values not in bold test difference between categorical variables which were compared in turn to the variable with the largest sample size. [d]Analysed as continuous variable in univariate analysis. [e]Place in article where AI is first mentioned was analysed as a ordered variable, in descending order from title, abstract, text to table. [f]Includes both individual and cluster randomised control trials.

Table IIIc: Lifetime prevalence of AI: subgroup analysis of sexually active, non-higher risk mixed gender

Sub-group	N	Range %	Sub-group analysis			Univariate analysis	
			Summary estimate (CI)	I^{2a} (%)	p-value[b]	R^2	p-value[c]
All	16	0.0-45.7	18.4 (13.0-23.7)	98.6	<.0001		
Study design						-	-
Cross-sectional	16	0.0-42.5	16.6 (11.7-21.6)	98.6	<.0001		
Cohort	0	-	-	-	-		
RCT	0	-	-	-	-		
Sampling method						**10.2**	**.486**
CRS	4	7.5-45.7	19.6 (4.6-34.6)	99.1	<.0001		.939
SRS	4	6.0-22.9	14.6 (9.4-19.9)	84.3	<.0001		.389
Convenience	8	0.0-42.5	23.0 (17.1-28.9)	97.9	<.0001		-
Response rate						**7.7[d]**	**.372**
≥80%	4	6.0-45.7	20.6 (8.7-32.5)	97.2	<.0001		
60-79%	1	-	22.0 (16.5-27.4)	-	-		
<60	3	16.7-42.5	27.4 (15.3-39.4)	97.1	<.0001		
NA	8	0.0-22.2	15.1 (11.2-18.9)	96.4	<.0001		
AI first mentioned						**5.7[e]**	**.320**
Title	2	22.6-28.3	22.6 (16.8-28.3)	0.0	.912		.652
Abstract	12	0.0-45.7	18.7 (11.6-25.8)	99.2	<.0001		-
Text	1	-	22.0 (16.5-27.4)	-	-		.771
Table	1	-	10.4 (4.9-15.9)	-	-		.326
Interview method						**0.0**	**.967**
FTFI	3	0.0-18.8	9.0 (0.0-27.6)	98.3	<.0001		.197
SAQ	12	6.0-45.7	20.1 (13.1-27.1)	98.0	<.0001		-
ACASI	3	14.8-22.2	18.5 (10.0-26.9)	24.7	.320		.856
Survey year						**0.0[d]**	**.699**

<2004	10	0.0-42.5	19.2 (13.3-25.1)	97.3	<.0001		
≥2004	5	6.0-45.7	20.0 (11.0-28.9)	93.4	<.0001		
Continent						**7.3**	**.277**
Africa	6	6.0-45.7	16.9 (7.4-26.3)	97.2	<.0001		.573
Asia	1	-	14.3 (7.9-24.0)	-	-		.634
Europe	0	-	-	-	-		-
L. America	0	-	-	-	-		-
N. America	9	0.0-42.5	22.4 (16.7-28.4)	98.4	<.0001		-
Mean age						**0.0[d]**	**.515**
<18 years	7	0.0-46.8	16.9 (5.4-26.3)	97.8	<.0001		
18-24 years	9	14.3-42.5	21.6 (17.7-25.6)	87.4	<.0001		
Number of lifetime sex partners						**24.9[d]**	**.081**
<3	4	6.0-22.0	14.5 (9.2-19.8)	70.8	<.0001		
3-6	0	-	-	-	-		
≥6	0	-	-	-	-		
Age at first VI						**47.1[d]**	**.002**
<16	6	6.0-42.5	12.9 (7.2-18.6)	93.3	<.0001		
≥16	2	22.9-42.5	32.7 (13.5-51.9)	95.5	<.0001		

ACASI – audio computer-assisted self-interview, AI – anal intercourse, CRS – cluster random sample, FTFI – face-to-face interview, NS – not specified, RCT –randomised control trial, SAQ – self-administered questionnaire, SRS – simple random sample, VI – vaginal intercourse

[a] I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity. [b]P-value to test significance of heterogeneity (I^2). [c]P-value in bold test significance of R^2 value. P-values not in bold test difference between categorical variables which were compared in turn to the variable with the largest sample size. [d]Analysed as continuous variable in univariate analysis. [e]Place in article where AI is first mentioned was analysed as a ordered variable, in descending order from title, abstract, text to table.

Table 4
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Table IV: Summary of available data on frequency of AI and percentage of sex acts which are AI

Reference	Sex	Population, Country	N	AI prevalence % (recall period)	Number of sex acts standardised per month[a]				% sex acts[b]	
					AI	VI	UAI	UVI	AI	UAI[c]
A) *Among those reporting AI*										
Non-higher risk										
Original AI frequency: past 1 month				Past 3 months						
Houston, 2007[1]	F	General, US	350	15.6	4.3 (main partner)[c] 2.0 (casual partner)[c]	NA	3.4 (main partner[c] 1.1 (casual partner)[c]	NA	NA	NA
Original AI frequency: past 3 months				Lifetime						
Rotheram-Borus, 1999[2]	M	Community, US	150	10.0	2.2	7.5	1.4	NA	24.7	NA
	F		112	6.0	0.7	7.9	0.4	NA	8.5	NA
Original AI frequency: past 12 months				Lifetime						
Reinisch, 1992[3]	F	University students, US	352	22.2	0.1	3.3	NA	NA	3.0	NA
	M		125	19.2	0.3	10.0	NA	NA	6.0	NA
Reinisch, 1995[4]	F	University students, US	235	13.1	0.2	5.0	NA	NA	4.0	NA
	M		344	13.6	0.2	6.7	NA	NA	3.0	NA
Higher risk										
Original AI frequency: past 3 months				Past 3 months						

