A neglected risk factor in HIV transmission and implications for prevention

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DECLARATION OF ORIGINALITY

I declare that all of the work presented in this thesis is my own, and is referenced or acknowledged otherwise. The thesis comprises original work I conducted between 2012 and 2018 during my part-time PhD programme at Imperial College London.

The following publications have arisen from the thesis so far:

Owen BN, Brock PM, Butler AR, Pickles M, Brisson M, Baggaley RF, Boily MC. Prevalence and Frequency of Heterosexual Anal Intercourse Among Young People: A Systematic Review and Meta-analysis. AIDS Behav. 2015;19(7):1338–60.

Owen BN, Elmes J, Silhol R, Dang Q, McGowan I, Shacklett B, Swann EM, van der Straten A, Baggaley RF, Boily MC. How common and frequent is heterosexual anal intercourse among South Africans? A systematic review and meta-analysis. J Int AIDS Soc. 2017 Jan 11;19(1):1–14.

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ABSTRACT

There is a greatly increased risk of HIV transmission during receptive anal intercourse (AI) compared to receptive vaginal intercourse (VI). If AI is commonly practised between men and women (heterosexual AI) it may substantially contribute to the spread of HIV epidemics. Heterosexual AI is, however, frequently overlooked as a risk factor and is incompletely understood. In order to assess the contribution of heterosexual AI to HIV epidemics we must first better understand who is engaging in AI, at what frequency, with whom, whether condoms are used, and whether once initiated, the practice is continued throughout the life course. This thesis aims to address these research gaps, using a variety of epidemiological approaches.

Systematic reviews and meta-analyses of heterosexual AI practice among young people, South Africans and female sex workers are conducted, as well as data analysis of a cross-sectional survey of Swazi female sex workers and longitudinal analysis of a large, on-going cohort study of U.S. women. Overall, the analyses in this thesis point to heterosexual AI being an integral part of many people's sexual practice, which often occurs in the context of sexual and physical violence, is associated with heavy drinking and drug use, having multiple partners and unprotected sex. It appears to be as likely practised with casual partners as steady partners and to be more likely condom unprotected than VI practice. Other than a sub-group who practise AI throughout the life course, it appears that most who practise AI do so sporadically and discontinue the practice with age.

PrEP may be a suitable to prevent HIV infection in sub-groups who practise AI as a routine part of their sexual practice. Public health messages should emphasise the importance of condom use during AI as well as VI, as the transmission risk during AI is underestimated by many.

LIST OF ABBREIVIATIONS

95%CI	95% confidence interval
ACASI	Audio-computer administered questionnaire
AI	Anal intercourse
AIC	Akaike information criteria
aOR	Adjusted odds ratio
ART	Antiretroviral therapy
BIC	Bayesian information criterion
CRS	cluster random sample
F	Female
FSW	Female sex workers
FTFI	Face-to-face interview
GBTM	Group-based trajectory modelling
GEE	Generalised estimating equations
HIV	Human immunodeficiency virus
HPV	Human papilloma virus
IDU	Injection drugs users
IQR	Inter-quartile range
M	Male
MSM	Men who have sex with men
NS	Not specified
OR	Odds ratio
PrEP	Pre-exposure prophylaxis
RCT	Cluster randomised trial
RSD	Respondent-driven sampling
SAQ	Self-administered questionnaire
SD	Standard deviation
SRS	Simple random sample
STI	Sexually transmitted infections
TLC	Time–location sampling
UAI	Anal intercourse unprotected by condoms
UVI	Vaginal intercourse unprotected by condoms
VI	Vaginal intercourse
WIHS	Women's Interagency HIV Study

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Chapter 1

Introduction

1.1. THESIS OVERVIEW

There is a greatly increased risk of HIV transmission during receptive anal intercourse (AI) compared to receptive vaginal intercourse (VI) (1–5). Prevalence of heterosexual AI (i.e. the proportion reporting AI practice) has been reported in many cross-sectional studies among diverse populations and the practice appears to be common, with condom use tending to be lower during AI compared to VI. Although it may commonly be practised, the risks of AI have often been omitted from sexual health messaging for people who practise heterosexual sex. This has potentially led to the misconception that AI unprotected by condoms (referred to throughout this thesis as UAI) is safe and may be responsible for lower condom use during heterosexual AI. The practice is also frequently overlooked in epidemiological examinations of HIV risk (2). For example, recent systematic reviews on HIV risk behaviour among female sex workers (FSW) in China (6) and young people in Africa (7) did not include AI, despite including numerous other measures of sexual risk-taking.

In order to assess the contribution of heterosexual AI to HIV epidemics we must first better understand who is engaging in AI, at what frequency, with whom, whether condoms are used, and whether once initiated, the practice is continued throughout the life course (Figure 1).

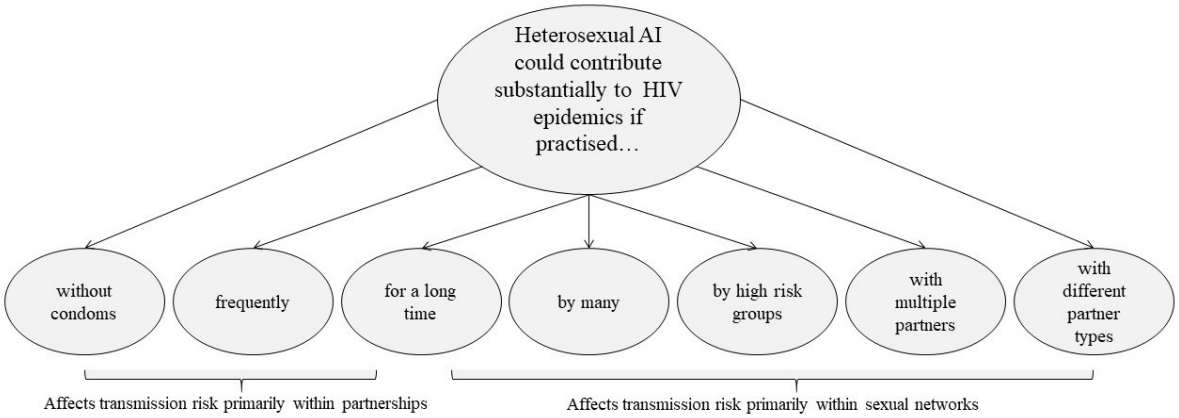

Figure 1.1. Schematic of the factors that must be explored in order to understand the impact of heterosexual AI on HIV epidemics

In this thesis I draw on different epidemiological methods, sources of evidence and populations to address some of these important research gaps in the following ways:

- Systematic reviews and meta-analyses to determine how commonly and frequently heterosexual AI is practised among young people, South Africans and FSW. These populations were chosen due to their particular vulnerability to HIV infection.

- Data analysis of cross-sectional data on a sample of Swazi FSW to examine with which partner types they practise AI and whether condom use during AI practice differs by partner type as well as to identify behaviours and exposures associated with AI.
- Analysis of longitudinal data of a cohort of low-income U.S. women in order to describe AI practice over the life course and to identify predictors of AI practice.

The overarching aim of this thesis is to examine heterosexual AI practice from an epidemiological and public health perspective. The analyses presented contribute to a better understanding of the importance of heterosexual AI to HIV transmission and help to better target interventions to reduce risk of transmission during heterosexual AI. They also identify areas where there are data gaps, further research is required, and highlight where data collection methods could be improved. Throughout this thesis, the discussion of the implications of the analyses focus on HIV transmission, but the findings are also relevant to the control of rectal sexually transmitted infections (STI).

This chapter introduces heterosexual AI practice in relation to HIV epidemics, including HIV transmission risk during UAI, how common heterosexual AI may be, whether condoms are used, how stigma of AI affects accurate reporting as well as the impact that its practice could have on HIV preventative measures such as vaginal microbicides. The structure of the thesis is presented at the end of this chapter

Box 1.1: Defining terms

Heterosexual: Throughout this thesis I use the term *heterosexual anal intercourse* to refer to penile-anal penetrative intercourse between men and women in which men are the insertive and women the receptive partners. Where relevant I use the term *heterosexual sex* to refer to any type of sex between men and women. I avoid referring to people who practise heterosexual sex as *heterosexuals* as this term refers to sexual orientation rather than to sexual behaviour.

Unprotected: At a time when HIV transmission during both AI and VI can be prevented through use of condoms as well as pre- and post-exposure prophylaxis, referring to sex unprotected by condoms simply as 'unprotected' is imprecise. There has been a move towards using the term ´condomless´ VI or AI, abbreviated to CVI or CAI, but I have opted to remain with the more familiar UVI or UAI abbreviations for ease of reading. The definition for UAI or UVI used throughout the thesis is AI or VI that is unprotected by condoms.

1.2. HOW EFFECTIVE IS HIV TRANSMISSION DURING ANAL INTERCOURSE?

The probability of heterosexual HIV transmission is frequently cited in academic literature as well as the media as being 1 infection per 1000 contacts between discordant couples. This, however represents a lower limit of infectivity and thus greatly underestimates HIV infectivity in many heterosexual contexts (3,8,9). This underestimation of the risks of heterosexual contact may lead to dangerous complacency with regard to unprotected heterosexual sex in general and UAI in particular (8).

The risk of HIV transmission is greater during receptive UAI than receptive vaginal intercourse unprotected by condoms (UVI) because the rectal mucous membrane 1) lacks the protective immune barrier present in cervical and vaginal secretions, 2) is thinner and more susceptible to traumatic abrasions which facilitate transmission than the vagina and 3) contains more CD4 target cells than the vagina (10–12). These biological factors are reflected in epidemiological data, with most studies finding an increased male-to-female transmission risk in couples practising AI (8,9). A meta-analysis estimated the risk of HIV transmission in developed countries as 1.4% (95%CI 0.2-2.5) during unprotected receptive AI compared to 0.08% (95% CI 0.06-0.11) during unprotected vaginal intercourse (VI) (3,13). Therefore, women may have an 18-fold increase in risk from practising unprotected AI compared to unprotected VI. The transmission risk during insertive AI is estimated to be twice that during insertive VI (3,13). Therefore, HIV-negative men practising UAI with HIV-infected women also face a substantially increased acquisition risk. However, there is considerable uncertainty surrounding these transmission risks due to the small number of available estimates, as well as methodological difficulties in measuring these values because infectiousness is affected by multiple factors, such as viral load in the index case and sexually transmitted infections (STI) co-infections (3,8) Further barriers to reliable estimates include recall bias and the uncertainty about serostatus of partners.

Given the far higher transmission risk of UAI compared to UVI, even practised at low frequency (5–10% unprotected sex acts being UAI), UAI could account for a substantial fraction of incident HIV cases (14). It has been suggested that the contribution of AI to HIV transmission may be as significant as that of primary infection (i.e. recent infection, which is a far more infectious stage than the later, asymptomatic stage), with Boily et al using AI prevalence and frequency data from South Africa (15) to estimate that 17-40% of new infections annually are likely due to heterosexual AI, with new infections being 2.0-2.6 times higher among females than males (14). This is similar to the narrower (25-31%) range of new infections caused by the primary infection stage estimated in the same model,

which implies that focusing on reducing UAI may be more cost-effective than efforts to test and treat for recent infection, especially given the hurdles to identification of primary infection cases (14).

Although the paucity of studies on heterosexual AI transmission dynamics result in uncertainty in the transmission rate estimates, and that accuracy is further hindered by the number of other factors which influence transmission rates, there is compelling biological and epidemiological evidence that AI poses a considerably higher risk of HIV transmission than VI (3,9,16). This elevated risk may mean that, even if practised infrequently, heterosexual AI may significantly contribute to HIV transmission at the population level.

Violence, AI and HIV transmission

Heterosexual AI often occurs in the context of coercion and violence, or when male partners claim to have 'slipped', which is discussed extensively in Chapter 2. When AI is forced it seems feasible that the increased risk of injury to the rectal mucous membrane would in turn increases risk of HIV transmission, although there are no estimates available. A mathematical model which assumed a threefold increased risk during UAI due to sexual violence (therefore, 4.2% risk per act if assuming 1.4% transmissibility per receptive UAI act without force) found that a women undergoing one forced UAI act per week within an HIV discordant relationship, has a cumulative risk of acquiring HIV over just 6 months of 67% (2). It is therefore important to understand how often AI is practised in the context of violence or coercion as practice under these circumstances is likely to lead to elevated transmission risk through rectal trauma.

Lubricant use, AI and HIV transmission

Condoms break more frequently during AI compared to VI (17–19). Use of water-based lubricant reduces the likelihood of condom breakage, while oil-based lubricant may increase the likelihood of breakage by degrading the latex (20,21). Most studies on lubricant use during AI sample MSM only, who are likely more knowledgeable about lubricant use than women; and than men who have sex with women. The few data available indicate that lubricant use is low during heterosexual AI, with 24% of U.S. women who report AI in the past month using lubricant consistently (22). One intervention in Zambia which provided men with condom-compatible lubricant and followed them for a year found that none had used it during VI, which suggests that lubricant use during AI is also likely to be infrequent (23). Qualitative research conducted among U.S. and Southern African women found that few knew about or used lubricants during AI, and when lubricant was used it was not condom-compatible (20,24). Other studies have found that the most common lubricant used during any type of sex between African men and women tend to be oil-based (21,25), as these are easily available and cheaper than water-based

lubricants (21). This wide-spread non-use or incorrect use of lubricants during heterosexual AI likely increases UAI prevalence through the elevated risk of condom breakage. Such events may however not be reported as UAI, which in turn affects the accuracy of UAI practice estimates.

When AI is not condom protected, however, it is unclear whether lubricant use helps or hinders HIV transmission. While the resultant reduction in friction may reduce trauma and thus make transmission less likely, a clinical study found that gel products similar to those commercially available caused short-term degradation of the rectal epithelium (26). Such damage to the rectal epithelia could plausibly enhance the probability of HIV transmission.

1.3. WHAT SIGNIFICANCE DOES HETEROSEXUAL AI HAVE ON BIO-MEDICAL HIV INTERVENTIONS?

a. Rectal microbicides

Microbicides are compounds applied inside the vagina or rectum to protect against HIV acquisition. The development of vaginal microbicides is currently more advanced than rectal microbicides. This is partly due to the scientific challenges related to the biology of the rectum and partly to cultural reluctance to address AI (27). Rectal microbicides have so far been shown to be safe and acceptable (among MSM; acceptability among women has not yet been examined) in numerous Phase I trials and one Phase II trial (28,29). As development and testing continues they will likely offer another choice for HIV protection during AI in the coming years.

While vaginal microbicides are currently mainly being tested as rings, rectal microbicides are mainly being developed as a lubricant. MSM tend to use lubricant frequently, so use of a microbicide lubricant may be more culturally and socially acceptable (27). However, as lubricant use seems to be low during heterosexual AI (22), other methods of application may have to be developed in order to achieve adequate adherence.

b. Vaginal Microbicide Effectiveness

The practice of AI may negatively impact the effectiveness of vaginal microbicides, especially given the higher HIV transmission rate associated with AI. Data from ongoing microbicide trials have been used to parameterise HIV transmission models in order to assess the effectiveness of vaginal microbicides under different conditions (30,31). However, heterosexual AI is rarely considered in

models that estimate the impact of prevention interventions (32), potentially leading either to over-estimation of effectiveness of some types of interventions, or the wrongful conclusion that a microbicide is inefficacious when in fact its impact has been diluted by the practice of AI.

Masse et al (5) modelled the effect of four sources of vaginal microbicide efficacy dilution: adherence, AI practice, time off product and the efficacy of the placebo gel (which may act as a physical barrier to HIV acquisition) and found that at AI levels observed in microbial trials (with 5% or 10% of sex acts being AI), these sources together can dilute true efficacy of a gel from 50% to 16%-33%. Other models have examined solely the impact of AI on microbicide efficacy dilution, with Boily et al.(14), finding that in a population where 5% of sex acts are AI, the cumulative preventive fraction of new HIV infections fell by 33% over 25 years. Depending on the relative risk of transmission during UAI compared to UVI, a rectal microbicide could be as efficacious as a vaginal microbicide when only 5% of sex acts are anal (assuming a relative risk of 20) (32). This 'break-even point' increased to 15-20% of sex acts being UAI when the lower and highly conservative relative risk of four was used (14).

The contribution of AI to the HIV epidemic is not considered in most mathematical models of vaginal microbicide interventions, which could lead to substantial over-estimation of effectiveness. Understanding the prevalence and frequency of AI practice in populations using vaginal microbicides could greatly aid development of realistic models of their effectiveness.

c. Pre-exposure prophylaxis

Pre-exposure prophylaxis (PrEP) is a promising HIV prevention strategy in which HIV-negative people at risk of HIV acquisition self-administer antiretrovirals orally. Clinical trial data demonstrate efficacy of consistent daily administration among both men and women, i.e. that PrEP 'works when taken' (33,34). Tenofovir, the active component in PrEP, has been found at higher concentration in rectal than vaginal tissue, and is therefore likely to be more protective during receptive AI than VI (35–39). In fact, although maximum protection for rectal exposure to HIV is conferred after 5-7 daily doses of PrEP (40), maximum protection during vaginal exposure is estimated to require a 20-day period (41). Given that condom use during AI is reportedly frequently lower during AI than VI and that PrEP is more efficacious during AI, it may be a potent tool to protect women who practise AI. Despite this, PrEP is not a magic bullet. Concerns for wide-spread use include potential drug resistance, side-effects, a compensatory increase in high-risk behaviour and the cost-effectiveness of long-term use (33,42). Adherence among women has been found to be low in clinical trials, and the negative findings in both FEM-PrEP (Kenya, South Africa and Tanzania) and VOICE (South Africa, Uganda and Zimbabwe)

have been attributed to low adherence (42). Therefore, while PrEP is a useful tool to prevent HIV acquisition during AI and may be suitable for certain high-risk individuals who are willing and able to comply with the regime, for many at risk it seems that condoms are still likely to offer the most effective and appropriate protection.

1.4. HOW DOES HETEROSEXUAL AI AFFECT THE EPIDEMIOLOGY OF OTHER SEXUALLY TRANSMITTED INFECTIONS?

It has been established that the risk of HIV transmission during AI is higher than during VI, but this is less clear for other STI (43). Generally, as in the case of HIV transmission, it is believed that the minor injuries that occur more often during AI compared to VI can increase transmission of other STIs (44,45). Although chlamydia, HPV and gonorrhoea infection can spread from the cervix or vagina and infect the rectum, such rectal infections are more common in women who report practising AI (45–48). An observed rise in anal cancer cases in U.S. women has been attributed to a concurrent increase in prevalence of heterosexual AI leading to increased prevalence of anal HPV infection (49) and the practice may therefore be causing increases in other STI. As in genital infections, rectal infection with STI can cause mucosal inflammation that further increases the already elevated risk of HIV infection during AI (50).

Many anal STI are asymptomatic; for example, 84% of anal gonorrhoea cases among MSM which were diagnosed through routine screening were asymptomatic in one U.S. study (51). A large proportion of anal infections are therefore likely to remain undetected if women presenting for STI testing are not routinely offered testing for anal infections as well as vaginal infections. Although MSM who visit sexual health services are often routinely screened for anal STI, this is not the case for women, with only 0.1% of a large sample of U.S. women tested for chlamydia or gonorrhoea receiving a rectal, rather than solely a genital test (52). At 11% prevalence of rectal chlamydia and/or gonorrhoea in the small proportion tested in this sample, it seems likely that a large number of rectal infections are left undiagnosed in women (52). The lack of routine screening in women, particularly those who practise AI, may result from health care providers and policy-makers associating anal infections with MSM only. A better understanding of heterosexual AI practice could inform interventions to increase testing and treatment of rectal STI among women.

1.5. HOW MANY PEOPLE PRACTISE HETEROSEXUAL ANAL INTERCOURSE AND HOW OFTEN?

Determining the contribution of heterosexual AI to HIV transmission at the population level requires not only estimates of probability of transmitting HIV during AI, but crucially, data on AI prevalence (i.e. the proportion of people practising AI) and frequency (i.e. how many AI acts they have). Although it has yet to be examined systematically, AI appears to be commonly practised. For example, in a recent representative national U.S. survey 36% of women and 42% of men reported practising heterosexual AI in their lifetime (53). A similar survey in Britain found that 15% of women had practised AI in the past year (54),while a narrative review of heterosexual AI practice among Africans concluded that in most studies, at least 20% of respondents have ever practised (1). AI practice does however, appear to be highly variable, not only across different populations, but also between different studies conducted on similar populations. Substantial variation can be seen among general adult populations in South Africa for example, with one study finding a three-month prevalence of less than 2% (55) and a second finding a prevalence of 19% over the same timeframe (15). AI prevalence among female sex workers (FSW) is likewise varied, with 40% of Kenyan FSW reporting AI in the past three months in one study (56) and only 4% reporting the practice over the same recall period in another (57).

Data on AI frequency appear to be reported by fewer studies than AI prevalence, but paint a similarly heterogeneous picture. For example, one study among young U.S. men from the general population who report practising heterosexual AI found that 25% of their sex acts were anal (58) compared to 3% of sex acts in a study from a similar population (59). The reason for such heterogeneity in AI prevalence and frequency is as yet unexamined, but may partly be because of inaccurate reporting due to the stigma attached to the behaviour, with social desirability possibly representing a very substantial bias (60) or in some cases may partly be due to an increase in AI practice over time.

1.6. WITH WHOM DO PEOPLE PRACTISE AI?

A further key factor to understanding the role of AI practice in HIV epidemics, is understanding who is practising AI with whom. AI practice may vary by partner type, although the pattern is not clear, with one study finding that AI is most commonly practised by young U.S. women with steady partners (61).Conversely, a survey of high risk urban U.S. women found no difference in practice between steady and casual partners, although it did find that it was more common with transactional partners (i.e. partners with whom sex is exchanged for money, drugs or favours) (62). Studies among FSW have

found a mixed pattern, with some studies finding AI prevalence to be lowest with primary partners (25,63), and others highest (64,65). Type of partner may also affect whether AI, if practised, is condom protected, with AI more likely to be unprotected with primary partners (25,65–67), a pattern also widely observed during VI (25,66,67).

Identifying patterns of AI practice and condom use during AI by partner type is important in order to understand the population-level risk of AI. For example, stable, monogamous couples practising UAI will contribute very little to population-level HIV risk, whereas FSW who practise UAI with their clients could contribute substantially to the spread of infection. Figure 1.2 illustrates the importance of position in a sexual network to individual- and population-level HIV risk.

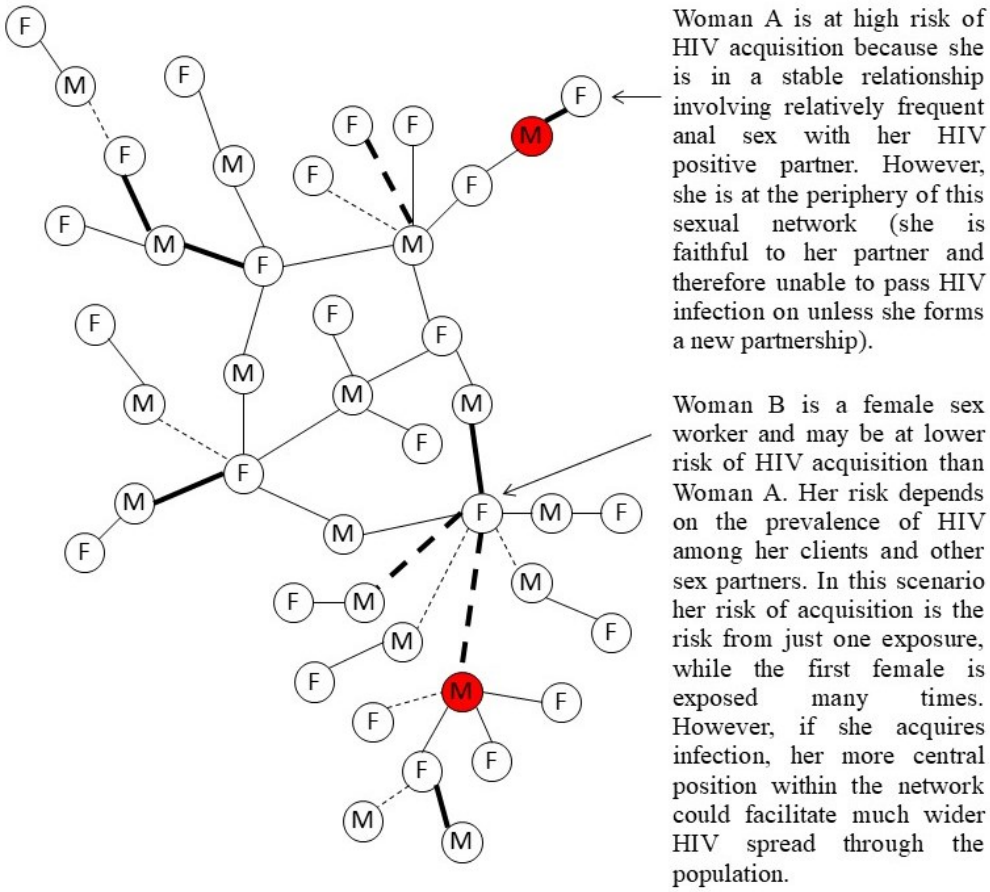

Figure 1.2. A static sexual network illustrating the very different individual-level and population-level HIV risks experienced by women in different positions in the sexual network.

A static network represents just a snapshot in time and does not show partnership formation or dissolution. Thicker lines represent relationships that involve some frequency of AI; thinner lines involve vaginal sex only. Short-term (even just one sex act) partnerships are represented by dotted lines and long-term sexual partnerships by solid lines. HIV-infected people are represented by red circles, non-infected people by white circles.

1.7. IS AI CONDOM PROTECTED?

A number of studies have suggested that among the general population condoms are used less frequently during AI than during VI (61,68–75). For example, a large national representative U.S. survey found that fewer than half of women who used a condom during their last VI act also used a condom during their last AI act (72). FSW may also tend to use condoms less frequently during AI compared to VI, with 81% of South African FSW reporting inconsistent condom use during AI with clients compared to 44% during VI (among those practising AI and VI, respectively) (56). Likewise, 25% of Indian FSW reported inconsistent condom use during AI compared to 17% during VI (76). However, other studies among Pakistani FSW (77) and low income young women in the U.S. (78) report higher condom use during AI compared to VI so the picture again is unclear and patterns remain to emerge. If condoms are less likely to be used during AI compared to VI, this may have substantial impact on susceptibility to HIV. It is therefore important to identify and understand patterns of condom use.

1.8. DO PEOPLE PRACTISE AI THROUGHOUT THEIR LIVES?

Data from cross-sectional studies give no clear age pattern of AI practice. Some studies have found the proportion reporting AI practice within the past year decreases with age (15,62,79), others find no difference by age (54,72), and yet others finding an increase (62,80) with increasing age. As such, it is unclear whether people continue to practise AI consistently once initiated, or whether practice is intermittent throughout life, or concentrated in a certain life phase. As yet, there has been no longitudinal examination of AI practice, which is necessary to understand AI practice over the life course, which can in turn be used to better target interventions.

1.9. IS AI BECOMING MORE COMMON?

AI practice may be becoming more common over time, and it is important to describe this possible increase in order to be able to interpret trends in HIV transmission and the transmission of other STI. Evidence from a number of repeated nationally representative surveys suggests an increase in heterosexual AI prevalence over time. For example, the National Survey of Sexual Attitudes and Lifestyles (Natsal) in the U.K. found that AI prevalence in the past year increased significantly from 7% of women in 1990-91 to 11% in 1999-2000 to 15% in 2010-12, with similar increases among men (54). Repeated national surveys in Croatia (81), Czechia (82) and the U.S. (83) similarly found increases

in AI prevalence over time. The increasing trend was found by other series cross-sectional surveys on specific sub-populations, with a series of three cross-sectional studies on female patients at a university health care clinic in Sweden finding that reported lifetime prevalence increased statistically significantly from 27% in 1999, to 31% and 39% in 2004 and 2009, respectively (84). Similarly, one series of studies conducted on patients at STD clinics in the US found that odds of AI were twice as high in 2004 compared to 10 years earlier (85) while another found that UAI prevalence increased from 7% to 18% in 1993-95 and 1999-2000, respectively (86). No similar such series of cross-sectional studies reporting AI prevalence over time has been identified in developing countries. However, qualitative research conducted in East Africa and India found that participants described the practice as becoming increasingly common and normalised (87,88):

> "*In the past when you talked about (AI), people would consider you as discussing something very unusual but nowadays, (AI) is seen as a normal aspect*." Rural Tanzanian quoted in Mtenga et al. (87)

1.10. STIGMA AND AI

Possibly given its long-standing association with male homosexual sex, AI is one of the most stigmatised of common heterosexual behaviours. This stigma likely leads to under-reporting of the behaviour due to social desirability bias. The cultural taboo surrounding heterosexual AI does seem to be eroding in some regions, however, which may aid more accurate reporting of the practice. This greater ease of reporting may in turn partly contribute to the observed increase in reported AI prevalence over time, so it is unclear whether it is the practice itself which is increasing, or the reporting of it which is becoming more honest.

Interview methods

Given the stigma often surrounding heterosexual AI, more confidential interview methods may collect more accurate data (89). This has been borne out by empirical data for example, 4% of married men in Cotonou, Benin reported AI in a face-to-face interview (FTFI), but 18% using the more anonymous polling booth survey method (90). This pattern is also seen among Indian FSW, of whom 19% reported UAI with a client in the previous 30 days using FTFI, but 36% using the polling booths (91). Likewise, when using self-administered coital diaries, South African FSW report that 16% of all sex acts are anal, compared to only 4% using FTFI (92). These discrepancies in reporting between more and less confidential interview methods imply that many available reports of AI practice are likely to be under-

estimates and that efforts should be made to develop and utilise more reliable tools to gather data on stigmatised behaviours.

A possible drawback of the use of confidential interviewing methods is that they may offer no opportunity for the participants to ask for clarification if questions are misunderstood. Qualitative research in South Africa has found that questions about AI are sometimes misinterpreted as referring to VI 'from behind' (93,94). To address this problem, effort has been made to develop confidential questionnaires with unambiguous pictorial clarification (93,95). This offers a promising method of gathering more accurate data on AI practice.

A further complication is that a minority of people may not regard AI as 'having sex', with 1 in 5 of U.S. university students in the 1990's (96) excluding AI from their definition of 'sex' and 1 in 6 nearly twenty years later (97). This may result in the exclusion of AI partners in survey questions focusing on sex partners unless surveys specifically include questions on AI partners.

Public health messaging

Public health messaging on HIV transmission seems to routinely neglect heterosexual AI practice. For example, none of the studies included in two systematic reviews on HIV prevention interventions among African FSW reported whether or not messaging on safe AI was included in the interventions (98,99). This omission may be due to the assumption that AI is not practised within the target population, or due to stigma and embarrassment.

Qualitative research has identified that as information about AI is often absent from public health messaging to people who have heterosexual sex, many assume that it is safe (100). In fact, one of the motivations for practising AI in some populations is the belief that it is safer than VI (101,102), with 78% and 84% of Ethiopian urban adolescents naming minimising the risk of HIV and other STIs, respectively, as motivators for their AI practice (102).

Despite how widespread AI practice is, several studies across diverse populations have found that only a minority know that AI poses an elevated HIV transmission risk compared to VI. Only 6% of FSW in Cote d'Ivoire (19) and The Gambia (103), 15% in Uganda (104) and 27% in India (105) could identify AI as conferring the highest sexual HIV risk. Knowledge that HIV can be transmitted at all during AI

can be remarkably low, with only around half of general population Mozambicans (106) and FSW in Iran (107) and the Philippines (108) able to identify AI as posing an HIV risk at all.

Given the large proportion who underestimate HIV transmission risk during AI, it seems reasonable to assume that this perceived lack of need to protect against disease transmission also contributes to the lower rates of condom use. Indeed, mixed methods research among Indian FSW found that HIV prevention programmes had raised awareness of the need for condoms during VI and that most refused to have UVI with clients (88). However, this awareness did not extend to AI, with half of those who practise AI rarely or never using condoms:

> "*I have always been using condoms… I do not use condoms when having anal and oral sex. There is no need. Some clients wear condom when doing anal sex. That is up to them. For normal sex, there is no way of doing it without condom even if clients offer more money*." Indian FSW quoted in Beattie et al. (88)

Likewise, qualitative research in East Africa has found participants associate condoms with protection against transmission during VI, but deem them unnecessary during AI (100,109). Some Tanzanians believed condoms available on the market to be suitable only for use during VI and that they would burst due to the tightness of the anus (109), representing a further barrier to condom use during AI.

Improved understanding of the extent to which AI is practised in various populations, and more thorough demonstration of its role in disease transmission, may in turn lead to the greater inclusion of AI practice in public health messaging.

1.11. CONCLUSION

Although a number of cross-sectional studies report on AI practice across different heterosexual populations, understanding of factors related to AI practice, how prevalent AI is in different populations, at what frequency it is practised, to what extent it is protected and whether people continue to practise once initiated, remain patchy. These data are needed in order for researchers and public health planners to gain a more precise understanding of the role of heterosexual AI in HIV epidemics in different contexts and to design effective prevention programmes.

1.12. THESIS OBJECTIVES AND CHAPTER PLAN

With the aim of better characterising heterosexual AI practice, this thesis employs a variety of epidemiological approaches to analyse diverse sources of evidence, particularly focussing on populations vulnerable to HIV acquisition. The results can be used to identify appropriate public health responses to this important HIV and STI risk factor. The data analyses presented in the thesis are all guided by a literature-based conceptual framework on the multiple factors influencing heterosexual AI practice and the pathways that facilitate the behaviour. This framework is presented in **Chapter 2**.

AI practice has been reported in studies across various populations, but the extent to which AI is practised and whether and how practice varies by risk group, age, partner type, setting and over time has yet to be comprehensively described. **Chapters 3 and 4** address this gap by presenting systematic reviews and meta-analyses of heterosexual AI among three populations selected due to their particular vulnerability to HIV infection: young people, South Africans and FSW. These extensive reviews are divided over two chapters, with **Chapter 3** outlining the reasons for reviewing AI practice in these particular populations and the methodology used. **Chapter 4** presents the results and discusses the implications of the findings.

Chapter 5 presents an analysis of AI practice among FSW in eSwatini (formerly known as Swaziland) using respondent-driven sampling (RDS) data from a cross-sectional study (110). eSwatini has the highest HIV prevalence in the world, and prevalence among Swazi FSW is alarmingly high at 70% (111). Understanding AI practice among this population is therefore pertinent, particularly as FSW are often central in sexual networks and if infected, can contribute substantially to onward transmission (Figure 1.1). As well as comparing AI practice and condom use by partner type, generalised estimating equations (GEE) for logistic regression are used to identify determinants of AI practice in this vulnerable population.

Although AI practice has been described in diverse cross-sectional studies, it has yet to be described longitudinally. With the aim of describing AI practice across the life course, **Chapters 6 and 7** present analyses on AI practice in the WIHS cohort, an ongoing cohort study among U.S. women (112). **Chapter 6** presents an examination of AI practice over the life course, both within the whole sample and among groups with distinct AI practice trajectories identified through group-based trajectory analysis. **Chapter 7** presents analysis of time-varying predictors of AI practice over the life course.

Conclusions and implications of the research presented and further research needed is discussed in **Chapter 8.**

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Chapter 2

Heterosexual anal intercourse practice: A conceptual framework

2.1. RATIONALE

This chapter presents an evidence based conceptual framework of the multiple factors influencing heterosexual AI practice and the pathways that facilitate the behaviour. Conceptual frameworks are an important epidemiological tool that can help to articulate linear connections, identify determinants of risk which interventions might then target, highlight gaps in the evidence and help structure the research needed to address these gaps (1). Throughout this thesis, I use the conceptual framework developed here to identify variables of interest to take account of in each analysis in the subsequent chapters.

The aim of this chapter is to lay the theoretical foundation and evidence base for the subsequent analyses in this thesis. The objectives of this chapter are to:

i. Review both the quantitative and qualitative evidence on the demographic, behavioural and structural factors associated with heterosexual AI practice.
ii. Develop a conceptual framework to guide the epidemiological analyses in this thesis

Box 2.1: Literature search

The conceptual framework is based on published quantitative and qualitative literature, which was identified through an extensive, but unsystematic search. PubMed and Google were searched using a variety of search terms and reference lists of relevant studies were scanned. PubMed was searched using the terms 'anal AND sex AND (heterosexual OR women)'. The term 'women' was included to avoid capturing studies which sampled only men who have sex with men. The term 'anal' was initially specified to be in the title in order to limit the search results to the most relevant. The majority of identified studies were conducted in the U.S. In an attempt to broaden the scope of the conceptual framework, I also conducted wider PubMed searches for studies from populous countries individually e.g. searching all fields for 'sex AND behaviour AND (heterosexual OR women) AND Kenya'. Reference lists of relevant studies were scanned. U.S. studies still constitute a large bulk of the evidence for the framework, which likely reflects the geographical distribution of research conducted on this topic. Evidence from studies which included men was used when it was specified that the reported AI among males was with female partners. As many studies did not specify this, a majority of the evidence here is based on women's reports of heterosexual AI practice.

2.2. INTRODUCTION

The framework unpacks intersecting structural, environmental, individual, and interpersonal factors which may influence heterosexual AI practice. A number of frameworks have been developed to elucidate the causal pathways of sexual HIV risk among various groups, with the importance of employing a structural determinants approach gaining prominence in recent years (2). This exploratory framework is grounded in the literature on determinants of heterosexual AI (see Box 1 for search strategy) and its construction draws on frameworks of HIV vulnerability by Shannon et al (2) and Baral et al (3). The framework depicts how macro-structural factors (such as religion and gender norms) may interact with an individual's wider community environment to form structural determinants of AI. These structural determinants can interact with an individual's behaviourial determinants as well as those of their partner's (e.g. alcohol use), which in turn shape dyadic (partnership) factors, resulting in whether or not AI is practised and whether condoms are used. However, the levels are inherently porous and structural influences can play out at various levels; macro-structural gender inequities can fuel gender-based power dynamics within a sexual relationship, for example. This framework follows that of Shannon et al. by including partner and interpersonal factors rather than factors relating to the individual alone, given the clearly gendered power dynamics that affect heterosexual sexual behaviour and condom use (2).

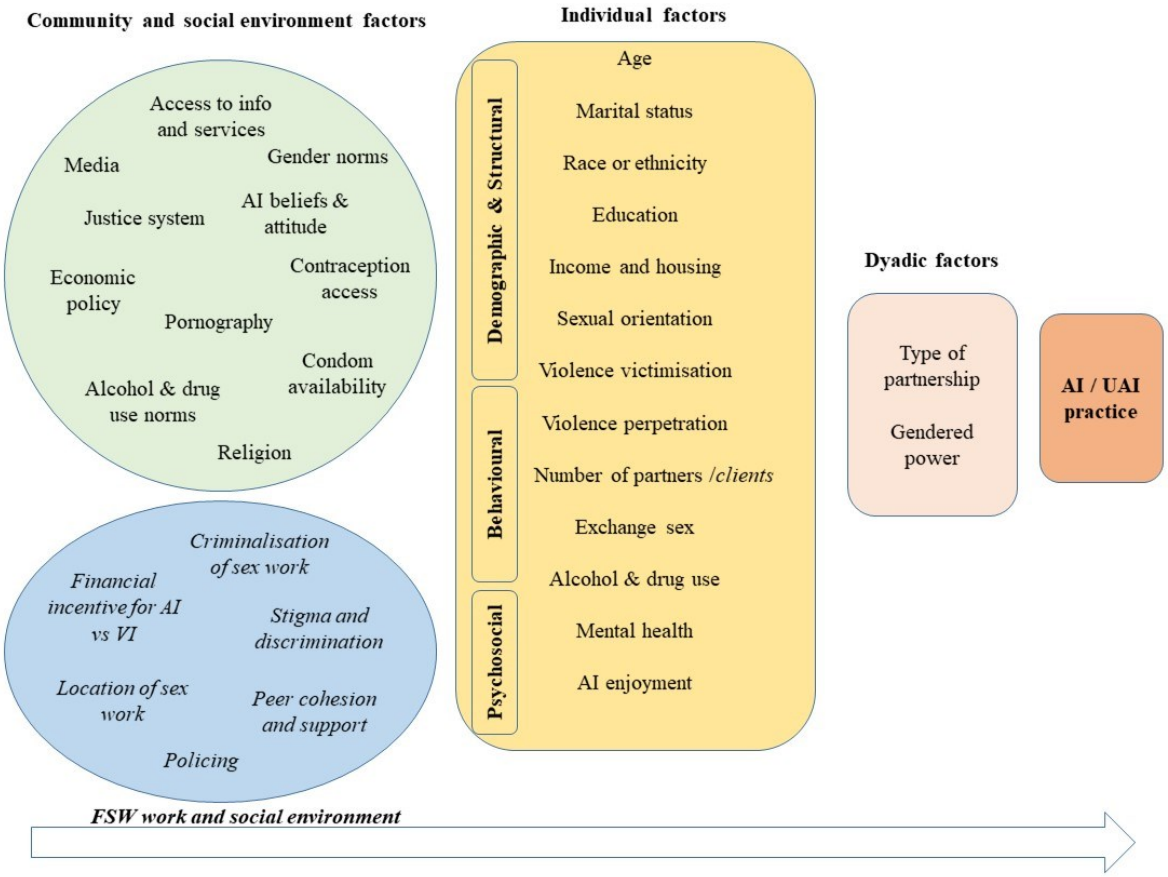

Figure 2.1: A conceptual framework of determinants of heterosexual AI practice. Factors which are specific to female sex workers (FSW) and their clients are in italics. AI – anal intercourse, UAI – anal intercourse unprotected by condoms, Exchange sex – sex in exchange for favours, goods, services or money, VI – vaginal intercourse.

2.3. SUMMARY OF PUBLISHED EVIDENCE

In total,134 studies identified through the literature search were relevant and included in this narrative review. The conceptual framework developed through the review is presented in Figure 2.1, and the factors presented in the framework are discussed in turn in this section.

2.3.1. Dyadic factors

Type of partnership

Interpersonal factors operate at the partner level within sexual networks and may encourage or discourage AI practice. AI practice may vary by partner type, although the pattern is not clear, with one study finding that AI is most commonly practised by young U.S. women with steady partners (4) while a survey of high risk urban U.S. women found no difference in practice between steady and casual partners, although it did find that it was more common with exchange partners (i.e. partners with whom

sex is exchanged for money, drugs or favours) (5). Findings from qualitative studies are likewise mixed, finding that some women reserve AI practice for 'special' partners (6–8) while others that:

> "[Anal sex] *is practised between people who are just using each other. … They don't love each other … I don't believe that there is anyone who can do such a thing to someone whom he loves*…". South Africa woman quoted in Duby et al. (9)

Studies among FSW have found a mixed pattern, with some studies finding AI prevalence (the proportion reporting AI practice) to be lowest with primary partners (10,11), and others highest (12,13). Type of partner may also affect whether AI, if practised, is condom protected, with AI more likely to be unprotected with primary partners (10,13–15); a pattern also widely observed during VI (10,14,15). Among U.S. dating couples, the likelihood of AI practice has been found to increase with number of nights spent together, but not with their emotional closeness (16), while a further U.S. survey found that feelings of love were unrelated to whether women engaged in AI with male partners (17).

Condom use during AI may be more common in casual partnerships, with STI clinic patients who have a new or a casual partner more likely to report consistent condom use during AI (18). Similarly, in a coital diary survey, adolescent girls were more likely to report that AI was condom-protected when feeling less in love (19). While this would appear to point to more condom use in higher risk, less monogamous relationships, another study found that U.S, women whose partners were potentially HIV-infected or were bisexual, were less likely to have used a condom at last AI (5). Of those women reporting UAI, 20% reported that their partner had had sex with men *during their relationship* (5).

Gendered power

Relationship power appears to have a great effect on the likelihood of AI practice, which was three times higher among non-injection drug using women in New York who perceive themselves to have low relationship power (20), and UAI more common among urban U.S. Hispanic women who perceive their male partners as having more power in the relationship (21). Correspondingly, AI was more common when male partners held a more traditional rather than less traditional gender role ideology in a national U.S. survey of dating heterosexual couples (22), as well as among university students in the U.S. (23). Similarly, when men made decisions about sexual positions and behaviours, couples were more likely to practise AI (22,24,25). Qualitative research from East Africa found that both male clients and FSW expressed the view that the paying client is entitled to demand whatever type of sex he wants (26). Gendered power dynamics also appear to play a role in condom use during AI, with the odds of condom use lower in relationships with intimate partner violence perpetrated against the woman than in relationships with no violence in the U.S. (27).

A minority of women who practise AI cite their own pleasure as a motivation for its practice (6,28–30), but fulfilling their partner's requests for AI appears to be the most common reason, as has been found in quantitative surveys (31–33) as well as qualitative research (9,28,34–36). Findings from qualitative research have described persuasion and coercion to be common features of AI practice in relationships (6,35,37), with authors of a study of AI among English teens concluding that:

> "*persuasion of women was a feature to a greater or lesser degree of most men's and women's narratives about anal sex events, with repeated, emphatic requests from men commonly mentioned*" (37).

The same study found that AI was often initiated when the male partner claimed that his penis 'slipped' during vaginal intercourse (37), and another qualitative study concluded that AI acts often had 'an element of surprise' (6). As discussed in Chapter 1, this action is likely to lead to more trauma which increase the risk of HIV transmission. That AI most frequently occurs at the male partners' request, even though women often describe AI as painful (6,30,37,38), and men are consistently more likely than women to report enjoying AI (22,27,29,39–42), points to AI practice often occurring in an environment of profoundly gendered power dynamics which may often include sexual coercion and lack of consent.

2.3.2. Individual factors

Demographic and structural factors

Numerous demographic and behavioural variables have been shown to be associated with heterosexual AI practice. Findings on these variables from studies identified through the targeted search (Box 1) have been summarised in Table 2.1. Several studies in the U.S. have found the practice to be more common among Hispanics than African-American women (43–46,34,47) and among white women compared to African-American women (5,48,49), while a smaller number of studies have found no differences by race (50,51). No studies examining differences by race in countries other than the U.S. were found.

The likelihood of lifetime experience of AI has been found to increase with higher levels of education (4,49,52–54) and with income (4,49,52–54), whereas more recent AI has not (22,52). This may indicate that those with higher socioeconomic status are more likely to experiment in a variety of sexual activities, but are less likely to do so on a regular basis. In fact, recent AI appears to be more common among women in more precarious situations, including those currently or recently homeless (5,27,50) and food insecure (21). AI has been found to be more common among Indian FSW who have no income other than sex work (55), those in debt (56) and the highly mobile (57). The picture is not clear,

however, with recent AI also having been found to be higher among better educated FSW (58) and those with higher income (59). Several studies have found heterosexual AI practice to be more common among bisexual (those who report sex with both men and women) women (16,45,60–62) and men (16,60,62–66).

Women reporting AI have been found to be more likely to have been sexually abused as children and to report coerced sex or rape (11,23,27,67–70). Intimate partner violence is likewise associated with increased likelihood of heterosexual AI, with the practice more common among U.S. women who have been victims (20,27,71,72) as well as female (27) and male perpetrators (27,72). One study of a large national U.S. sample found AI practice to be most strongly associated with intimate partner violence when women reported disliking AI (27). Studies which sampled only FSW found that those who were victims of forced sex (11,68) and physical violence perpetrated by clients also report higher AI prevalence (11,55,73–75).

Anal rape seems to be common during sexual attacks on women, with the prevalence of recent anal rape over half that of vaginal rape among Russian FSW (76) and a quarter of binge drinking young urban women in the U.S. who had been raped reported anal rape (77). In qualitative research FSW in the U.S. described forced or coerced AI as a common feature of their work (78). Anal rape may be more violent than other types of rape with one study finding that, during rapes that included AI, two-thirds of the victims had also been beaten during the attack compared to 28% of vaginal rape victims (79).

Behavioural factors

Various sexual behaviours are more common among those who practise AI, forming a generally higher sexual risk profile. These include having multiple recent partners (5,51,80,52), a higher number of lifetime partners (32,81), practising group sex (43), a lower age at first sex (45,52,32), sex in exchange for money or drugs (4,5,43,47,48,51,62,69,82), and lower rates of condom use (83–86). AI practice among FSW is likewise often associated with other risky sexual behaviour practices, including having a greater number of clients (14,58,59,87), practice of 'dry' sex (11,68), more unprotected sex (68,73) and an inability to negotiate condom use (58). In studies that did not specifically recruit FSW or their clients, a history of engaging in exchange sex was associated with AI among women (4,5,16,43,47,48,62,69,82) and men (82,88). Among clients of FSW, reporting a greater number of sex acts with FSW (89) and regularly visiting the same FSW (65) have been found to be positively associated with AI practice.

Substance use is frequently found to be positively associated with AI practice, with studies variously finding AI to be more common among men and women using any type of illegal drugs (48,52,82), or having sex while high (65,81,90) and among women using cocaine (20), ecstasy or methamphetamine use (43,34) or crack (83). A daily diary survey among drug-using women found that AI occurred more commonly on days when drugs were used (91). Similarly, those who report recent binge drinking (47,5,92), or drinking alcohol before or during sex (34,81), are more likely to report practising AI. The same associations have been found in studies sampling FSW only, with any drug use (73,93), any alcohol consumption (58), heavy drinking (55) and drinking before sex (73,94) found to be positively associated with AI practice. AI may be more common when clients are under the influence of drugs or alcohol (65), when it may also be more likely unprotected (89). This association between AI and alcohol and drug use has been elucidated in qualitative research, with women explaining that they only practise AI when high or drunk because it is too painful or too objectionable otherwise (8,28,34,95):

> "*..but the anal thing-- like, that is the worst thing ever to do and --I can't do it unless I have like a whole lot to drink, because it hurts*." Female U.S. STI clinic patient, quoted in Hutton et al, 2016 (96).

In one qualitative study on urban women in the U.S., women described how men take advantage of drunk women in order to practise AI which the woman may object to when sober:

> "*You know, they'll let them do that when, if they were sober, oh, no, we're not going there, but they're drunk out of their mind and the guy just totally just takes advantage of them and does whatever--and they have no means to say stop, anything like that, because they're so out of it*". Heavy-drinking U.S. women, quoted in Lewis et al 2015 (95)

Psychosocial factors

Negative psychological conditions have been found to be associated with AI, with those suffering from depression more likely to practise AI (20,97), and its practice among U.S. adolescent girls more likely on days of 'negative mood' (19). Again, this relationship has also been found in qualitative research:

> "*That's how low I felt in myself, that it was ok. It got to be where he started doing this on a regular basis. I didn't feel like I was worth nothing that I allowed him to do it!"* U.S. woman quoted in Reynolds et al (6).

Other studies have found AI practice to be inversely associated with life, relationship, and sexual satisfaction indices, and that AI may be related to sensation-seeking traits (90,98,99).

Differences in trends between men and women

The identified trends in associations between heterosexual AI practice and demographic and behavioural factors did not differ between men and women, with the exception of education level and sexual orientation. The tendency for AI to be more commonly reported among the better educated was more consistent among women, with six of seven studies finding a positive association and one finding no association. Among men, in contrast, one of two studies found a positive association while the other found a negative association. All five studies examining AI practice by sexual orientation found the practice to be more common among bisexual and/or lesbian women, whereas two of the four relevant studies among men found positive associations and two found negative associations with bisexuality and/or homosexuality. The reasons for these observed differences are not yet understood.

Table 2.1: Associations between demographic, structural and behavioural factors and heterosexual anal intercourse practice in published studies among A) women and B) men.

A. Women	Population	AI recall period	Direction of association
Demographic and structural factors			
Age	Urban women at risk of HIV, U.S.(83) Urban women, U.S.(5) National rep. samples, U.S.(52), U.K.(100) Low income urban adults, South Africa(82)	≤12 months	↓ with increasing age(5,82,83) ↔ with increasing age(52,100)
	National rep. sample, U.S. (52,101), Puerto Rico(54), Czechia(62)	Lifetime	↔ with increasing age(52,62,101) ↓ with increasing age(54)
Marital status	Low income urban adults, South Africa (82)	≤12 months	↑ among unmarried(82)
	National rep. sample, U.S.(52)	Lifetime	↑ among cohabiting women(52)
Race or ethnicity	Urban sexually active adolescents, U.S.(43,45) Black and Hispanic women, U.S.(47) Young Hispanic and Black adults, U.S.(44) Women at risk of HIV, U.S.(34,50) Low income urban women, U.S.(46) STI clinic patients, U.S.(48,51) National representative sample, U.S.(27,49)	≤12 months	↑ among Hispanic vs African-Americans(34,43–47) ↑ among White vs African-Americans(27,48,49) ↔ among Hispanic, White and African-Americans(50,51)
Education	Urban women at risk of HIV, U.S. (83) Dating couples U.S.(22) *FSW, India*(58)	≤12 months	↓ with more years education(83) ↔ with more years education among women(22) ↑ with more years education(58)
	Low income young women, U.S.(4) National rep. samples, U.S. (49,52,53), Puerto Rico(54)	Lifetime	↑ with more years education(4,49,52–54)
Income	Urban U.S. Hispanic women(102) *FSW, India*(55,56,59)	≤12 months	↓ with income(56,102) ↓ with additional sources of income(55) ↑ with income(59)
	Low income young women, U.S.(4) Adult dating couples, U.S.(22) National rep sample, U.S.(52)	Lifetime	↑ with income(4,22,52)
Sexual orientation	Urban women, U.S. (61,64) Female drugs users, U.S.(16)	≤12 months	↑ among bisexual women(16,61) ↑ female partners of MSM
	National rep. sample, U.S. (60), Czechia(62) Urban sexually active adolescents, U.S. (45)	Lifetime	↑ among bi- or homosexual women(45,60,62)
Housing	Women at risk of HIV, U.S.(50) National rep. youth sample, U.S.(27)	≤12 months	↑ with housing insecurity(27,50)
Sexual violence victimisation	University students, U.S. (23) Urban adolescents at risk of HIV, U.S. (43,67) National rep. sample of young adults, U.S.(27) *FSW, Kenya*(11,68)	≤12 months	↑ in women sexually abused as children (43) ↑ in relationship in which woman is sexually abused(27) ↑ among women ever raped(11,23,67,68)
	Female STI patients, U.S. (103) Urban Black women, U.S. (104) Adults, Tanzania(69) Secondary school students, South Africa(70)	Lifetime	↑ in women sexually abused as children (103,104) ↑ among women ever raped(69) ↑ among girls ever coerced sex(70)

A. Women	Population	AI recall period	Direction of association
Physical violence victimisation	Female drug users, U.S.(20,71) National rep. youth sample, U.S.(27) *FSW, Kenya*(11), *Russia*(75), *Thailand*(74), *India*(55) *and Armenia*(73)	≤12 months	↑ among female IPV victims(20,27,71) ↑ *among victims of client's violence* (11,55,73–75)
Behavioural factors			
Violence perpetration	National rep. youth sample, U.S.(27)		↑ among female IPV perpetrators(27)
Number of partners	Urban adults, U.S.(5) STI clinic patients, U.S.(51) Drug users, U.S.(80) *FSW, India*(58,59), *South Africa*(87), *Papua New Guinea*(14)	≤12 months	↑ with greater number of recent partners (5,14,51,58,59,80,87)
	University students, U.S.(32) STI clinic patients, U.S.(51) National rep. sample, Croatia(86) Adults, Tanzania(69)	Lifetime	↑ with greater number of lifetime partners(32,51,69,86) ↑ with concurrent partners(86)
Exchange sex	Urban sexually active adolescents, U.S. (43) STI clinic patients, U.S.(48) Black and Hispanic urban women, U.S.(47) Female drugs users, U.S.(16) Urban adults, U.S.(5)	≤12 months	↑ among women who report recent exchange sex (5,16,43,47,48,82)
	Young low income women, U.S. (4) Adults, Tanzania(69), Czechia(62)	Lifetime	↑ among those who report exchange sex ever(4,62,69)
Alcohol use	Urban adults, U.S.(5) Black and Hispanic women, U.S.(47) HIV infected women(92). U.S. Women at risk of HIV(34), U.S. Adolescents, The Bahamians(97)	≤12 months	↑ among binge drinkers(5,47,92) ↑ when drinking before sex(34) ↑ with any drinking(97)
Drug use	Female drug users(20), U.S. Urban sexually active adolescents, U.S.(43) Women at risk of HIV(34), U.S. Urban women at risk of HIV, U.S.(83) National rep. sample, U.S. (52), STI clinic patients, U.S.(48,88) Low income adults, South Africa(82)	≤12 months	↑ with frequency of cocaine use(20) ↑ with ecstasy and methamphetamine(34,43) or crack use(83) ↑ with any drug use(48,52,82) ↑ with marijuana use(97) ↑ when taking drugs before sex(88)
Mental health	Female drug users(20), U.S. Female adolescents, U.S. (105) Adolescents, The Bahamas(97)	<12 months	↑ among depressed women(20) and adolescents(97) ↑ on days of 'negative mood'(105)

B. Men	Population	AI recall period	Direction of association
Demographic and structural factors			
Age	Urban adults, U.S.(5) National rep. sample, U.K.(100), South Africa(81) Low income urban adults, South Africa(82)	≤12 months	↓ with increasing age(5,82) ↔ with increasing age(100) ↑ with increasing age(81)
	National rep. sample, U.S.(101), Puerto Rico(54), Czechia(62)	Lifetime	↔ with increasing age(62,101) ↓ with increasing age(54)
Marital status	Low income urban adults, South Africa(82)	≤12 months	↑ among unmarried(82)

B. Men	Population	AI recall period	Direction of association
Race or ethnicity	Young Hispanic and Black adults, U.S.(44) STI clinic patients, U.S.(48,51) National rep. sample, U.S.(27,49)	≤12 months	↑ among Hispanic vs African-Americans(44) ↑ among White vs African-Americans(27,48,49) ↔ among Hispanic, White and African-Americans(51)
Education	Dating couples U.S.(22)	≤12 months	↓ among men(22)
	National rep. samples, U.S. (49,53), Puerto Rico(54)	Lifetime	↑ with more years education(49,53,54)
Sexual orientation	Rep. urban sample, Mexico(63) *Clients of FSW, Mexico*(65)	≤12 months	↑ among bisexual men(63,65)
	National rep. sample, U.S. (60), Czechia(62)	Lifetime	↓ among bi- or homosexual men(60,62)
Income	Adult dating couples, U.S.(22)	Lifetime	↑ with income(22)
Housing	National rep. sample of young adults, U.S.(27) STI clinic patients, U.S.(88)	≤12 months	↑ with housing insecurity(27) ↑ among homeless(88)
Violence victimisation	No studies identified		
Behavioural factors			
Violence perpetration	National rep. sample of young adults, U.S.(27) Young men at health clinic, U.S.(72)	≤12 months	↑ in heterosexual relationships in which man sexually abuses woman(27) ↑ among perpetrators of IPV(27,72)
Number of partners	Urban men, U.S.(5) STI clinic patients, U.S.(51) Drug users, U.S.(80) National rep. sample, South Africa(81)	≤12 months	↑ with greater number of recent partners (5,51,80,81)
	STI clinic patients, U.S.(51) Adults, Tanzania(69) National rep. sample, Croatia(86)	Lifetime	↑ with greater number of lifetime partners (51,69,86) ↑ with concurrent partners(86)
Exchange sex	Low income adults, South Africa(82) STI clinic patients, U.S.(88)	≤12 months	↑ among men with exchange partners (82,88)
Alcohol use	Urban men, U.S.(5) National rep sample, South Africa(81) Adolescents, The Bahamians(97)	≤12 months	↑ among binge drinkers(5) ↑ when drinking before sex(81) ↑ with any drinking(97)
Drug use	National rep. sample, South Africa(81) STI clinic patients, U.S.(48,88) Low income adults, South Africa(82) *Clients of FSW, Mexico*(65)	≤12 months	↑ with any drug use(48,82) ↑ when taking drugs before sex(65,81,88)
Mental health	Adolescents, The Bahamas(97)	<12 months	↑ among depressed adolescents(97)

↑, ↓ and ↔ indicate a significant increase, a significant decrease and no difference in likelihood of AI practice, respectively. AI – anal intercourse, FSW – female sex workers, exchange sex – sex in exchange for goods, money or services. Rep – representative. AI practice was reported over many different recall periods. For simplicity, recall periods of past 12 months and shorter are grouped together. Evidence from studies on FSW or their clients are in italics

2.3.3. Community and social environment factors

This framework so far has addressed the interpersonal and individual level factors that shape AI practice: factors that have received far more research attention than the more distal community and societal factors which shape downstream proximate factors. Societal determinants operate outside the locus of control of individuals and include macro-societal factors such as the justice system and the media as well as cultural factors such as alcohol and drug use. This section of the framework also includes societal and work environment factors specific to FSW and their clients.

Gender norms shape men's and women's perceptions of appropriate and expected sexual behaviours and the extent to which individuals endorse gender norms has been found to affect their sexual behaviour, including number of partners and condom use (106). There is some indication that gender norms likewise affect AI practice, with one study finding that AI was more common among young women who hold beliefs of hegemonic masculinity (23). Qualitative research has also found beliefs that AI practice acts as a marker or proof of masculinity (36,37,107). Alcohol and drug use patterns in the community can in turn shape one's own as well as one's sexual partners' alcohol and drug use behaviour.

In some countries, the religious and cultural importance of remaining a virgin until marriage may increase the practice of AI among unmarried people. Unmarried couples in the Middle East and North Africa reportedly commonly practise AI while avoiding VI in order to leave the hymen intact (108) but there is no empirical data available on this (109). It is likewise widely believed that AI is often practised in lieu of VI by religious young people in the U.S. in order to preserve virginity (110), however two studies found that only 1% of young people who report never having practiced VI had practiced AI (111–113). An extreme example of how cultural practices can influence AI practice is female genital mutilation, with some indication that women who have undergone it may practise AI at higher rates due to difficult and painful VI (114), although no studies quantitatively investigating this were found.

Portrayals of sexual behaviour in the media in general, and in pornography in particular, may shape norms and behavioural expectations. Some have linked recorded increases in AI practice to increased exposure to pornography at young ages, arguing that it causes de-stigmatisation of anal sexual behaviour (115,116). Higher AI prevalence has been found among Swedish and U.S. adolescents (41,117–120) and Indian FSW clients exposed to online pornography (121). Likewise, in qualitative research participants have frequently cited their own or their partner's pornography viewing as

motivation for AI practice (26,28,35–37,122). FSW in India reported an increase in client requests for AI over the years, which they attribute to exposure to pornography:

> "*The younger ones…. They bring movies* [pornography]. *They do as the white men do*." Indian FSW quoted in Beattie et al. (123).

A content analysis study found that pornography targeting heterosexual audiences featured AI in 56% of scenes, which the authors state is a vast increase from previous decades (124). Although there is no evidence of causality as yet, the increased exposure to pornography at ever younger years and the increased portrayal of heterosexual AI within that media may well be fuelling an increase in AI practice.

A number of macro-level governmental decisions may have downstream consequences for an individual's sexual life and AI practice. Economic policies affect employment, housing, income and recourse to exchange sex, all of which in turn play a part in shaping an individual's sexual behaviour. Health care policies affect access to birth control, particularly among poor and marginalised women (125), who may then engage in AI as a way to avoid unwanted pregnancy. Both quantitative and qualitative research has found that women cite pregnancy avoidance as one of several motivations for practicing AI (26,107,126). However, to what extent avoiding pregnancy is the primary motive for AI practice is not clear; on the one hand UAI has been found to be more common among young U.S. women who do not use birth control compared to those who do (20), and on the other only 5% of women in Canada who practise AI cited birth control as the sole reason (24).

2.3.4. FSW work and social environment

The criminalisation of sex likely has myriad down-stream effects including forcing sex work to be conducted in informal, unregulated settings, increased stigma against FSW, increased physical and sexual violence perpetrated by clients, pimps and police, inconsistent condom use and may increase HIV prevalence (127). These consequences of criminalisation in turn affect the practice of AI, with victims of physical violence (11,55,73–75) and forced sex (11,68) reporting higher AI prevalence. Location of sex work also affects levels of AI practice, with AI more common among Indian FSW working in 'hidden' locations compared to brothel workers (128) and among illegal compared to registered Australian FSW (129).

There are clear financial incentives to practising AI, with several studies finding that FSW charge more for AI than for VI (11,26,59,130,131) and that higher earnings are the main reason for its practice (26,36,55,59,94,132). Despite this financial incentive, client demand for AI appears to outstrip supply

(129,133), and AI practice is usually initiated by clients rather than FSW themselves (11,130). There are also financial incentives for practicing unprotected sex (134–136), which may contribute to the lower condom use rates with AI compared to VI, with unprotected AI possibly garnering the highest rates of all sex acts (131). Client demand for AI may be partly driven by societal stigma against AI, with some men feeling unable to practise it with their wives, and so request it with FSW, which was succinctly described as 'front is for wife, back for prostitute' by a Ugandan respondent in a qualitative study (26). Indeed, among Indian clients of FSW, prevalence of AI with FSW was more than double that reported with their wives (137).

2.4. DISCUSSION

In this chapter, I have proposed a literature-based conceptual framework of the interplay of interpersonal, personal and societal factors, which can affect whether or not an individual practises AI. Briefly, those who: practise higher risk sexual activities, use drugs and alcohol and are victims and/or perpetrators of violence are disproportionately more likely to practise heterosexual AI. The confluence of factors leading to AI practice has perhaps best been summarised in Fahs and Gonzalez's conclusion of their investigation into heterosexual AI practice:

> "*This …. reveals a messy cocktail of ingredients—normative representations in pornography, desire for ''edgy'' and ''hip'' sexual activities, heterosexual men encouraging each other to try it, women wanting to please and seem ''normal'' or ''cool'' via trying anal sex, avoiding pregnancy and (for some) maintaining ''virginity,'' beliefs that women should accommodate men's desires, focus on the anus as an abjected site, distance between the imagined and lived realities of sex, tentative desire for anal eroticism—that have all created a growing momentum behind a sexual act that many women find prescriptive, painful, or dissatisfying* (35)."

Narrative reviews and conceptual frameworks are subjective by definition. The approach used here focused on the experience of individuals who practise heterosexual AI with the aim of understanding why and in which situations the practice occurs. The strength of this review is that it looks at a wide variety of behaviours and exposures which can influence sexual behaviour, and it is thus able to capture some of the diversity of experiences. Most of the evidence used in developing this framework is on women's AI practice and therefore likely does not fully reflect factors influencing men's practice. This imbalance is in large part a reflection of poor reporting of AI practice among males, as many studies do not report separately on men's heterosexual and homosexual AI practice.

Nonetheless, this model can be used to guide epidemiological studies of sexual behaviour in collecting the data needed to enhance characterisation of the multi-layered contexts of heterosexual AI practice. Defining and characterising individual level risk behaviours like AI practice are imperative to better understanding the dynamics of HIV and STI epidemics. However, it is the more distal community and societal levels that likely facilitate transmission on a population level. Every epidemiological study examining sexual behaviour and sexual risk should thus ensure that, as well as gathering data on individual behaviour, it also characterises social and structural factors that underlie high-risk practices.

The framework can also be used to identify targets for prevention strategies. Behavioural and biomedical interventions often focus on individual level HIV risks. However, the effectiveness of these interventions may be undermined when societal level factors are not taken into account(3). A third use for conceptual frameworks is to guide data analysis and to determine variable selection. The framework is used for this purpose throughout this thesis; it is used to guide data extraction for the systematic reviews in Chapters 3 and 4, and to identify co-variates of interest in the data analyses in Chapters 5-7.

The extensive narrative review conducted to inform the framework identified a substantial number of relevant studies, and also revealed imbalances in the currently available research. Most studies were conducted in the U.S. (82 of 134 included studies), more described AI practice among women, than among men (109 vs 49 studies included women and men, respectively) and all studies were cross-sectional in nature (or longitudinal trials which reported on AI practice at baseline). This means that while AI practice is fairly well understood cross-sectionally among U.S. women, it is far less well understood among other populations.

The work in this thesis redresses these imbalances to some extent. Two of three systematic reviews in Chapters 3 and 4 examine AI practice among men as well as among women and are either global in scope or focus on South Africa. Chapter 5 examines AI practice among FSW in eSwatini; a population for which there is currently no estimate of AI practice, despite having an alarmingly high HIV prevalence. Chapters 6 and 7 present the first longitudinal examination of AI practice over the life course, using data from a large, ongoing cohort study among U.S. women.

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PUBLICATIONS

The research presented in this and the following chapters has been published or submitted for publication as three separate papers.

The review on AI practice among young people:

> **Owen BN**, Brock PM, Butler AR, Pickles M, Brisson M, Baggaley RF, Boily MC. Prevalence and Frequency of Heterosexual Anal Intercourse Among Young People: A Systematic Review and Meta-analysis. AIDS Behav. 2015;19(7):1338–60.

The review on AI practice among South Africans:

> **Owen BN**, Elmes J, Silhol R, Dang Q, McGowan I, Shacklett B, Swann EM, van der Straten A, Baggaley RF, Boily MC. How common and frequent is heterosexual anal intercourse among South Africans? A systematic review and meta-analysis. J Int AIDS Soc. 2017 Jan 11;19(1):1–14.

The review on AI practice among female sex workers:

> **Owen BN**, Baggaley RF, Elmes J, Harvey A, Shubber Z, Butler AR, Silhol R, Anton P, Shacklett B, van der Straten A, Boily MC..What proportion of female sex workers practise anal intercourse and how frequently? A systematic review and meta-analysis. Submitted 2018

All co-authors of each publication provided feedback and guidance and approved the final manuscript. I conducted the searches, extracted data, conducted data analysis and wrote the articles.

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Chapter 3

Systematic review and meta-analysis on prevalence and frequency of heterosexual anal intercourse among young people, South Africans and female sex workers: Introduction and Methods

3.1. RATIONALE

Although heterosexual AI practice has been reported in numerous studies on sexual behaviour worldwide. it has not, to the best of my knowledge, been systematically reviewed in any population. As such, 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. Here and in the following chapter I address this gap by presenting systematic reviews of heterosexual AI among three populations selected due to their particular vulnerability to HIV infection: young people (aged 24 years and under), South Africans and female sex workers (FSW).

3.2. BACKGROUND

The rationale for choosing the populations and methods of the systematic reviews are presented in this chapter, while the results are presented and discussed in Chapter 4. The reviews on heterosexual AI among young people and South Africans are published (1,2).

Young people face a disproportionate burden of HIV infection, with an estimated 34% of total new HIV infections in 2012 occurring among young people (3). This increased risk is due in part to the multiple biological and psychological transitions and developmental tasks (establishing identity) in this period of the lifespan (4). In generalised epidemics of southern and eastern Africa, adolescent girls and young women are at increased risk compared to their male peers, to the extent that young women acquire HIV around five to seven years earlier than young men in South Africa (5). As well earlier sexual debut and increased HIV infection susceptibility compared to their male peers, a major cause of this age-sex disparity in HIV acquisition are intergenerational relationships between young women and girls and older men; as the HIV prevalence is higher among older than younger men given the aggregating prevalence of HIV with increasing age. The gender-power dynamics often at play in intergenerational relationships, mean a young woman or girl may be less likely to negotiate condom use or to avoid higher risk activities like AI.

South Africa is an important setting to examine patterns of heterosexual AI, as it has the largest HIV epidemic driven by heterosexual sex in the world (6). Although its epidemic is among the most researched in sub-Saharan Africa, the reasons for the high prevalence of HIV infection, particularly among young women, and the extent to which AI plays a role, are incompletely understood (5,7).

FSW suffer a disproportionately high burden of disease (8), with odds of HIV infection over 13-fold that of women in the general population. It is therefore particularly pertinent to identify patterns of AI practice among FSW in order to estimate the contribution of UAI to HIV/STI incidence in this group and transmission to their clients and non-paying partners.

The primary aim of chapter 3 and 4 are to systematically review and summarise published estimates from self-reported sexual behaviour data from young people, South Africans and FSW. The outcomes of interest are the proportion who have had AI (which is referred to as AI prevalence) and the number of AI acts (which is referred to as AI frequency) over various recall periods. A further aim is to examine how AI practice varies by participant and study characteristics, including survey year in order to explore whether AI practice is increasing over time. These reviews will be useful to improve our understanding of AI practices, inform prevention messages and highlight knowledge gaps. Key parameter estimates derived from this review can be used in mathematical models to explore the contribution of AI to the HIV epidemic and assess the influence of AI on the predicted effectiveness of prevention interventions.

3.3. METHODS

The methods followed were largely the same for each of the three systematic reviews, so will be described here together.

3.3.1. Search strategy

All reviews were conducted following PRISMA guidelines for reviews of observational studies (9). I conducted all the searches for the studies on young people and South Africans and on FSW from 1990 onwards. The search, article selection and data extraction for studies among FSW published between 1980 and 1989 were undertaken by Amy Harvey as part of her BSc in Global Health summer project. The search terms for each review contained terms on population group of interest and terms on sexual behaviour. The search for studies on young people contained the word ‘anal’, but this was not included in the searches for the two other reviews so as to avoid rejecting studies that, while containing AI data, did not refer to AI in the title or abstract. This was not feasible for the review among young people given its wider scope. Search terms and dates for each review are presented in Table 3.1.

Abstracts were screened for relevance and retrieved full-text articles if heterosexual sexual behaviour among the relevant population was reported. Full-text articles were screened for quantitative data on AI practices as described below. Bibliographies of all included articles were scanned for further relevant citations. Additionally, for the review among South Africans, relevant data from national surveys in reports unpublished in peer-reviewed journals was included, which were identified through an internet search. Reports from cross-sectional and cohort studies and randomised controlled trials (RCTs) were included. Articles were excluded if the study explicitly reported including data from MSM (not applicable to the FSW review), and if data on AI and VI data were not separated. For the review of young people, publications were included if they reported outcomes for a study sample with mean age <25 years (following the UN's definition of young people aged 10-24 years (10)). For the FSW review, women were defined as being FSW if they reported exchanging sexual services for payment; either cash or in-kind.

Table 3.5. Search strategies for each systematic review

Review	Databases	Dates	Search terms
Young people	PubMed, Embase & PsychINFO	Jan. 1st 1975 to July 2014 31st	Anal AND (sexual OR sex) AND (adolescents OR young OR youth OR school OR university) AND (heterosexual OR females OR girls OR women))
South Africans	PubMed & Embase	Jan. 1st 1990 to December 31st 2015	((South Africa OR South African) AND (sexual OR sex) AND (behaviour OR risk) AND (women OR female OR heterosexual))
Female sex workers	PubMed & Embase	Jan. 1st 1980 to Jan. 31th 2018	(FSW OR female sex workers OR sex workers OR prostitutes OR transactional sex) AND (behaviour OR risk) AND (sexual OR sex OR sexually) AND (survey OR trial OR cohort OR cross-sectional OR longitudinal))

The searches in PubMed used Medical Subject Heading (MeSH) terms. This ensures that the search includes all spelling variations of included terms.

3.3.2. Data extraction

The four main outcomes of interest in each review were:

i) AI prevalence (i.e. the proportion of participants practising AI among sexually active respondents, see Box 3.1),

ii) The monthly number of AI and VI acts

iii) The fraction of all sex acts and all unprotected sex acts which are AI and UAI

iv) The fraction of AI and VI sex acts that are unprotected by condoms (see Box 3.2)

Where possible and relevant these outcome were extracted or derived for each gender separately.

When directly reported, these outcome estimates were extracted, otherwise the relevant information to derive them was extracted when available (see Boxes 3.1 and 3.2 for calculations). Thus, information on the fraction and number of respondents reporting AI and VI over the various reported recall periods, the mean number of AI, UAI, VI and UVI acts among the subset reporting AI and/or the whole sample (i.e. including those who report no AI), the fraction of all sex acts which are AI and UAI, and the fraction of AI and VI sex acts unprotected over each recall period, as well as the 95% confidence intervals (CI) or standard deviation (SD) of each of these were extracted, where available.