Reference	Sex	Population, Country	N	AI prevalence % (recall period)	Number of sex acts standardised per month[a]				% sex acts[b]	
					AI	VI	UAI	UVI	AI	UAI[c]
Lescano, 2009[5]	F	At risk young people, US	759	14.9	1.1	NA	0.9	NA	NA	NA
	M		589	17.3	1.6	NA	0.9	NA	NA	NA
B) Among all (i.e. including also those only reporting VI)										
Non-higher risk,										
Original AI frequency: 1 day				Past 1 month						
Garry[6]	Mix	University students, US	37	32.4	0.8	5.6	NA	NA	20.6	NA
Original AI frequency: last sex										
Herbenik,2010 [7]	F	General, US	592	3.6	NA	NA	NA	NA	6.4	NA
Original AI frequency: past 3 months				Past 3 month;						
Scott-Sheldon, 2010[8]	Mix	Binge drinking students, US	221	4.0	0.1	9.1	NA	NA	1.1	NA
Original AI frequency: past 1 month										
Hensel, 2008[9]	F	Clinic, US	387	5.9	0.1	2.8	NA		3.6	3.6
Original AI frequency: past 3 months				NA						

Reference	Sex	Population, Country	N	AI prevalence % (recall period)	Number of sex acts standardised per month[a]				% sex acts[b]	
					AI	VI	UAI	UVI	AI	UAI[c]
Morrison-Beedy, 2013[10]	F	Community, US	738	NA	0.53	9.2	NA	0.32	5.4	NA
Simbayi, 2005[11]	F	Community, South Africa	115	NA	0.46	4.04	0.24	2.16	10.1	10.1
	M		113		0.97	4.89	0.37	2.55	16.6	12.6
Higher risk,										
Original AI frequency: past 3 months										
Kabakchieva, 2006[12]	M	Roma, Bulgaria	296	47.3	NA	NA	3.6	NA	NA	43.2
Original AI frequency: past 3 months				NA						
Harvey, 2004[13]	F	Couples at STI clinic, US	112	NA	0.4	12.1	NA	NA	3.3	NA
	M		112	NA	0.4	15.4	NA	NA	2.6	NA

AI – anal intercourse, F – female, M – male, Mix – data available on mixed gender only, NA – not available, UAI – unprotected anal intercourse, VI – vaginal intercourse.

[a]To enable comparison across articles which reported AI acts by different recall periods, we calculated the number per month (e.g. divided number of sex acts reported over three months by three).
[ab]Calculated from available data on number of AI and VI acts, see supplementary material for equation. [c]Percentage of unprotected sex acts that are UAI. [C] AI reported separately by partner type, any overlap not reported.

Table S1

Table SI: Summary of individual study characteristics

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
Africa																		
Flisher, 1993[1]	1989[a]	South Africa	CS	NS	SAQ	CRS	N	school	Mix	5850	16.0[b]	1.3	17.4	7.5	ever	N	N	N
Smith, 1998[2]	1996[a]	South Africa	CS	NS	SAQ	CV	N	university	M&F	228	20.0[b]	16.0	58.2	27.5	NS	Y	Y	N
Ramjee, 2001[3]	1999	South Africa	CS	NS	FTFI	CV	N	university	M	50	23.0	12.0	100.0	12.0	CP	N	N	N
Simbayi, 2005[4]	2002	South Africa	CS	90.0	SAQ	CV	N	community	M&F	228	20.0[b]	NA	NA	NA	NA	Y	Y	Y
Mpofu, 2006[5]	2002	South Africa	CS	NS	SAQ	CRS	N	school	Mix	630	16.0[b]	11.6	100.0	11.6	ever	N	N	N
Lane, 2006[6]	2003	South Africa	CS	87.4	FTFI	CRS	N	general	M&F	11904	19.5[b]	3.6	55.8	5.6	12M	N	N	N
Pluddemann, 2008[7]	2005	South Africa	CS	NS	ACASI	CRS	N	school	M&F	4605	15.3	14.1	25.3	55.7	ever	N	N	N
Jaspan, 2007[8]	2006	South Africa	CS	1.0	SAQ	SRS	N	community	Mix	212	14.5	2.4	35.6	6.0	ever	N	N	N
Jaspan, 2007[8]	2006	South Africa	CS	1.0	ACASI	SRS	N	community	Mix	212	14.5	3.8	26.0	14.8	ever	N	N	N
Abdool Karim, 2010[9]	2007	South Africa	RCT	NS	FTFI	CV	N	clinic	F	889	23.9	0.5	61.8	0.7	1M	N	Y	N
Nell, 2011[10]	2007	South Africa	CS	NS	FTFI	CV	N	community	F	1598	24.0	1.7	100.0	1.7	ever	N	Y	N
Matasha, 1998[11]	1997	Tanzania	CS	0.9	SAQ	CRS	N	school	M&F	892	16.5[b]	4.3	47.8	8.9	FSA	N	N	N