Box 3.1: Extraction and calculation of AI prevalence outcomes

AI prevalence

For prevalence data the numerator, denominator and proportion of respondents reporting AI and VI over a given recall period as well as those reporting any AI or VI unprotected by condoms were extracted, or where necessary calculated. For the reviews among South Africans and young people, AI prevalence was calculated among the sexually active, which was defined as engaging in VI. FSW were assumed to be sexually active, so for that review, AI prevalence was calculated among the whole sample. Proportion reporting AI, *p*, was calculated using the following equation:

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

where *n* is the number of participants reporting AI over the recall period (numerator) and *d* (denominator) is the number of participants reporting VI or, among FSW, was the number who answered the question on AI practice (i.e. were not missing values) or if the denominator for the question was not available, the total number of study participants was used. If the numerator was not available, then the following equation was used:

$$n = p \,.\, d$$

Confidence interval for AI prevalence

$$CI = p \pm 1.96 \cdot \sqrt{\frac{p(1-p)}{d}}$$

Where CI is 95% confidence interval, *p* is proportion reporting AI, *d* is the number of participants who answered the question, or if not available, then the number of study participants.

Prevalence of AI unprotected by condoms (UAI) among those reporting AI

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

Where *p* is the proportion reporting UAI, *n* (numerator) is the number of participants reporting UAI over the recall period and *d* (denominator) is the number of participants reporting AI. The equivalent equation was used for calculating the prevalence of vaginal intercourse unprotected by condoms (UVI).

Information on key participant and study characteristics (gender, study location, survey year, population, mean age, setting: urban or rural) including factors reflecting study quality (interview method, study design, sampling method, response rate and whether heterosexuals only were included) were also extracted. Additionally, the location in the article where AI was first mentioned (title, abstract or main text) was extracted in order to explore publication bias, as papers may be more likely to include or highlight AI data when the practice is common.

Baseline data only were extracted from cohort or RCT studies in order to capture AI practice in the absence of any intervention and to minimise potential Hawthorne effect (the alteration of behaviour by the participants of a study due to their awareness of being observed). Where data from the same or overlapping study populations were reported in more than one article, the publication with the largest sample size or with the most information on AI (if the sample size was the same) was included. Authors were contacted when key participant and study characteristics or recall period of AI prevalence or AI frequency were not reported.

Box 3.2: Extraction and calculation of AI frequency outcomes

Standardising number of AI acts per month

Where number of sex acts was reported over recall periods other than one-month, this was standardised by either dividing by the number of months reported or multiplying the number of weeks to make up one-month. A month was assumed to have 4.3 weeks and 30.5 days and a working week was assumed to have five days.

Fraction of sex acts that are AI

When a study did not report the fraction of sex acts that was AI, or unprotected sex acts that were UAI directly, and sufficient information was provided, these were derived as the ratio of the mean number of AI or UAI and mean number of all sex acts or of all unprotected sex acts, respectively. Similarly, the fraction of AI that was unprotected by condoms was derived as the ratio of mean number of UVI or UAI acts and mean of all AI acts or all VI acts.

$$F^a = \frac{n_a}{(n_a \ + \ n_v)}$$

Where F^a is the fraction of sex acts that are AI, n_a is the mean number of AI acts and n_v is the number of VI acts.

Fraction of sex acts that are UAI

$$F_{ua} = \frac{n_{ua}}{(n_{ua} + n_{ua} \ )}$$

Where F_{ua} is the fraction of unprotected sex acts that are UAI, n_{ua} is the mean number of UAI acts per person, n_{uv} is average number of UVI acts per person.

Mean number of AI acts among the whole sample, when reported among the sub-sample who report practising AI

$$n_w = n_s . p$$

Where n_w is the average number of AI acts per person for the whole sample, a_s is the average number of AI acts per person in the sub-sample who report practising AI and p is the proportion of the whole sample who practise AI (AI prevalence). The equivalent equation is used to calculate number of unprotected anal acts.

For the reviews on South Africans and young people, samples recruited from communities, schools, universities, health clinics, shebeens (informal drinking establishments) and from national representative samples were classified as general risk, while sexually transmitted infection (STI) clinic patients, female sex workers (FSW), their clients, and HIV-infected individuals were classified as higher risk. Relevant information was initially extracted (or derived) into a standard datasheet by myself and reviewed for accuracy by one of six co-authors (see acknowledgements on Chapter title page).

3.3.3. Data synthesis and presentation, and statistical methods

AI prevalence: Extracted data were used to derive AI prevalence estimates (and 95%CIs) amongst sexually active participants (among South Africans and young people this was defined as those reporting practising VI, whereas FSW were assumed to be sexually active and AI prevalence was calculated among the whole sample) (Box 3.1). Individual study estimates by recall period were displayed in forest plots. All results from general and higher risk populations are presented separately among South Africans and young people. Sub-group analysis of AI prevalence, by participant and study characteristics was conducted for each recall period with sufficient study estimates (defined as the single most common recall period among young people, recall periods with five and ten study estimates among South Africans and FSW, respectively). The effect of survey year was examined by dichotomising at the median survey year in reviews among South Africans and FSW, and in the review among young people survey year was dichotomised at 2004 (ten years before the search). Mean age was dichotomised at 18 years among young people to differentiate between adolescents and young adults, at 25 years among South Africans to differentiate between young people and older adults and at the median among FSW.

Dealing with heterogeneity: Heterogeneity across study estimates was investigated using I^2 statistics (15,16). As each review included diverse populations, which in the case of young people and FSW came from different countries, significant heterogeneity in prevalence estimates across articles was anticipated. To account for this, random-effects models for the meta-analysis were used and extensive sub-group analyses were conducted to explore the influence of participant and study characteristics (17–19).

Dealing with bias: The effect of different aspects of methodological quality (study design, sampling method, response rate and survey language for South Africa only) and thus the impact of various biases on AI prevalence were explored through sub-group analysis. Social-desirability bias was explored through assessing the effect of interview method on reported AI prevalence. Publication bias was explored through funnel plot in the review on young people. Additionally, the effect of section in the

articles where AI was first mentioned: title, abstract or main text, was examined through sub-group analysis as it is possible that authors may be more likely to include or highlight AI data when prevalence is higher. The effect of these measures of study quality on AI frequency were explored through AI graphical display only, given the small number of estimates.

Frequency data: To facilitate comparison across studies, sex act frequency estimates were standardised to one-month (Box 3.2). When a study did not directly report it, the fraction of sex acts that are AI or UAI and the fraction of UAI and UVI were derived from the necessary extracted data when provided (Box 3.2). Due to the scarcity of frequency data generally, and measures of variance around estimates in particular, analysis was limited to narratively describing the available data. In the reviews among South Africans and FSW the effect of participant and study characteristics on i) the fraction of sex acts that are AI and ii) the fraction of unprotected sex acts that are UAI were graphically explored through scatter plots.

All models were fitted and pooled estimates derived using maximum-likelihood random-effects models based on inverse-variance (11–13) with the procedure 'Metafor' (14) in R version 3.4.0.

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Chapter 4

Systematic review and meta-analysis on prevalence and frequency of heterosexual anal intercourse among young people, South Africans and female sex workers: Results and Discussion

The results of the systematic reviews of AI prevalence and frequency among young people, South Africans and female sex workers (FSW) are presented in turn in this chapter, and the findings are compared and contrasted in the discussion. The rationale and methods of these reviews are detailed in Chapter 3, but to briefly reiterate, the objectives are to systematically review and summarise published estimates from self-reported sexual behaviour data from young people, South Africans and FSW. Outcomes of interest are the proportion who have had AI (which is referred to as AI prevalence) and the number of AI acts (which is referred to as AI frequency) over various recall periods. A further aim is to examine how AI practice varies by participant and study characteristics, including survey year in order to explore whether AI practice is increasing over time.

4.1 RESULTS: AI PRACTICE AMONG YOUNG PEOPLE

4.1.1 Search results and study and particpant characteristics

The study selection procedure and search results are summarised in Appendix Figure A4.1. 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. Appendix Table A4.1 provides a summary of the characteristics of the included articles. 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. More articles reported AI prevalence over a lifetime (n=73) than over shorter recall periods (n=46); with past three months being the next most common (n=22). 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).

Most reported on general risk populations (n=110) and 27 reported on higher risk populations. One study reported on both higher- and general risk young people. 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 only reported AI information by mixed gender. 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). Few articles reported on alcohol or condom use, number of sex partners, age at first AI or VI (Appendix Table A4.1).

Study quality and potential bias

The majority of studies were cross-sectional in design (n=114) and used convenience sampling (n=85). Response rate was not reported by a majority of articles (n=71). The majority of articles first mentioned AI in the abstract (n=92), followed by in the title (n=22), the text (n=19) and in tables (n=2). 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).

4.1.2. How common is AI among young people?

Lifetime AI prevalence was heterogeneous and ranged from 4.6% to 61.7%, 1.7% to 48.1% and 0% to 45.7% in general risk sexually active male, female and mixed samples respectively (Appendix Figure A4.2). Among general risk young people, pooled estimates of lifetime AI were similar between males, at 22.7%, (95%CI: 17.4-28.1%) and females at 21.5% (95%CI: 18.7-24.3%) (Table 4.1). Lifetime AI prevalence among higher risk young people tended to be higher, with a pooled estimate of 33.6% (95%CI: 26.0-41.3). Pooled 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 (Table 4.1).

Table 4.1. Pooled estimates of AI prevalence over all recall period used, among sexually active general risk and higher risk young people

	GENERAL RISK									HIGHER RISK		
	Male			Female			Mixed Gender[a]			Combined genders[b]		
Recall period	N	Pooled estimate (95% CI)	I^{2b} %	N	Pooled estimate (95% CI)	I^{2b}	N	Pooled estimate (95% CI)	I^{2b}	N	Pooled estimate (95% 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

Combined gender = due to the small number of studies reporting on higher risk young people, genders were combined. Mixed gender = studies which reported AI practice on males and females combined. [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 (1). I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity.

Table 4.2. Sub-group analyses of lifetime AI prevalence by participant and study characteristics, among sexually active general risk populations

Sub-group	MALES				FEMALES				MIXED			
	N	Range %	Pooled estimate (95%CI)	I^{2a} (%)	N	Range %	Pooled estimate (95%CI)	I^{2a} (%)	N	Range %	Pooled estimate (95%CI)	I^{2a} (%)
ALL	22	4.6-61.7	22.7 (17.4-28.1)	99.1	51	1.7-48.1	21.5 (18.7-24.3)	98.4	16	0.0-45.7	18.4 (13.0-23.7)	98.6
Key particpant characteristics												
Continent												
Africa	2	8.4-61.6	35.1 (0.0-87.3	99.9	3	1.7-48.1	18.4 (0.0-42.1)	99.7	6	6.0-45.7	16.9 (7.4-26.3)	97.2
Asia	1	-	4.6 (3.5-5.9)	-	4	3.1-28.0	12.0 (3.1-20.9)	84.0	1	-	14.3 (7.9-24.0)	-
Europe	5	11.4-44.3	23.5 (11.4-35.6)	97.5	9	10.8-39.4	23.6 (18.6-28.6)	94.8	0	-	-	-
L. America	2	26.4-26.9	26.7 (17.5-35.8)	0.0	4	6.2-29.1	19.1 (8.6-29.7)	78.4	0	-	-	-
N. America	12	14.3-39.1	23.5 (19.5-27.6)	98.9	32	8.0-46.6	25.3 (22.0-28.6)	97.4	9	0.0-42.5	22.4 (16.7-28.4)	98.4
Mean age												
<18	9	8.4-61.7	23.3 (11.5-35.0)	99.6	17	5.4-48.1	22.9 (17.3-28.5)	98.1	7	0.0-46.8	16.9 (5.4-26.3)	97.8
18-24	13	4.6-42.7	24.2 (18.8-29.7)	99.4	38	1.7-46.6	22.8 (19.6-25.6)	98.8	9	14.3-42.5	21.6 (17.7-25.6)	87.4
Survey year												
<2004	15	11.4-26.5	18.4 (14.1-22.7)	88.7	33	2.5-42.9	20.7 (17.7-23.7)	97.8	10	0.0-42.5	19.2 (13.3-25.1)	97.3
≥2004	7	4.6-61.7	27.6 (19.5-35.7)	99.6	19	1.7-48.1	26.3 (21.3-31.4)	99.2	5	6.0-45.7	20.0 (11.0-28.9)	93.4
Number of lifetime sex partners												
<3	0	-	-	-	4	6.2-22.1	13.0 (6.8-19.2)	87.0	4	6.0-22.0	14.5 (9.2-19.8)	70.8
3-6	3	15.0-32.1	24.9 (17.1-32.7)	85.8	5	13.5-27.3	20.0 (15.7-24.4)	83.6	0	-	-	-
>6	2	17.0-19.5	18.3 (13.8-22.8)	0.0	3	17.9-39.4	30.5 (22.9-38.1)	91.2	0	-	-	-
Age at first VI (years)												
<16	2	8.4-26.4	17.4 (5.0-29.8)	91.8	5	5.4-36.8	20.8 (11.1-30.5)	96.0	6	6.0-42.5	12.9 (7.2-18.6)	93.3
≥16	7	4.6-32.1	18.3 (11.9-24.8)	94.0	11	3.1-39.4	23.5 (18.5-28.5)	95.4	2	22.9-42.5	32.7 (13.5-51.9)	95.5
Study quality and potential for bias												
Interview method												
FTFI	1	-	14.7 (7.8-21.6)	-	6	1.7-21.7	13.7 (7.7-19.6)	98.2	3	0.0-18.8	9.0 (0.0-27.6)	98.3
SAQ	19	4.6-42.7	19.9 (15.5-24.3)	96.4	38	3.1-39.4	21.4 (18.5-24.7)	95.1	12	6.0-45.7	20.1 (13.1-27.1)	98.0
ACASI	3	22.8-61.7	35.5 (26.6-44.5)	99.8	7	6.5-48.1	31.1 (25.6-36.7)	99.4	3	14.8-22.2	18.5 (10.0-26.9)	24.7
Telephone	0	-	-	-	1	-	2.5 (0.0-8.7)	-				
Study design												
Cross-sectional	21	4.6-61.7	23.8 (18.8-28.8)	99.5	46	1.7-48.1	23.1 (20.2-26.0)	98.9	16	0.0-42.5	16.6 (11.7-21.6)	98.6
Cohort	0	-	-	-	4	8.0-20.8	13.1 (7.7-18.6)	86.1	0	-	-	-
RCT	1	-	26.9 (9.9-44.0)	-	3	13.0-42.9	26.2 (16.3-36.0)	85.3	0	-	-	-
Sampling method												
CRS	4	8.4-61.7	29.1 (8.7-49.5)	99.0	10	22.4 (15.3-29.4)	22.4 (15.3-29.4)	98.1	4	7.5-45.7	19.6 (4.6-34.6)	99.1
SRS	6	17.0-42.7	29.7 (24.4-34.9)	99.4	7	27.6 (22.4-32.9)	27.6 (22.4-32.9)	99.3	4	6.0-22.9	14.6 (9.4-19.9)	84.3
Convenience	11	11.4-26.5	18.2 (14.1-22.4)	82.2	32	21.5 (18.0-24.9)	21.5 (18.0-24.9)	96.7	8	0.0-42.5	23.0 (17.1-28.9)	97.9

Sub-group	MALES				FEMALES				MIXED			
	N	Range %	Pooled estimate (95%CI)	I^{2a} (%)	N	Range %	Pooled estimate (95%CI)	I^{2a} (%)	N	Range %	Pooled estimate (95%CI)	I^{2a} (%)
RDS	0	-	-	-	1	12.8 (8.3-17.5)	12.8 (8.3-17.5)	-	0	-	-	-
NS	1	-	14.5 (11.4-17.6)	-		16.3 (13.2-19.4)	16.3 (13.2-19.4)	-	0	-	-	-
AI first mentioned												
Title	4	22.8-42.7	33.4 (27.2-39.7)	98.5	8	13.0-42.9	27.7 (23.2-32.2)	91.8	2	22.6-28.3	22.6 (16.8-28.3)	0.0
Abstract	14	8.4-61.7	21.7 (17.1-27.1)	99.2	35	2.5-48.1	21.6 (18.3-25.0)	97.9	12	0.0-45.7	18.7 (11.6-25.8)	99.2
Text	3	4.6-24.5	14.6 (3.6-25.6)	83.2	8	1.7-46.6	16.2 (9.3-23.2)	98.6	1	-	22.0 (16.5-27.4)	-
Table	0	-	-	-	0	-	-	-	1	-	10.4 (4.9-15.9)	-

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 (1) 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.

4.1.3. Who practises AI the most?

Sub-group analysis was conducted on lifetime AI prevalence (Table 4.2), as this was by far the most commonly used recall period. In sub-group analysis, pooled estimates of lifetime AI prevalence increased substantially from pre-2004 and 2004 onwards among males and females, although not significantly. When time trends were examined by continent, all pooled estimates for 2004 onwards were higher than pre-2004 pooled estimates. This, however, was only statistically significant in Europe, where pooled estimates nearly doubling between pre-2004 (18.2%, 95%CI: 14.2-22.3%) and 2004 onward (33.7%, 95%CI:28.8-38.6%) (Appendix Table A4.2). Neither continent nor mean age explained variation in AI prevalence among any gender group (Table 4.2).

The effect of the number of lifetime sex partners and age at first VI on lifetime AI prevalence were examined in the subsets of articles in which these variables were reported (listed in Appendix Table A4.1). Among females, but not males, pooled estimates increased with number of sex partners, but this was not significant (Table 4.2). Pooled estimates did not vary by age at first VI among males or females, but was higher among young people of mixed gender reporting first VI at age 16 or later, compared to <16 years (Table 4.2).

Is reported AI prevalence influenced by study quality and other biases?

Pooled estimates increased significantly with confidentiality of interview method among males and females, but not among mixed gender. Among females, for example, the pooled estimate of AI prevalence when ACASI was used was over twice that when FTFI was used (Table 4.2). The pooled estimate of baseline prevalence from cohort studies was significantly lower than from cross-sectional studies among females, which may indicate selection bias in the cohort studies (Tables 4.2). There was insufficient information to assess the influence of study designs were among males and mixed gender as all but one were cross-sectional. Pooled estimates did not vary significantly by sampling method. Pooled estimates tended to be higher the earlier AI is mentioned in the article, although the difference was not significant in any gender group. This may indicate publication bias, as article authors may be inclined to highlight high levels of AI practice and, conversely, disinclined to report AI practice at all when it is reported by no or few participants.

4.1.3. Is AI more often condom protected than VI?

Of the 136 articles included, 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, AI and VI unprotected by condoms was analysed over only the most frequent recall periods, which were: general unprotected

sex (proportion of respondents reporting 'never' or 'rarely' using condoms, n=9), any unprotected sex over past three months (n=7), and no condom use at last sex (n=12), (Table 4.3). Given the small number of articles reporting for each recall period, gender groups were combined for the analysis.

When measured over the concrete recall periods of past three months and at last sex, pooled estimates for any UAI were higher than for any UVI, but only statistically significantly different when measured at last sex (pooled estimates for UVI at last VI 48.8%, 95%CI: 40.9-56.8%, vs 70.1%, 95%CI: 64.2-76.0% for UVI at last AI). There was no difference when UAI and UVI were measured as general unprotected sex. This analysis was hindered, however, by the small sample sizes in each category.

Table 4.3. Pooled estimates of prevalence of unprotected sex[a] among general risk young people, over most commonly reported recall periods

	N	Range, %	Pooled estimate, unprotected sex, % (95%CI)[a]	I^{2b}
General unprotected sex[c]				
UVI	7	33.0-100.0	64.9 (48.3-81.6)	98.2
UAI	5	0.0-90.2	61.3 (33.1-84.8)	99.8
Past three months				
UVI	6	21.7-68.0	40.7 (25.7-55.8)	96.7
UAI	5	37.3-79.1	60.0 (45.0-75.0)	91.2
Last sex				
UVI	11	25.7-71.0	48.8 (40.9-56.8)	97.6
UAI	5	50.0-80.0	70.1 (64.2-76.0)	94.5

[a]Unprotected sex is defined as prevalence of any sex which was unprotected during recall period (i.e. report anything other than 'always' using condoms. [b]I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity. [c]General unprotected sex is defined as % of respondents reporting 'never' or 'rarely' using condoms over an undefined time period

4.1.4. How frequent is AI among young people?

Of the thirteen articles reporting monthly AI frequency data, all but two were conducted in the US (Table 4.4). Ten reported on general risk and three on higher risk young people. Some articles reported frequency among the subset of participants who reported AI (2–6), whereas other articles reported among all study participants, including those only practicing VI (7–14). 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 comparisons across articles. Given the diversity of reporting methods and outcomes, it was not possible to produce pooled 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) (2–6) and number of UAI acts 0.4 to 3.4 (n=2) (2,6). The fraction of sex acts which were AI was estimated to be between 3.0 and 8.5% in females (n=3) and 3.0 and 24.7% in males (n=3) (3,4,6).

AI frequency appeared to vary by both AI prevalence and frequency recall period, with higher monthly frequency reported when original recall period was shorter. For example, among articles on general risk populations 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 (7,12). These observations 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 to 2.2 acts/month). Comparatively, the monthly average of VI acts varied between 2.8 to 15.4 across both genders (n=9).

Based on the few data available, 3.0 to 24.7% (from the minimum and maximum frequencies reported by the relevant articles) of all sex acts may be AI, among the general risk youth who report AI (3,4,6). Similarly, 1.1 to 20.6% of all sex acts in a month may be AI among the whole sample of general risk young people (7–9,12–14) (n=6). (Table 4.4). Percentage of AI acts which were unprotected was high in the three articles in which it was possible to calculate it, ranging from 55 to 79% among general risk (2,6,14) and 56 to 82% among higher risk young people (5).

Box 4.1. AI practice among young people: key findings

- AI is common, but varied among young people worldwide
- Overall pooled estimates of lifetime AI prevalence was 22% (95%CI: 20-24) among sexually active young people, and was similar when measured over shorter recall periods .
- Pooled lifetime AI prevalence:
  - did not differ by gender, continent or age
  - tended to be higher in studies published after 2004, which was significant in Europe only, indicating that the practice may be becoming more common over time
  - increased significantly with confidentiality of interview method
- Condoms tended to be used more inconsistently during AI compared to during VI, although pooled estimates for UAI and UVI prevalence were only significantly different when measured at last sex.
- An estimated 3% to 24% of all reported sex acts were AI

Table 4.4. Summary of available data on frequency of sex acts and percentage of sex acts which are AI among young people.

Reference	Sex	Population, Country	N	AI prevalence %	Number of sex acts standardised per month[a] AI	VI	UAI	UVI	% sex acts[b] AI	UAI[c]
A) *Among those reporting AI*										
General risk										
Original AI frequency: past 1 month										
Houston, 2007(2)	F	General, US	350	15.6 / 3 months	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										
Rotheram-Borus, 1999(6)	M	Community, US	150	10.0 / ever	2.2	7.5	1.4	NA	24.7	NA
	F		112	6.0/ ever	0.7	7.9	0.4	NA	8.5	NA
Original AI frequency: past 12 months										
Reinisch, 1992(3)	F	University students, US	352	22.2/ever	0.1	3.3	NA	NA	3.0	NA
	M		125	19.2/ever	0.3	10.0	NA	NA	6.0	NA
Reinisch, 1995(4)	F	University students, US	235	13.1/ever	0.2	5.0	NA	NA	4.0	NA
	M		344	13.6/ever	0.2	6.7	NA	NA	3.0	NA
Higher risk										
Original AI frequency: past 3 months										
Lescano, 2009(5)	F	At risk young people, US	759	14.9/3 months	1.1	NA	0.9	NA	NA	NA
	M		589	17.3/ 3 months	1.6	NA	0.9	NA	NA	NA
B) Among all (i.e. including also those only reporting VI)										
General risk,										
Original AI: frequency: 1 day										
Garry(12)	Mix	University students, US	37	32.4/1 month	0.8	5.6	NA	NA	20.6	NA
Original AI frequency: last sex										
Herbenik,2010(7)	F	General, US	592	3.6/ 1 month	NA	NA	NA	NA	6.4	NA
Original AI frequency: past 3 months										
Scott-Sheldon, 2010(8)	Mix	Binge drinking students, US	221	4.0/ 3 months	0.1	9.1	NA	NA	1.1	NA
Original AI frequency: past 1 month										
Hensel, 2008(9)	F	Clinic, US	387	5.9/ 3 months	0.1	2.8	NA		3.6	3.6
Original AI frequency: past 3 months				NA						
Morrison-Beedy, 2013(13)	F	Community, US	738	NA	0.53	9.2	NA	0.32	5.4	NA
Simbayi, 2005(14)	F	Community,	115	NA	0.46	4.04	0.24	2.16	10.1	10.1
	M	South Africa	113		0.97	4.89	0.37	2.55	16.6	12.6
Higher risk,										
Original AI frequency: past 3 months										
Kabakchieva, 2006(10)	M	Roma, Bulgaria	296	47.3/ months	NA	NA	3.6	NA	NA	43.2
Original AI frequency: past 3 months				NA						

Reference	Sex	Population, Country	N	AI prevalence %	Number of sex acts standardised per month[a]				% sex acts[b]	
					AI	VI	UAI	UVI	AI	UAI[c]
Harvey, 2004(11)	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, the number per month were calculated (e.g. divided number of sex acts reported over three months by three). [b]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. [d]AI reported separately by partner type, any overlap not reported.

4.2. RESULTS: AI PRACTICE AMONG SOUTH AFRICANS

4.2.1. Search results and study and participant characteristics

The study selection procedure and search results are summarized in Appendix Figure A4.3. Of the 2,520 titles initially identified, 41 articles were included. Most articles were identified from the database search, with three included articles identified through reference scanning and none through the internet search for grey literature. Additional information was obtained from three of the eleven authors contacted.

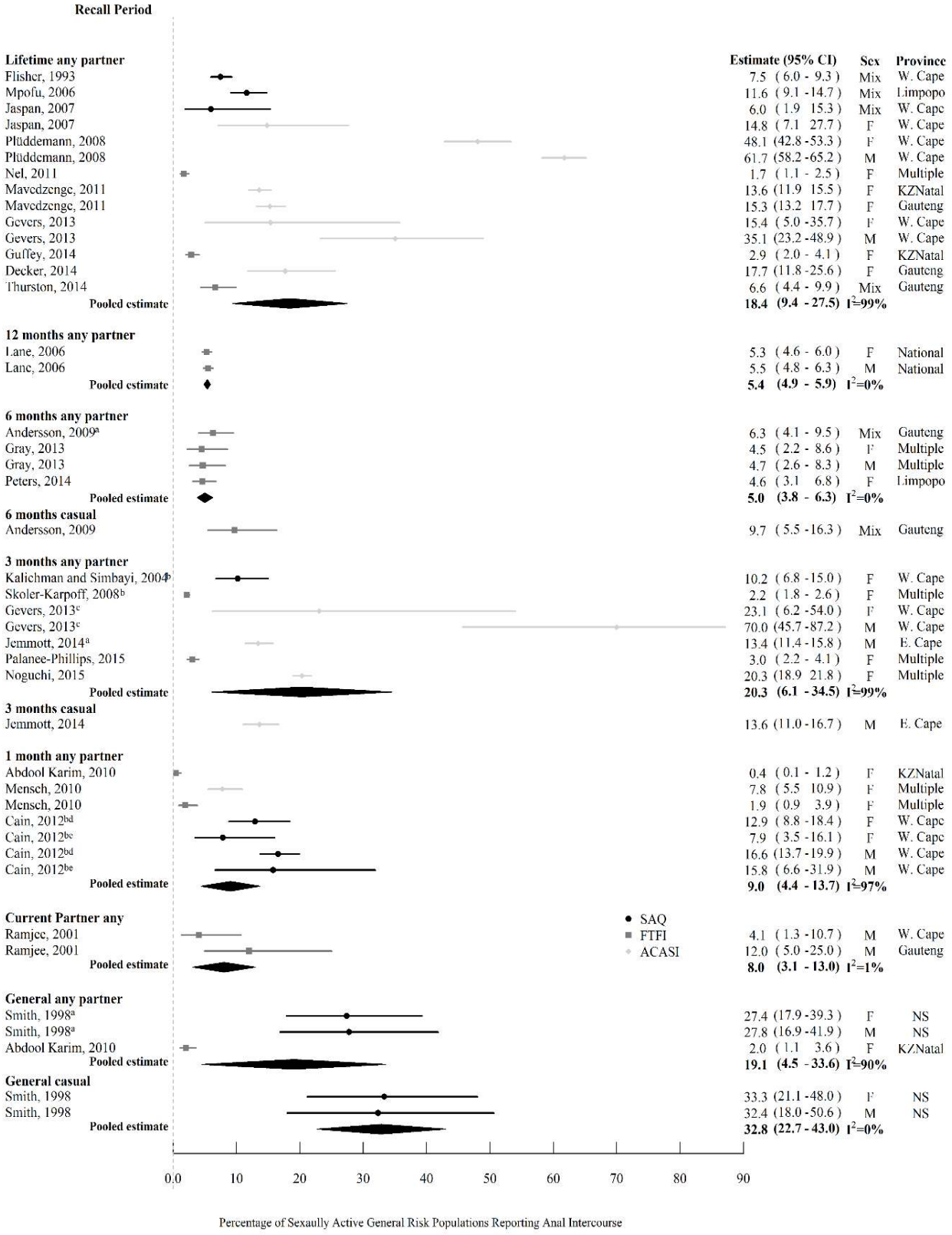
A summary of the participant and study characteristics and markers of study quality is provided in Appendix Table A4.3. Of the 41 studies included, 29 and 14 were conducted among general and higher risk populations respectively, including two studies which reported on both risk groups separately (15,16). AI prevalence and AI frequency were reported over various recall periods by 31 and 14 studies, respectively. Only nine studies reported on condom use during AI and VI, using a variety of recall periods. It was therefore not possible to produce pooled estimates of UAI and UVI prevalence. No studies reported on lubricant use or condom breakage during AI.

Over twice as many studies reported on females than males or mixed gender only. Most studies were conducted among participants with a mean age of 25 years or over. The majority of studies on general risk populations recruited from the community, while the majority on higher risk populations were of FSW or their clients. Most studies were conducted in the Western Cape or KwaZulu-Natal, with the large majority recruiting in urban settings.

Study quality and potential bias

The most commonly used interview method was FTFI, followed by ACASI and SAQ (Appendix Table A4.3). Three studies directly compared reports of AI practice using different methods (17–19). The majority of studies were cross-sectional and used convenience sampling with only one nationally representative survey (20). Most studies first mentioned AI in the main text. Response rate was not reported by most studies. Although studies that explicitly stated that the sample included MSM were excluded, only six studies among men or mixed gender reported asking about heterosexual AI specifically or excluded men who reported having male partners. Half of the studies reporting AI frequency data did not report the proportion of the sample that were sexually active.

a.


Recall Period
Estimate (95% CI)
Sex
Province
Lifetime any partner
Fisher, 1993 7.5 (6.0 - 9.3) Mix W. Cape
Mpofu, 2006 11.6 (9.1 -14.7) Mix Limpopo
Jaspan, 2007 6.0 (1.9 15.3) Mix W. Cape
Jaspan, 2007 14.8 (7.1 27.7) F W. Cape
Plüddemann, 2008 48.1 (42.8 -53.3) F W. Cape
Plüddemann, 2008 61.7 (58.2 -65.2) M W. Cape
Nel, 2011 1.7 (1.1 - 2.5) F Multiple
Mavedzenge, 2011 13.6 (11.9 15.5) F KZNatal
Mavedzenge, 2011 15.3 (13.2 17.7) F Gauteng
Gevers, 2013 15.4 (5.0 -35.7) F W. Cape
Gevers, 2013 35.1 (23.2 -48.9) M W. Cape
Guffey, 2014 2.9 (2.0 - 4.1) F KZNatal
Decker, 2014 17.7 (11.8 -25.6) F Gauteng
Thurston, 2014 6.6 (4.4 - 9.9) Mix Gauteng
Pooled estimate 18.4 (9.4 - 27.5) I²=99%
12 months any partner
Lane, 2006 5.3 (4.6 - 6.0) F National
Lane, 2006 5.5 (4.8 - 6.3) M National
Pooled estimate 5.4 (4.9 - 5.9) I²=0%
6 months any partner
Andersson, 2009a 6.3 (4.1 - 9.5) Mix Gauteng
Gray, 2013 4.5 (2.2 - 8.6) F Multiple
Gray, 2013 4.7 (2.6 - 8.3) M Multiple
Peters, 2014 4.6 (3.1 6.8) F Limpopo
Pooled estimate 5.0 (3.8 - 6.3) I²=0%
6 months casual
Andersson, 2009 9.7 (5.5 -16.3) Mix Gauteng
3 months any partner
Kalichman and Simbayi, 2004b 10.2 (6.8 -15.0) F W. Cape
Skoler-Karpoff, 2008b 2.2 (1.8 - 2.6) F Multiple
Gevers, 2013c 23.1 (6.2 -54.0) F W. Cape
Gevers, 2013c 70.0 (45.7 -87.2) M W. Cape
Jemmott, 2014a 13.4 (11.4 -15.8) M E. Cape
Palanee-Phillips, 2015 3.0 (2.2 - 4.1) F Multiple
Noguchi, 2015 20.3 (18.9 21.8) F Multiple
Pooled estimate 20.3 (6.1 - 34.5) I²=99%
3 months casual
Jemmott, 2014 13.6 (11.0 -16.7) M E. Cape
1 month any partner
Abdool Karim, 2010 0.4 (0.1 - 1.2) F KZNatal
Mensch, 2010 7.8 (5.5 10.9) F Multiple
Mensch, 2010 1.9 (0.9 3.9) F Multiple
Cain, 2012bd 12.9 (8.8 -18.4) F W. Cape
Cain, 2012bc 7.9 (3.5 -16.1) F W. Cape
Cain, 2012bd 16.6 (13.7 -19.9) M W. Cape
Cain, 2012be 15.8 (6.6 -31.9) M W. Cape
Pooled estimate 9.0 (4.4 - 13.7) I²=97%
Current Partner any
SAQ
FTFI
ACASI
Ramjee, 2001 4.1 (1.3 -10.7) M W. Cape
Ramjee, 2001 12.0 (5.0 -25.0) M Gauteng
Pooled estimate 8.0 (3.1 - 13.0) I²=1%
General any partner
Smith, 1998a 27.4 (17.9 -39.3) F NS
Smith, 1998a 27.8 (16.9 -41.9) M NS
Abdool Karim, 2010 2.0 (1.1 3.6) F KZNatal
Pooled estimate 19.1 (4.5 - 33.6) I²=90%
General casual
Smith, 1998 33.3 (21.1 -48.0) F NS
Smith, 1998 32.4 (18.0 -50.6) M NS
Pooled estimate 32.8 (22.7 - 43.0) I²=0%
0.0
10
20
30
40
50
60
70
80
90
Percentage of Sexaully Active General Risk Populations Reporting Anal Intercourse

b.

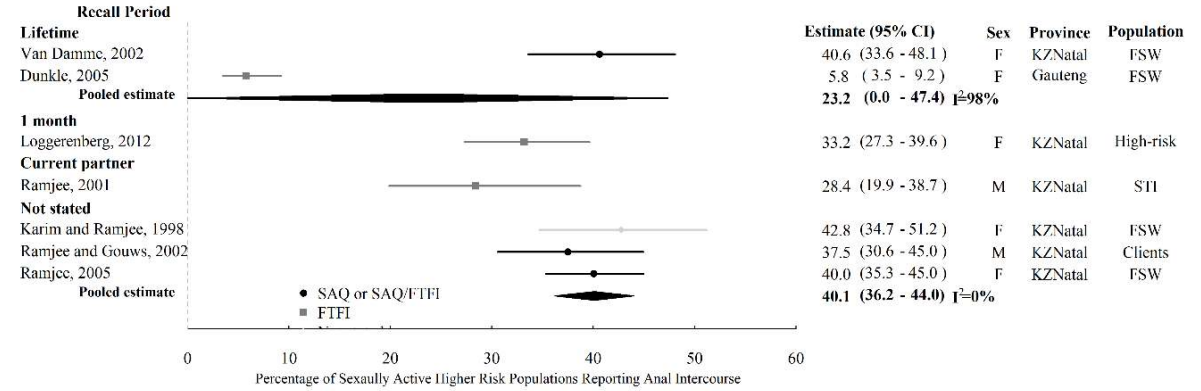


Figure 4.1. Prevalence of AI over the various recall periods reported, among South Africans. Study estimates of AI prevalence among heterosexual men and women among a) general-risk study participants and b) higher-risk study participants. Shown on the graph, study estimates are ordered by survey year and 95% confidence intervals (95% CI) and Higgins I^2 (1). I^2 can lie between 0 and 100%; where 0% and 100% indicate no and the most observed heterogeneity across study estimates.

ACASI = audio computer-assisted self-interview, Clients = clients of female sex workers, F = female, FTFI = face-to-face interview, FSW = female sex workers, M = male, Mix = data available for mixed gender only, High risk = defined by authors as being at high risk of HIV infection (79% were FSW), SAQ = self-administered questionnaire; STI = STI clinic patients.
[a]AI prevalence with steady partners has been grouped with any partner type here. [b]Estimates are for unprotected AI only. [c]12 of the 18 school classes recruited used ACASI, the remainder used SAQ. [d]Recruited from shebeens. [e]Recruited from the community

4.2.2. How common is AI among South Africans?

Figure 4.1 show independent AI prevalence study estimates among sexually active respondents, for general and higher risk groups, respectively. AI prevalence estimates in general risk populations ranged from 0.4% to 70.0% across recall periods. Estimates over the same recall period coming from different studies were very heterogeneous ($I^2 \geq 90\%$). The two highest AI prevalence estimates were reported by male school pupils (61.7% and 70.0%) in studies using ACASI (46) and a mixture of ACASI and SAQ (49). In contrast, the lowest estimates (≤3% over various recall periods) were reported by adult women in FTFI (18,21–26) (Figure 4.1a). Apart from one estimate (27), AI prevalence among higher risk respondents was consistently high across recall periods (28.4 to 42.8%; Figure 4.1b) and generally higher than for general risk populations.

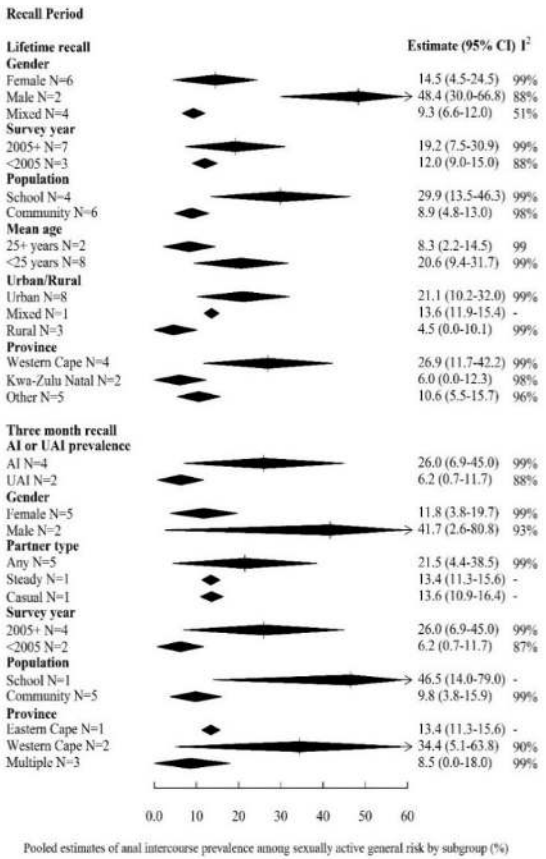
4.2.3. Who practises AI the most?

Figure 4.2 displays pooled estimates from sub-group analyses of AI prevalence for the recall periods (lifetime and three months) and risk populations (general risk populations only) with sufficient study estimates. The only clear difference in pooled estimates were between those from urban and rural samples, with urban estimates being higher. Although 95%CIs of pooled estimates by sub-group of other variables overlapped in either one or both recall periods, pooled estimates was larger for males than females and in samples recruited from schools compared to communities. Pooled estimates were also higher in samples with mean age below 25 years and in studies conducted after 2005. Although pooled estimates are higher in the Western Cape compared to elsewhere, this is likely confounded by interview methods.

Is reported AI prevalence influenced by study quality and other biases?

Figure 4.2b presents the subgroup analyses assessing the influence of study quality among general risk populations. The only measure of study quality that clearly influenced AI estimates was interview method, while 95%CIs overlapped for other variables. Pooled estimates were lower for studies using FTFI compared to ACASI or SAQ over both recall periods, with estimates highest for ACASI in lifetime, but not past three months' recall. For example, pooled lifetime AI prevalence was 3.2% (95%CI 0.9-5.4% n=3), 8.4% (95%CI 5.5-11.2%, n=3) and 28.5% (95%CI 13.2-43.9%, n=4) using FTFI, SAQ and ACASI, respectively. Pooled estimates of convenience samples were lower than for other sampling methods, while those from cross-sectional studies were higher than from other study types. Studies not explicitly stating that the sample was heterosexual only, and those that stated using English and regional languages compared to not stating language used tended to have higher estimates. Pooled estimates were higher when AI was first mentioned in the abstract compared to the main text. The sole study which mentioned AI in the title reported the highest AI prevalence (28).

a.



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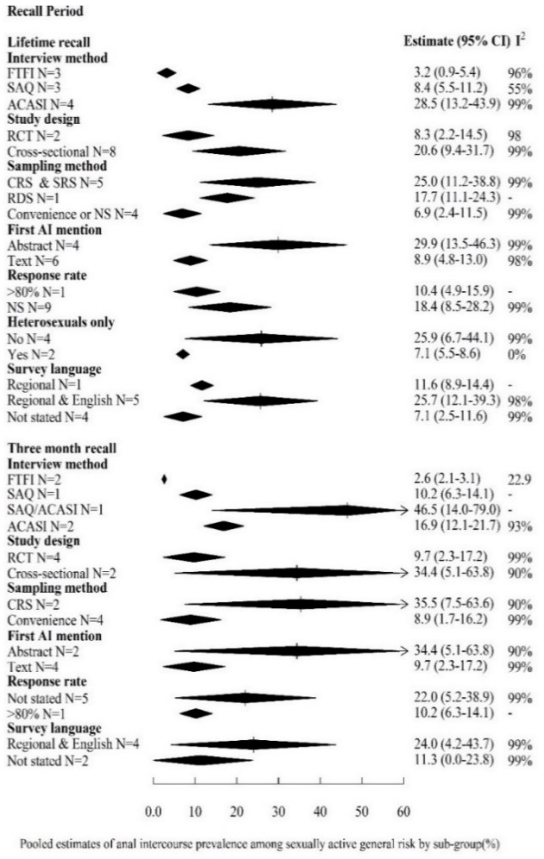


Figure 4.2. Forest plot of sub-group analyses prevalence of AI among sexually active general risk populations, for a)study and b) participant characteristics.

Results are presented for recall periods reported by at least five studies (lifetime and three months). I^2 is calculated as described in Higgins (1). I^2 lies between 0 and 100 %; 0 % indicates no observed heterogeneity and larger values show increasing heterogeneity. One study reported prevalence for casual and steady partners over three month recall. Prevalence for steady partners only was pooled from this study, except when comparing prevalence by partner type. Mean age was not examined in three month recall as all studies recruiting from the community either did not report on mean age, or had a mean age of 25+ years. Sub-group analysis of population (school vs. community) acts as proxy for analysis by age. Neither of the studies reporting on past three months explicitly included heterosexuals only
AI = anal intercourse, ACASI = audio computer-assisted self-interview, CRS = cluster random sampling, FTFI = face-to-face interview, NS = not specified, RCT = randomised control trial, SAQ = self-administered questionnaire, Shebeens = informal alcohol serving establishments, UAI = unprotected anal intercourse.

AI prevalence among higher risk populations

Given the small number of estimates per recall period among higher risk populations, it was not possible to conduct sub-group analyses by participant or study characteristics or study quality. Only two studies reported on higher risk males compared to five on females, all of which sampled FSW, or predominantly FSW, with no discernible difference in prevalence by gender or population. No studies on higher risk populations reported prevalence by partner type and all were conducted before 2005 and in urban settings (Appendix Table A4.3). All but one AI prevalence estimates were from KwaZulu-Natal, with the lowest prevalence across recall periods reported in the sole study from Gauteng (29)**.** All studies on higher risk respondents used convenience samples or failed to specify sampling method (30), and response rate was only reported by one study (31). Both studies on males explicitly stated that they consisted of men who had sex with women only (15,31).

4.2.4. How frequent is AI among South Africans?

Among higher risk 0.6 to 29.2% acts (n=6) were AI and 1.2 to 40.0% (n=5) were UAI (Appendix Figure A4.4b), compared with 0.6 to 16.5% acts (n=6) and 0.7 to 21.0% (n=7) for AI and UAI respectively among general risk populations (Table 4.5). Thus, the fraction of all sex acts that were AI or UAI were slightly higher for higher risk than general risk populations. Condom use during AI was similar to that for VI. Among general risk populations, the fraction of AI and VI acts that were unprotected was 27.0 to 53.6% and 26.9 to 57.0%, respectively (n=5) (Appendix Figure A4.5a and Table 4.5).

Who practises AI most frequently? General risk males reported a higher number of AI acts and tended to report a slightly larger fraction of AI but a similar fraction of UAI compared to women (Table 4.5 and Figure 4.3a). The fraction of sex acts that were AI was similar across partner types in both risk groups (Figure 4.3). A smaller fraction of sex acts were AI in samples recruited from VCT services than from communities or shebeens among the general risk population but estimates among higher risk groups did not vary by population.

Potential sources of bias: As with AI prevalence, confidentiality of interview method seemed to affect reporting of AI frequency among general risk populations, with the lowest fraction of sex acts that were AI being found in the only study using FTFI (61) and the highest fraction of UAI found in the only study using ACASI (32) (Figure 4.3a). Studies among higher risk populations used a wider variety of interview methods and differences between methods were less clear than among general risk populations (Figure 4.3b), although both the highest fraction of AI and UAI were reported using ACASI (Figure 4.3b). A FSW study comparing FTFI and pictorial coital diaries (17) documented a substantially

higher fraction of AI sex acts through coital diary than daily FTFI (Table 4.5, Figure 4.3b). Greater numbers of both types of sex acts were reported over shorter recall periods (when standardised to one month) (Table 4.5).

Box 4.2. AI practice among South Africans: key findings

- AI is common, but varied among both general and higher-risk South Africans
- Pooled estimates of AI prevalence did not vary by recall period e.g. lifetime = 18.4% and past three months = 20.3% among general risk populations
- Prevalence among general risk samples tended to be higher in urban areas, among males and among younger people, particularly adolescents.
- Condoms tended to be used as often during AI as VI, when measured at the sex act data level.
- An estimated 1% to 17% (n=6) of all reported sex acts were AI among general risk and 1% to 29% among higher risk South Africans
- Higher prevalence and frequency of AI tended to be reported when using more confidential interview methods

Table 4.5. Number and fraction of reported sex acts that are anal sex among South Africans, standardised per month, stratified by risk group and ordered by publishing year. Sex acts reported among whole sample (i.e. including also those who report no AI)

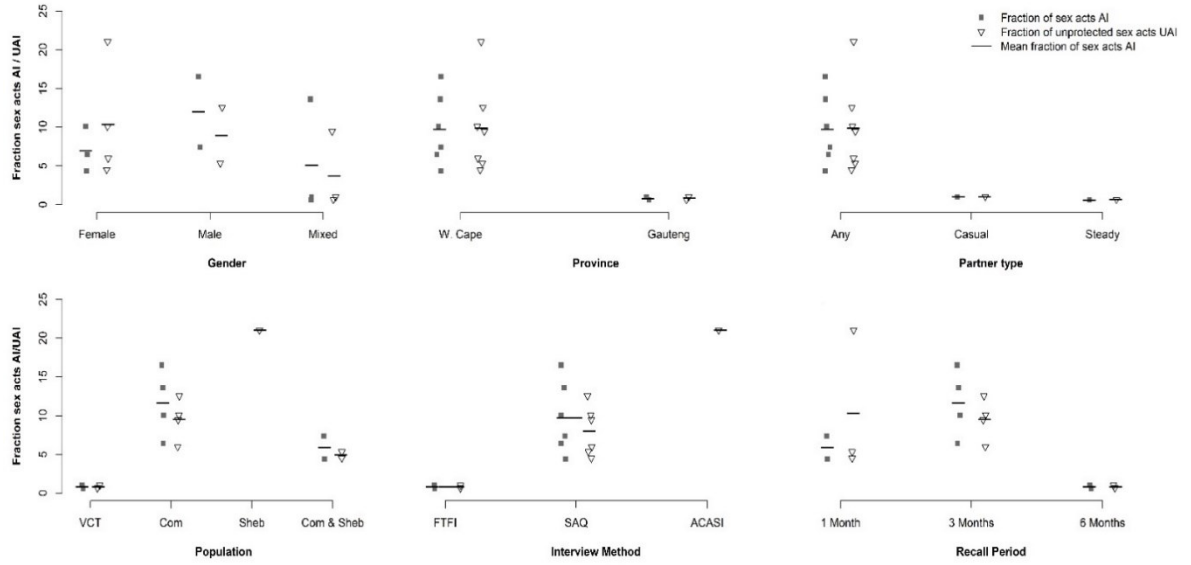
Reference	Sex	Population. Interview method	Partner type	N	AI prev. (%)	Prev. recall period	Number of sex acts per month				Original freq. recall period	% sex acts that are AI	% unpro. sex acts that are UAI	% sex acts unpro.	
							AI	VI	UAI	UVI				During AI	During VI
SEX ACTS REPORTED AMONG SUB-SAMPLE WHO REPORT PRACTICING AI															
General risk populations															
Andersson, 2009(33)[140][140][c]	Mix	VCT, Soweto. FTFI	Steady	350	6.2	6 month	1.12	11.42	0.57	5.33	6 months	8.93%	NA	50.5%	NA
			Casual	141	9.2		0.50	4.44	0.13	1.20		10.12%	NA	27.0%	NA
Kalichman & Simbayi, 2004[c]	F	General, Western Cape. SAQ	Any	272	8.8[e]	3 month	3.09	4.07	1.66	2.31	3 months	43.15%	41.86%	53.7%	56.6%
Higher risk populations															
Loggeren-berg, 2012[ac]	F	High-risk e- Durban. FTFI	Any	245	33.2	1 month	1.49	10.20	NA	NA	1 month	12.75%	NA	NA	NA
Van Damme, 2002[a]	F	FSW (HIV- at recruitment), Durban. SAQ/FTFI	Any	187	40.6	Ever	7.63	NA	NA	NA	1 week	NA	NA	NA	NA
SEX ACTS REPORTED AMONG WHOLE SAMPLE (i.e. including also those who report no AI)															
General risk populations															
Kalichman, 2013	F	Community & Shebeen , Cape Town. SAQ	Any	1788	NA	NA	0.57	12.44	0.30	6.46	1 month	4.37%	4.49%	53.52%	51.95%
	M			3988			1.06	13.31	0.38	6.67		7.39%	5.34%	35.40%	50.08%
Pitpitan, 2012	F	Shebeen , Cape Town. ACASI	Any	560	NA	NA	NA	NA	0.66	2.48	1 month	NA	21.02%	NA	NA
Andersson, 2009[b]	Mix	Voluntary counselling and testing, Soweto. FTFI	Steady	350	6.2	6 month	0.07	11.42	0.03	5.33	6 months	0.60%	0.65%	50.5%	46.7%
			Casual	141	9.2		0.50	4.44	0.01	1.20		1.02%	1.01%	27.0%	26.90%
Kalichman, 2009	Mix	Community, Cape Town. SAQ	Any	3051	NA	NA	0.27	1.74	0.10	0.99	3 months	13.60%	9.45%	37.80%	57.00%
	F		Any	115	NA	NA	0.46	4.06	0.24	2.16	3 months	10.08%	10.08%	53.11%	53.12%

Reference	Sex	Population. Interview method	Partner type	N	AI prev. (%)	Prev. recall period	Number of sex acts per month				Original freq. recall period	% sex acts that are AI	% unpro. sex acts that are UAI	% sex acts unpro.	
							AI	VI	UAI	UVI				During AI	During VI
Simbayi, 2005	M	Community, Cape Town. SAQ		113	NA		0.97	4.94	0.37	2.58		16.51%	12.54%	37.97%	51.93%
Kalichman & Simbayi, 2004	F	Community, Western Cape. SAQ	Any	272	8.8[e]	3 month	0.28	4.07	0.15	2.31	3 months	6.43%	5.97%	53.57%	56.76%
Higher risk populations															
Loggerenberg, 2012	F	High-risk[d], Durban. FTFI	Any	245	33.2	1 month	0.49	10.00	NA	NA	1 month	4.71%	NA	NA	NA
Kalichman, 2011	Mix	STI clinic patients, Cape Town. ACASI	Any	617	NA	NA	NA	NA	0.32	2.14	1 month	NA	12.83%	NA	NA
Kalichman, 2010	Mix	HIV+, Cape Town, Eastern Cape, Jo'burg. ACASI	Any	218	NA	NA	1.09	2.64	0.47	0.71	1 month	29.17%	39.97%	43.60%	27.00%
Kalichman, 2009	Mix	STI clinic patients, Cape Town. SAQ	Any	1360	NA	NA	0.55	5.50	0.21	3.32	3 months	9.04%	6.04%	38.20%	60.40%
Kalichman, 2008	Mix	STI clinic patients, Cape Town. ACASI	Any	221	NA	NA	NA	NA	0.11	1.12	3 months	NA	9.15%	NA	NA
Kiene, 2008	Mix	HIV+, Cape Town. Phone	Any	82	NA	NA	0.70	42.93	0.41	34.57	42 days (daily interview)	1.60%	1.16%	58.20%	80.50%
Kiene, 2006	Mix	HIV+, Kwa-Zulu Natal, FTFI	Any	152	NA	NA	0.06	3.17	NA	NA	3 months	1.74%	NA	NA	NA
Van Damme, 2002[f]	F	FSW (HIV- at recruitment), Durban. SAQ/FTFI	Any	187	40.6	Ever	13.43	NA	NA	NA	1 week	NA	NA	NA	NA

Reference	Sex	Population. Interview method	Partner type	N	AI prev. (%)	Prev. recall period	Number of sex acts per month				Original freq. recall period	% sex acts that are AI	% unpro. sex acts that are UAI	% sex acts unpro.	
							AI	VI	UAI	UVI				During AI	During VI
Ramjee, 1999	F	FSW, highway, KwaZulu-Natal Weekly FTFI	Any	25	NA	NA	3.03	12.56	NA	NA	1 week	19.44%	NA	NA	NA
		Daily FTFI	Clients	25	NA	NA	3.47	75.39	NA	NA	1 week	4.40%	NA	NA	NA
		Daily FTFI	Primary	25	NA	NA	0.87	14.73	NA	NA	1 week	5.56%	NA	NA	NA
		Coital diary	Clients	25	NA	NA	16.90	89.26	NA	NA	1 week	15.92%	NA	NA	NA
		Coital diary	Primary	25	NA	NA	4.33	28.60	NA	NA	1 week	13.16%	NA	NA	NA

AI = anal intercourse, F = female, M = male, Mix = data available on mixed gender only, NA = not available, RR = Relative Risk, Shebeen = informal establishment serving alcohol, UAI = unprotected anal intercourse, UVI = unprotected vaginal intercourse,VCT = voluntary counselling and testing, VI = vaginal intercourse. [a]Number of AI and VI acts reported originally for whole sample, recalculated here for subset reporting AI. [b]Number of AI and VI acts reported originally for subset reporting AI, recalculated here for whole sample. [c]VI acts are reported for whole sample, whereas AI acts are for subset reporting AI. [d]Participants defined by author as high-risk, 79% self-identify as FSW. [e]Data available for UAI prevalence only. [f]Data is from baseline, obtained through personal correspondence

a.



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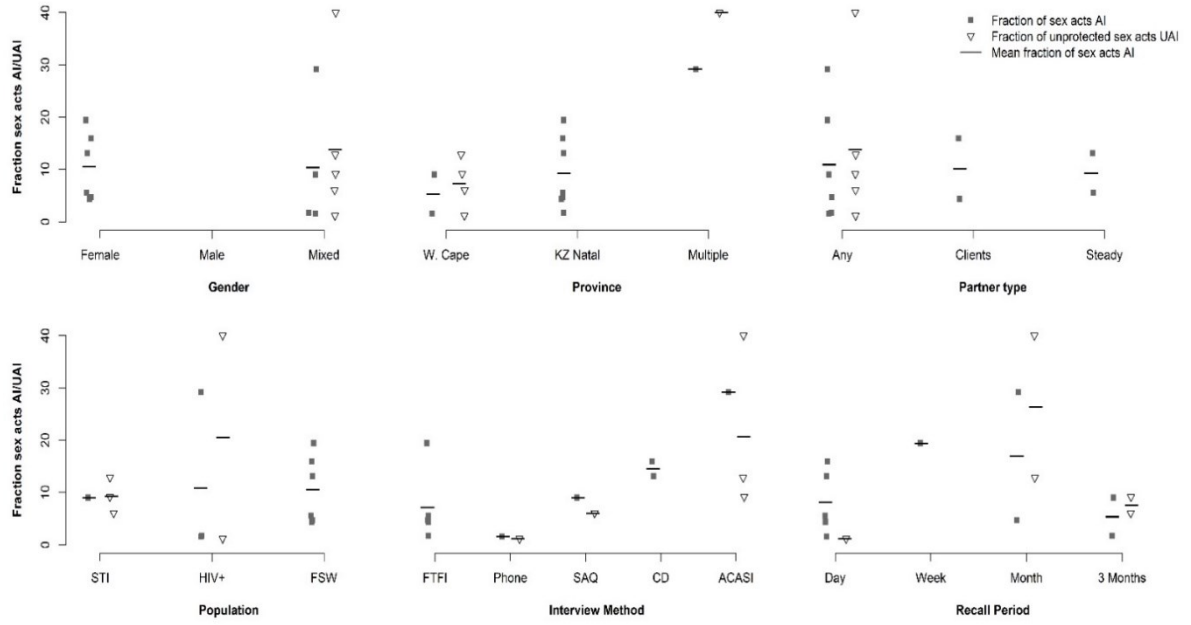

Figure 4.3. Fraction of sex acts that are AI and unprotected sex acts that are UAI by selected study and participant characteristics among a) general risk study and b) higher risk study participants.

AI=anal intercourse, ACASI=audio computer assisted self-interview, casual=casual partners, CD=coital diary, clients=clients of FSW, FTFI=face-to-face interview, KZ Natal=KwaZulu Natal, Mix=data only available for men and women combined, SAQ=self-administered questionnaire, steady=steady partners (in Figure 4.3b steady = non-paying partners of FSW), sheb=shebeen (informal drinking establishments), UAI=unprotected anal intercourse, W. Cape=Western Cape. It was not possible to examine the effect of study design or sampling method as all were cross-sectional studies using convenience sampling.

4.3. RESULTS: AI PRACTICE AMONG FEMALE SEX WORKERS

4.3.1. Search results and study and participant characteristics

The study selection procedure and search results are summarised in Appendix Figure A4.6. Of the 12,343 unique articles initially identified, 129 were included. Most articles were identified from the database searches, and two were identified through reference scanning. Additional information was obtained from 23 of the 35 authors contacted.

Participant and study characteristics are summarised in Appendix Table A4.4. Sample sizes ranged from 12 to 9,667 for a total sample size of 74,242 across all studies. Nearly half of the studies specified partner type, with 14 reporting AI practice separately for non-paying partners and paying clients. Most studies were conducted in Asia (n=53), followed by Africa (n=33) and Europe (n=23), with few conducted in the Americas (n=13 in North America and n=10 in South America). Median age across studies was 28 years and median survey year 2003. The vast majority of studies either did not report location of work (n=53) or reported on samples with a mixture of indoor and outdoor sex workers (n=37). More studies reported on FSW who worked only indoors (n=32), than outdoors (n=12). Most studies used FTFI (n=110), employed convenience sampling (n=95) and were cross-sectional (n=114). Three studies compared the reporting of AI practice by interview method (17,34,35). More studies first mentioned AI in the main text (n=85), than title (n=11) or abstract (n=33).

AI prevalence was reported over various recall periods by 126 studies (including four studies reporting UAI prevalence only (34,36–38) with five comparing AI prevalence over two or more recall periods (3,9,29–31). The most common AI prevalence recall periods were lifetime (n=30) and one month (n=17). Although not a recall period, AI prevalence was most commonly reported as FSW offering AI as part of their service (i.e. asking FSW whether they practised AI with their clients) (n=35), which is difficult to interpret. A large number of studies failed to state the recall period at all (n=20). AI frequency data (either number of AI acts and/or the proportion of sex acts which were AI) was provided by only 13 studies.

4.3.2. How common is AI practice among female sex workers?

Figure 4.4 displays pooled estimates of AI prevalence for all recall periods and Appendix Figure A4.7 displays individual study estimates for the three most common recall periods (lifetime, service offered and past month), respectively. Reported AI prevalence varied substantially between studies, ranging from 0.0% to 84.0% across recall periods. Estimates stratified by recall period remained very

heterogeneous (I^2>90%). Pooled AI prevalence did not vary substantially by length of recall period apart from two months, 15 days and one day recall periods, which all only had one study each (Figure 4.4). Aside from these, pooled estimates varied between 8.7% (95%CI: 4.2-13.3%, n=8) in the past week and 21.5% (95%CI: 15.6-27.5%, n=6) in the past year, and the pooled estimate for reporting ever having practised AI was 15.7% (95%CI: 12.2-19.3).

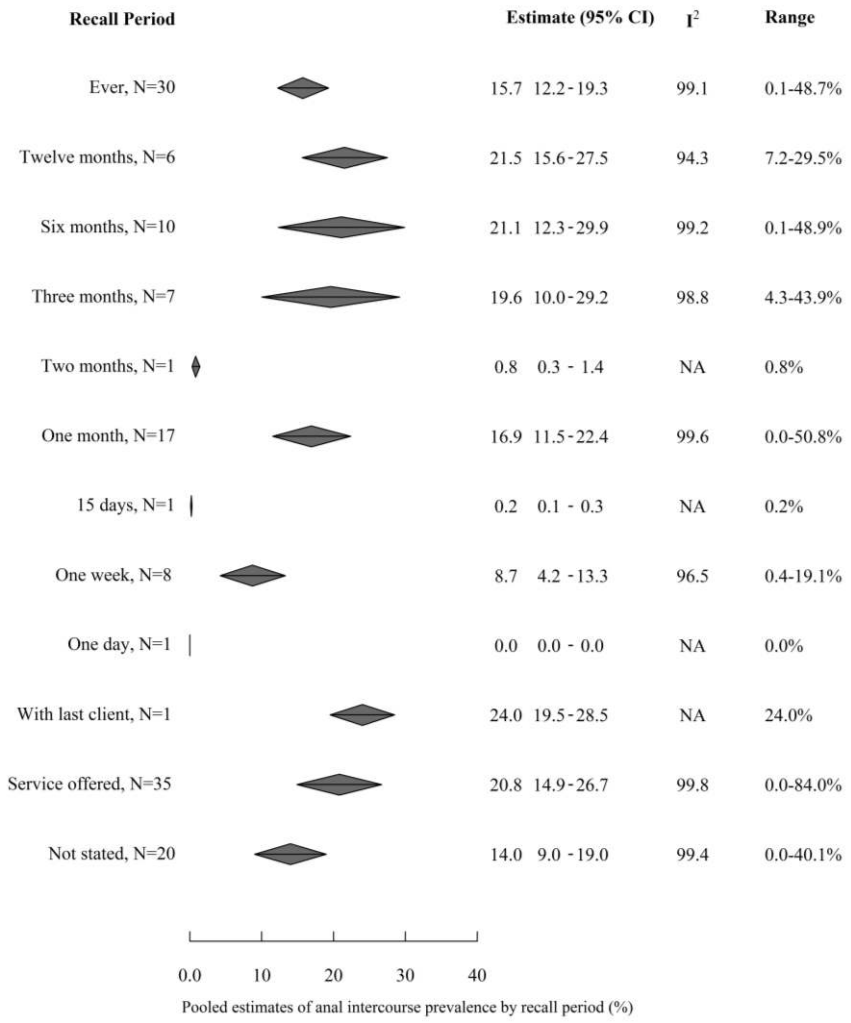

Figure 4.4. Pooled estimates of the prevalence of anal intercourse among FSW over each recall period reported. The top of each diamond represents the pooled estimate, while furthest points represent 95% confidence intervals. Several studies asked whether participants practised AI with clients generally, rather than specifying a recall period, which is referred to as "service offered". AI=anal intercourse, NA=not applicable, 95%CI=95% confidence interval.

4.3.3. Who practises AI the most?

Table 4.6 shows pooled estimates from sub-group analyses of AI prevalence by participants' and study characteristics for recall periods with sufficient numbers of study estimates (ever, one month and service offered). Across recall periods, pooled estimates of AI practice tended to be higher among older FSW, in studies conducted after 2002 and when the word 'anal' was first mentioned in the article title

compared to in the abstract or main text, but differences were not significant. Pooled estimates did not vary by partner type, continent, average number of clients, location of work, or interview or recruitment method.

Table 4.6. Subgroup analysis of AI prevalence among female sex workers over the most common recall periods, by participant and study characteristics.

		EVER				SERVICE OFFERED				PAST MONTH			
		N	Pooled estimate (95% CI)		I^2	N	Pooled estimate (95% CI)		I^2	N	Pooled estimate (95% CI)		I^2
Participant characteristics													
Partner type	Any	25	14.8%	(11.0-18.6)	99	0	-	-	-	14	15.2%	(8.8-21.6)	99
	Clients	6	19.7%	(11.3-28.0)	97	36	20.5%	(14.4-26.6)	99	6	24.0%	(13.9-34.1)	99
	New clients	0	-	-	-	1	32.0%	(24.4-39.5)	-	2	20.3%	(8.7-32.0)	90
	Regular clients	0	-	-	-	1	17.7%	(11.5-23.9)	-	2	24.8%	(10.0-39.5)	94
	Non-paying partners	2	43.9%	(14.7-73.1)	97	0	-	-	-	5	16.5%	(11.4-21.6)	83
Continent	Africa	10	15.1%	(8.8-21.4)	98	4	25.0%	(10.6-39.5)	97	6	20.9%	(10.1-31.8)	98
	Asia	13	14.5%	(10.2-18.8)	99	16	15.6%	(9.5-21.8)	99	12	14.0%	(6.3-21.6)	99
	Europe	3	8.0%	(1.9-14.0)	86	11	26.5%	(12.4-40.6)	98	2	21.4%	(12.9-29.8)	64
	South America	3	22.2%	(14.3-30.2)	82	2	38.2%	(1.0-5-75.3)	99	0	-	-	-
	North America	2	29.1%	(1.8-56.3)	95	5	14.0%	(4.8-23.1)	99	2	18.4%	(10.4-26.4)	0
Mean age	<28 years	14	11.9%	(7.9-15.9)	98	16	20.6%	(10.9-30.4)	99	10	15.5%	(5.4-25.6)	99
	28+ years	13	20.7%	(14.5-26.9)	99	19	23.3%	(14.6-32.0)	99	11	18.7%	(13.4-24.2)	95
	Not stated	4	10.8%	(4.3-17.3)	98	3	6.1%	(1.8-10.4)	9	1	11.4%	(7.1-15.7)	-
Survey year	Pre-2003	13	12.9%	(5.3-19.2)	99	26	16.8%	(10.2-23.3)	99	7	10.5%	(1.0-19.9)	99
	2003 onwards	18	19.2%	(15.4-24.8)	98	12	29.4%	(17.7-41.1)	99	15	20.0%	(13.9-26.0)	98
Workplace	Indoors	7	21.4%	(12.2-30.5)	94	8	20.5%	(7.4-33.5)	99	5	14.4%	(0.0-33.8)	99
	Outdoors	2	5.5%	(0.0-11.7)	86	5	26.0%	(12.9-39.1)	90	1	40.6%	(33.6-47.7)	-
	Mixed	10	8.8%	(4.8-12.8)	98	10	16.8%	(9.5-24.0)	99	3	13.9%	(11.5-16.2)	1
	Not stated	12	20.0%	(15.7-24.3)	97	15	21.9%	(10.2-33.7)	99	13	16.8%	(11.6-22.0)	96
Number of clients/week	<8	12	18.6%	(10.5-26.7)	99	12	19.3%	(10.0-28.5)	99	5	13.6%	(7.1-20.0)	97
	8+	9	13.5%	(10.6-16.5)	84	15	23.7%	(15.1-32.4)	97	10	19.6%	(9.3-29.9)	99
	Not stated	10	14.3%	(9.8-18.8)	97	11	18.5%	(5.2-31.8)	99	7	15.5%	(9.4-21.7)	96
Study quality and potential for bias													
Interview method	ACASI	3	19.3%	(9.8-28.7)	95	0	-	-	-	1	15.0%	(12.7-17.3)	-
	SAQ	0	-	-	-	5	12.9%	(0.0-27.4)	99	0	-	-	-
	FTFI	28	15.4%	(11.6-19.1)	99	30	21.8%	(15.0-28.5)	99	15	17.0%	(10.3-23.6)	99
	SAQ/FTFI	0	-	-	-	3	24.3%	(8.8-39.9)	95	0	-	-	-
	Coital diary	0	-	-	-	0	-	-	-	5	15.4%	(2.9-27.9)	97

		EVER				SERVICE OFFERED				PAST MONTH			
		N	Pooled estimate (95% CI)		I^2	N	Pooled estimate (95% CI)		I^2	N	Pooled estimate (95% CI)		I^2
	Polling box	0	-	-	-	0	-	-	-	1	26.0%	(20.8-31.3)	-
Recruitment method	Convenience	16	13.2%	(8.3-18.1)	98	29	23.2%	(15.4-30.9)	99	13	14.6%	(7.5-21.6)	99
	Simple randomised	2	36.4%	(30.2-42.5)	12	2	17.6%	(0.0-37.4)	96	0	-	-	-
	Cluster randomised	5	14.8%	(10.9-18.9)	96	2	11.9%	(1.0-22.8)	91	3	26.9%	(7.8-46.1)	99
	Respondent-driven	5	17.8%	(9.9-25.6)	96	5	16.4%	(12.4-20.4)	82	6	17.1%	(12.5-21.7)	90
	Time-location	3	13.7%	(10.2-17.2)	90	0	-	-	-	0	-	-	-
AI first mentioned	Title	4	23.9%	(14.0-33.8)	97	2	30.9%	(19.1-42.7)	87	3	23.8%	(12.8-34.7)	95
	Abstract	10	16.9%	(13.4-20.5)	95	8	14.5%	(7.6-21.5)	98	5	20.1%	(6.0-34.2)	99
	Text	17	13.2%	(8.0-18.3)	99	28	21.4%	(13.8-28.9)	99	14	14.3%	(8.5-20.2)	99
Sample Size	<100	3	22.4%	(0.8-44.0)	96	11	30.0%	(15.6-43.5)	96	3	17.3%	(4.5-29.9)	85
	100+	28	17.0%	(12.7-21.3)	99	27	17.2%	(11.5-23.0)	99	19	18.4%	(13.8-30.0)	99

Studies provided one estimate of AI prevalence with the following exceptions: Among studies reporting lifetime AI prevalence Kinsler et al. and Hakre et al. (39,40) provided estimates by partner type and Bradley (41) by survey year. Among studies reporting AI prevalence by whether it was offered as a service, Plumridge et al. (42) provided estimates by workplace, Westhoff et al. (43) by country (Mexico and Russia) and Seib et al. (44) by survey year. Among studies reporting one month AI prevalence Priddy et al., Kazerooni et al., Ojeda et al. and Maheu et al. (45–48) provided estimates by partner type and Van Damme et al. (49) by country (South Africa, Cote d'Ivoire, Thailand and Benin), Mishra et al. (50) by survey year and Hanck et al. (34) by interview method. All available estimates were used in each sub-group analysis with the exception of estimates by partner type, which was used only in the sub-group analysis on partner type and for all other sub-group analyses used only the estimate with clients.

4.3.4. Condom use during AI and VI

Pooled estimates of the prevalence of UAI among those reporting AI were higher than UVI among those reporting VI in four of the five recall periods over which it was reported (Figure 4.5) (e.g. general UAI=46.0%, 95%CI: 30.8-61.3, UVI=31.6%, 95%CI: 18.7-44.5), although 95%CIs overlapped substantially (individual study estimates are plotted in Appendix Figure A4.8).

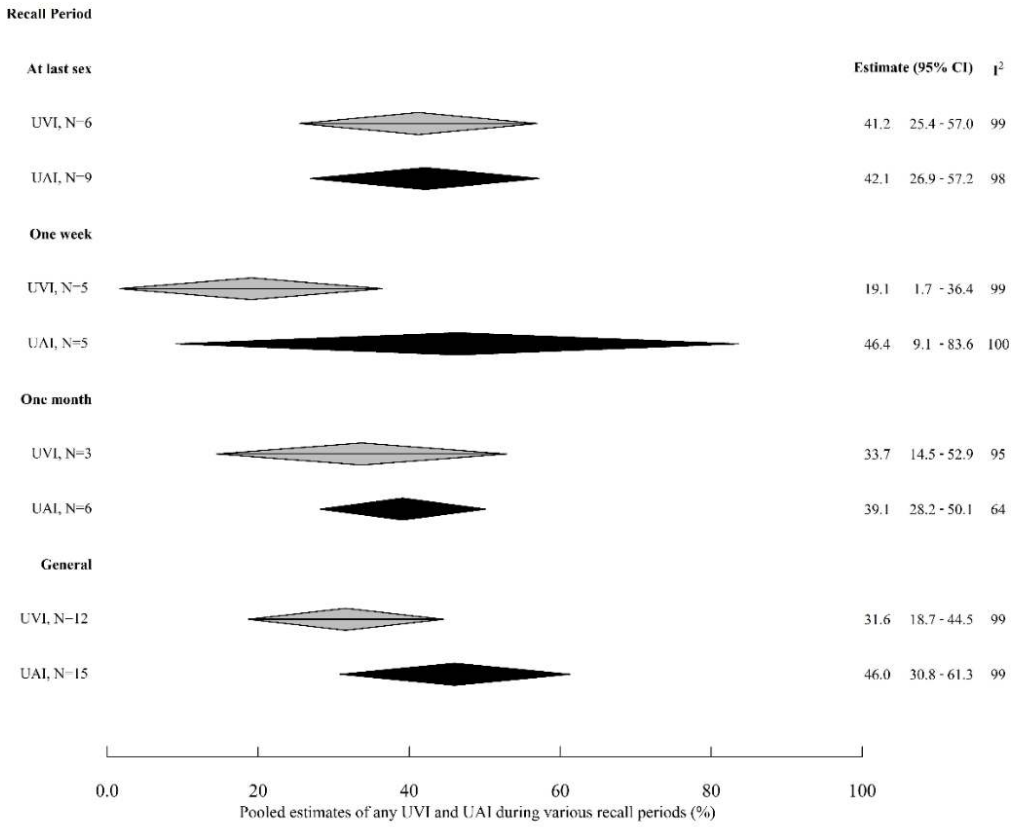

Figure 4.5. Pooled estimates of the prevalence of AI and VI unprotected by condoms among FSW over each recall period reported
The top of each diamond represents the pooled estimate, while furthest points represent 95% confidence intervals. Several studies asked whether participants practised AI with clients generally, rather than specifying a recall period, which is referred to as "service offered". AI=anal intercourse, NA=not applicable, 95%CI=95% confidence interval.