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
Kazaura, 2009[12]	2006	Tanzania	CS	NS	SAQ	CRS	N	community	M&F	2749	15.3	2.4	32.0	7.5	ever	N	N	N
Kakoko, 2013[13]	2009[a]	Tanzania	CS	88.5	SAQ	CRS	N	school	Mix	2820	13.0	6.4	13.3	45.7	ever	N	N	N
Feldman, 1997[14]	1992	Zambia	CS	NS	FTFI	CV	N	community	Mix	276	16.9	10.2	78.8	18.8	ever	Y	N	N
Morhason-bello, 2008[15]	2005	Nigeria	CS	NS	SAQ	CRS	N	school	Mix	695	16.0[b]	4.3	27.9	15.5	ever	N	N	N
Opoku, 2010[16]	2006	Ghana	CS	79.3	SAQ	CV	Y	at risk	F	1070	22.7	11.5	100.0	11.5	ever	N	Y	N
Asia																		
Rosenthal , 1994[17]	1990[a]	Australia	CS	NS	SAQ	CV	Y	school	F[g]	26	16.6	27.0[f]	85.0	31.8	ever	N	N	N
Smith, 1998[2]	1996[a]	Australia	CS	NS	SAQ	CV	N	university	M&F	920	20.0[b]	6.9	46.8	14.0	NS	Y	Y	N
Ma, 2009[18]	2003	China	CS	NS	SAQ	NS	N	university	M&F	1850	20.8	3.8	92.1	4.2	ever	N	N	N
Perera, 2006[19]	2004	Sri Lanka	CS	NS	SAQ	CRS	N	school	F	1760	18.8	0.8	2.8	28.0	ever	N	N	N
Tho, 2007[20]	2005	Vietnam	CS	NS	SAQ	SRS	N	community	Mix	880	20.1	1.4	9.5	14.3	ever	Y	Y	N
Zhang, 2013[21]	2010	China	CS	11.0	ACASI	CV	N	university	F[g]	435	22.0[b]	0.9	14.3	6.5	ever	N	N	N
Europe																		
Weinberg, 1998[22]	1992	Sweden	CS	52.0	SAQ	SRS	N	university	M&F	570	21.0	12.4[f]	77.4	16.1	12M	N	N	N
Rogala, 2003[23]	1998	Sweden	CS	98.9	SAQ	CV	Y	STD clinic	F	1000	18.5[b]	46.0	98.4	46.7	ever	Y	N	N
Edgardh, 2000[24]	1999	Sweden	CS	90.0	SAQ	CV	N	general	F	1943	17.0	6.9	63.9	10.8	ever	N	Y	N
Edgardh, 2002[25]	1999	Sweden	CS	76.0	SAQ	CV	N	school	M&F	258	17.0	9.7	55.5	17.7	ever	N	Y	N
Haggstrom-Nordin, 2005[26]	2003	Sweden	CS	77.0	SAQ	CRS	N	school	M&F	724	18.0	14.6	72.3	20.2	ever	Y	N	N
Tyden, 2004[27]	2001	Sweden	CS	99.0	SAQ	CV	Y	STD clinic	M	292	21.9	57.1	99.3	55.5	ever	Y	Y	N
Tyden, 2012[28]	1999	Sweden	CS	92.0	SAQ	CV	N	university	F	333	22.9	26.7	97.9	27.3	ever	N	N	N
Tyden, 2012[28]	2004	Sweden	CS	92.0	SAQ	CV	N	university	F	315	23.9	31.4	97.8	32.1	ever	N	N	N

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
Tyden, 2012[28]	2009	Sweden	CS	92.0	SAQ	CV	N	university	F	350	23.5	38.9	98.6	39.4	ever	Y	N	N
Breakwell, 1992[29]	1989	UK	CS	33.9	SAQ	CV	N	community	M&F	2171	18.0	8.2[f]	68.2	12.4	ever	N	N	N
Madhok , 1993[30]	1989	UK	CS	74.0	SAQ	SRS	N	university	F	794	20.3	2.6	68.3	2.4	12M	N	N	N
Stone, 2006[31]	2003	UK	CS	NS	SAQ	CRS	N	school	F	765	17.0[b]	9.3[f]	51.5	17.4	ever	N	N	N
Mercer, 2013[32]	2010	UK	CS	57.7	ACASI	CRS	N	general	M&F	3869	20.5[b]	17.6[f]	57.8	22.4	12M	N	N	N
Stulhofer,2009[33]	2005	Croatia	CS	80.0	SAQ	SRS	N	general	M&F	1093	21.5	22.6	84.8	26.6	ever	N	Y	N
Stulhofer, 2011[34]	2010	Croatia	CS	32.0	SAQ	SRS	N	general	M&F	1005	21.5[b]	31.2	85.7	36.8	ever	Y	Y	N
Lepusic, 2013[35]	2009	Croatia	cohort	84.4	SAQ	CV	N	school	F	610	17.9	28.0	NS	NS	3M	N	N	N
Kabakchieva, 2002[36]	2001	Bulgaria	CS	NS	FTFI	CV	Y	Roma	M	324	24.1	72.0[f]	94.4	73.9	3M	Y	Y	N
Kabakchieva, 2006[37]	2003	Bulgaria	CS	90.0	FTFI	RDS	Y	Roma	M	296	19.6	47.3[f]	90.2	65.1	3M	Y	Y	Y
Stankovic, 2009[38]	1999	Serbia	CS	NS	SAQ	CV	N	school	F	629	20.3	14.3[f]	64.9	22.1	ever	N	Y	N
Latin America																		
Raffaelli, 1993[39]	1989[a]	Brazil	CS	62.0	FTFI	CV	Y	street youth	M&F	379	14.1	24.0[f]	63.2	37.9	ever	N	N	N
Caetano, 2010[40]	2007	Brazil	CS	NS	SAQ	CV	N	university	M&F	447	20.2	16.3	59.5	27.4	ever	Y	N	N
Alzate, 1978[41]	1974	Colombia	CS	68.9	SAQ	CV	N	university	F	113	22.8	9.7[f]	34.5	28.2	ever	N	N	N
George, 2007[42]	2000	Dominica	CS	92.0	SAQ	CV	N	school	F	204	16.0[b]	2.5	39.7	6.2	ever	N	N	N
Yu, 2007[43]	2004	The Bahamas	cRCT	95.1	SAQ	CRS	N	school	F	1274	10.4	0.8	3.8	20.4	ever	N	N	N
North America																		
Story, 1982[44]	1974	US	CS	NS	SAQ	CV	N	university	F[g]	50	23.9	28.0	72.0	38.9	ever	N	N	N
Story, 1982[44]	1980	US	CS	NS	SAQ	CV	N	university	F[g]	50	23.8	16.0	76.0	21.1	ever	N	N	N
DeBuono, 1990[45]	1975	US	CS	97.2	SAQ	CV	N	clinic	F	486	21.5	11.5	85.8	12.0	NS	N	N	N