4.3.5. How frequent is AI among female sex workers?

Of the 13 studies which provided data on the number of AI acts, eight estimates were extracted or derived among the subset of FSW who report practicing AI (41,48,49,51–55) and eight over the whole sample (17,48,49,55–59), which includes FSWs not practicing AI (Table 4.7). AI frequency estimates vary substantially across studies. Across the studies providing data among the subset of FSWs reporting AI, the number of AI and UAI acts per month ranged from 1.8 to 27.8 (n=8) and from 0.2 to 6.2 (n=3), respectively. Among studies reporting mean frequency across the whole study sample, the total number

of AI and UAI acts ranged from 1.1 to 16.9 (n=8) and 1.0 to 1.7 (n=3). The percentage of all sex acts that were anal ranged from 2.4% to 15.9% in the six studies that reported it across the whole sample (17,48,56–59). In the sole study which reported it among the subset practicing AI (48), 17.0% of sex acts were anal. The proportion of sex acts that were anal did not vary substantially by any participant or study characteristics (Appendix Figure A4.9).

Box 4.3. AI practice among female sex workers: key findings

- AI practice was common among FSW, with an estimated 20.8% (95% CI, 14.9-26.7%) offering AI as part of their service.
- Pooled estimates of AI prevalence varied little by recall period, e.g. lifetime = 15.7% and past month = 16.9%
- Neither AI prevalence nor frequency varied substantially by any participant or study characteristics
- Condoms tended to be used more inconsistently during AI compared to during VI, although 95% CI's of pooled estimates overlapped substantially.
- An estimated 2.4% to 15.9% of all sex acts were anal

Table 4.7. Frequency of anal sex acts among female sex workers, standardised per month and fraction of reported sex acts that are anal

	Country	N	Interview method	Partner type	AI prevalence (recall period)	Number of sex acts/month				Original recall period	% sex acts that are:		% sex acts condom protected during:	
					%	AI	VI	UAI	UVI		AI	UAI[c]	AI	VI
Sex acts reported among sub-sample who report practicing AI														
Van Damme, 2002(49)	Multiple[a]	765	Coital diary	Any	14 (1 month)	8.7	NS	NS	NS	1 week	NS	NS	NS	NS
Schwandt, 2006(53)	Kenya	147	FTFI	Any	41 (ever)	3.4	NS	NS	NS	1 month	NS	NS	NS	NS
Markosyan, 2007(55)	Armenia	98	FTFI	Any	28 (1 month)	7.4	NS	6.2	NS	1 month	NS	NS	83.8	NS
Bradley, 2011(41)	India	2394	FTFI	Any	10 (ever)	8.5	NS	2.6	NS	1 week	NS	NS	30.9	NS
Hladik, 2017(52)	Uganda	942	ACASI	Any	15 (1 month)	3.0	NS	NS	NS	1 month	NS	NS	NS	NS
Tucker, 2012(51)	India	555	FTFI	Any	13 (1 month)	1.8	NS	0.2	NS	1 month	NS	NS	11.1	NS
Marek, 2013(54)	Hungary	34	SAQ	Clients	50 (service)	27.8	NS	NS	NS	1 day	NS	NS	NS	NS
Maheu-Giroux, 2017(48)	Cote d'Ivoire	466	FTFI	Any	19 (1 month)	NS	NS	NS	NS	1 week	17.0	NS	NS	NS
Sex acts reported among whole sample (i.e. including also those who report no AI)														
Van de Perre, 1985(57)	Rwanda	33	FTFI	Any	NA	1.1	43.9	NS	NS	past 5-10 sexual encounters	2.4	NS	NS	NS
Van Damme, 2002(49)[b]	South Africa	187	Coital diary	Any	41 (1 month)	4.0	NS	1.0	NS	1 month	NS	NS	25.0	NS
Ramjee, 1999(17)	South Africa	52	Weekly FTFI	Any	NS	3.0[de]	12.6	NS	NS	1 week	19.4	NS	NS	NS
		25	Daily FTFI	Clients	NS	3.5[df]	75.4	NS	NS	1 day	4.4	NS	NS	NS
		25	Daily FTFI	Primary	NS	0.9[dg]	14.7	NS	NS	1 day	5.6	NS	NS	NS
		25	Coital diary	Clients	NS	16.9[dh]	89.3	NS	NS	1 day	15.9	NS	NS	NS
		25	Coital diary	Primary	NS	4.3	28.6	NS	NS	1 day	13.1	NS	NS	NS
Voeten, 2007(58)	Kenya	64	Coital diary	Any	NS	1.5	37.5	NS	NS	2 weeks	4.0	NS	NS	NS
Markosyan, 2007(55)	Armenia	98	FTFI	Any	28 (1 month)	2.0	NS	1.7	NS	1 month	NS	NS	85.0	NS
Carney, 2016(59)	South Africa	457	FTFI	Any	NS	2.6	30.0	1.0	9.6	3 months	8.0	3.1	38.6	32.0
Bradley, 2012(56)	India	223	Telephone[b]	Any	19 (ever)	2.9	47.0	NS	NS	1 day	5.9	NS	NS	NS

	Country	N	Interview method	Partner type	AI prevalence (recall period)	Number of sex acts/month				Original recall period	% sex acts that are:		% sex acts condom protected during:	
					%	AI	VI	UAI	UVI		AI	UAI[c]	AI	VI
Maheu-Giroux, 2017(48)	Cote d'Ivoire	466	FTFI	Any	19 (1 month)	4.3[di]	138.6	NS	NS	1 week	3.0	NS	NS	NS

AI=anal intercourse, NS=not stated UAI=unprotected anal intercourse, UVI=unprotected vaginal intercourse. VI=vaginal intercourse,
[a]South Africa, Cote d'Ivore, Benin and Thailand. [b]Baseline data, including AI prevalence was collected through FTFI, all sex act data was collected via subsequent daily telephone calls. [C]Percentage of all sex acts, both protected and unprotected that are UAI. [d]95%CI for sex act data provided: [e]95%CI=0.0-7.4. [f]95%CI=0.0-11.3. [g]95%CI=0.0-3.5. [h]95%CI=0.0-32.0. [i]95%CI=4.3-8.7

4.4. DISCUSSION

These extensive reviews add substantially to the current literature and understanding of heterosexual AI practice among these populations of interest. The findings suggest that AI is commonly practised among these populations, although patterns appear to vary substantially both within and between groups. The available data suggest that, among young people and FSW, but not South Africans, condoms tend to be used less frequently during AI than during VI. While it is clear that many young people, South Africans and FSW experience AI, given the paucity of data on AI frequency, it is unclear how regularly it is practised.

AI prevalence was most commonly reported over lifetime in all three reviews. Pooled estimates for this recall period were very similar among South Africans and young people (e.g. 19.3% and 21.5% among sexually active South Africans and sexually active non-higher risk young women, respectively). Surprisingly, the lifetime pooled estimate was lowest among FSW, at 15.7%.

Previous modelling studies suggest that only 5–10% of unprotected sex acts being UAI could explain a substantial fraction of HIV infections among women (60,61). As such, the frequency of UAI found in these reviews implies that AI may be a significant driver of HIV epidemics among people who practice heterosexual sex. The reported fractions of sex acts that are AI are high given that the majority of participants in all studies reported not practicing AI, implying that those who do practise AI, practise it frequently. Taking an example from the South African review; the two studies of general-risk participants which reported AI frequency solely among those reporting AI, between 8.9% and 43.2% of all sex acts were AI (8,19).

One of the most consistent findings across the reviews is that AI prevalence did not increase with longer recall periods, and that in fact, recall period had no discernible effect; possibly indicating that individuals who initiate AI continue to practise it. This hypothesis is bolstered by the four studies which report AI prevalence among FSW over multiple recall periods finding no statistically significant increase in the practice as recall period lengthened (48,52,62,63) (e.g. AI prevalence of 19.1%, 20.9% and 22.1% over the past week, past month and past year was reported among FSW in Cote d'Ivoire (48)). Alternatively, differences may be obscured by reporting bias, with more accurate reporting of behaviours over shorter recall periods. These observations are similar to previous studies showing that accuracy in reporting of sexual behaviour decreased over longer recall periods (64–66).

Collecting data on AI over both shorter and longer recall periods is desirable because it provides an indication of reporting accuracy by recall period (e.g. if AI is lower over longer recall period within the same sample) and also indirectly provides information on how long people practise AI (e.g. if AI is higher over longer recall period). Most studies reported estimates of AI prevalence over a lifetime only. While this information is useful, it is insufficient to fully reflect the current level of HIV risk due to AI in population since many may have ceased practicing AI.

Age does not appear to have a clear effect on how commonly AI is practised, with lifetime prevalence non-significantly higher among younger South Africans, and lower among younger FSW. Among all young people (including those not sexually active) lifetime AI prevalence increased with age, but no increase was seen with age among the sexually active, which may suggest that those who are sexually active at younger ages (<16 years) engage disproportionally in AI. 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 (67).

There is a popular opinion that heterosexual AI is on the increase (68). Anecdotally, general practitioners at US universities have reported an increasing number of female students presenting with anal fissures caused by AI (69). 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 (70,71). Higher AI prevalence has been found among Swedish and US adolescents exposed to online pornography (72–76), as well as among Indian clients of FSW (77), although the directionality of the association is not clear. However, female participants in qualitative interviews do frequently cite their own or their partner's pornography viewing as motivation for AI practice (78–80).

There is some evidence in my reviews to support the argument that AI prevalence may be 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. All three reviews identified a tendency for AI prevalence to increase over time, although this trend was significant only among young males and among European young people. However, series cross-sectional studies did find a significant increase; prevalence among Swedish female university students was found to increase by 12 percentage points over ten years, and national surveys from the US and Croatia reported increases of 2 percentage points over four years and 8 percentage points over five years, respectively, among sexually active females, with similar increases among males (70,71,81,82). This discrepancy between the meta-analysis' findings and the findings of

the time-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.

AI is often a highly stigmatised behaviour (83,84) leading to social desirability bias in reporting. Therefore, it may be more willingly reported using more confidential interviewing methods (85–87). Both the review among South Africans and among young people found significantly higher prevalence reported using ACASI, followed by SAQ and FTFI, although as articles using ACASI tended to be more recent; this finding may be confounded by an increase in AI prevalence over time. Further supporting this finding; the three studies in the reviews which compared AI prevalence by interview method all found higher prevalence using more confidential methods compared to FTFI (19,34,35). The highest number of AI acts across reviews was recorded among South African FSW completing daily pictorial coital diaries, with the same study finding a substantially lower number reported through daily FTFI and lower again through weekly FTFI (17). Likewise, the few studies using confidential ACASI to collect frequency data in the review among South Africans found the highest fraction of AI and UAI acts. Together, these findings support the need to use more confidential methods in the reporting of AI practice, but also highlight the importance of using short recall periods (one week or one month, depending on population) to record frequency data. AI practice may be more stigmatised for women than men, so the lower reported prevalence among women may partly be explained by greater social-desirability bias in women reporting stigmatised sexual behaviour (88).

All but one of the included RCTs testing vaginal microbicides or vaginal rings used FTFI and reported low AI prevalence (≤3% across recall periods) (21,23,25,26). The VOICE microbicide trial, however, used ACASI and found AI prevalence to be over six times higher than other trials (89). This suggests that in order to understand to what extent AI practice may be interfering with the efficacy of vaginal tract interventions, FTFI should be avoided. Qualitative work exploring participants' understanding of questions on AI found that they were often misunderstood; in particular, AI was often confused with other sexual practises such as vaginal sex 'from behind' (90,91). Therefore, although more confidential methods reduce social desirability bias, and thus often elicit higher responses on sensitive questions, they also have the drawback of offering little or no opportunity for clarification of misunderstood questions (90). Reporting may be improved by using clearer questions on AI and visual aids, such as demonstrated in a study which used unambiguous pictorial coital diaries; finding the highest number of AI acts reported in this review (17).

4.4.1. Limitations

These reviews have a number of limitations. I 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. The 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 the review on young people, particularly from samples of university students. However, given that lifetime prevalence among the sexually active did not differ significantly by study sample or by age, it is unlikely that this has affected the findings. Although the reviews among FSW and young people included studies from the 1980s, the review among South Africans included only studies published from 1990 onwards, as I was most interested in behaviour in the context of South Africa's HIV epidemic, which started to explode in the 90s. As a substantial amount of heterogeneity in all three reviews remains unexplained, it is possible that I 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. The use of engagement in VI as the definition of sexual activity among young people and South Africans may mask the practice of AI by those who do not engage in VI, and for shorter recall periods this definition may selectively include individuals with higher sexual activity. It may also mask the practice of AI by those who had not yet 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% (67,92,93). All included papers referred either to "anal sex" or "anal intercourse", which may be ambiguous terms that could include non-penetrative sexual activity; my assumption that this refers only to penile-anal intercourse may have inflated estimates in these reviews. In the reviews among young people and South Africans studies on men and boys were included that did not explicitly state that MSM were excluded from the sample, and thus study estimates may include some homosexual AI. As the majority of studies in all three reviews employed convenience sampling, we cannot be confident that the included studies are representative of the various populations.

The largest limitation to the analysis is the wide variability and frequently poor quality of reporting methods both for prevalence and frequency across studies. The wide range of different recall periods hindered comparison of AI prevalence across studies and limited interpretation of sub-group analyses. Analysis focused on lifetime prevalence of AI among young people as this was overwhelmingly the most common recall period. Shorter recall periods are, however, more epidemiologically useful. AI prevalence was often poorly reported, for example, of 127 studies included in the FSW review, 20 failed

to report the recall period of AI practice, and a further 34 reported that the AI was offered as a service rather than over a specific recall period. 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.

Only a handful of studies in each review reported on AI frequency, which in turn was also reported in a variety of ways, limiting the scope of my analysis. For example, of the 15 studies reporting on AI frequency among South Africans, only a fifth of studies with frequency data reporting CI or standard deviation on all types of sex acts (16,94,95) which prevented me from pooling or conducting detailed subgroup analyses of frequency data. The analysis of frequency data in the other reviews were limited to descriptive analysis for the same reason.

These reviews have a number of strengths and they make a valuable contribution to understanding this oft overlooked sexual risk behaviour. The reviews were greatly strengthened by using wide search terms, for example, omitting the word "anal", ensured that studies for which AI practice was not a primary outcome variable were captured. Given that both prevalence and frequency tended to be lower the later in the article that AI was first mentioned, not using 'anal' in the search terms limited the impact of publication bias, thus increasing the validity of my results.

4.4.2. Conclusions

The reviews found that, while varied, heterosexual AI is commonly and frequently practised across diverse populations and that condoms are often less consistently used during AI compared to VI. As such, heterosexual AI may substantially contribute to HIV epidemics. These reviews provide valuable information that can be used to guide policy, research and survey design internationally as well as to inform future mathematical models of HIV epidemics within the populations examined. Given the high risk of HIV transmission during AI, questions on its practice should be routinely included in surveys on sexual behaviour, particularly in routine national surveys so that trends over time can be examined. Accuracy of AI estimates can be improved by using visual aids, and combined with confidential interview methods in order to reduce social-desirability bias. In order to obtain more epidemiologically useful estimates, surveys should report AI prevalence over lifetime and shorter recall periods such as past three months. Frequency data on number of both protected and unprotected AI and VI acts should be reported over one month or one week, along with confidence intervals. Such data is crucial to strengthen our understanding of the extent to which AI impacts on HIV epidemics.

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Chapter 5

Prevalence and determinants of anal intercourse among female sex workers in eSwatini

5.1. RATIONALE

In this chapter, I use a bio-behavioural respondent-driven sampling (RDS) cross-sectional survey conducted in 2011 among 325 FSW throughout eSwatini (formerly known as Swaziland) to estimate the prevalence of AI and to identify the determinants of AI practice. The systematic review on AI practice among FSW presented in Chapters 3 and 4 identified a large number of studies reporting on AI practice among FSW, but it also identified a number of important research gaps, some of which can be addressed through analysis of this dataset.

1. The systematic review among FSW identified nine studies providing estimates of AI practice among FSW in Southern Africa, of which seven were among FSW in South Africa, three analysed data collected in the past ten years, and none analysed data on Swazi FSW. Thus, this analysis provides the first estimates of AI practice among Swazi FSW. This is an important population in which to understand AI practice, as eSwatini faces the highest HIV prevalence in the world.
2. The systematic review found that there are few data on AI practice among FSW by partner type. As explained in Chapter 1, these data on AI practice within the sexual network structure are needed in order to better target prevention messages and to accurately simulate the spread of HIV via heterosexual AI at the population level. In this survey, data on AI practice were collected by partner type (new clients, regular clients and non-paying partners) and can therefore be used to explore whether AI practice differs by partner type and if so, how.
3. Few of the studies included in the systematic review examined the association of violence perpetration and AI practice and none of the studies which did were on FSW in Southern Africa. No included studies examined the association of discrimination against FSW and AI practice. As discussed in Chapter 2, violence has been found to be associated with AI practice among FSW. As well as gathering data on sexual risk behaviours, this survey gathered numerous measures of violence, intimidation and social discrimination. It thus offers an opportunity to examine for the first time whether violence is associated with AI practice among FSW in southern Africa and also to examine for the first in any FSW population whether discrimination is associated with AI practice.

5.2. BACKGROUND

eSwatini has the highest national HIV prevalence in the world, with an estimated 34% of 15 to 49 year old women living with HIV (1). Worldwide, female sex workers (FSW) bear a disproportionately high burden of disease compared to other women of reproductive age in the population (2), and this is no different in eSwatini, where 70% of FSW are estimated to be living with HIV (3).

As elucidated in Chapter 2, AI practice among FSW appears to be associated with other sexual behaviours associated with higher risk of HIV and sexually transmitted infections (STI), including having a greater number of clients (4–7), practice of 'dry' sex (8,9), sex unprotected by condoms (9,10). AI practice is often more common among FSW who suffer physical (8,10–13) or sexual violence (8,9). Previous research on Swazi FSW points to conditions where AI is likely to be commonly practised and to frequently be condom unprotected (14–17). Sex work is illegal in eSwatini, and as such is hidden, marginalised and stigmatised (14,15). Violence, both physical and sexual, is commonly perpetrated against Swazi FSW, but given the legal status of sex work, is rarely reported to the police(15,16), who are themselves frequently the perpetrators (17). Most FSW report wanting to use condoms consistently, but structural factors, including financial incentives, act as barriers to condom use (14,15). Swazi FSW, like their counterparts in other southern African countries (18) have unmet health needs which may increase their vulnerability to HIV. For example, treatment for STIs is hindered by government STI clinics requiring that FSW bring all sex partners with them to receive treatment. It is therefore not surprising that most FSW who had STI symptoms in the past year reported having not sought treatment (19).

In this chapter I aim to: 1) estimate the proportion of Swazi FSW reporting AI and AI with inconsistent condom use (which is referred to as AI prevalence and AI prevalence with inconsistent condom use, respectively), 2) compare condom use during AI and VI by partner type, and 3) identify the determinants of AI practice. Such information is necessary to tailor appropriate HIV prevention interventions for FSW in eSwatini and other southern African countries.

5.3. METHODS

5.3.1. Study design and population

From July to September 2011, 325 Swazi FSW were recruited using RDS and administered a bio-behavioural survey. RDS is a peer-driven chain referral sampling technique designed for use among hard-to-reach populations and uses statistical adjustment to control for inherent biases introduced by the method's non-random nature (20). To initiate the chain referral process, 'seeds' were identified through contact with local organisations serving FSW. Seeds were well-connected members of the FSW community willing to recruit others in their social network. Three seeds were selected to begin the referral process, with another eleven added as accrual slowed. Each seed and each subsequent participant received three coupons to distribute to eligible members of their social network. Each coupon had an identifying code so that the recruitment chains could be traced, as well as an expiration

date to control recruitment pace. Participants were reimbursed for their time and for travel costs upon completion of the survey and were additionally rewarded for every eligible participant that they recruited to the study. Recruitment continued until the target sample size was met (size needed to significantly detect differences in HIV prevalence between participants with different exposures and behaviours at 80% power).

Women aged 16 years or older who had exchanged sex for money, favours or goods in the past year and who presented a valid recruitment coupon were eligible for the study. Participants completed a structured survey via face-to-face interview in SiSwati or English with whichever one of four interviewers (two male, two female) was available at the time. All interviews took place in private at a centrally located study clinic. The questionnaire covered demographic characteristics, sexual behaviour, violence, substance use, discrimination, social capital and sexual health knowledge. Sexual behaviour questions included items on consistency in condom use separately for AI and VI in the past month with new clients, regular clients and non-paying partners, and condom use at last sex (VI or AI) with any partner type. The questionnaire did not include questions on the number of AI or VI sex acts. Participants were asked to report the size of their social network, defined as the number of other FSW the participant personally knows and has seen or talked to in the past six months, in order to account for bias introduced through the increased probability of recruiting FSW with comparatively larger networks. Additionally, participants were tested for HIV (using Unigold by Trinity Biotech and Determine HIV by Alere, with indeterminate samples sent to a laboratory for further testing) and syphilis (using Determine Syphilis by Alere) and referred for treatment if positive.

5.3.2. Data analysis

Sample characteristics are presented as both crude and RDS-adjusted estimates. Adjusted estimates take into account participants' varying network sizes. 95% confidence intervals (95%CI) were calculated by clustering the standard errors at the recruiter level (21).

Both crude and RDS-adjusted prevalence estimates of AI and AI with inconsistent condom use with any partner type (i.e. with one or more partner type) and by partner type (new clients, regular clients and non-paying partners) among FSW reporting sex with that partner type were produced. Inconsistent condom use during VI in the past month by partner type as well as the subsets who report practising VI only and practising AI and VI among FSW reporting that partner type were derived. AI practice with inconsistent condom use was defined as reporting AI practice and using condoms most of the time, sometimes, rarely or never during AI in the past month, with the equivalent definition for VI with inconsistent condom use. The proportion reporting a condom breaking or slipping during VI and during AI by partner type in the past month was reported.

Interviewers' characteristics and behaviour can influence how respondents answer questions, particularly of stigmatised topics like AI (22). Possible interview effects were therefore explored by calculating the intraclass correlation coefficient (ICC) of variables included in the regression model. The ICC measures the percentage of total variance for a particular question that is attributable to the interviewer (23).

The determinants of practice of AI and AI with inconsistent condom use were examined using univariate and multivariable logistic regression models. Generalised Estimating Equations (GEE) were used to account for clustering of participants by recruiter in the regression models (24) using a an exchangeable working correlation structure. Continuous variables were dichotomised at the median. Variables were selected for inclusion in the regression model based on the conceptual framework developed in Chapter 2 (Figure 5.1). Some variables of interest (binge drinking, social participation and ability to negotiate condoms) were not included because they are believed to be of limited accuracy (e.g. several participants' answers to the two drinking questions: 'have you drunk in the past week', and 'number of drinks in the past week' were contradictory). For variables which measured similar constructs (e.g. having been harassed, beaten or tortured), the variable with fewer missing cases was entered. To control for the potential confounding of interviewer effects, respondents' interviewer identification were entered as dummy variables into the multivariable analysis.

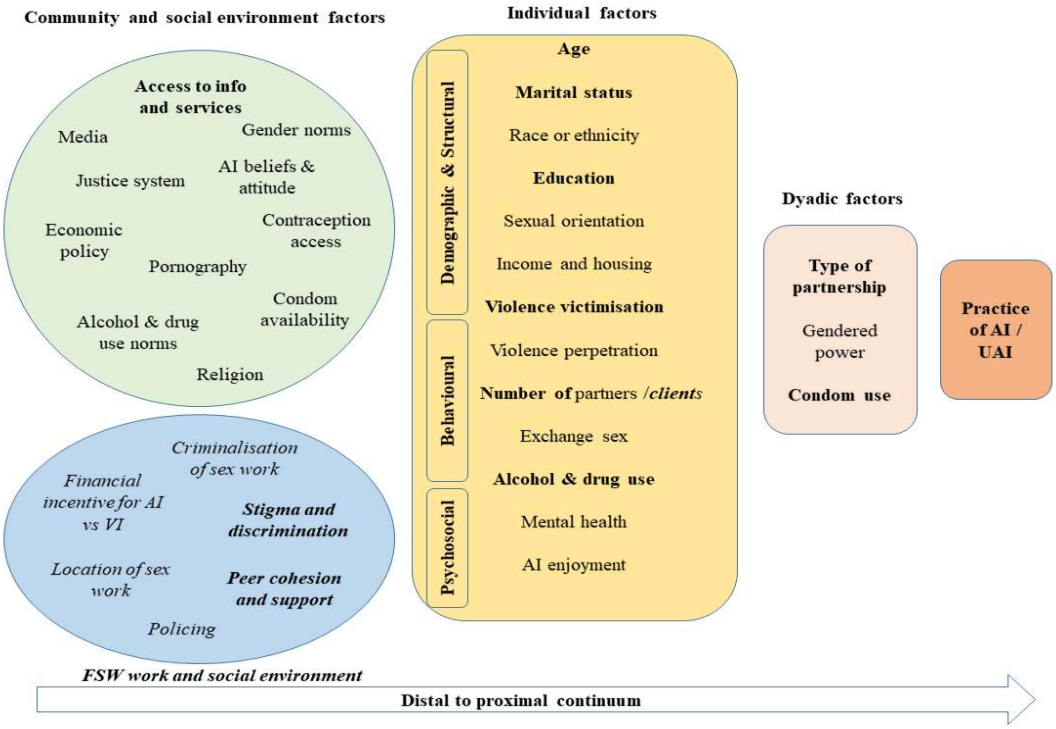

Figure 5.1. The conceptual framework of heterosexual anal intercourse developed in Chapter 2. Factors in italics are relevant to FSW specifically. Factors in bold were available in this dataset and have been included in the analysis.

Eleven of the 20 variables in the final AI model and ten of 19 in the AI with inconsistent condom use model contained missing data. In this context, a complete case analysis would have dropped 22% (n=70) of the sample from the analysis. Missing values were therefore dealt with using multiple imputation chained equations, an iterative process that imputes multiple variables through posterior prediction distribution using a series of univariate chained equations (25). Ten iterations were used and the multiple datasets produced were combined following Rubin's rules (26). Missing values for the outcome variables (AI and AI with inconsistent condom use practice) were not imputed, but were included in the imputation models as predictors (27,28).

The logistic models did not include RDS survey weights, as this is often unwarranted in regression modelling (29). All analyses were conducted in R version 3.2.0 (30) using the "*RDS"* (31) package to produce RDS adjusted estimates, "*geepack"* (32) to fit the regression models and the "*mi"* (33) and "*mitml"* (34) packages to conduct multiple imputation.

5.3.3. Ethics

All participants provided written informed consent. Ethical approval was granted by review boards at the Swazi Ministry of Health, Johns Hopkins School of Public Health (IRB No:00003508) and Imperial College London (ICREC: 16IC3661).

5.4. RESULTS

5.4.1. Survey participants

Ten of the 14 seeds recruited peers over a maximum of seven waves, resulting in a sample size of 325 women (Appendix, Figure A5.1). Sample characteristics are presented in Table 5.1 with both crude and RDS-adjusted estimates. The mean (median) age of the sample was 26 (25) years (range: 16-49). Most participants (74%) initiated sex work after reaching 18 years of age and had at least some secondary education (67%). Nearly half of the sample were living in Manzini (49%) at the time of the study, which is the most populous region of the country and where the study centre was located. The sample was equally split between having grown up in urban and rural areas. A large majority had never been married (96%) but most had at least one child (76%) and half financially supported three or more people through their sex work (52%). The most common primary place of work was in private homes (60%). Most FSW had no pimp (69%) and no other source of income beside sex work (67%). Just over half of the sample took only cash as payment (51%), with others also accepting goods. HIV prevalence was very high in the sample at 70%, while 8% tested positive for syphilis. Only 10% knew that AI carries the highest sexual HIV risk. Few women reported any lubricant use (21%), and of those, less than a

third used condom-compatible lubricant. Crude and RDS-adjusted estimates of sample characteristics were largely similar, although HIV prevalence was lower after the RDS-weights adjustment (62%;95%CI:51-73%), reflecting, in part, the larger network size of HIV-positive respondents (median was 14 and 10 among HIV-positive, and HIV-negative women, respectively). The intraclass correlation coefficient was high for the practice of AI and AI with inconsistent condom use, at 0.10 and 0.14, respectively, indicating that responses varied substantially by interviewer. Values for other covariates of interest were lower, ranging from 0.0-0.07 (Table A5.1).

Table 5.6. Selected characteristics of surveyed female sex workers in eSwatini in 2011(N=325).

			Crude estimates		RDS-adjusted	
Variable	**Categories**	**n**	**%**	**95% CI**	**%**	**95% CI**
Age in years	≤20	64	20	14-26	30	19-41
	21-25	103	32	26-38	27	19-36
	26-30	84	26	20-32	26	17-35
	31+	74	23	17-29	17	10-25
Years age started to sell sex (4 missing values)	<18	83	26	20-32	31	20-41
	18-21	121	38	32-44	39	28-49
	22+	117	36	31-42	30	21-39
Highest level of education	Primary or lower	106	33	28-38	33	24-42
	Secondary or higher	219	67	62-73	67	58-77
Region of residence	Manzini	159	49	43-55	51	40-61
	Hhohho	102	31	26-37	27	18-36
	Shiselweni	57	18	12-23	20	12-29
	Lubombo	6	2	0-8	2	0-7
	Outside eSwatini	1	0	0-6	0	0-0
Place grew up (3 missing values)	Urban	157	49	43-54	43	33-54
	Rural	153	48	42-53	52	41-62
	Foreign country	12	4	0-9	5	0-10
Marital status (4 missing values)	Single or widowed	308	96	94-98	95	87-100
	Married or cohabiting	13	4	2-6	5	0-13
Number of living children (1 missing value)	0	79	24	19-30	29	19-40
	1 or 2	182	56	51-62	55	44-66
	3+	63	19	14-25	15	9-22
Number of dependents	0-2	156	48	42-54	54	44-65
	3-5	114	35	30-41	33	23-43
	6+	55	17	11-23	13	7-19
Most common location for sex with clients (2 missing values)	Private home	195	60	55-66	61	51-72
	Hotel	87	27	22-32	27	17-38
	Car, street or park	33	10	5-16	9	5-13
	Bar/club or other	8	3	0-8	2	1-3
Has pimp (9 missing values)	Yes	97	31	31-36	28	19-37
	No	219	69	64-74	72	63-81
Income other than sex work (1 missing value)	Yes	108	33	28-39	29	20-39
	No	216	67	62-72	71	61-80
Payment type (5 missing values)	Cash only	164	51	46-60	51	41-62
	Cash and/or goods	156	49	43-54	49	38-59
HIV infected (8 missing values)	Yes	223	70	66-76	62	51-73
	No	94	30	25-35	38	27-49
Syphilis infected (6 missing values)	Yes	24	8	5-10	9	2-17
	No	295	92	90-95	91	8
Know type of sex with highest transmission risk (1 missing value)	Yes	34	10	7-14	8	4-12
	No	290	90	86-93	92	89-96
Any lubricant use with any partner, generally[†] (4 missing values)	Yes	70	22	17-26	21	16-26
	No	251	78	74-83	79	74-85
AI practice with any partner in past month (5 missing values)	Yes	129	40	35-46	44	34-54
	No	191	60	54-65	56	46-66
AI with inconsistent condom use with any partner in past month (7 missing values)	Yes	104	33	28-38	34	26-42
	No	214	67	62-73	66	56-76

95% CI=95% confidence interval. RDS-II method is used to calculate RDS adjustments. [†]Question was: 'Do you use lubricants?'

5.4.2. Prevalence of anal intercourse and condom use during AI and VI

The prevalence of AI and AI with inconsistent condom use (RDS-adjusted) with any partner in the past month was 44% (95%CI: 34-54%) and 34% (95%CI: 26-42%), respectively (Table 5.1). The reported prevalence of AI and AI with inconsistent condom use ranged from 23% to 61% and 15% to 57% across interviewers, respectively. Of the four interviewers, the two males recorded the highest AI prevalences (Table A5.1).

AI prevalence did not vary by partner type, ranging from 36% (95%CI:27-44%) with non-paying partners to 39% (95%CI: 30-48%) with regular clients (Table 5.2). The proportion reporting inconsistent condom use during AI, however, did vary by partner type; being lowest with new clients and highest with non-paying partners. The same pattern was seen for inconsistent condom use during VI by partner type. The proportion reporting inconsistent condom use during AI was higher than during VI with each partner type, e.g. 54% (95%CI: 38-71%) reported inconsistent condom use during AI with new clients compared to 30% (95%CI: 21-39%) during VI. A smaller proportion of FSW who exclusively practiced VI in the past month reported inconsistent condom use during VI with new and regular clients compared to FSW who practiced both VI and AI (Table 5.2). A higher proportion reported broken or slipped condoms during VI in the past month compared to during AI with both new and regular clients, but the proportions reporting broken condoms during AI and VI with non-paying partners were similar.

Table 5.7. Prevalence of anal and vaginal intercourse and inconsistent condom use over the past month among Swazi female sex workers by partner type

	Missing Values	n/N	Crude Estimates (%)	Crude Estimates (95% CI)	RDS-Adjusted Estimates (%)	RDS-Adjusted Estimates (95% CI)
With new clients (N=297)						
Fraction reporting AI	3	100/294	34%	29-40%	37%	29-46%
Inconsistent condom use during AI	0	67/100	67%	62-79%	54%	38-71%
Inconsistent condom use during VI	2	75/297	25%	20-30%	30%	21-39%
Inconsistent condom use during VI, subset practising VI only	0	39/197	20%	14-25%	27%	15-38%
Inconsistent condom use during VI, subset practising VI and AI	2	35/98	36%	26-45%	35%	21-50%
Broken or slipped condom during AI	1	8/50	16%	8-26%	17%	2-32%
Broken or slipped condom during VI	8	81/288	28%	23-34%	26%	17-34%
With regular clients (N=312)						
Fraction reporting AI	3	104/309	34%	28-39%	39%	30-48%
Inconsistent condom use during AI	0	77/104	74%	65-82%	69%	53-86%
Inconsistent condom use during VI	0	161/312	52%	46-58%	52%	43-61%
Inconsistent condom use during VI, subset practising VI only	3	104/205	51%	44-58%	54%	43-66%
Inconsistent condom use during VI, subset practising VI and AI	0	56/104	53%	44-64%	48%	32-64%
Broken or slipped condom during AI	0	12/46	26%	15-39%	28%	11-45%
Broken or slipped condom during VI	2	110/288	38%	33-44%	32%	23-41%
With non-paying partners (N=284)						
Fraction reporting AI	1	93/283	33%	28-39%	36%	37-44%
Inconsistent condom use during AI	0	74/93	80%	72-87%	76%	63-88%
Inconsistent condom use during VI	0	189/284	67%	61-72%	62%	53-71%
Inconsistent condom use during VI, subset practising VI only	1	133/190	70%	63-76%	69%	59-80%
Inconsistent condom use during VI, subset practising VI and AI	0	55/93	59%	49-69%	53%	36-65%
Broken or slipped condom during AI	4	6/24	25%	10-47%	39%	14-66%
Broken or slipped condom during VI	27	84/206	41%	34-48%	37%	26-47%

AI=anal intercourse, VI=vaginal intercourse. Inconsistent condom use was defined as reporting using condoms with a particular partner type 'most of the time', 'sometimes', 'rarely', or 'never' during anal or vaginal intercourse, as relevant. The denominator for the proportion practising inconsistent condom use during AI is the number reporting AI, and the equivalent denominator is used for VI. If participants reported any condom use they were asked if any condoms during the past month had broken or slipped, the denominator in this case is those who reported any condom use (i.e. excluding those who report 'never' using condoms with that partner type). All those who reported AI with a particular partner type also reported VI with that partner type

5.4.3. Determinants of AI

Odds ratios measuring the association between AI and demographic, behavioural and structural factors are presented in Table 5.3. In univariate analysis, FSW reporting fewer sex acts in the past week, fewer new clients in the past month, never having been blackmailed and not feeling afraid to walk in public places because of being a sex worker were statistically more likely to report AI practice. After adjustment for potential confounders, the multivariable regression results show that AI practice was more common among FSW who have at least some secondary education (adjusted Odds Ratio (aOR)=1.92; 95%CI:1.03-3.57) and had grown up in rural areas (aOR=1.90; 95%CI: 1.09-3.32). FSW whose last sex act with a client was condomless were more likely to report AI (aOR=2.09; 95%CI: 1.07-4.08). FSW who had five or more new clients in the past month had 66% lower odds of practising AI (aOR=0.33; 95%CI: 0.16-0.68). The odds of reporting AI practice were halved among FSW who had ever been blackmailed (aOR=0.50; 95%CI: 0.25-0.98) and FSW who ever felt afraid to walk in public places (aOR=0.46; 95%CI: 0.25-0.87). Conversely, FSW who had been verbally or physically harassed because of being a sex worker (aOR=2.09; 95%CI: 1.16-3.74) or had been raped (aOR=1.95; 95%CI: 1.05-3.65) had around twice the odds of reporting AI practice. Determinants of AI with inconsistent condom use were similar to AI practice, with the exception that the aOR for having been blackmailed was closer to the null and had a wider confidence interval (Table A5.2

Table 5.8. Demographic, behavioural and structural determinants of anal intercourse in the past month with any partner, among Swazi female sex workers (stratified by AI practice, and univariate and multivariable logistic regression with clustered standard errors). Stratified analysis shows crude data, logistic regression results are from models with imputed missing data.