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
DeBuono, 1990[45]	1986	US	CS	97.5	SAQ	CV	N	clinic	F	161	21.4	7.5	82.0	7.5	NS	N	N	N
DeBuono, 1990[45]	1989	US	CS	100.0	SAQ	CV	N	clinic	F	132	21.6	9.1	82.6	9.1	NS	N	N	N
Cochran , 1990[46]	1986	US	CS	NS	SAQ	CV	N	university	F[g]	343	19.3	12.4	67.1	18.4	ever	N	N	N
Cochran, 1991[47]	1987	US	CS	NS	SAQ	CV	N	university	M&F	152	21.0[b]	7.2[f]	47.4	15.3	ever	N	Y	N
Thomas, 1989[48]	1987	US	CS	NS	SAQ	CV	N	university	M&F	968	21.0	16.3	NS	NS	NS	N	N	N
Moscicki, 1993[49]	1987	US	CS	84.0	SAQ	CV	Y	STD clinic	M&F	906	17.2	21.6	NS	NS	ever	Y	N	N
McGuire, 1992[50]	1987	US	CS	NS	SAQ	CV	N	university	M&F	156	18.1	5.1	42.3	12.1	SN	N	N	N
Reinisch , 1992[51]	1988	US	CS	NS	SAQ	CV	N	university	M&F	593	20.4	17.2	79.8	21.6	ever	N	N	Y
Kotloff, 1991[52]	1988	US	CS	NS	SAQ	CV	N	university	M&F	3394	22.3	25.0	85.8	29.2	ever	N	N	N
Goodman, 1989[53]	1988	US	CS	91.0	SAQ	CV	N	school	Mix	170	16.5	8.0	58.0	13.5	NS	N	Y	N
Hein , 1995[54]	1989	US	CS	NS	FTFI	CV	N	clinic	F	483	17.6	25.4	98.8	25.7	NS	Y	Y	N
Erickson, 1995[55]	1990[a]	US	CS	47.0	phone	SRS	N	general	M&F	464	21.0[b]	8.8[f]	NS	NS	CP	N	N	N
Hsu , 1994[56]	1990[a]	US	CS	NS	SAQ	CV	N	university	M&F	160	24.4	25.0	90.6	32.9	ever[c]	N	N	N
Johnson, 1994a[57]	1990[a]	US	CS	NS	SAQ	NS	N	university	Mix	408	21.9	15.9[f]	NS	NS	NS	N	N	N
Johnson, 1994b[58]	1990[a]	US	CS	NS	SAQ	NS	N	university	F[g]	219	22.7	14.0[f]	78.0	18.1	NS	N	N	N
Morrison, 1994[59]	1990	US	CS	NS	FTFI	SRS	Y	prisoners	F[g]	59	16.5	22.4[f]	86.4	22.4	3M	Y	Y	N
Reinisch, 1995[60]	1991	US	CS	58.0	SAQ	SRS	N	university	M&F	579	20.7	13.3	76.0	14.3	ever	N	N	Y
Norris, 1999[61]	1991	US	CS	85.0	FTFI	SRS	N	community	Mix	1062	20.0	15.2[f]	100.0	15.2	ever	N	N	N
Ehde, 1995[62]	1991	US	CS	NS	SAQ	CV	N	university	Mix	552	20.7	8.4[f]	76.3	10.9	12M	Y	Y	N
Hale, 1993[63]	1991	US	CS	45.4	SAQ	SRS	N	university	F[g]	464	21.0[b]	18.9[f]	84.9	18.8	12M	N	Y	N
Maxwell, 1995[64]	1991	US	CS	NS	FTFI	CV	Y	STD clinic	M&F	100	18.5	9.0	100.0	9.0	1M	N	N	N
Weinberg, 1998[22]	1992	US	CS	43.0	SAQ	SRS	N	university	M&F	407	21.0	11.3[f]	76.2	14.8	12M	N	N	N

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
Hutchison , 1996[65]	1992	US	CS	NS	NS	NS	N	university	Mix	NS	20.0 [b]	NS	87.0	13.0	NS	Y	N	N
Koniak-Griffin, 1993[66]	1992 [a]	US	CS	NS	SAQ	CV	Y	pregnant	F	151	16.6	11.9	100.0	11.9	ever	N	Y	N
Schuster, 1996[67]	1992	US	CS	84.0	SAQ	CV	N	school	Mix	851	16.0 [b]	1.0	NS	NS	ever	N	N	N
Taylor, 1997[68]	1993	US	CS	25.2	SAQ	NS	N	university	M&F	649	20.4	2.2 [f]	NS	NS	NS	N	N	N
Satterwhite , 2007[69]	1993	US	RCT	44.0	FTFI	CV	Y	STD clinic	Mix	NS	17.0 [b]	13.0	NS	NS	ever	N	N	N
Rotheram-Borus, 1999[70]	1993	US	CS	90.0	FTFI	CV	N	community	M&F	262	18.1	8.0 [f]	74.0	11.1	ever	Y	Y	Y
Stanton, 1994[71]	1993	US	RCT	NS	ACASI	CV	N	community	F [g]	158	11.0	5.7	13.0	42.9	ever	N	N	N
Foxman, 1998[72]	1993	US	CS	67.0	phone	SRS	N	general	F [g]	40	22.0 [b]	2.5	100.0	2.5	ever	N	N	N
Flannery, 2003[73]	1993	US	CS	NS	SAQ	CV	N	university	F	813	20.0 [b]	30.3	93.6	32.5	ever	Y	N	N
Fleuridas, 1997[74]	1993	US	CS	NS	SAQ	CV	N	university	Mix	107	24.8	5.6	82.2	6.7	6M	N	N	N
Shapiro, 1999[75]	1994	US	CS	74.3	SAQ	CV	N	university	Mix	319	20.8	15.4 [f]	69.8	22.0	ever	N	N	N
Jaffe, 1988[76]	1994	US	CS	NS	FTFI	CV	N	clinic	F	148	18.0 [b]	19.0 [f]	NS	NS	ever	N	N	N
Baldwin, 2000[77]	1994	US	CS	50.2	SAQ	SRS	N	university	Mix	647	20.8	22.9 [f]	100.0	22.9	ever	Y	Y	N
Gilbert, 1998[78]	1994	US	CS	NS	SAQ	CV	N	university	F	556	21.0 [b]	17.8	91.9	NS	ever	N	N	N
Gindi , 2008[79]	1994	US	CS	NS	FTFI	CV	Y	STD clinic	Mix	4724	21.0 [b]	2.0 [f]	NS	NS	NS	N	N	N
Gindi , 2008[79]	2004	US	CS	NS	FTFI	CV	Y	STD clinic	Mix	6307	21.0 [b]	6.0 [f]	NS	NS	NS	N	N	N
Gates, 2000[80]	1995	US	CS	NS	SAQ	SRS	N	general	M	1297	17.0 [b]	10.8 [f]	60.6	18.6	ever	N	N	N
Misegades, 2001[81]	1996	US	CS	71.5	FTFI	CRS	N	community	F	2545	23.0	20.8 [f]	95.7	21.7	ever	Y	Y	N
Dilorio, 2000[82]	1996 [a]	US	CS	25.2	SAQ	CV	N	university	Mix	1380	20.6	16.0 [f]	95.8	16.7	ever	N	N	N
Civic, 2000[83]	1996	US	CS	NS	SAQ	CV	N	university	Mix	210	20.0	18.1	100.0	18.1	CP	Y	Y	N
Friedman , 2001[84]	1997	US	CS	NS	FTFI	CRS	N	general	F	202	21.0 [b]	29.2	NS	NS	ever [e]	N	N	N