			AI practice/past month		No AI practice/past month		Univariate		Multivariable[†]	
Variable	**Category**	**N**	**n**	**%**	**n**	**%**	**OR**	**95% CI**	**aOR**	**95% CI**
Personal characteristics										
Age	<26 years	167	69	54%	98	51%	Ref	-	Ref	-
	26+	153	60	47%	93	49%	0.88	0.56-1.36	1.04	0.59-1.84
Highest level of education	Primary or lower	104	35	27%	69	36%	Ref	-	Ref	-
	Some secondary or higher	216	94	73%	122	64%	1.54	0.90-2.62	1.92*	1.03-3.57
Grew up	Urban	157	60	47%	97	51%	Ref	-	Ref	-
	Rural	148	64	50%	84	44%	1.32	0.83-2.10	1.90*	1.09-3.32
	Foreign country	12	5	4%	7	4%	1.16	0.40-3.42	3.19	0.93-10.75
Number of dependents supported by sex work	0-2	153	60	47%	93	51%	Ref	-	Ref	-
	3+	167	69	53%	98	49%	1.09	0.71-1.67	1.10	0.66-1.83
Individual behaviour										
Number of sex acts/week[‡]	<5	162	80	64%	82	44%	Ref	-	Ref	-
	5+	152	46	37%	106	56%	0.45**	0.28-0.73	0.75	0.42-1.34
Condom use at last sex with new or regular client	Condom used	242	89	71%	153	80%	Ref	-	Ref	-
	Condomless	75	37	29%	38	20%	1.50	0.85-2.66	2.09*	1.07-4.08
Number of new clients/month (14 NAs)	<5	183	90	76%	93	50%	Ref	-	-	-
	5+	123	29	24%	94	50%	0.35***	0.21-0.58	0.33***	0.16-0.68
Number of regular clients/month	<7	184	78	62%	106	56%	Ref	-	-	-
	7+	131	48	38%	83	44%	0.83	0.54-1.28	1.40	0.78-2.49
Number of non-paying partners/month	0 or 1	206	77	60%	129	68%	Ref	-	Ref	-
	2+	113	51	40%	62	33%	1.41	0.89-2.22	1.18	0.67-2.06
Any drug use/year	No	207	82	65%	125	66%	Ref	-		
	Yes	108	45	35%	63	34%	1.08	0.67-1.72	1.00	0.57-1.74

Variable	Category	N	AI practice/past month		No AI practice/past month		Univariate		Multivariable†	
			n	%	n	%	OR	95% CI	aOR	95% CI
Social discrimination and violence										
Ever blackmailed	No	210	95	74%	115	60%	Ref	-	Ref	-
	Yes	110	34	26%	76	40%	0.56*	0.33-0.95	0.50*	0.25-0.98
Ever physically or verbally harassed	No	125	49	38%	76	40%	Ref	-	Ref	-
	Yes	195	80	62%	115	60%	1.08	0.69-1.68	2.09**	1.16-3.74
Ever raped since age 18	No	180	63	53%	117	67%	Referent	-	Ref	-
	Yes	123	57	48%	66	36%	1.62	0.98-2.69	1.95*	1.05-3.65
Ever afraid to access health services	No	180	68	53%	112	59%	Referent	-	Ref	-
	Yes	140	61	47%	79	41%	1.27	0.81-2.00	1.54	0.86-2.78
Ever afraid to walk in public places	No	167	79	61%	88	46%	Referent	-	Ref	-
	Yes	153	50	39%	103	54%	0.54**	0.36-0.82	0.46*	0.25-0.87
Social cohesion score§	High	157	58	49%	83	46%	Ref	-	Ref	-
	Low	141	60	51%	97	54%	0.91	0.59-1.39	0.85	0.50-1.45
Knowledge, information and services access										
Knowledge of type of sex with highest transmission risk	Anal	34	15	12%	19	10%	Ref	-	Ref	-
	Other	286	114	88%	172	90%	0.84	0.42-1.66	0.79	0.32-1.98
Tested for STIs/year	Yes	232	36	28%	52	27%	Ref		Ref	-
	No	82	93	72%	139	73%	0.92	0.56-1.49	1.29	0.71-2.35
Received information on HIV prevention/year	Yes	272	109	85%	163	86%	Ref	-	Ref	-
	No	45	19	15%	26	14%	1.11	0.56-2.20	1.34	0.57-3.15

AI=anal intercourse, aOR=adjusted odds ratio, OR=odds ratio, STI=sexually transmitted infection, 95%CI=95% confidence interval, Ref=reference level. *p<0.05, **p<0.01, ***p<0.001.† Multivariable results are mutually adjusted for all variables listed in this table. In addition to the variables listed, interviewer was entered into the model as a dummy variable in order to control for its potential confounding effect. ‡Condom use at most recent sex with new or regular clients was derived from two questions on condom use at last sex with new and regular clients separately§ Social cohesion is an index comprised of a series of questions on relationship with other FSW, developed among Brazilian FSW (35). For more information on social cohesion index, see Appendix Table A5.2 footnotes

Table 5.4. Association between the practice of anal intercourse and anal intercourse with inconsistent condom use and HIV and syphilis infection

Outcome	AI practice in past month					AI with inconsistent condom use in past month				
		Univariate		Multivariable†			Univariate		Multivariable†	
	n/N	OR	95% CI	aOR	95% CI	n/N	OR	95% CI	aOR	95% CI
Tested positive for HIV (8 missing values)	219/313	0.97	0.58-1.60	0.88	0.50-1.52	218/311	1.09	0.65-1.85	0.91	0.51-1.64
Tested positive for syphilis (6 missing values)	23/315	0.29*	0.08-0.79	0.44**	0.05-0.74	22/313	0.30*	0.07-0.91	0.31*	0.07-0.98

AI=anal intercourse, N=number of whole sample for whom test results are available, aOR=adjusted odds ratio, NA=number of missing values, OR=odds ratio, STI=sexually transmitted infection, 95%CI=95% confidence interval, Ref=reference level. *p<0.05, **p<0.01, ***p<0.001.

†Multivariable models are adjusted for covariates that have previously been found to be significantly associated with HIV infection in this sample (3): age, highest level of education, reporting STI symptoms in the past 12 months, reporting ever disclosing sex work to a health care worker and condom use during vaginal intercourse with new clients in the past month. These same covariates with the addition of the number of new clients in the past month were used to adjust the syphilis model

5.4.4. Associations between anal intercourse, HIV and syphilis

Practice of AI and AI with inconsistent condom use was negitively associated with testing positive for syphilis (aOR for syphilis infection among those practising AI=0.44; 95%CI: 0.05-0.74) but had no association with HIV status (Table 5.4).

5.5. DISCUSSION

AI practice in the past month was very common among this sample of Swazi FSW (RDS estimate=44%) and a third reported AI with inconsistent condom use. While there are no other data on AI among Swazi FSW with which to compare these results, these estimates are similar to estimates from FSW in two studies conducted in neighbouring KwaZulu-Natal (South Africa): 43%and 40% reporting practising AI as part of their service (7,36). Consistent condom use was statistically significantly lower during AI than during VI with each partner type. A third of the total sample reported AI with inconsistent condom use in the past month which, given the increased HIV transmission risk during AI, may substantially contribute to this population's very high HIV prevalence, although no association was found between recent AI practice and HIV infection in this cross-sectional sample. Reporting any broken condoms in the past month was more common during VI than AI, but lack of data on the number of each type of sex act hinders the interpretation of this finding, as the total number of VI acts is likely to be higher than the number of AI acts.

These results suggest that FSW who practice AI have fewer new clients and tend to have fewer sex acts. Several other studies have found that FSW typically charge more for AI than for VI (6,8,37), and practice it because of this financial incentive (38,39), so it is possible that those who practice AI do so in order to maximize sex-work revenue while reducing their number of clients. This conjecture is supported by the finding that despite reporting fewer clients and sex acts, there was no difference in the overall income from sex work reported by FSW who do and do not practice AI (median=$140/month). The reported mean fee for UVI (US$17) was over twice that for condom protected VI (US$8) (data on fee for AI was not collected), and those practising AI were more than twice as likely to report that their last sex act with clients was condomless. This may imply that the same FSW are motivated by the financial incentive to practise both UVI and UAI.

The finding that those who report being verbally or physically harassed or having been raped are also more likely to report AI is in agreement with other studies' findings that victims of violence are more likely to practise AI (8,10–13). However, results also suggest that FSW who report AI were less likely

to be afraid to walk in public and less likely to have been blackmailed. This mixed picture may reflect AI being practised by two distinct groups of Swazi FSW, as described by qualitative researchers: one who felt that poverty left little choice other than to enter sex work, and the other who appreciates the autonomy that the relatively lucrative work provides (14,15). This conjecture is supported by my finding that, among those who practice AI, those who have been harassed are significantly more likely to be afraid to walk in public and to have been blackmailed. (OR=2.3, 95%CI:1.5-2.8)

Despite a well-recognised heightened risk of transmission during UAI (40), no association between AI practice and HIV infection was found and an inverse association with syphilis infection in this cross-sectional sample. AI practice was measured over short time-periods (past month) which may not reflect FSW's behaviour at the time of infection. A recent review also found that associations between AI and HIV prevalence were inconsistent in cross-sectional samples (41). Prospective studies are more appropriate to determine causality and there is indeed strong evidence that AI enhances HIV risk in women(40).The transmission risk of syphilis during AI is less well understood, but is believed to be higher than during VI(42). My finding that the small number infected with syphilis are less likely to practise AI is therefore surprising and may be a result of residual confounding.

Foremost among this study's limitations is the use of face-to-face interviews. Heterosexual AI is highly stigmatised in Southern Africa (43,44), and use of non-confidential interview methods is likely to have resulted in underreporting of AI and other sensitive topics included in the analysis (45–47). AI reporting was shaped by substantial interviewer effects and I therefore adjusted for interviewer in the multivariable analyses. Reporting AI practice was more common with the male interviewers, but with only four interviewers it is not possible to make solid conclusion regarding the effect of interviewers' gender. If interviewer gender does have an effect, one reason may be that given the high demand for AI from their male clients, FSW may feel less shame in reporting AI practice to men as in their experience men are accepting of AI. Although this is an interesting question, I recommend that rather than conducting research to identify causes of interviewer effects, similar surveys in the future simply employ more confidential interview methods to collect data on AI practice and other stigmatised behaviours. It was not possible to use the available data on lubricant use to explore the reasons for condom breakage as the recall periods differed, and while condom breakage was reported by partner type and type of sex act, lubricant use was not. A further limitation is that the survey did not include questions on the number of AI and VI sex acts, without which it is not possible to estimate the contribution of AI practice to HIV transmission among Swazi FSW and to the wider Swazi epidemic.

Lack of sex act data is a common weakness of behavioural surveys, with a systematic review of heterosexual AI practice among South Africans (48) identifying only one study which reported on frequency of AI acts among FSW, which found that around 20% of all sex acts were anal (49). A recent study among Côte d'Ivoire FSW found that a similar proportion of sex acts were anal (21%) among the fifth of the sample who reported AI and mathematical modelling of these data suggest that 22% of new HIV infections could have been averted in this population had AI been substituted for VI (37). If AI is practiced as frequently among Swazi FSW, then AI's contribution to the country's HIV epidemic is likely substantial (50).

There are a number of possible approaches to reducing the HIV transmission risk from AI among Swazi FSW. Tenofovir, the active component in oral pre-exposure prophylaxis (PrEP) has been found at higher concentration in rectal than vaginal tissue, and is likely more protective during receptive AI than VI (51–55). Increasing access to PrEP could be effective for some FSW, although during a demonstration project adherence among FSW has been found to be low in neighbouring South Africa (56). In the future, rectal microbicides or dual vaginal and rectal microbicides may also provide an option for FSW to protect themselves during AI (57). However, given ease of access, interventions to increase condom use in this population is likely to remain an efficient and cost-effective approach that cannot be overlooked. Counselling on proper condom and lubricant use may decrease the rate of condom breakage (58). Additionally, decriminalisation of sex work may help reduce many of the structural barriers to safe sex practice faced by FSW (59).

5.5.1. Conclusion

In conclusion, AI is very commonly practised among Swazi FSW with all types of sex partners. Both condom use during AI and knowledge of HIV risk associated with AI is low. Taken together, these results highlight the importance of structural interventions that reduce FSW vulnerability to violence, biomedical interventions that address HIV acquisition risks associated with AI combined with integration of education regarding safe anal sex in sexual health education programmes in eSwatini.

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Chapter 6

Patterns and trajectories of anal intercourse practice over the life course among U.S. women in the WIHS cohort

6.1. RATIONALE

This chapter describes AI practice over the life course, using data from the Women's Interagency HIV Study (WIHS) cohort, which is a large on-going cohort study of both HIV-positive and HIV-negative women in the U.S. This thesis so far has examined heterosexual AI practice and explored its correlates using cross-sectional data. All studies in the systematic reviews and meta-analyses presented in Chapters 3 and 4, as well as those included in the literature review in Chapter 2, were either cross-sectional in nature or reported AI practice at baseline only. Likewise, the analysis of AI practice among Swazi FSW in Chapter 5 used cross-sectional data.

This means that while AI practice is fairly well understood cross-sectionally, longitudinal patterns of AI practice over the life course are much less well understood. AI practice has, to my knowledge, yet to be examined longitudinally over an extended period of time. As such, little is known of the patterns of AI practice over the life course; whether its practise declines with age concomittant to VI practice or earlier, and whether those who practise AI do so episodically or as a consistent part of their sexual repetoire. Analysis of the 20 year follow-up data from the WIHS cohort provides an opportunity to address these substantial research gaps.

6.2. INTRODUCTION

Cross-sectional studies in the U.S. suggest that AI is common among women (1–4). In the most recent *Sexual Exploration in America Study*, a nationally representative survey of heterosexual women and men conducted in 2015, 11% of sampled women (which included some who were sexually inactive) reported practising AI in the past year (5). The National HIV Behavioral Surveillance (NHBS-HET), a 2013 survey among sexually active women living in 20 U.S. cities with high HIV prevalence, found that 30% reported practising AI in the past year (6). The systematic review and meta-analysis on AI among young people presented in Chapter 3 and 4 of this thesis estimated that 25% (95%CI: 20-29%) of sexually active young women and girls (aged <25 years) in North America had ever practised AI in their lifetime (7). All three systematic reviews in Chapters 3 and 4 found that AI prevalence did not increase with length of recall period. Without a longitudinal analysis of AI practice, it is unclear whether this is due to people continuing to practise AI once initiated or whether AI is most accurately reported over shorter recall periods. Whether AI practice increases or descreases with age among U.S. women is also not clear, with one cross-sectional study finding that reporting AI practice over the past year decreases with age (8), another that it remains constant (9) and another that it increases (6).

This chapter aims to describe, characterise and predict patterns of AI over the life course. AI practice over the life course is described for the whole sample and additionally, sub-groups with distinct trajectories of AI practice are identified and described. This analysis could inform which is the most suitable public health intervention. For example, if women who practice AI tend to have longer periods of continuous practice, offering PrEP during these periods may be the most suitable intervention. Whereas if AI practice tends to be sporadic, this may imply that the practice is not really planned, in which case, messaging on the importance of condom use during AI may be more suitable.

This chapter aims to:

a. describe AI practice over follow-up
b. identify groups with distinct trajectories of AI practice over the life course
c. describe AI practice within each trajectory group
d. identify individual baseline characteristics associated with group membership

6.3. METHODS

6.3.1. The WIHS Cohort

The WIHS study is the largest ongoing prospective cohort study of HIV infection among U.S. women and includes a demographically matched HIV-negative comparison group. Initial recruitment occurred in 1994, with further recruitment waves in 2001-02 and 2011-12 at six urban sites (The Bronx, Washington DC, San Francisco, Los Angeles, Chicago and Brooklyn). In 2013, a fourth wave expanded recruitment to sites in the southern U.S. (Chapel Hill, Atlanta, Miami, Birmingham and Jackson). To date, a total of 4,982 women (3,677 HIV-positive and 1,305 HIV-negative) have been enrolled in the WIHS cohort. At the baseline visit, data were collected on lifetime AI practice (ever having practised AI). Follow-up visits were then conducted every 6 months and data were collected on whether AI had been practised since the last visit. Condom use was measured by asking whether condoms had been used '*always*', '*sometimes*' or '*never*' during AI since the last visit. The equivalent data were collected on VI. Demographic, behavioural, structural and psychosocial factors were gathered at both baseline and over follow-up.

6.3.2. Data Analysis

All WIHS participants, both HIV-positive and -negative, with baseline data and at least three 6-monthly follow-up visits, were included in this analysis. Data on HIV-negative and HIV-positive women were analysed separately. Detailed methods for each sub-aim follows, but in summary, this chapter employed 1) data visualisation and descriptive statistics to describe AI practice over follow-up, 2) group-based trajectory modelling (GBTM) to identify groups with distinct trajectories of AI practice, and 3) multinomial regression to identify baseline characteristics associated with trajectory group membership. Table 6.1 provides an overview of the analysis.

Table 6.1. Overview of analysis: summary of study population, variables and types of analysis used to fulfil each of the described aims

Study population	Dependent variable(s)	Covariates of interest	Type of analysis
a: To describe AI practice over follow-up			
Whole sample stratified by HIV status and sub-sample reporting male partner(s) since last visit	AI since last visit	Age, in 5-year categories	Descriptive: data visualisation, summary statistics on AI practice and other sexual behaviours
b: To identify trajectory groups of AI practice over the life course			
Whole sample, stratified by HIV status	Categories of sexual activity (1= no male sex partner, 2=male sex partner(s) and no AI, and 3=AI practice)	Age, continuous	Group-based trajectory modelling
c: To describe AI practice within each trajectory group			
Whole sample, stratified by trajectory group and HIV status	AI since last visit	Age, in 5-year categories	Descriptive: data visualisation, summary statistics on AI practice and other sexual behaviours
d: To identify individual baseline characteristics associated with trajectory group membership			
Whole sample, by HIV status	Membership of trajectory groups	Demographic, structural and behavioural variables at baseline.	Multinomial regression using the largest identified group as the comparison group.

AI=anal intercourse

Aim a: Describe AI practice over follow-up

The patterns of AI across the whole sample were described in a variety of ways. Patterns of AI practice by age were graphically explored by plotting the proportion reporting AI since the last study visit by age among the whole sample, as well as for the subgroup including only women who report any male sex partner at the same visit. Individual longitudinal behaviour of the whole sample was displayed as a heat map. The proportion of total visits (both including and excluding visits in which no male sexual partner was reported) when AI was reported over follow-up was calculated. The proportion of visits with AI practice in which condom use during AI was consistent (always using condoms during AI) was compared with the equivalent measure for VI.

Aim b: Identify trajectory groups of AI practice over the life course.
To identify sub-groups of women that follow different AI practice trajectories, GBTM, also referred to as latent class growth modelling, was used. This is a semi-parametric approach used to identify sub-groups (or classes) of individuals within populations that follow distinct trajectories over time, in contrast to traditional growth curve modelling which identifies a mean trajectory for the entire sample. Trajectory groups can be thought of as unobserved (latent) longitudinal strata where population variability is captured by the different trajectories across groups.

As the magnitude and direction of change can vary freely across trajectories, a set of model parameters (intercept and slope) is estimated for each trajectory(2,3). GBTM differs from the very similar latent class growth mixture approach in that it assumes no random effects; fixing the slope and intercept to equality across individuals within a given trajectory group. As such, individual differences are captured instead solely by the multiple trajectories included in the model (2).

In order to distinguish between visits when women do and do not report any sexual activity with men since the last visit, heterosexual AI practice at each survey visit was trichotomised into: 1) no male sex partner, 2) no AI but sexual activity with male partner(s), and 3) AI practice. This ordinal variable formed the outcome of interest in the GBTM, while age (as a continuous variable) was entered as a covariate. A number of criteria were used to determine the optimal number of groups: the Bayesian Information Criterion (BIC) as a measure of goodness-of-fit, average posterior probabilities of group membership as a measure of classification quality and group size (groups comprising <5% of the sample should be avoided) (11,13).

Aim c: Describe AI practice within each trajectory group.
The patterns of AI within each trajectory group were described using the same steps as described in Aim 1a. above. Briefly, the proportions reporting AI by age as well as those reporting any male sex partner were plotted, and the proportion of visits at which various sexual behaviours were reported calculated for each trajectory group.

Aim d. Identify individual baseline characteristics associated with group membership.
In order to identify socio-demographic and behavioural factors associated with longitudinal patterns of AI practice, univariate and multivariable multinomial regression were used to examine associations between baseline characteristics and trajectory group membership. The largest identified trajectory group was used as the reference group to maximize statistical power. Using the conceptual framework

developed in Chapter 2, demographic, behavioural and structural covariates of interest available in the WIHS dataset were identified and selected *a priori* (Appendix Figure A6.1). Longer-term baseline characteristics only were used (e.g. ever having injected drugs), rather than shorter-term and possibly more transient exposures and behaviours (e.g. injecting drugs in the past 6 months).

Structural and demographic covariates of interest were race or ethnicity (Black versus Hispanic, versus non-Hispanic White, versus other races), highest educational level (high school+ versus less than high school), sexual orientation or identity (heterosexual versus other), ever raped (yes versus no) and ever severely beaten (yes versus no). Behavioural covariates were ever injected drugs (yes versus no), ever traded sex for money or drugs, referred to here as practising transactional sex (yes versus no) and number of male sex partners ever (dichotomised at median). Additionally, the model was controlled for recruitment wave (wave 1, 2, 3, or 4 as fixed effects) and age (as a continuous variable) as these variables could potentially confound the association of other structural and demographic covariates with group membership.

Generalised Estimating Equations (GEE) were used to account for possible correlation between observations within each study site using an exchangeable working correlation structure (14). Missing values in the covariates of interest were dealt with using multiple imputation chained equations, an iterative process that imputes multiple variables through posterior prediction distribution using a series of univariate chained equations (15). Ten iterations were used and the datasets produced were combined following Rubin's rule(16).

Data on physical (beaten ever) and sexual (raped ever) violence were missing from 25.7% and 26.0% of baseline visits, respectively. This is largely because ethical approval for gathering these two variables was not granted for the Los Angeles site (comprising of 14.3% of total study participants), and was first granted for the San Francisco site (comprising of 13.9% of total study participants) in 2006. Women who were recruited prior to 2006 in San Francisco and remained in the cohort once ethical approval was granted were asked the missing baseline questions in a catch-up round.

All analyses were conducted using the R statistical software (17) with the "*ggplot2*" package (18) used for producing plots, "*llcm*" (19) used to identify distinct trajectory groups, "*MICE*" (20) for multiple imputation and "*nnet*" for multinomial regression (21).

6.4. RESULTS

6.4.1. Participant Characteristics

Of the 4,982 women recruited over four recruitment waves, data from at least three follow-up visits were available for 4,090 women (82.1%), all of whom were included in this analysis. Baseline characteristics stratified by HIV status are presented in Table 6.2 and stratified by recruitment wave in Appendix Table A6.1. Participants were followed-up for a median of 10.5 years (IQR=4-18). As per the study design, length of follow-up varied substantially by recruitment wave, with a median of 18.0, 15.0, 5.5 and 3.0 years among first, second, third and fourth wave recruits, respectively. A quarter of women (n=1,085) were HIV-negative at baseline, of whom 23 (2.1%) sero-converted during follow-up. Nearly half were recruited during the first recruitment wave. Women were recruited in similar numbers at each of the seven original sites, while smaller numbers were recruited at the five sites added during the fourth recruitment wave (Atlanta, Birmingham, Chapel Hill, Miami and Mississippi). Median age at enrolment was 36 years. Over half of women described themselves as Black (63.1%), and a fifth as Hispanic or Latina (21.4%), with the remainder as non-Hispanic White (12.4%) and other races (3.1%). Most (87.7%) identified as heterosexual, with more identifying as bisexual (8.0%) than as lesbian (4.0%). Two-thirds had a high school diploma or higher, and a similar proportion (64.5%) were not currently married or living with a partner. Income tended to be low, with 57.4% having a household income of less than $12,000/year. A minority were employed (28.5%). A quarter (24.1%) had ever injected drugs. The median number of lifetime male sex partners was 10, and a quarter had ever had at least one or female sex partner. Ever having practised AI was reported by 36.8% and ever having practised transactional sex by 35.1%.

Most baseline characteristics varied little by HIV status as HIV-negative participants were matched on demographic characteristics. For variables that participants were not specifically matched on, a higher proportion of HIV-negative women were employed and they reported a higher median number of lifetime male sex partners (12 compared to 10), while a higher proportion of HIV-positive women reported ever having injected drugs (25.4% compared to 20.6%). Many characteristics did, however, vary substantially by recruitment wave (Appendix Table A6.1). Women recruited during waves 3 and 4 tended to be older (median age was 36 and 31 for waves 1 and 2, compared to 45 and 44 for waves 3 and 4, respectively) and a higher proportion were Black compared to earlier waves. A larger proportion of those recruited during waves 2 and 4 were currently employed (e.g. 24.1% and 36.1% were employed in wave 1 and 2, respectively). Ever having injected drugs was substantially more common among women recruited during wave 1 compared to subsequent waves (e.g. 38.6% in wave 1, 11.1% in wave 2).

Table 6.2: Baseline characteristics of WHIS cohort participants, stratified by HIV status

		Total N (%) or median (IQR)	HIV-positive N (%) or median (IQR)	HIV-negative N (%) or median (IQR)
	TOTAL	4090 (100%)	3005 (75.0%)	1085 (25.0%)
Years of follow-up	Median (IQR)	10.5 (4.0-18.0)	10.5 (4.0-18.0)	14.0 (5.0-18.0%)
Recruitment wave	First (1994)	2022 (49.4%)	1577 (52.5%)	445 (41.0%)
	Second (2001-02)	996 (24.4%)	642 (21.4%)	354(32.6%)
	Third (2011-12)	316 (7.7%)	235 (7.8%)	81 (7.5%)
	Fourth (2013)	756 (18.5%)	551 (18.3%)	205 (18.9%)
Site	Atlanta	243 (5.9%)	167 (5.6%)	76 (7.2%)
	Birmingham	102 (2.5%)	78 (2.6%)	24 (2.2%)
	Bronx	667 (16.3%)	473 (15.7%)	195 (17.9%)
	Brooklyn	548 (13.4%)	399 (13.3%)	149 (13.7%)
	Chapel Hill	180 (4.4%)	136 (4.5%)	44 (4.1%)
	Chicago	482 (11.8%)	371 (12.3%)	111 (10.2%)
	District of Columbia	483 (11.8%)	354 (11.8%)	129 (11.9%)
	Los Angeles	585 (14.3%)	449 (14.9%)	136 (12.5%)
	Miami	126 (3.1%)	91 (3.0%)	35 (3.3%)
	Mississippi	105 (2.6%)	79 (2.6%)	26 (2.4%)
	San Francisco	569 (13.9%)	408 (13.6%)	161 (14.8%)
Age in years	Median (IQR)	36 (30-43)	37 (31-43)	35 (28-42)
Race	Black	2580 (63.1%)	1889 (62.9%)	691 (63.7%)
	Hispanic	877 (21.4%)	647 (21.5%)	230 (21.1%)
	White	506 (12.4%)	384 (12.8%)	122 (11.2%)
	Other	127 (3.1%)	85 (2.8%)	42 (3.9%)
Sexual orientation	Heterosexual	3548 (86.7%)	2658 (88.5%)	890 (82.0%)
	Bisexual	329 (8.0%)	211 (7.0%)	118 (10.9%)
	Lesbian	163 (4.0%)	103 (3.4%)	60 (5.5%)
	Missing	50 (1.2%)	33 (1.1%)	17 (1.6%)
Education	High school or more	2619 (64.0%)	1893 (63.0%)	726 (66.9%)
	Less than high school	1465 (35.8%)	1109 (36.9%)	356 (32.8%)
	Missing	6 (0.2%)	3 (0.1)	3 (0.3)
Marital status	Married or partnered[1]	1439 (35.2%)	1077 (36.0%)	362 (33.4%)
	Not married or partnered	2639 (64.5%)	1917 (64.0%)	722 (66.6%)
	Missing	12 (0.3%)	11 (0.4)	1 (0.1)
Household income	<$12,000/year	2349 (57.4%)	1740 (57.9%)	609 (56.1%)
	$12,000+/year	1608 (39.3%)	1173 (39.0%)	435 (40.1%)
	Missing	133 (3.3%)	92 (3.1)	41 (3.8)
Employed	Yes	1165 (28.5%)	803 (26.7%)	362 (33.4%)
	No	2916 (71.3%)	2196 (73.1%)	620 (66.4%)
	Missing	9 (0.2%)	6 (2.0%)	3 (0.3)
Injection drug use/ ever	Yes	987 (24.1%)	764 (25.4%)	223 (20.6%)
	No	3102 (75.9%)	2240 (74.5%)	862 (79.4%)
	Missing	1 (0.0%)	1 (0.0%)	-
Number of male sex partners/ever	Median (IQR) *Missing=71*	10 (5-35)	10 (5-35)	12 (6-35%)
Any female sex partners/ever	1+	1022 (25.0%)	694 (23.1%)	328 (30.2%)
	0	3050 (74.6%)	2295 (76.4%)	755 (69.6%)
	Missing	18 (0.4%)	16 (0.5%)	2 (0.2%)
Anal intercourse/ever[2]	Yes	1505 (36.8%)	1086 (36.1%)	419 (38.6%)
	No	1954 (47.8%)	1392 (46.3%)	562 (51.8%)
	Missing	631 (15.4%)	527 (17.5%)	104 (9.6%)
Transactional sex/ever	Yes	1437 (35.1%)	1055 (35.2%)	382 (35.3%)
	No	2641 (64.6%)	1941 (64.8%)	700 (64.5%)
	Missing	12 (0.2%)	9 (0.3%)	3 (0.3%)

NA=not applicable, IQR= interquartile range. [1]'Partnered' refers to living with a partner. [2]The number of missing values is high because at the baseline visit of the first recruitment wave, women reporting no sex partner in the past 6 months were not asked whether they had ever practised AI. In subsequent waves, all women were asked whether they had ever practised AI. Variables for which there is no missing category contain no missing values.

6.4.2. AI practice and other sexual behaviours over-follow-up

The proportions of HIV-positive and HIV-negative women reporting a male sex partner at any time over follow-up were similar, at 90.1% (2707/3005) and 94.3% (1023/1085), respectively. AI practice was less common among HIV-positive than -negative women, however, with 23.2% (698/3005) and 32.9% (357/1085) reporting AI practice at any time over follow-up, respectively. Figure 6.1 shows that the proportion of women reporting AI decreased with age, regardless of HIV status, both among the whole sample (including women reporting no male sex partner) and among the subset reporting a male sex partner since last visit. The proportion reporting VI, on the other hand, decreased concomitantly with reporting a male sex partner (Appendix Figure A6.2). The proportion reporting AI was significantly lower among HIV-positive women than HIV-negative women at most age groups among the whole sample, and from ages 25 to 45 among the subset reporting a male sex partner since the last visit (Figure 6.1).

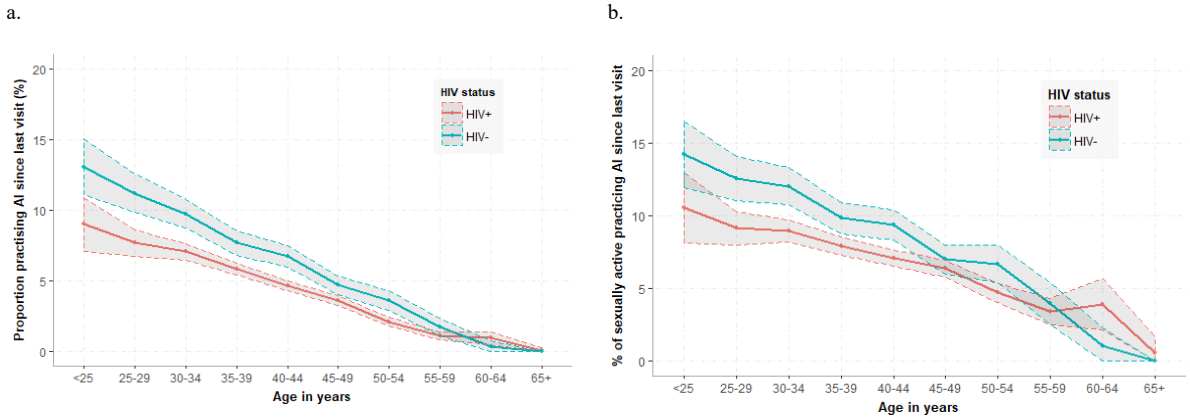
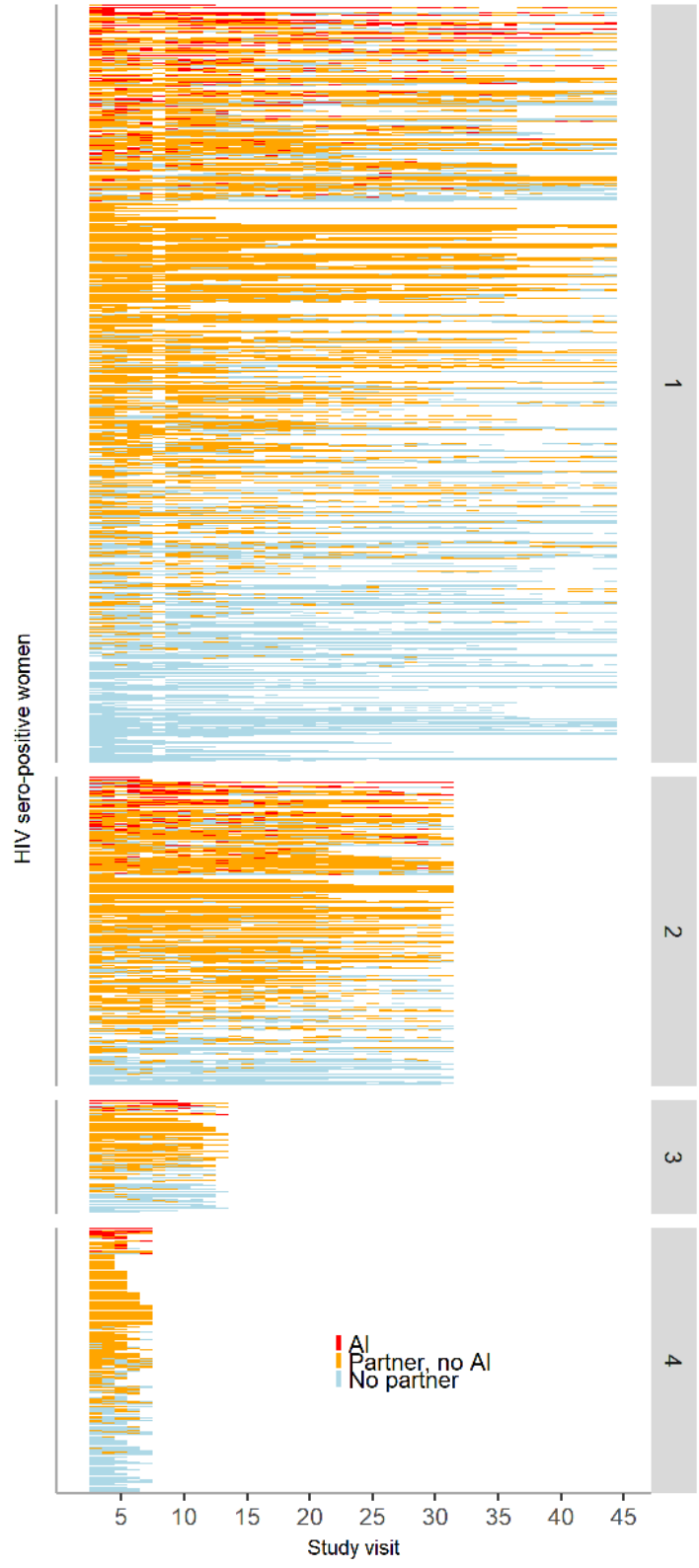


Figure 6.1. The proportion of women reporting AI practice since the last visit, by age among a) the whole sample and b) the subset reporting a male sex partner since the last visit. Shaded areas represent 95% confidence intervals.

Figure 6.2 displays the individual trajectories of AI practice as well as having a male sex partner and shows the wide variety of patterns of sexual activity over the lifespan, although the general tendency for both practising AI and having a male sex partner decreasing with age can be seen.

a.



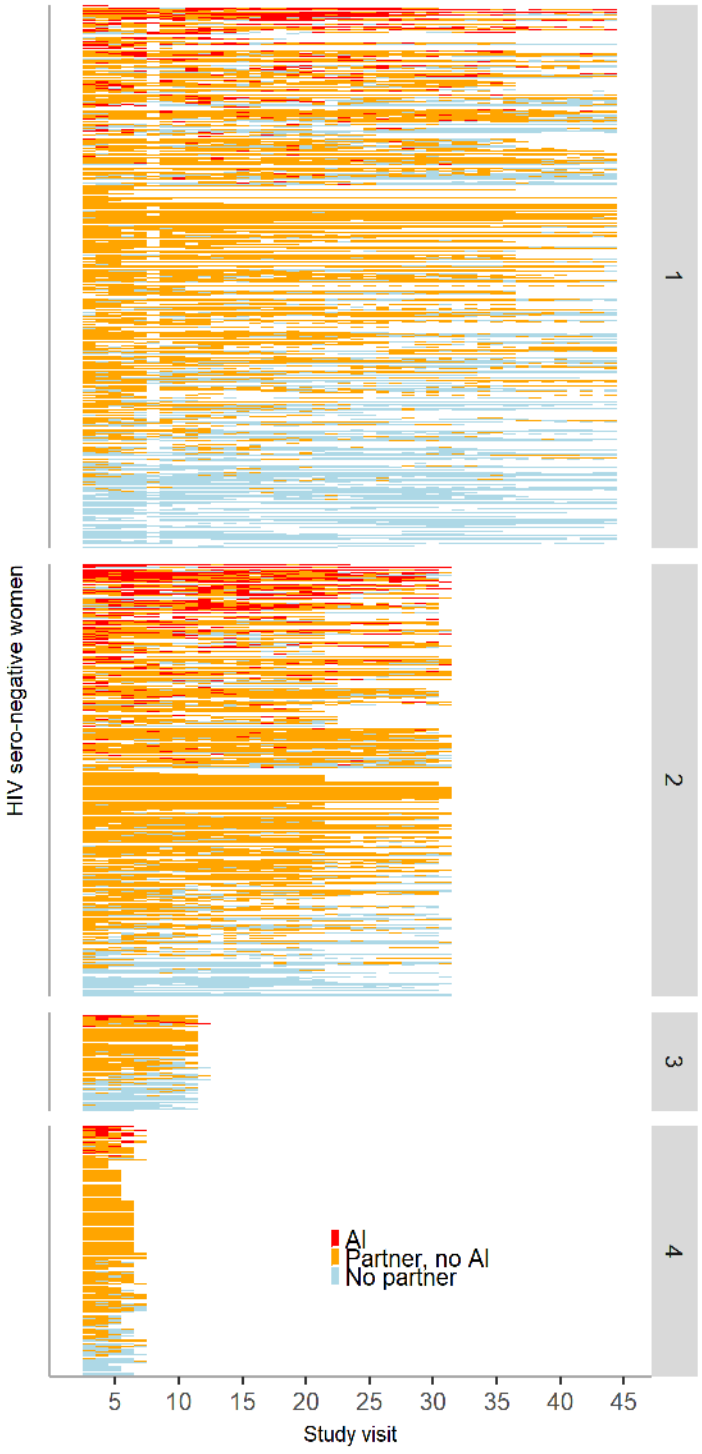
Median age at baseline=36 years (IQR:31-41)
Proportion reporting any AI over follow-up=26.1%

Median age at baseline=33 years (IQR:27-38)
Proportion reporting any AI over follow-up=31.8%

Median age at baseline=44 years (IQR:38-48)
Proportion reporting any AI over follow-up=12.8%

Median age at baseline=45 years (IQR:36-51)
Proportion reporting any AI over follow-up=9.6%

b.