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
Garry, 2002[85]	1998[a]	US	CS	77.1	coital diary	CV	N	university	Mix	37	23.4	32.4	NS	NS	1M	N	N	Y
Harvey , 2004[86]	1998	US	CS	NS	FTFI	CV	Y	STD clinic	M&F	224	23.4	NS	NS	NS	NS	N	N	Y
Jemmott, 2002[87]	1998a	US	CS	33.0	SAQ	CV	N	university	Mix	199	23.2	35.9	84.1	42.5	ever[c]	Y	Y	N
Hensel, 2008[88]	1999	US	cohort	NS	SAQ	CV	N	clinic	F	387	15.5[b]	5.9	73.9	8.0	ever	N	N	Y
Higgins, 2010[89]	1999	US	CS	NS	SAQ	CV	N	university	M&F	1504	20.6	19.8	76.1	26.0	ever	N	N	N
Koniak-Griffin, 2003[90]	1999[a]	US	cohort	NS	SAQ	CV	Y	pregnant	F	572	16.5	6.3	73.1	8.6	3M	N	Y	N
Tian , 2008[91]	1999	US	RCT	44.0	ACASI	CV	Y	STD clinic	Mix	3243	20.0[b]	17.7[f]	NS	NS	3M	N	N	N
Flannery , 2003[92]	2000	US	CS	NS	SAQ	CV	N	university	M&F	778	18.0	11.1[f]	71.0	15.5	ever	Y	Y	N
Lescano , 2009[93]	2000	US	RCT	74.0	ACASI	CV	Y	at risk	M&F	1348	18.2	15.9	100.0	15.9	3M	Y	Y	Y
Ompad, 2006[94]	2000	US	cRCT	74.2	FTFI	CRS	N	community	F[g]	924	19.5	16.3[f]	93.9	17.4	ever	N	N	N
Gorbach, 2009[95]	2001	US	CS	100.0	ACASI	CV	Y	STD clinic	M&F	1084	22.0[b]	36.9	93.9	39.3	ever	Y	Y	N
Houston, 2007[96]	2001	US	cohort	NS	ACASI	CV	N	community	F	350	16.7	15.6	90.1	17.3	3M	Y	Y	Y
So, 2005[97]	2001[a]	US	CS	NS	SAQ	CV	N	university	Mix	248	20.0	9.0	48.5	17.5	ever[d]	Y	Y	N
Solorio, 2006[98]	2001	US	CS	NS	FTFI	CV	Y	homeless	F	81	15.4	14.8	95.1	15.6	3M	Y	Y	N
Kaestle, 2007[99]	2001	US	cohort	92.0	FTFI	SRS	N	general	M&F	6421	22.0	22.7[f]	98.9	23.0	3M	N	N	N
Mellins, 2005[100]	2001	US	CS	NS	FTFI	CV	N	community	Mix	220	12.1	0.0	6.4	0.0	ever	N	Y	N
Roye, 2010[101]	2002[a]	US	RCT	NS	SAQ	CV	N	clinic	F	345	17.8	31.3	100.0	31.3	ever	Y	Y	N
Gurman, 2010[102]	2002	US	CS	NS	SAQ	CRS	N	university	F	1088	21.6	23.9	73.1	32.5	ever[d]	N	N	N
Leichliter, 2007[103]	2002	US	CS	79.0	ACASI	SRS	N	general	M&F	39765	19.5	21.0	69.1[f]	30.4	ever	N	N	N
McDonnell, 2009[104]	2002	US	CS	97.0	SAQ	CV	Y	prisoners	F	914	15.8	29.6	81.8	36.2	NS	Y	Y	N
Markham, 2009[105]	2004	US	CS	62.0	ACASI	CRS	N	school	M&F	1279	12.5	4.0	7.6	52.6	3M	Y	Y	N