Median age at baseline=35 years (IQR:29-41)
Proportion reporting any AI over follow-up=33.3%

Median age at baseline=28 years (IQR:22-36)
Proportion reporting any AI over follow-up=47.2%

Median age at baseline=48 years (IQR:42-53)
Proportion reporting any AI over follow-up=17.3%

Median age at baseline=44 years (IQR:34-50)
Proportion reporting any AI over follow-up=13.7%

Figure 6.2. Individual trajectories of reporting AI, having a male sex partner but not reporting AI and having no male sex partner since the last visit among a) HIV-positive and b) HIV-negative women. Trajectories are arranged by recruitment wave (1=first recruitment wave etc.) and within each recruitment wave, by proportion of visits with AI and proportion of visits with a male partner but no AI.

The proportion of follow-up visits during which AI, VI, having any female and male partners and having multiple male partners were reported are presented in Table 6.3. HIV-negative women tended to be more sexually active than HIV-positive women, with HIV-negative women reporting AI, VI, and any male and female sex partners as well as multiple male sex partners at a larger fraction of visits than HIV-positive women. At visits during which women reported at least one male sex partner, AI practice was reported at 7.1% and 9.5% of visits among HIV-positive and -negative women, respectively. At visits where multiple male partners were reported, the proportion reporting AI practice approximately doubled in both groups (e.g. from 7.1% to 16.6% among HIV-positive women).

Table 6.3. Percentage of visits in which various sexual practices since the last visit were reported, by HIV status

	HIV-positive women % (95% CI)	HIV-negative women % (95% CI)
All visits	N^v=62,799	N^v=23,651
AI	4.3% (4.1-4.5%)	6.6% (6.3-6.9%)
VI	60.2% (59.8-60.5%)	69.1% (68.5-69.8%)
Any male sex partner	61.6% (61.3-62.0%)	70.4% (69.9-71.0%)
Any female sex partner	4.1% (3.9-4.2%)	8.3% (8.0-8.8%)
Multiple male sex partners (2+)	7.9% (7.7-8.2%)	17.3% (16.8-17.8%)
Transactional sex	1.5% (1.4-1.6%)	3.7% (3.5-4.0)
Visits with male sex partner(s) reported	N^v=38,694	N^v=16,659
AI	7.1% (6.9-7.3%)	9.5% (9.0-9.9%)
VI	98.7% (98.5-98.85)	98.8% (98.5-98.9%)
Visits with AI practice	N^v=2,608	N^v=1,495
Consistent condom use during AI	50.8% (48.9-52.8%)	25.8% (23.5-28.0%)
Visits with VI practice	N^v=37,124	N^v=16,101
Consistent condom use during VI	61.0% (60.5-61.5)	24.1% (23.4-23.4%)
Visits with multiple male sex partners	N^v=4,987	N^v=4,090
AI	16.6% (15.5-17.7%)	17.3% (16.1-18.5%)
VI	98.5% (98.2-98.9%)	98.5% (98.1-98.9%)
Visits with AI practice and multiple male partners	N^v=747	N^v=641
Consistent condom use during AI	49.1% (45.5-52.2%)	36.0% (32.3-39.8%)
Visits with VI practice and multiple male partners	N^v=4,678	N^v=3,931
Consistent condom use during VI	51.6% (47.0-49.9%)	26.2% (24.8-27.6%)

N^v=number of visits over follow-up, AI=anal intercourse, VI=vaginal intercourse. The recall period for all sexual behaviours was 'since the last visit', the majority (93.1%) were 6 months prior, 5.0% 12 months prior and 1.9% longer than 12 months prior. Consistent condom use during AI was calculated as the proportion of visits with reported AI in which condoms were used 'always' rather than 'sometimes' or 'never' during AI. The equivalent definition was used for consistent condom use during VI.

As shown in Figure 6.3a, most women report no AI practice over follow-up. Among the subset who report any AI (Figure 6.3b), nearly two-thirds report it rarely (at <25% of visits with a male sex partner), while 11.3% of HIV-positive and 12.6% of HIV-negative women report it at half or more of visits when a male sex partner is reported.

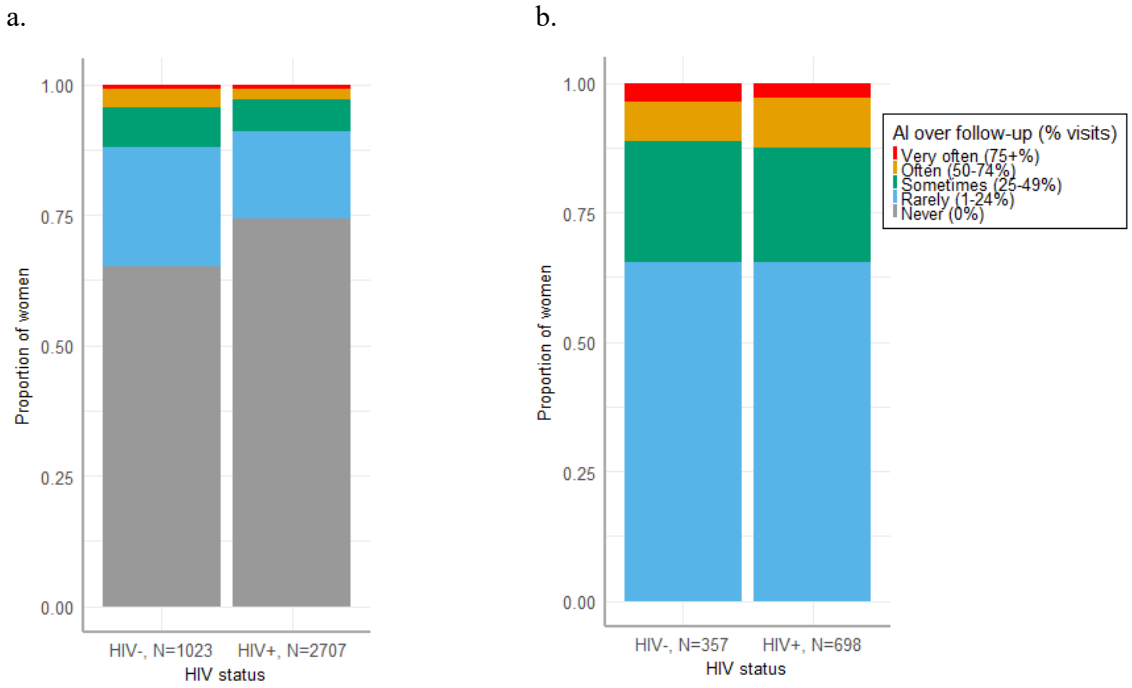


Figure 6.3. Proportion of women reporting AI very often, often, sometimes, rarely and never over follow-up among a) the whole sample and b) the sub-sample reporting any AI over follow-up. The frequency categories are defined by the percentage of visits with a male sex partner at which each woman reports practising AI.

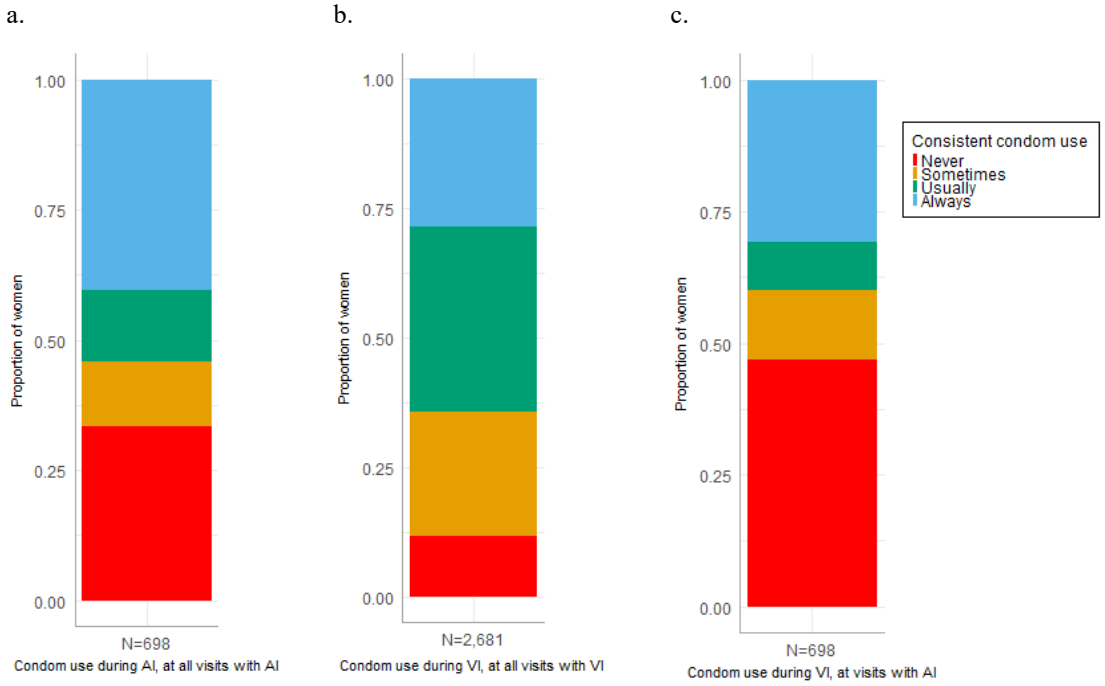
6.4.3. Condom use during AI and VI

Consistent condom use during both AI and VI was reported at approximately twice the fraction of visits among HIV-positive women than HIV-negative women (Table 6.3). HIV-positive women reported consistent condom use during AI less frequently (i.e. at a lower proportion of visits) (at 50.8% of visits) compared to VI (at 61.0% of visits). In contrast, HIV-negative women reported consistent condom use during AI and VI with similar frequencies (25.8% and 24.1% of visits, respectively). HIV-negative women reported using condoms more consistently during AI at visits when they also reported multiple partners (at 25.8% of visits), compared to all visits (at 25.1% of visits), whereas there was no difference among HIV-positive women. Patterns of condom use during VI also differed by HIV-status, with HIV-positive women reporting consistent condom use less consistently at visits when multiple male partners were reported (at 61.0% of visits), compared to all visits with VI (at 51.6% of visits) while these proportions differed little among HIV-negative women (at 24.1% and 26.2% of visits).

Figure 6.4 displays the proportion of women never, sometimes, usually and always using condoms consistently during AI and VI over follow-up. Among both HIV-positive and HIV-negative women, a higher proportion report never using condoms consistently during AI than VI, when comparing all visits at which each respective behaviour was reported. However, when considering condom use during VI at visits where AI was also reported, the proportion never using condoms consistently during VI increased substantially, indicating that periods with AI practice may generally be periods of higher sexual risk-taking. For example, 28.2% (95% CI; 25.5-31.1%) of HIV-negative women reported never using a condom during VI at all visits with VI, whereas 74.7% (95% CI; 70.3-79.3%) never used condoms during VI at visits where AI was also reported, with a similar pattern observed among HIV-positive women. Appendix Figure A6.3 compares condom use during AI and VI among the subset of women who report any AI unprotected by condoms over follow-up (report 'sometimes' or 'never' using condoms during AI) and shows that among both HIV-positive and HIV-negative women, the proportion never using condoms during AI was substantially higher compared to during VI. For example, 75.4% (95% CI; 69.4-79.5%) of HIV-negative women who report any AI unprotected condom use over follow-up never used condoms during AI, compared to 28.0% (95% CI; 24.3-32.6%) never using condoms during VI (at all visits when VI was reported).

In summary, when comparing condom use using *visits* as the denominator, there was minimal difference in consistent condom use during AI and VI among HIV-negative women, while HIV-positive reported consistent condom use during VI at a higher proportion of visits than during AI (Table 6.3). However, when comparing condom use using number of *women* as the denominator it emerged that there was a substantially higher proportion of both HIV-positive and HIV-negative women reporting never using condoms during AI compared to VI (Figure 6.4).

Among HIV-positive women



Among HIV-negative women

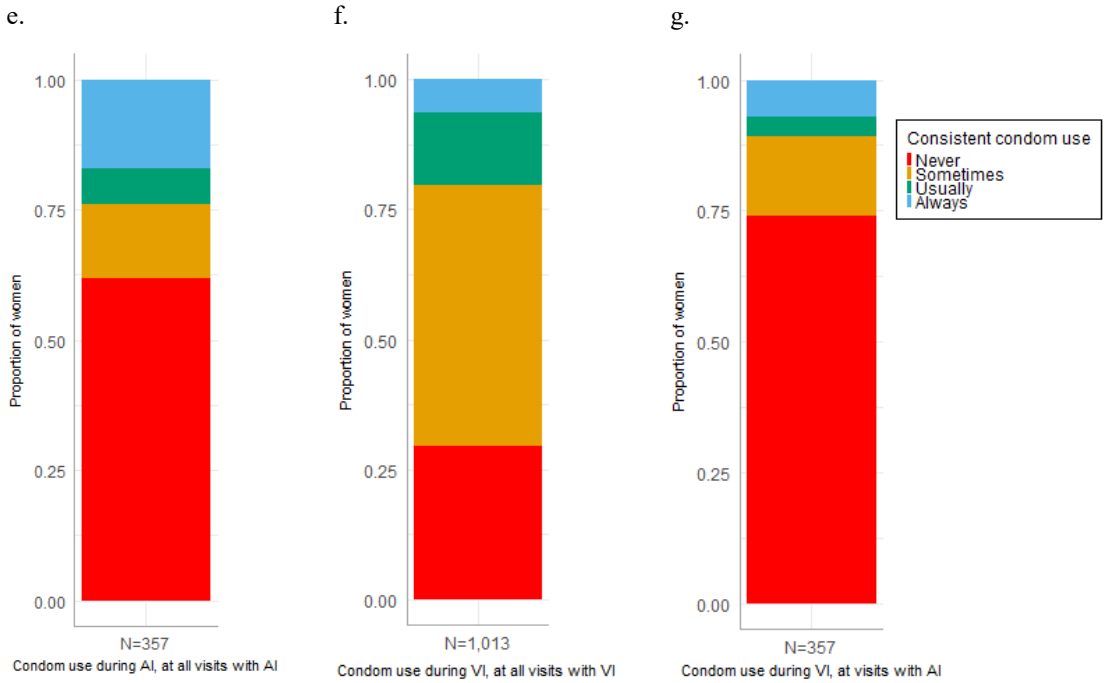


Figure 6.4. Proportion of HIV-positive women who use condoms consistently a) during AI at all visits when they report AI, b) during VI at all visits when they report VI and c) during VI at all visits when they report both VI and AI. Figures d-g) display the equivalent data for HIV-negative women. Consistent condom use is defined as reporting having always usd condoms since the last visit. Never=consistent condom use during AI since the last visits at 0% of visits with AI, sometimes=consistent condom use during AI at 1-49% of visits with AI, usually=consistent condom use during AI at 50-99% of visits with AI, always=consistent condom use during AI at 100 0% of visits with AI. Equivalent measures and categorisations were used for condom use during VI.

6.4.4. Selection of group-based trajectory models of AI practice over the life course

Using the trichotomised variable of sexual activity (1. no male sex partner, 2. no AI but sexual activity with male partner(s), and 3. AI practice) as the model indicator and age as a covariate, trajectory group models with two, three, four and five groups were fitted to the data for HIV-positive and HIV-negative women separately, and fit statistics for each model compared (Table 6.4). The four-group model was chosen for HIV-positive women and the five-group model for HIV-negative women. Despite BIC and maximum log-likelihood values indicating that trajectory groups among HIV-positive women may be slightly better described using five groups, the four-group model was chosen because of the drop in mean posterior probability in the five-group model, indicating that a fifth of the sample may have been assigned to the wrong group. A further reason for not choosing the five-group model was that the smallest group identified in the five-group model was only 3.2% of the sample.

The five- group model was chosen for HIV-negative women as the model fit statistics indicated that it was a better fit compared to the four-group model, there was only a very slight decrease in mean posterior probability and the smallest group identified was above 5% of the sample (Table 6.4). The identified trajectory groups were numbered in descending order of the proportion of visits during which AI was reported.

Table 6.4. Group-based trajectory model selection criteria

	2 groups model	3 groups model	4 groups model	5 groups model
A. HIV-positive women. N=3005				
BIC	75105	71113	**69797**	68567
Maximum log-likelihood	-37528	-35520	**-34850**	-34223
Mean posterior probability of belonging to assigned group	96.5%	88.8%	**86.3%**	80.4%
% of sample in smallest group	37.5%	22.5%	**9.0%**	3.2%
B. HIV-negative women. N=1085				
BIC	27730	26091	25222	**24852**
Maximum log-likelihood	-13844	-13014	-12569	**-12373**
Mean posterior probability of belonging to assigned group	97.3%	92.5%	88.9%	**87.6%**
% of sample in smallest group	27.3%	15.2%	8.8%	**6.9%**

BIC – Bayesian Information Criterion. Selected models are indicated in bold.

6.4.5. Description of AI practice and other sexual behaviours within trajectory groups: among HIV-positive women

Of the four trajectory groups identified among HIV-positive women, three (Groups 2-4) reported little AI practice over follow-up, but these three groups differed in the proportion of women reporting having any male sex partner (Figure 6.5). Group 1: *AI desistors & VI persistors* was the smallest (N=271) and was distinct from the other groups in its pattern of AI practice: the fraction of visits with a male partner at which AI was reported was much higher at 25.2% among women in Group 1 than women in Groups 2 to 4 (ranged from 1.6% to 4.0%) (Table 6.5). Two-thirds of women in Group 1 who reported any AI over follow-up reported AI at a quarter or more of visits whereas the majority of women in Groups 2-4 who reported any AI reported AI rarely (at <24% of visits with a male sex partner) (Figure 6.6a).

The fraction of visits at which having a male sex partner was reported was highest in Group 1 and lowest in Group 4 (94.8% and 9.5%, respectively), with Group 4 reporting the highest fraction of visits with a female sex partner (Table 6.5). Women in Group 1 reported having multiple male sex partners at a fifth of visits, while women in other groups reported this behaviour at a substantially lower fraction of visits (Table 6.5).

Women in Group 1 reported consistent condom use during both AI and VI at a smaller fraction of visits than women in Groups 2 to 4 (Table 6.5). Women in Group 1 reported consistent condom use at a similar fraction of visits during AI (at 48.7% of visits) and during VI (at 46.9% of visits), whereas in Groups 2 to 4, consistent condom use was reported at a lower fraction of visits during AI compared to during VI (e.g. at 52.3% and 62.0% of visits during AI and VI, respectively, among Group 2).

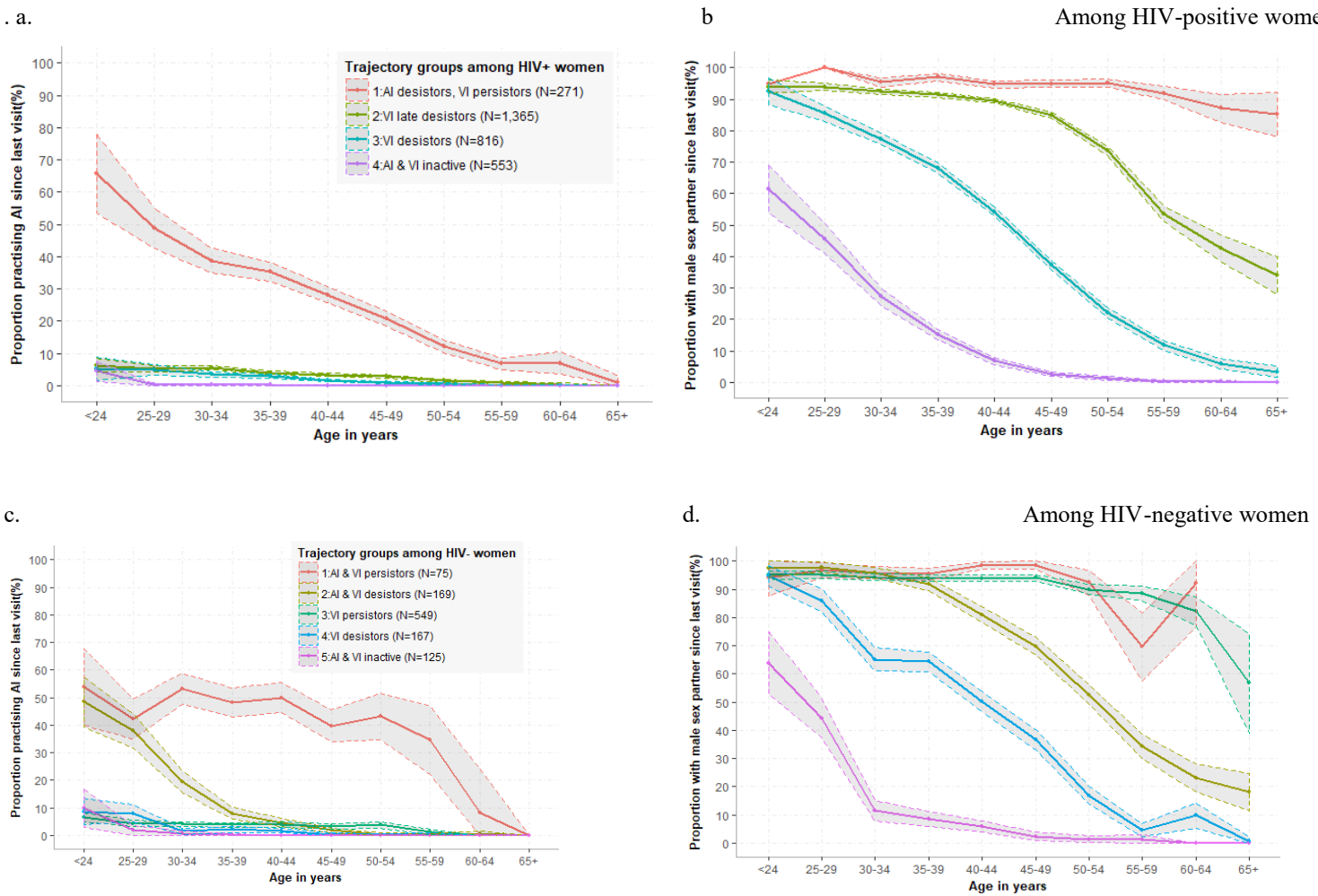


Figure 6.5. The proportion reporting a) AI practice among HIV-positive women, b) any male sex partner among HIV-positive women, c) AI practice among HIV-negative women and d) any male sex partner among HIV-negative women since the last visit by age group and by trajectory group. Trajectory groups are numbered in descending order of the proportion of visits during which AI was reported. Shaded areas represent 95% confidence intervals.

Table 6.5. Percentage of visits in which various sexual practices since the last visit were reported, by trajectory group among HIV-positive women

	Group 1: *AI desistors, VI persistors* % (95% CI)	Group 2: *VI late desistors* % (95% CI)	Group 3: *VI desistors* % (95% CI)	Group 4: *AI & VI inactive* % (95% CI)
All visits	N^v=6,268	N^v=27,477	N^v=18,676	N^v=10,378
AI	23.9% (22.8-25.0%)	3.4% (3.2-3.6%)	1.6% (1.4-1.8%)	0.1% (0.0-0.2%)
VI	93.3% (92.7-93.9%)	83.3% (82.9-83.8%)	44.0% (43.3-44.7%)	8.5% (8.0-9.1%)
Any male sex partner	94.8% (94.2-95.3%)	84.5% (84.0-84.9%)	45.9% (45.2-46.6%)	9.5% (8.9-10.1%)
Any female sex partner	2.2% (1.9-2.6%)	1.5% (1.3-1.6%)	2.5% (2.3-2.8%)	14.7% (14.0-15.4%)
Multiple male sex partners (2+)	20.6% (19.6-21.6%)	9.6% (9.3-10.0%)	5.4% (5.1-4.8%)	0.8% (0.6-1.1%)
Transactional sex	5.4% (48-5.9%)	1.4% (1.3-1.5%)	1.2% (1.0-1.4%)	0.2% (0.1-0.3%)
Visits with male sex partner(s) reported	N^v=5,939	N^v=23,205	N^v=8,564	N^v=986
AI	25.2% (24.1-26.3%)	4.0% (3.7-4.3%)	3.5% (3.1-3.9%)	1.6% (0.7-2.4%)
VI	98.6% (98.3-98.9%)	99.0% (98.8-99.1%)	98.0% (97.7-98.3%)	97.9% (96.9-98.8%)
Visits with AI practice	N^v=1,434	N^v=879	N^v=282	N^v=13
Consistent condom use during AI	48.7% (46.2-51.3%)	52.3% (49.0-55.6%)	56.4% (50.6-62.2%)	61.5% (30.9-92.1%)
Visits with VI practice	N^v=5,736	N^v=22,449	N^v=8,063	N^v=876
Consistent condom use during VI	46.9% (45.6-48.7%)	62.0% (61.3-62.6%)	67.8% (66.8-68.9%)	67.1% (64.0-70.2%)
Visits with multiple male sex partners	N^v=1,293	N^v=2,646	N^v=957	N^v=91
AI	37.9% (35.1-40.6%)	9.5% (8.3-10.7%)	7.4% (5.6-9.2%)	1.5% (0.0-4.5%)
VI	98.1% (97.3-98.8%)	98.8% (98.3-99.2%)	98.4% (97.6-99.2%)	100.0% (99.8-100.0%)
Visits with AI practice and multiple male partners	N^v=457	N^v=227	N^v=71	N^v=1
Consistent condom use during AI	45.3% (40.7-50.1%)	56.4% (49.9-62.9%)	51.6% (38.7-64.4%)	0% (NA)
Visits with VI practice and multiple male partners	N^v=1263	N^v=2,591	N^v=942	N^v=88
Consistent condom use during VI	40.7% (38.0-43.5%)	54.3% (52.4-56.3%)	58.4% (55.1-61.6%)	55.1% (43.8-66.4%)

N=number of women, N^v=number of visits over follow-up, AI=anal intercourse, VI=vaginal intercourse. The recall period for all sexual behaviours was 'since the last visit', which was typically 6 months prior. The groups identified through group-based trajectory modelling are numbered in order of declining proportion of visits in which AI was reported. Consistent condom use is defined as 'always' using condoms since the last visit during AI or VI, as relevant. Group 1 consists of 271 women, Group 2 of 1365, Group 3 of 816 and Group 4 of 553.

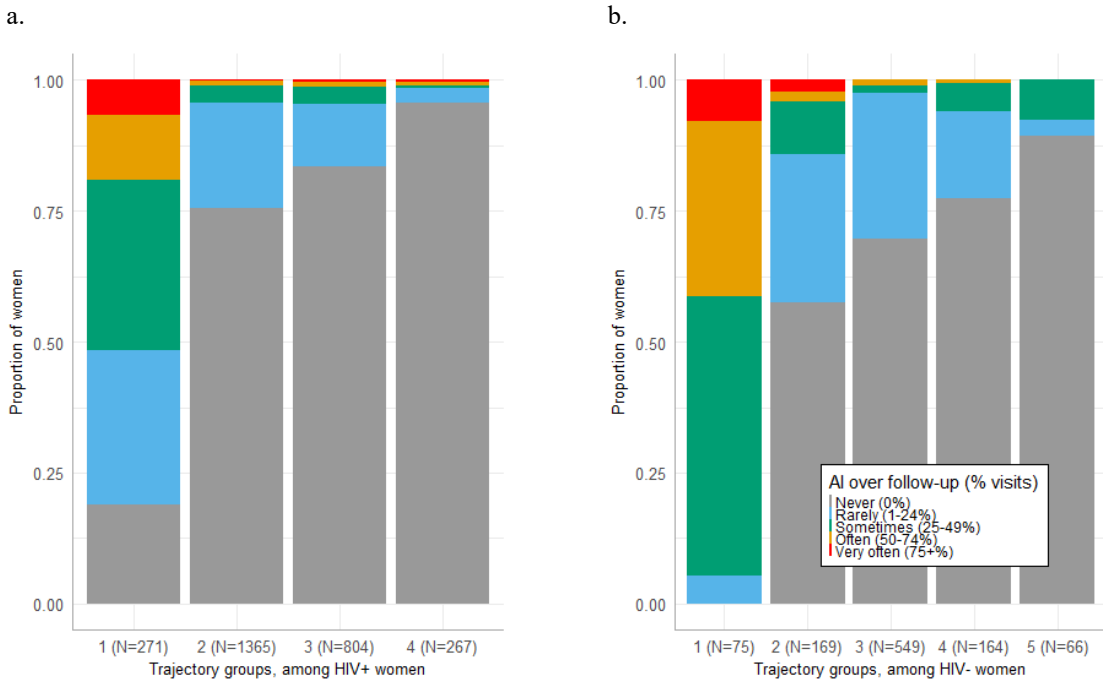


Figure 6.6. Proportion of women reporting AI very often, often, sometimes, rarely and never over follow-up, by trjectory group among a)HIV-positive women and b)HIV-negative women. The frequency categories are defined by the percentage of visits with a male sex partner at which each woman reported practising AI.

6.4.6. Description of AI practice and other sexual behaviours within trajectory groups: among HIV-negative women

Three of the groups identified among HIV-negative women (Group 3-5) reported little AI practice over follow-up, while the practice was more common among Groups 1 (*AI & VI persistors)* and 2 (*AI & VI desistors)* (Figure 6.5c). While AI practice decreased slowly with age among Group 1, AI practice among Group 2 declined sharply from 25 years. AI practice was reported during 48.5% of visits with a male partner among Group 1 members, which was substantially higher than Groups 3-5, where it ranged from 3.9% to 10.3% of visits (Table 6.6). Nearly all women (96.2%) in Group 1 reported AI during at least a quarter of visits with a male sex partner, with 40% reporting the practice during at least half of visits (Figure 6.6b). In contrast, the majority of women in the other groups who reported any AI over follow-up reported it rarely (at <24% of visits with a male sex partner).

The proportions reporting a male partner were similar in Group 1 (*AI & VI persistors)* and 3 (*VI persistors)*, at 95.6% and 93.1% of visits, respectively, but the fraction of visits at which AI was reported among Group 1 was over 10-fold that of Group 3. As with trajectory groups among HIV-positive women, the group with the smallest fraction of visits with a male sex partner (Group 5:*AI & VI inactive*) reported the largest fraction of visits with a female sex partner.

The fraction of visits with consistent condom use during AI was smallest among women in Groups 1 and 3 (at 24.8% and 21.7% of visits, respectively); during VI, the fraction was smallest among women in Groups 1 and 2 (at 15.9% and 13.8% of visits, respectively). Consistent condom use during both AI and VI was reported at a larger fraction of visits when multiple male partners were reported in all groups except Group 5 (Table 6.6).

Table 6.6. Percentage of visits in which various sexual practices since the last visit were reported, by trajectory group among HIV-positive women

B.	Group 1: *AI&VI persistors* % (95% CI)	Group 2: *AI & VI desistors* % (95% CI)	Group 3: *VI persistors* % (95% CI)	Group 4: *VI desistors* % (95% CI)	Group 5: *AI & VI inactive* % (95% CI)
All visits	N^v=1,660	N^v=4,458	N^v=10,622	N^v=4,231	N^v=2,680
AI	46.4% (43.9-48.8)	6.9% (6.2-7.7)	3.8% (3.4-4.2)	1.7% (1.3-2.1)	0.4% (0.2-0.7)
VI	93.8% (92.7-95.0)	66.5% (65.1-67.9)	92.2% (91.6-92.7)	43.2% (41.7-44.7)	8.0% (7.0-9.0)
Any male sex partner	95.6% (94.6-96.6)	68.0% (66.6-69.3)	93.2% (92.7-93.7)	44.9% (43.4-46.4)	9.3% (8.2-10.4)
Any female sex partner	7.7% (6.4-9.0)	2.5% (2.0-3.0)	3.0% (2.6-3.3)	8.2% (7.3-9.0)	39.8% (37.8-41.6)
Multiple male sex partners (2+)	40.1% (37.8-42.5)	15.5% (14.5-16.6)	21.9% (21.1-22.6)	8.1% (7.3-8.9)	2.5% (1.9-3.1)
Transactional sex	13.6% (11.9-15.2)	3.0% (2.5-3.5)	3.8% (3.4-4.2)	2.1% (1.7-2.6)	1.1% (0.7-1.5)
Visits with male sex partner(s) reported	N^v=1,587	N^v=3,030	N^v=9,896	N^v=1,898	N^v=248
AI	48.5% (46.0-51.1)	10.3% (9.2-11.4)	4.1% (3.7-4.5)	3.9% (3.0-4.8)	6.1% (2.7-9.5)
VI	98.2% (97.5-98.9)	98.5% (98.1-99.0)	99.0% (98.8-99.2)	98.1% (97.5-98.7)	94.2% (91.2-97.3)
Visits with AI practice	N^v=735	N^v=297	N^v=382	N^v=69	N^v=12
Consistent condom use during AI	24.8% (21.6-27.9)	31.3% (26.0-36.6)	21.7% (17.6-25.9)	36.2% (24.6-47.9)	16.7% (0.0-41.4)
Visits with VI practice	N^v=1,534	N^v=2,919	N^v=9,634	N^v=1,802	N^v=212
Consistent condom use during VI	15.9% (14.1-49.2)	13.8% (9.9-17.8)	23.2% (22.3-24.0)	32.0% (29.9-34.2)	32.1% (38.4-25.7)
Visits with multiple male sex partners	N^v=666	N^v=693	N^v=2,321	N^v=342	N^v=68
AI	54.7% (50.8-58.6)	19.2% (16.1-22.3)	7.1% (6.0-8.2)	7.3% (4.4-10.3)	12.5% (2.8-22.2)
VI	98.2% (97.1-99.2)	98.8% (98.0-99.6)	68.9% (98.4-99.3)	97.6% (95.9-99.2)	91.9% (85.0-98.9)
Visits with AI practice and multiple male partners	N^v=342	N^v=122	N^v=149	N^v=22	N^v=6
Consistent condom use during AI	37.7% (32.4-42.9)	36.9% (28.2-54.6)	30.2% (22.7-37.7)	50.0% (27.3-72.7)	16.7% (0.0-59.5)
Visits with VI practice and multiple male partners	N^v=644	N^v=670	N^v=2,239	N^v=321	N^v=57
Consistent condom use during VI	20.8% (17.7-240)	28.1% (24.6-31.5)	25.9% (24.1-27.8)	34.0% (28.7-39.2)	31.6% (19.1-44.0)

N^v=number of visits over follow-up, AI=anal intercourse, VI=vaginal intercourse. The recall period for all sexual behaviours was 'since the last visit', which was typically 6 months prior. The groups identified through group-based trajectory modelling are numbered in order of declining proportion of visits in which AI was reported. Consistent condom use is defined as 'always' using condoms since the last visit during AI or VI, as relevant. Group 1 consists of 75 women, Group 2 of 169, Group 3 of 549, Group 4 of 167 and Group 5 of 125

6.4.7. Baseline correlates of trajectory group membership

Univariate comparisons between trajectory group membership and demographic and structural characteristics and behaviours are shown in Table 6.7. Multivariable multinomial regression results are shown in Table 6.8. The reference group among HIV-positive and HIV-negative women were in both cases the largest trajectory group; namely *VI late desistors* (Group 2*)* and *VI persistors* (Group 3) among HIV-positive and negative, respectively)

Among HIV-positive women

Compared to the reference group, *AI desistors & VI persistors* (Group 1) were less likely to have been recruited during wave 4 in both univariate and multivariable analysis (aOR=0.57, 95%CI: 0.37-0.89) and in multivariable analysis were more likely to have been recruited during wave 2 (aOR=1.43, 95%CI: 1.09-2.03) than during wave 1, Women in Groups 3 and 4 were less likely to be recruited after wave 1 in both univariate and multivariable analysis. In an additional analysis, recruitment remained associated with group membership even when controlled for length of follow-up and study site (data not shown).

Median age at baseline was higher among *AI desistors & VI persistors* (Group 1) and *VI & AI inactive* women (Group 4) compared to the reference group in both univariate and multivariable analysis. *AI desistors & VI persistors* (Group 1) were more likely than the reference group to be Hispanic than Black in multivariable analysis only (aOR=1.42, 95%CI: 1.02-1.96). Interestingly, members of *AI & VI inactive* (Group 4) were also more likely to be Hispanic (aOR=1.42, 95%CI: 1.06-1.82) or White (aOR=1.43, 95%CI: 1.03-1.97) rather than Black, compared to the reference group. These findings imply that while Black women are less likely to report practising AI, they are also more likely to practise VI for longer over the life course. Women in *AI & VI inactive* (Group 4) had over four times the odds of identifying as lesbian or bisexual, rather than heterosexual in multivariable analysis, compared to the reference group.