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
Morrison-Beedy, 2013[106]	2004	US	CS	NS	ACASI	CV	N	community	F	738	16.5	NS	NS	NS	NS	N	N	Y
Auslander, 2009[107]	2005 [a]	US	cohort	NS	FTFI	RDS	N	school	F	202	18.2	12.9	100.0	12.9	ever	N	N	N
Fielder, 2010[108]	2005	US	cohort	NS	SAQ	CV	N	university	F	109	18.0	5.0 [f]	42.0	10.9	ever	N	Y	N
Braun-Courville, 2009[109]	2005	US	CS	88.0	SAQ	CV	N	clinic	Mix	433	18.0	18.2 [f]	86.4	21.1	ever	N	N	N
Hennessy, 2008[110]	2005	US	CS	NS	ACASI	CV	N	community	M&F	458	15.0	10.1	26.0	37.6	ever	N	N	N
Tortolero, 2010[111]	2005	US	cRCT	NS	ACASI	CRS	N	school	Mix	907	13.0	2.0	4.4	45.0	3M	Y	Y	N
Carter, 2010[112]	2006	US	CS	NS	FTFI	CV	N	community	M&F	400	21.0	21.4 [f]	100.0	21.5	CP	Y	Y	N
Champion, 2014[113]	2006	US	CS	NS	FTFI	CV	Y	STD clinic	F	559	16.5	21.8	100.0	21.8	ever	N	N	N
Chandra, 2011[114]	2006	US	CS	75.0	ACASI	SRS	N	general	M&F	41752	19.5	20.5 [f]	63.9	32.1	ever	N	N	N
Childs, 2008[115]	2006	US	CS	NS	SAQ	CV	N	community	F	94	14.2	7.4	20.2	36.8	ever	N	Y	N
Markham, 2012[116]	2006	US	cRCT	93.0	ACASI	CRS	N	school	Mix	1258	12.6	1.4	6.4	21.3	3M	N	Y	N
Rahman, 2013[117]	2006	US	cohort	70.0	FTFI	CV	N	clinic	F	1155	19.9	20.8	100.0	20.8	ever	Y	Y	N
Scott-Sheldon, 2010[118]	2006 [a]	US	CS	NS	NS	SRS	N	university	Mix	221	19.0	4.0 [f]	80.0	5.1	3M	N	N	Y
Seth, 2011[119]	2006	US	RCT	84.4	ACASI	CV	Y	STD clinic	F	323	17.9	31.2	100.0	14.1	2M	N	Y	N
Silverman, 2011[120]	2006	US	CS	66.0	ACASI	CV	N	clinic	F	356	17.2	27.0	100.0	0.0	ever	N	N	N
Kerr, 2013[121]	2007	US	CS	NS	SAQ	CRS	N	university	F	60645	20.0	3.1	47.8	6.7	1M	Y	Y	N
Decker, 2012[122]	2008	US	CS	89.2	ACASI	CV	Y	STD clinic	F	1174	22.0	13.8 [f]	100.0	13.8	3M	N	N	N
Roye, 2012[123]	2008	US	CS	NS	ACASI	CV	N	community	Mix	61	18.0	19.7	88.5	20.4	ever	Y	Y	N
Dake, 2011[124]	2009	US	CS	90.3	SAQ	CRS	N	school	M&F	766	14.5	7.0	24.9	27.6	ever	N	N	N
Fortenberry, 2010[125]	2009	US	CS	37.0	ACASI	SRS	N	general	M&F	820	15.5 [b]	2.0 [f]	14.8	13.1	3M	N	N	N

Reference	Survey start year	Country	Study design	Response rate	Interview method	Sampling method	Higher risk	Population	Gender	N	Mean age	AI prev.	VI prev.	AI prev. among sexually active	Recall period	Data on UAI	Data on UVI	Data on AI freq.
Herbenick, 2010[126]	2009	US	CS	70.0	ACASI	SRS	N	general	F	592	17.3	15.0[f]	41.2	36.5	ever	N	N	Y
Prado, 2012[127]	2009	US	RCT	84.8	ACASI	CV	Y	at risk	Mix	242	14.7	24.8	50.8	48.8	ever[c]	Y	Y	N
DeMaria, 2011[128]	2010	US	CS	NS	SAQ	CV	N	university	F	450	20.6	10.2	61.1	16.7	ever	N	N	N
McCauley, 2014[129]	2012	US	cRCT	95.0	ACASI	CV	N	clinic	F	564	16.0	11.3	85.6	13.3	recent	N	N	N
Decker, 2014[130]	2011	US	CS	NS	ACASI	CV	Y	STD clinic	F	3504	21.0	10.0[f]	100.0	10.0	3M	Y	Y	N
Jozokowski, 2013[131]	2009	US	CS	NS	SAQ	CV	N	university	F[g]	621	20.0	21.1	85.0	24.8	ever	N	N	N
MacDonald, 1990[132]	1988	Canada	CS	97.0	SAQ	CRS	N	university	F[g]	3217	19.6	12.8[f]	68.9	18.6	ever	N	N	N
Langille, 1994[133]	1990	Canada	CS	NS	SAQ	CV	N	school	F[g]	646	15.8	9.8	52.0	18.8	12M	N	N	N
MacDonald, 1994[134]	1991	Canada	CS	90.0	FTFI	CV	Y	street youth	F[g]	321	16.8	22.4	93.0	24.1	NS	N	N	N
Roy, 2000[135]	1995	Canada	CS	NS	FTFI	CV	Y	homeless	F[g]	263	19.4	35.0[f]	99.2	35.2	ever	Y	Y	N
Langille, 2005[136]	2003	Canada	CS	91.0	SAQ	NS	N	school	M&F	2135	16.8	7.5	48.7	15.4	ever	N	N	N

Details for each article, including AI prevalence are only listed once, except if reported over two or more years in the same article. Where prevalence was reported over more than one recall period, the most common is reported here. Where AI was reported for sub-groups of the sample, the prevalence from the largest denominator is reported.

ACASI – audio computer-assisted self-interview, AI – anal intercourse, cRCT - cluster randomised trial, CRS – cluster random sample, CS – cross-sectional, CV-convenience sample, F- females only in sample, FSA- first sex act, FTFI – face-to-face interview, M – males only in sample, M&F- Data reported for males and females separately in article, but compiled together in this table, Mix – Data available for mixed gender only, NS – not specified, RCT- randomised control trial, RDS – respondent driven sampling, SAQ – self-administered questionnaire, SRS – simple random sample, UAI – unprotected anal intercourse, UVI – unprotected vaginal intercourse, VI – vaginal intercourse

[a]Survey year or [b]mean age had to be estimated as the information could not be extracted from article, and was not obtained from author / we were not able to contact author. [cde]Article also reported AI prevalence over [c]past 3 months article over [d]past 1 month or [e]past 12 months. Data from these recall periods have been included in meta-analysis, but not in this table. [f]Nominator was calculated from proportion and denominator (for equation see supplementary material). [g]Article includes data on both males and females, but males have been excluded from this review as estimates included homosexual as well as heterosexual AI.

Table SIIa: Lifetime prevalence of AI: subgroup analysis all young peope, both sexually active and inactive

Sub-group	N	Range %	Sub-group analysis: Summary estimate (CI)	Sub-group analysis: I^{2a} (%)	Sub-group analysis: p-value[b]	Univariate analysis: R^2	Univariate analysis: p-value[c]
Interview method						**0.0**	**.007**
FTFI	11	0.0-26.7	13.5 (8.7-18.8)	99.4	<.0001		.616
SAQ	52	0.7-38.9	13.9 (11.4-16.5)	99.5	<.0001		-
ACASI	9	0.9-27.0	13.8 (8.7-18.8)	99.6	<.0001		.000
Survey year						**0.1[d]**	**.752**
<2004	47	0.0-35.7	14.2 (1.8-16.5)	99.7	<.0001		
≥2004	27	0.7-38.9	12.9 (9.1-16.7)	99.7	<.0001		
Continent						**0.0**	**.013**
Africa	9	1.3-14.1	5.8 (3.1-8.5)	99.0	<.0001		.106
Asia	5	0.8-7.7	2.9 (0.6-5.2)	88.7	<.0001		.151
Europe	9	6.9-38.9	19.4 (13.2-25.7)	98.7	<.0001		.705
L. America	4	7.8-16.3	7.3 (1.1-13.5)	96.8	<.0001		.576
N. America	46	14.3-39.1	15.6 (13.3-17.9)	99.5	<.0001		-
Mean age						**23.0[d]**	**.001**
<18	26	0.0-14.1	8.2 (5.6-10.8))	99.7	<.0001		
18-24	13	4.6-38.9	16.7 (14.0-18.9))	99.4	<.0001		

ACASI – audio computer-assisted self-interview, AI – anal intercourse, FTFI – face-to-face interview, SAQ – self-administered questionnaire, VI – vaginal intercourse

[a] I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity . [b] P-value to test significance of heterogeneity (I^2). [c] P-value in bold test significance of R^2 value. P-values not in bold test difference between categorical variables which were compared in turn to the variable with the largest sample size.

Table SIIb: Lifetime prevalence of VI: subgroup analysis all young people

Sub-group	N	Range %	Sub-group analysis			Univariate analysis	
			Summary estimate (CI)	I^{2a} (%)	p-value[b]	R^2	p-value[c]
Interview method						**2.0**	**.131**
FTFI	8	6.3-100.0	76.2 (41.1-100.0)	-99.4	<.0001		.616
SAQ	52	0.0-100.0	64.6 (57.2-72.1)	98.2	<.0001		-
ACASI	10	13.0-88.5	44.2 (33.7-54.6)	99.9	<.0001		.000
Survey year						**0.5[d]**	**.250**
<2004	44	0.0-100.0	67.8 (59.8-75.8)	99.7	<.0001		
≥2004	26	2.8-100.0	57.5 (45.7-69.4)	99.7	<.0001		
Continent						**2.0**	**.130**
Africa	7	17.4-100.0	49.3 (27.2-71.3)	99.0	<.0001		.106
Asia	5	42.8 -92.1	44.4 (0.0-97.4)	88.7	<.0001		.151
Europe	10	7.3-37.3	79.0 (70.1-87.8)	98.7	<.0001		.705
L. America	4	3.8-59.5	34.4 (1.6-67.2)	96.8	<.0001		.576
N. America	44	0.0-100.0	67.1 (58.9-75.3)	99.5	<.0001		-
Mean age						**43.0[d]**	**.001**
<18	24	0.0-100.0	43.2 (31.8-54.7)	99.7	<.0001		
18-24	43	2.8-100.0	74.1 (67.1-81.1)	99.4	<.0001		

ACASI – audio computer-assisted self-interview, AI – anal intercourse, FTFI – face-to-face interview, SAQ – self-administered questionnaire, VI – vaginal intercourse

[a] I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity. [b] P-value to test significance of heterogeneity (I^2).[c] P-value in bold test significance of R^2 value. P-values not in bold test difference between categorical variables which were compared in turn to the variable with the largest sample size.

Table S3

Table SIII: Lifetime prevalence of AI: subgroup analysis of sexually active young people; genders combined

Sub-group	N	Range %	Sub-group analysis			Univariate analysis	
			AI summary estimates (CI)	I^{2a}	p-value	R^2	p-value
Survey year by continent							
Africa						5.1[b]	.475
<2004	4	7.5-18.8	12.0 (7.3-16.7)	87.9	.002		
≥2004	8	1.7-55.7	21.0 (6.4-35.6)	99.6	<.0001		
Asia						1.4[b]	.889
<2004	2	4.2-10.5	7.4 (0.4-14.3)	0.0	.368		
≥2004	3	3.1-28.0	16.3 (7.0-25.5)	72.3	.001		
Europe						65.2[b]	.001
<2004	7	10.8-27.3	18.2 (14.2-22.3)	90.9	<.0001		
≥2004	3	26.7-39.4	33.7 (28.8-38.6)	83.8	<.0001		
L. America						1.25[b]	.657
<2004	2	6.2-28.2	17.2 (2.2-32.2)	74.7	.004		
≥2004	2	20.4-27.4	23.9 (17.7-30.2)	1.0	.270		
N. America						4.3[b]	.327
<2004	30	0.0-42.9	20.9 (17.7-24.1)	98.7	<.0001		
≥2004	13	10.9-37.6	25.2 (20.6-29.7)	94.4	<.0001		
Subset of articles in which variables were reported							
Mean age at first AI (years)						3.0[b]	.106
<17	3	22.2-36.8	30.1 (21.8-38.4)	0.1	.280		
≥17	4	12.9-22.9	17.5 (14.3-20.6)	78.5	.002		
Prevalence of alcohol use							
Ever used [c]						0.0[b]	.554
<35%	1	0.0-20.4	20.4 (9.1-31.7)	92.3	<.0001		
≥35%	4	0.0-14.3	8.7 (2.7-14.7)	94.6	<.0001		

Sub-group	N	Range %	Sub-group analysis			Univariate analysis	
			AI summary estimates (CI)	I^{2a}	p-value	R^2	p-value
Use with sex[d]					-	83.1[b]	.003
<35%	3	17.5-27.3	23.6 (17.9-29.3)	-	-		
≥35%	1	32.1-39.4	35.8 (29.0-42.6)	-	-		

AI – Anal intercourse

[a] I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity. [b] Analysed as a continuous variable. [c&d] Effect of alcohol use on AI prevalence was examined in the two ways in which it was predominantly reported: [c] ever used (i.e. drank alcohol in lifetime) and [d] had sex under influence of alcohol in lifetime

Table S4

Table SIV: Summary estimates of prevalence of unprotected sex among non-higher risk young people, over most commonly reported recall periods

	N	Range %	Summary estimate, unprotected sex, % (CI)[a]	I^{2b}	p-value	Country	References
Frequent unprotected sex[c]							
UVI	7	33.0-100.0	64.9 (48.3-81.6)	98.2	<.0001	6 US, 1 Croatia	[41,62,85,95,103,110,134]
UAI	5	0.0-90.2	61.3 (33.1-84.8)	99.8	<.0001	5 US	[41,89,95,103,134]
Past three months							
UVI	6	21.7-68.0	40.7 (25.7-55.8)	96.7	<.0001	6 US	[37,78,120,121,128,139]
UAI	5	37.3-79.1	60.0 (45.0-75.0)	91.2	<.0001	5 US	[37,78,120,128,139]
Last sex							
UVI	11	25.7-71.0	48.8 (40.9-56.8)	97.6	<.0001	5 US, 2 Sweden, 2 South Africa, 1 Croatia, 1 Vietnam	[36,57,58,77,96,97,102,107,119,125,127]
UAI	5	50.0-80.0	70.1 (64.2-76.0)	94.5	<.0001	3 US, 1 Croatia, 1 Vietnam	[36,97,107,119,127]

UAI – Unprotected Anal Intercourse, UVI – Unprotected Vaginal Intercourse.

[a] Unprotected sex is defined as prevalence of any sex which was unprotected during recall period. [b]I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity. [c]Frequent unprotected sex is defined as percentage of respondents reporting 'never' or 'rarely' using condoms over an undefined recall period.

Table S5

Table SV: Sub-group analysis of AI prevalence by recall period among sexually active non-higher risk and higher risk young people

	Non-higher Risk									Higher Risk		
	Male			Female			Mixed Gender[a]			Combined genders[b]		
Recall period	N	Summary estimate (CI)	I^{2b} %	N	Summary estimate (CI)	I^{2b}	N	Summary estimate (CI)	I^{2b}	N	Summary estimate (CI)	I^{2b} %
Lifetime	22	22.7 (17.4-28.1)	99	51	21.5 (18.7-24.3)	98	16	18.4 (13.0-23.7)	99	10	33.6 (26.0-41.3)	97
12 Months	3	19.4 (5.7-33.1)	99	5	13.1 (7.7-18.6)	97	1	10.9 (8.0-13.9)	-	0	-	-
6 Months	0	-	-	0	-	-	1	6.8 (1.6-12.1)	-	0	-	-
3 Months	4	23.9 (10.8-37.0)	93	6	21.2 (12.5-29.8)	96	3	25.4 (5.9-45.0)	93	9	23.6 (12.7-34.5)	99
2 Months	0	-	-	0	-	-	0	-	-	1	14.1 (11.6-16.7)	-
1 Month	0	-	-	4	8.1 (3.4-12.9)	99	1	7.9 (1.3-14.6)	-	1	8.8 (4.7-13.0)	-
Current Partner	2	14.5 (9.3-19.8)	2	1	25.0(19.3-30.7)	-	1	18.1 (12.9-23.3)	-	1	20.3 (13.7-26.9)	-
First sex act	1	6.6 (3.7-9.5)	-	1	13.8 (8.0-19.5)	-	0	-	-	0	-	-
Not specified	2	17.1 (12.3-25.4)	87	5	15.4 (10.4-20.5)	82	1	12.8 (7.6-18.1)	-	2	30.2 (18.3-42.1)	94

[a] Data available for mixed gender only. [b]Due to the small number of studies reporting on each recall period, male, female and mixed gender samples have been combined for higher risk. [c] I^2 is calculated as described in Higgins et al.[23] I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity.

Supplementary information on calculations used

AI prevalence

Proportion reporting AI was calculated using the following equation

$$p = \frac{n}{d}$$

Where n is the number of participants reporting AI over recall period (numerator) and d is the number of participants who answer question on AI prevalence (denominator). If the denominator for the question was not available, the number of participants in survey was used.

If numerator was unavailable, then the following equation was used

$$n = p.d$$

Equation used to calculate proportion of sex acts that were AI

If data on number of sex acts were provided, but the proportion of sex acts that were AI were not, then the proportion was calculated using this equation:

$$P_a = \frac{n_a}{(n_a + n_v)}$$

Where P^a is the proportion of sex acts that are AI, n^a is number of AI acts and n^v is number of VI acts.

Equation used to calculate proportion of sex acts that were UAI

$$P_{ua} = \frac{n_{ua}}{(n_{ua} + n_{uv})}$$

Where P^{ua} is the proportion of sex acts that are UAI, n^{ua} is number of AI acts and n^{uv} is number of VI acts.