Compared to the reference group, *AI desistors & VI persistors (*Group 1) were more likely to have a history of violence victimisation with higher odds of both having ever been raped and having ever being severely beaten (aOR=1.58, 95%CI: 1.04-2.41). In univariate analysis, women in Groups 1, 3 and 4 were all more likely than the reference group to report a history of injection drug use, but after multivariable adjustment, this association remained significant only for Groups 3 and 4. *AI desistors & VI persistors* (Group 1) were more likely than the reference group to report ever having practised

transactional sex (aOR=1.52, 95%CI: 1.09-2.12) and to report an above median number of lifetime male sex partners (aOR=1.71, 95%CI: 1.23-2.37) in both univariate and multivariable analysis.

Among HIV-negative women

Recruitment wave showed fewer correlations with group membership among HIV-negative compared to HIV-positive women. Even so, after multivariable adjustment members of Groups 2, 4 and 5 were less likely to have been recruited during wave 4 than during wave 1 with Group 2 also less likely to have been recruited during wave 3, compared to women in the reference group. As observed among HIV-infected women, the associations between group membership and recruitment wave remained even when additionally controlled for length of follow-up and study site (data not shown).

In univariate analysis, *AI & VI persistors* (Group 1) were more likely to be White or Other races than Black, compared to the reference group. However, after adjustment in multivariable analysis *AI & VI persistors* (Group 1) were more likely to be Hispanic than Black (aOR=1.36, 95%CI: 1.02-2.60), while White and Other races were not statistically significantly associated with Group 1 membership, despite elevated odds ratios. After multivariable adjustment *AI & VI persistors* (Group 1) had twice the odds of identifying as bisexual or lesbian and *AI & VI inactive* women (Group 5) had 12-fold the odds.

In multivariable analysis, AI & VI persistors (Group 1), as well as *AI & VI desistors* (Group 2) had around twice the odds of having ever been both raped and beaten compared to the reference group (e.g. among *AI & VI desistors*; aOR=1.88, 95%CI: 1.13-3.12). Members of Groups 1, 4 and 5 were all more likely than the reference group to report ever having injected drugs, in univariate, but not multivariable analysis. *AI & VI persistors (Group 1)* had nearly twice the odds of reporting a history of transactional sex in univariate analysis, but there was no association after multivariable adjustment. *AI & VI persistors* had twice the odds (aOR=2.08, 95%CI: 1.09-3.88) and *AI & VI inactive* had 74% lower odds (aOR=0.26, 95%CI: 0.12-0.46) of reporting above median number of lifetime male sex partners in multivariable analysis, compared to the control group.

Table 6.7. Univariate analysis of baseline characteristics associated with trajectory group membership among a) HIV-positive women and b) HIV-negative women in the WIHS cohort

A		Reference group (N=1,365)	Group 1:*AI & VI persistors* (N=271)			Group 3: *VI desistors (*N=816*)*			Group 4: *VI and AI inactive* (N=553)		
		% or median	% or median	OR	95% CI	% or median	OR	95% CI	% or median	OR	95% CI
Recruitment wave	1 (1994)	45.5%	48.3%	Ref		61.2%	Ref		59.0%	Ref	
	2 (2001-02)	23.7%	26.2%	1.04	0.75-1.43	20.3%	**0.64****	**0.51-0.80**	14.6%	**0.48*****	**0.36-0.63**
	3 (2011-12)	8.9%	9.9%	1.05	0.66-1.66	6.3%	**0.53*****	**0.38-0.75**	6.1%	**0.53****	**0.35-0.80**
	4 (2013)	21.8%	15.5%	**0.67***	**0.46-0.97**	12.1%	**0.41*****	**0.32-0.53**	20.3%	**0.72****	**0.55-0.92**
Age in years	Continuous	36.0	37.0	**1.02***	**1.01-1.04**	37.0	**1.02****	**1.01-1.03**	39.0	**1.03****	**1.02-1.05**
Race	Black	65.3%	62.4%	Ref		62.3%	Ref		58.0%	Ref	
	Hispanic	20.6%	22.1%	1.13	0.81-1.55	21.1%	1.07	0.86-1.34	24.2%	**1.32****	**1.04-1.69**
	White[1]	11.1%	13.3%	1.26	0.84-1.88	14.1%	**1.34***	**1.02-1.74**	14.8%	**1.51****	**1.12-2.03**
	Other	3.1%	2.2%	0.75	0.32-1.80	2.6%	0.88	0.51-1.50	2.9%	1.06	0.59-1.91
Sexual orientation	Heterosexual	93.1%	90.3%	Ref		90.8%	Ref		78.0%	Ref	
	Lesbian/bisexual	6.9%	9.7%	1.43	0.94-2.33	9.2%	**1.43****	**1.05-1.97**	22.0%	**3.82*****	**2.85-5.12**
Education	<High school	37.0%	32.1%			40.0%			34.5%		
	High school+	36.0%	63.0%	1.20	0.95-1.46	60.0%	0.85	0.69-1.04	65.5%	1.10	0.89-1.26
Raped/ever[3]	No	63.7%	50.2%	Ref		58.0%	Ref		58.6%	Ref	
	Yes	36.3%	49.8%	**1.48****	**1.12-1.96**	42.0%	**1.21***	**1.01-1.46**	41.3%	**1.28****	**1.02-1.59**
Severely beaten/ever[3]	No	47.8%	35.0%	Ref		43.9%	Ref		51.9%	Ref	
	Yes	52.2%	65.0%	**1.68****	**1.24-2.29**	56.1%	1.15	0.92-1.43	48.1%	0.87	0.69-1.09
Injection drug use/ever	No	80.6%	74.9%	Ref		68.4%	Ref		68.5%	Ref	
	Yes	19.4%	25.1%	**1.40***	**1.03-0.39**	31.6%	**1.93*****	**1.58-2.35**	31.4%	**1.91*****	**1.53-2.39**
Transactional sex/ever[2]	No	67.0%	50.2%	Ref		62.4%	Ref		70.1%	Ref	
	Yes	33.0%	49.8%	**2.01*****	**1.55-2.62**	37.6%	**1.22***	**1.02-1.46**	29.9%	0.86	0.70-1.07
Male sex partners/ever	<11	52.3%	33.7%	Ref		52.1%	Ref		65.0%	Ref	
	11+	47.7%	66.3%	**2.14****	**1.62-2.82**	47.9%	1.00	0.84-1.19	35.0%	**0.58*****	**0.47-0.71**

B.		Reference group	Group 1: *AI & VI persistors* N=75			Group 2: *AI & VI desistors* N=169			Group 4: *VI desistors* N=167			Group 5: *AI & VI inactive* N=125		
		% or median	% or median	OR	95% CI	% or median	OR	95% CI	% or median	OR	95% CI	% or median	OR	95% CI
Recruitment wave	1 (1994)	33.7%	34.7%	Ref		46.7%	Ref		55.7%	Ref		49.6%	Ref	
	2 (2001-02)	33.7%	42.7%	1.23	0.71-2.15	30.2%	**0.65***	**0.43-0.97**	30.5%	**0.55****	**0.37-0.82**	28.0%	**0.56***	**0.36-0.90**
	3 (2011-12)	7.1%	8.0%	1.09	0.42-2.84	6.5%	0.66	0.32-1.32	7.2%	0.61	0.31-1.22	10.4%	1.00	0.50-1.98
	4 (2013)	25.5%	14.7%	0.56	0.27-1.17	16.6%	**0.47****	**0.29-0.76**	6.6%	**0.16*****	**0.08-0.30**	12.0%	**0.32****	**0.17-0.59**
Demographic and structural variables														
Age in years	Continuous	33.0	33.0	0.99	0.97-1.02	38.0	**1.04****	**1.02-1.05**	35.0	1.01	0.99-1.03	37.0	1.03	1.01-1.05
Race	Black	67.4%	53.3%	Ref		64.5%	Ref		60.5%	Ref		54.8%	Ref	
	Hispanic	20.8%	22.7%	1.38	0.75-2.53	20.7%	1.04	0.67-1.61	22.2%	1.19	0.77-1.83	21.6%	1.23	0.76-2.01
	White[1]	8.7%	16.0%	**2.31***	**1.13-4.71**	10.0%	1.20	0.66-2.18	14.4%	**1.83***	**1.07-3.13**	16.8%	**2.28***	**1.29-4.04**
	Other	3.1%	8.0%	**3.26***	**1.22-8.75**	4.7%	1.60	0.67-3.80	3.0%	1.08	0.39-2.99	4.8%	1.84	0.70-4.82
Sexual orientation	Heterosexual	90.1%	76.7%	Ref		86.8%	Ref		84.2%	Ref		50.8%	Ref	
	Lesbian/ bisexual	9.9%	23.3%	**2.69****	**1.47-4.93**	13.2%	1.32	0.78-2.24	15.8%	**1.66***	**1.00-2.74**	49.2%	**8.92*****	**5.69-13.97**
Education	<High school	34.6%	27.0%	Ref		34.3%			28.1%			33.6%		
	High school+	65.4%	73.0%	1.32	0.84-1.29	65.7%	1.01	0.69-1.42	71.9%	1.26	0.91-1.57	66.4%	1.04	0.73-1.41
Raped/ever[3]	No	65.0%	42.2%	Ref		56.5%	Ref		67.7%	Ref		52.2%	Ref	
	Yes	32.3%	57.8%	**2.40****	**1.26-4.55**	43.5%	1.32	0.83-2.07	32.3%	0.93	0.60-1.44	47.8%	**1.76****	**1.16-2.69**
Severely beaten/ever[3]	No	49.5%	35.3%	Ref		31.9%	Ref		45.7%	Ref		46.2%	Ref	
	Yes	50.5%	64.7%	**1.94***	**1.06-3.53**	68.1%	**2.18****	**1.45-3.25**	54.3%	1.18	0.79-1.74	53.8%	1.23	0.77-1.95
Behavioural variables														
Injection drug use/ever	No	85.1%	76.0%	Ref		79.3%	Ref		73.1%	Ref		65.6%	Ref	
	Yes	14.9%	24.0%	**1.80***	**1.01-32.1**	20.7%	1.49	0.96-2.31	26.9%	**2.10*****	**1.39-3.18**	34.4%	**2.99*****	**1.93-4.62**
Transactional sex/ever[2]	No	66.4%	53.3%	Ref		59.2%	Ref		69.1%	Ref		65.6%	Ref	
	Yes	30.9%	46.7%	**1.73***	**1.07-2.82**	40.8%	1.37	0.96-1.95	30.9%	0.90	0.62-1.31	34.4%	1.04	0.69-1.57
Male sex partners/ever	<11	46.2%	24.0%	Ref		44.0%	Ref		52.8%	Ref		62.9%	Ref	
	11+	53.8%	76.0%	**2.71*****	**1.55-4.72**	56.0%	1.09	0.77-1.55	47.2%	0.77	0.54-1.09	37.1%	**0.50****	**0.33-0.75**

OR=odds ratio, 95% CI= 95% confidence interval, Ref=referent NA=missing data. *p-value<0.05, **p-value<0.01, ***<p-value<0.001. Missing values were imputed. The largest trajectory group was used as the reference group: for HIV-positive women this was *VI late desistors (Group 2)*, and for HIV-negative women *VI persistors* (Group 3*)*. Trajectory groups are numbered in descending order of the proportion of visits during which AI practice was reported. [1]Non-hispanic white. [2]Ever exchanged sex for drugs or money. 3Violence victimisation questions have many missing values as ethical approval was not granted at the LA and San Francisco study sites. Among HIV-positive women, the variables recruitment wave, age and race had no missing values, sexual orientation had 33, education status had 3, ever raped had 810, ever beaten had 801, injection drug use ever had 1, transactional sex ever had 9 and lifetime number of male sex partners had 61. Among HIV-negative women, the variables recruitment wave, age, race and injection drug use ever had no missing values, sexual orientation had 17, education status had 3, ever raped had 255, ever beaten had 251, transactional sex ever had 3 and lifetime number of male sex partners had 10.

Table 6.8. Baseline characteristics associated with trajectory group membership among A) HIV-positive women and B) HIV-negative women (multivariable generalised estimating equations clustered by study site

A		Group 1*: AI desistors, VI persistors* (N=271)		Group 3: *VI desistors* (N=816)		Group 4: *AI & VI inactive*(N=553)	
		aOR	95% CI	aOR	95% CI	aOR	95% CI
Recruitment wave	1 (1994)	Ref.		Ref.		Ref.	
	2 (2001-02)	**1.43***	**1.09-2.03**	**0.75***	**0.59-0.96**	**0.55****	**0.41-0.85**
	3 (2011-12)	0.88	0.52-1.42	**0.47*****	**0.32-0.68**	**0.48****	**0.31-0.74**
	4 (2013)	**0.57***	**0.37-0.89**	**0.36*****	**0.27-0.49**	**0.68***	**0.49-0.93**
Demographic and structural variables							
Age in years	Continuous	**1.02***	**1.01-1.05**	1.01	0.99-1.02	**1.04*****	**1.03-1.06**
Race/ethnicity	Black	Ref.		Ref.		Ref.	
	Hispanic	**1.42***	**1.02-1.96**	0.95	0.75-1.21	**1.42***	**1.06-1.82**
	White	1.16	0.77-1.76	1.16	0.88-1.53	**1.43***	**1.03-1.97**
	Other	0.68	0.28-1.65	0.88	0.51-1.52	1.22	0.65-2.26
Sexual orientation	Heterosexual	Ref.		Ref.		Ref.	
	Lesbian/ bisexual	1.15	0.75-1.92	1.18	0.85-1.65	**4.31*****	**3.17-5.93**
Education	<High school	Ref.		Ref.		Ref	
	High school+	1.32	0.98-1.76	0.88	0.73-1.07	1.15	0.92-1.44
Violence victimisation/ever[1]	No	Ref.		Ref.		Ref.	
	Either raped or severely beaten	1.40	0.93-2.11	0.82	0.63-1.07	0.71	0.53-0.94
	Both raped and severely beaten	**1.58***	**1.04-2.41**	1.05	0.78-1.43	0.92	0.64-1.32
Behavioural variables							
Injection drug use/ever	No	Ref.		Ref.		Ref.	
	Yes	0.79	0.54-1.13	**1.32***	**1.03-1.68**	**1.34***	**1.01-1.79**
Transactional sex/ever	No	Ref.		Ref.		Ref.	
	Yes	**1.52***	**1.09-2.12**	1.02	0.80-1.28	0.79	0.60-1.05
Number of male sex partners/ever	<11	Ref.		Ref.		Ref.	
	11+	**1.71****	**1.23-2.37**	0.85	0.69-1.05	**0.49*****	**0.37-0.63**

aOR=adjusted odds ratio, 95$ CI= 95% confidence interval, Ref=referent *p-value<0.05, **p-value<0.01, ***<p-value<0.001. The largest trajectory group was used as the reference group: for HIV-positive women this was Group 2:*VI late desistors* and for negative women Group 3:*VI persistors*. [1]Ever having been raped and ever having been severely beaten were highly correlated with one another among both HIV-positive and -negative women. The two variables were therefore combined into one in order to reduce multicollinearity in the models. For all other details see Table 7 footnotes.

B		Group 1: *AI & VI persistors* (N=75)		Group 2 *AI & VI desistors* (N=169)		Group 4: *VI desistors* (N=167)		Group 5: *AI & VI inactive* (N=125)	
		aOR	95% CI	aOR	95% CI	aOR	95% CI	aOR	95% CI
Recruitment wave	1(1994)	Ref		Ref		Ref		Ref	
	2 (2001-02)	1.35	0.72-2.85	0.88	0.56-1.38	0.67	0.46-1.33	0.67	0.43-1.71
	3 (2011-12)	0.97	0.37-3.53	**0.27****	**0.12-0.63**	0.41	0.21-1.08	0.72	0.45-3.05
	4 (2013)	0.76	0.19-1.22	**0.25*****	**0.13-0.44**	**0.41*****	**0.19-0.29**	**0.46***	**0.12-0.96**
Demographic and structural variables									
Age in years	Continuous	1.00	0.96-1.03	**1.07*****	**1.04-1.10**	**1.04****	**1.01-1.06**	**1.02***	**1.01-1.05**
Race	Black	Ref		Ref		Ref		Ref	
	Hispanic	**1.36***	**1.02-2.60**	1.04	0.62-1.96	0.98	0.62-1.57	0.89	0.45-1.92
	White	1.51	0.77-4.67	1.08	0.61-2.05	**1.68***	**0.92-4.30**	**2.39***	**1.20-4.76**
	Other	2.29	0.55-6.45	1.38	0.57-3.39	0.91	0.35-2.55	1.44	0.27-3.71
Sexual orientation	Heterosexual	Ref		Ref		Ref		Ref	
	Lesbian/ bisexual	**1.98***	**1.01-3.86**	1.47	0.83-2.59	1.94	1.12-3.37	**12.5*****	**7.43-26.37**
Education	<High school	Ref		Ref		Ref		Ref	
	High school+	1.35	0.76-2.40	1.01	0.67-1.49	1.43	0.95-2.15	1.12	0.70-1.80
Violence victimisation/ ever[1]	None	Ref		Ref		Ref		Ref	
	Either raped or beaten	1.34	0.85-2.82	1.08	0.64-1.84	1.86	0.69-2.04	1.31	0.75-2.27
	Both raped and beaten	**2.22***	**1.09-4.81**	**1.88***	**1.13-3.12**	0.91	0.51-1.63	1.28	0.70-2.37
Behavioural variables									
Injection drug use/ever	No	Ref		Ref		Ref		Ref	
	Yes	1.02	0.51-2.01	0.81	0.55-1.74	1.26	0.78-2.05	1.25	0.72-2.19
Transactional sex/ever	No	Ref		Ref		Ref		Ref	
	Yes	1.05	0.56-1.93	1.09	0.65-1.77	1.03	0.40-1.24	0.95	0.54-1.67
Male sex partners/ ever	<11	Ref		Ref		Ref		Ref	
	11+	**2.08***	**1.09-3.88**	0.87	0.57-1.32	0.68	0.45-1.05	**0.26*****	**0.12-0.46**

6.5. DISCUSSION

This analysis offers the first longitudinal examination of heterosexual AI practice. AI practice was fairly common in the WIHS sample, with 23.2% and 32.9% of HIV-positive and HIV-negative reporting it at least once over follow-up. While both AI and VI practice decrease with age, the decrease in AI practice occurs earlier. AI is practiced intermittently by most women who report the practice over follow-up, with two-thirds (of both HIV-positive and -negative women) reporting the practice at fewer than a quarter of follow-up visits.

The proportion of women who report never consistently using condoms during AI is twofold that during VI. At visits when AI is reported, the proportion of women never using condoms during VI is threefold that never using condoms during VI at all visits when VI is reported. AI practice was twice as common at visits when multiple male partners were reported. Taken together, these findings point to AI practice often being accompanied by other higher risk behaviours.

Among HIV-positive women, GBTM identified a group comprising of 9% of the sample who reported AI at a quarter of visits with male partner (AI desistors and VI persistors), while other groups reported AI at less than 5% of visits with male partners. Among HIV-negative women, one group comprising of 7% of the sample (AI and VI persistors) reported AI practice at nearly half of visits with male sex partners, and a second group comprising of 15% of the sample reported AI practice at a tenth of visits with male partners (AI and VI desistors). In contrast, the other groups identified reported AI at less than 5% of visits with male partners.

Women in the groups which practised AI most commonly over follow-up (*AI desistors and VI persistors* and *AI and VI persistors,* among HIV-positive and -negative, respectively) also reported more commonly having any male sex partners, having multiple male sex partners, and reporting condom use less consistently during both AI and VI compared to other groups. Members of these two groups (*AI desistors and VI persistors* and *AI and VI persistors*) were more likely to be Hispanic, to identify as bisexual or lesbian (among HIV-negative women only), more likely to have ever been both raped and severely beaten, to have ever practiced transactional sex (among HIV-positive women only) and more likely to report a greater number of male sex partners ever, compared to the largest trajectory group. These associations with longitudinal AI practice are similar to associations with AI practice identified in cross-sectional studies. Namely that AI is more common among Hispanic women compared to Black

women Hispanic (22–27), and White women compared to Black women (6,28,29), and among women who have sex with both men and women (6,24,30,31), are victims of sexual (22,32–37) and physical violence (32,38–40) and women who report transactional sex (6,22,27,28,41,42) and multiple male sex partners (6,9,42,43). Many cross-sectional studies have also identified higher AI prevalence among women who inject drugs (48,52,82), so it is surprising that in multivariable regression, members of the AI practicing trajectory groups were not found more likely to have ever injected drugs. This may be due to the inclusion of transactional sex in the model, which in turn is very closely correlated with having a history of injection drug use in this sample (data not shown).

On average, AI was reported at 7% of visits at which a male sex partner was reported by HIV-positive women and at 10% of visits by HIV-negative women. This is less common than reported among NHBS-HET, a survey sampling a similar population of sexually active women living in 20 U.S. cities with high HIV prevalence, which found that 30% reported practising AI in the past year (6). The NHBS-HET sample displayed higher risk behaviour overall, however, with a third reporting transactional sex in the past year, whereas transactional sex is reported at 5% of visits over follow-up in the WIHS cohort. AI practice was also more common, however, in a nationally representative survey, which found that 11% of women reported AI in the past year (which included women with no male sex partner), although respondents did not display higher risk behaviours overall compared to WIHS participants. That both these studies employed confidential interview methods, while WIHS used face-to-face interview, may have contributed to the higher AI prevalence found.

Cross-sectional studies among U.S. women have found conflicting patterns of recent AI practice with age, with one finding that it decreases (8), another that it remains constant (9) and another that it increases (6) with age. This longitudinal analysis, however, identified a very clear decrease in AI practice with age among both HIV-positive and HIV-negative women, even among women with male sex partners.

The analysis has a number of limitations. While the analysis design allowed for the identification and description of distinct longitudinal patterns of AI and VI practice, it did not allow for the examination of the clustering off other risk behaviours and exposures concurrent with AI practice, and this analysis is therefore unable to clarify how AI may cluster with other risk activities over the life course. The only data available on male partners in the WHIS dataset is the number of sex partners since the last visit. This provides no insight into the perspective of male partners and limits this analysis.

The reason why recruitment wave remained a significant correlate of membership of most trajectory groups among both HIV-positive and HIV-negative women, even when additionally controlling for length of follow-up and study site is not well understood as it is difficult to disentangle age-period-cohort effects. It is possible that the slight variations in eligibility criteria from wave to wave or changes in interviewer techniques over time played a role. The use of face-to-face interviews to collect all data, including data on sexual behaviour, is likely to have affected the accuracy of reporting, particularly of AI practice, given that it is stigmatised. The description of AI over the life course would have been more complete if data on the number of sex acts, as well as data on AI and VI practice by partner type had been collected. As participants were recruited using convenience sampling it is not representative of the overall U.S. female population. It is therefore difficult to ascertain the population-level impact of AI practice on HIV epidemics. Given the small number of HIV-negative women who sero-converted over follow-up, I was unable to examine how AI practice affected subsequent HIV infection.

This analysis has a number of strengths. It is the first description of longitudinal heterosexual AI practice; describing AI practice over 20 years of follow-up among a large and well-understood cohort of HIV-positive and HIV-negative women. Not only was AI practice described over the whole sample, by HIV status, but sub-groups with distinct trajectories of AI practice were identified and described. As such, AI practice over the life course is now much better understood.

These findings have public health implications, as the trajectory group of HIV-negative women who practise AI throughout their life course may benefit greatly from access to PrEP. As well as being identifiable through their reported AI practice, U.S. women with similar patterns of AI practice to this trajectory group may also be characterised by their exposure to physical and sexual violence, reporting a high number of male partners, identifying as lesbian or bisexual and being Hispanic. This characterisation may aid in better targeting of PrEP to U.S. women at risk of HIV through heterosexual sex. AI practice was reported by some women in all trajectory groups, but in contrast to the more consistent AI practice in the two groups (HIV-positive and HIV-negative) with the most AI practice, the practice in other groups tended to be intermittent. The sporadic nature of AI practice among many women may imply that its practice is often unplanned. In this case, PrEP is unlikely to be the most suitable intervention. A more suitable approach to avoiding HIV transmission during these sporadic periods of AI practice may be to try to increase condom use during AI through widespread public health messaging; emphasising the importance of condom use during AI, as well as VI.

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Chapter 7

Predictors of anal intercourse over the life course among U.S. women in the WIHS cohort

7.1. RATIONNALE

This chapter uses data from the WIHS cohort study to identify time-varying predictors of AI and UAI practice over a 20-year period of follow-up. The group-based trajectory modelling in Chapter 6 identified demographic characteristics and lifetime behaviours and exposures which predict to some extent distinct trajectories of AI practice over the life course. This analysis did not, however, address the role of recent exposures and behaviours in shaping AI practice in the short-term. While we have a fair understanding from cross-sectional studies of current behaviours and exposures which accompany AI practice among women, results from cross-sectional studies are limited by the lack of clear temporal ordering between exposure and outcome. Estimating the effect of different covariates on AI practice could be used for targeting public health messaging by identifying women most likely to practise AI in the near future.

7.2. BACKGROUND

Numerous cross-sectional studies have identified correlates of AI practice among women in the U.S. Overall, these results suggest AI is less common among African-American women compared to Hispanic (1–6) or white women (7–9). Although the analysis in Chapter 6 showed AI practice to clearly decrease with age among the WIHS sample, the effect of age on AI practice has not been clear in other, cross-sectional, studies. Some studies found the practice more common among young U.S. women while others found that it is less common (7,10). U.S. women who report AI also tend to report other higher risk behaviour, including multiple sexual partners (7,11–13), group sex (1), lower age at first sex (3,13,14), transactional sex (1,6–8,11,15), lower condom use (10,16,17) and sex with both men and women (3,7,18,19). Substance use is also frequently found to be positively associated with AI practice, with various studies finding AI to be more common among U.S. women using any type of illegal drugs (8,13), those using cocaine (20), ecstasy or methamphetamine (1,5), and crack (10). Women who report binge drinking (6,7,21), or drinking alcohol before, during or after sex (5), are more likely to report practicing AI. Violence victimisation has been repeatedly shown to be associated with AI, with women reporting AI more likely to have been sexually abused as children (1,22–24), to report rape or coerced sex (25–27), and to have experienced physical intimate partner violence (20,25,28,29). Condom use during AI has also been found to be less common in partnerships in which women are victims of physical violence (25) and when either partner is under the influence of drugs during sex (30). Poor mental health has been found to be associated with AI, with the practice more common among depressed women (20,31). Several similar associations were found in the analysis of WIHS data in Chapter 6, with women in trajectory groups with the most AI practice more likely to be Hispanic, to identify as

bisexual or lesbian, to report more lifetime male sex partners, to report ever having practised transactional sex and to have ever been the victims of sexual and physical violence.

Although these associations suggest a profile of higher risk behaviours and exposures among women who practise AI, other studies have found that lifetime experience of AI increased with income (9,13,15,32) and with higher levels of education (9,13,15). In contrast, no relationship between income and education was found with recent AI (within the past year) (13,32). This discrepancy suggests that women with higher socioeconomic status may be more likely to experiment with AI, but not to practise on a regular basis, resulting in higher lifetime prevalence, but not higher recent prevalence. Indeed, many studies suggest that recent AI appears to be more common among women in more economically precarious situations, including those currently or recently homeless (7,25,33) and food insecure (34).

The primary aim of this chapter is to identify time-varying predictors of AI and UAI practice over follow-up among the whole sample, by HIV status. A further aim is to identify predictors of first AI practice during follow-up among those who reported never having practised AI at baseline. Additionally, I aim to identify predictors of AI practice within each trajectory group identified through the group-based trajectory modelling conducted in Chapter 6.

7.3. METHODS

7.3.1. Study participants

The WIHS cohort study is described in Chapter 6. Briefly, WIHS is a large, ongoing cohort study including both HIV-positive and HIV-negative women from multiple study sites in the U.S. The current analysis uses the same inclusion criteria applied for analyses in Chapter 6; namely both HIV-positive and -negative women, with available data from both and at least three 6-monthly follow-up visits were included in the regression models.

7.3.2. Data analysis

In order to determine behavioural and structural predictors of AI and UAI practice over follow-up, univariate and multivariable logistic regression models using generalised estimating equations (GEE) were fitted. As observations were not independent, the standard errors were clustered at the participant level. Visits with and without AI practice (or UAI, as relevant) were compared using predictors

measured during the prior visit. The logistic models were run across the whole sample (for HIV-positive and -negative women separately). Reporting any AI practice and any UAI practice since the last visits were the two outcomes of interest. Any UAI was defined as both reporting AI and reporting that condoms were used 'sometimes' or 'never' since the last visit, rather than 'always'.

Using the conceptual framework developed in Chapter 2, time-varying behavioural and structural covariates of interest available in the WIHS dataset were identified and selected *a priori* (Appendix, Figure A7.1). These time-varying covariates were measured over follow-up and are behaviours and exposures reported since the last study visit. Structural and demographic covariates of interest were current marital status (married or living with partner, yes versus no), employment (yes versus no) and housing status (living in own or other person's house versus homeless/living in temporary accommodation), current annual household income (<$12,000 versus $12,000+) and physical (severely beaten, yes versus no) and sexual (raped, yes versus no) violence victimisation. Behavioural covariates of interest were alcohol use (<8 versus 8+ drinks per week, as 8 or more drinks per week among women is considered to be problematic drinking (35)), illicit drug use (measured as any injection drug use (yes versus no) and any crack, cocaine or heroin use (yes versus no), the number of male and female sexual partners (both dichotomised at the median), vaginal intercourse unprotected by condoms (reporting never or sometimes versus always using condoms) and practising transactional sex (yes versus no) since the last visit. "Likely depression" was a psychosocial covariate of interest (scores 16+ on the Center for Epidemiologic Studies Depression Scale (36) versus scores <16). Although not a direct measure of gendered relationship power, feeling afraid of partner (yes versus no) was used as a proxy measure of this dyadic factor. Models were additionally controlled for age (as a continuous variable), educational level (high school or higher versus less than high school, measured at baseline) and race (Black versus Hispanic, non-Hispanic White, and Other, measured at baseline).

Some covariates of interest were dropped due to concerns over multicollinearity. Multicollinearity was assessed using the Variance Inflation Factor (37). When multicollinearity was detected, covariate choice was in this case based on Akaike information criteria (AIC) values to measure model fit, or if missing values varied substantially between multicollinear covariates, the covariate with the fewest missing values was retained. Household income, housing status and employment status were multicollinear, with household income retained based on AIC measures. Injection drug use and crack, cocaine or heroin since last visit were correlated, with crack, cocaine or heroin since last visit retained based on number of missing values. As having been raped and having been severely beaten since the last visits were highly correlated, these were combined into one variable.

All analyses were conducted using the R statistical package (38), with the "*geepack*" package used (39) for GEE regression models.

Handling missing data

Data on violence (raped since last visit, beaten since last visit, and feeling afraid of current partner) were missing from nearly half of visits (48%) because ethical approval for gathering these three variables was not granted for the Los Angeles site (comprising of 14.3% of total study participants), and was first granted for the San Francisco site (comprising of 13.9% of total study participants) in 2006. At all other sites between study visits 10 and 38 (1999-2013), violence data were gathered at only every other visit, while all other covariates of interest used in this analysis were gathered at every visit. Given the magnitude of missing values, having been raped or beaten since the last visit, and feeling afraid of current partner were excluded from the main analyses. Other covariates of interest had far fewer missing values, so a complete case analysis was conducted. However, in order to explore the potentially important role of violence in predicting AI practice in this population, a supplementary analysis was conducted by entering these covariates on violence into the same models as used for the main analysis, using complete case analysis.

Handling missing follow-up visits

AI practice, as well as all behavioural covariates of interest are measured 'since the last visit', rather than over a definite recall period. In order to assess whether skipping visits and therefore lengthening the recall period affected AI prevalence, the proportion of visits during which AI was reported over the whole sample was compared when the previous visit was a) six months, b) 12 months, or c) more than 12 months previous. To determine whether missed visits affected the regression models and therefore which visits could reasonably be included in analysis, the models for Aim 2a were run i) including all visits; ii) including all visits except those for which the last visit was more than 12 months ago; and iii) for visits where the last visit was six months ago, and results compared.

Supplementary analysis 1: Exploring violence

As described in the *Handling missing data* section, the covariates on violence were entered into the main models for predicting AI and UAI practice in a supplementary analysis. As these variables contain a large number of missing values, the number of visits included in this analysis compared was greatly decreased compared to the main analysis.

Supplementary analysis 2: ART and AI/UAI practice

Taking antiretroviral therapy (ART) was not included in the conceptual framework on heterosexual AI practice, partly as no other studies have examined the association of heterosexual AI practice and taking ART and it is unclear whether taking ART might reasonably be expected to affect AI practice. Taking ART was therefore not included in the main analysis on predictors of AI among HIV-infected women. As it is important, however, to understand whether AI practice is more or less likely when taking ART, it was included in a supplementary analysis. HIV-positive women were asked throughout follow-up whether they had taken ART since the last visit, and a blood sample was tested to measure viral load. Taking ART was categorised as 1) reporting taking ART and having an undetectable viral load or a viral load of less than 50/ml, 2) reporting taking ART and having a viral load of 50+/ml or more, and 3) reporting not taking ART. Associations with taking ART and practicing AI at the next visit were examined in univariate and multivariable analysis; multivariable models included all variables included in the main analysis, with the additional of ART.

Supplementary analysis 3: AI initiation

Within the sub-sample of women who report never having had AI at baseline but report AI at least once during follow-up, univariate and multivariable logistic regression models clustered by person using generalised estimating equations (GEE) were used to determine behavioural and structural predictors of first AI practice, using the same covariates of interest as defined above. Visits in which first AI practice was recorded were compared to the participants' visits preceding first AI.

Supplementary analysis 4: Predictors of AI practice within trajectory groups

In order to further characterise groups identified in Chapter 6, models for identifying predictors of AI and UAI over follow-up were run within each trajectory group, using the same covariates as included in the main model.

7.4. RESULTS

7.4.1. Study participants and study visits

As the inclusion criteria are the same as applied in Chapter 6, the participant characteristics are nearly identical to those displayed in Table 6.2. The small differences are a result of applying criteria to the length of time between visits. Most follow-up visits (93.1%) were six months apart, with 5.0% of visits occurring after one skipped visit (i.e. visits 12 months apart), and only 1.9% occurring after more than one skipped visit. The proportion of visits during which AI practice was reported did not differ when

the last visit was six months and 12 months previous (AI reported at 4.9% and 4.8% of visits, respectively), but did increase substantially when the last visit was longer than 12 months previous (AI reported at 6.6% of visits). The main model to identify predictors of AI over follow-up did not change when visits at which the last visit occurred 12 months previous were included, other than a slight narrowing of confidence intervals for some covariates. Therefore, visits at which one previous visit was skipped, but not more, were included.

Using complete case analysis retained 86.2% of visits among HIV-positive women and 86.7% among HIV-negative women in the main models (i.e. not including violence covariates). However, the number of participants lost was minimal, with 0.3% (n=10) and 0.4% (n=4) of HIV-positive and -negative women excluded from analysis. In total, 2,995 HIV-positive and 1,081 HIV-negative women were included in the main analysis.

7.4.2. Predictors of AI and UAI practice over follow-up

Tables 7.1. and 7.2. show results of models of predictors of AI practice and UAI practice, respectively, over follow-up among HIV-positive and -negative women. AI practice decreased significantly with years of age among both HIV-positive and -negative women (e.g. adjusted odds ratio (aOR)=0.95 per one-year increase in age; 95% confidence interval (95% CI): 0.94-0.96 among HIV-positive women). White and Hispanic HIV-positive women were around 1.5 times more likely to report AI practice relative to Black women, as were Hispanic women among HIV-negative women. Although not significant in univariate analysis, after multivariable adjustment, AI practice was significantly more likely among both HIV-positive and -negative women who had finished high school (e.g. aOR=1.35; 95% CI: 1.08-1.70 among HIV-positive women). After adjustment, HIV-negative, but not -positive women with higher income had slightly elevated odds of reporting AI practice at the subsequent visits (aOR=1.32; 95% CI: 1.03-1.69).

Several time-varying behavioural determinants were found to significantly predict AI practice. In multivariable analysis, HIV-positive, but not -negative women, who reported heavy drinking had nearly 1.5 times the odds of reporting AI. While recently (since the last visit) having taken crack, cocaine or heroin increased the odds of AI practice in both univariate and multivariable analysis among HIV-positive and negative women (e.g. aOR=1.58; 95% CI: 1.15-2.16 among HIV-negative women). Recent transactional sex was a strong predictor of AI practice regardless of HIV status (e.g. odds ratio (OR)=4.20; 95% CI: 3.04-5.81 among HIV-positive women) but after multivariable adjustment, this associations only remained among HIV-negative women (aOR=1.61; 95% CI: 1.02-2.55). Reporting

multiple recent male sex partners strongly predicted AI practice in both univariate and multivariable analysis in both groups (e.g. aOR=2.20; 95% CI: 1.71-2.84 among HIV-negative women), as did reporting recent UVI (e.g. aOR=2.64; 95% CI: 2.24-3.11 among HIV-positive women). Scoring positive for likely depression significantly predicted AI practice in univariate analysis in both groups, but after multivariable adjustment, this slightly elevated odds of AI practice among HIV-negative women only (aOR=1.29, 95% CI: 1.02-1.63).

The differences seen in some predictors of AI practice among HIV-positive and -negative women may partly be explained by the differing associations that having multiple male sex partners has among each group. At visits when multiple male sex partners are reported, a higher proportion of HIV-positive women have a low annual household income, report heavy drinking and transactional sex and test positive for likely depression, compared to HIV-negative women (data not shown).

Predictors of UAI practice were similar to predictors of AI, although being White compared to Black was not associated with UAI practice among HIV-positive women, implying that condoms are used more consistently during AI among White women. Having finished high school did not predict UAI among HIV-negative women, while it did predict AI practice. The most prominent change among the demographic determinants examined was that being married or living with a partner slightly elevated the odds of UAI practice (e.g. aOR=1.35; 95% CI: 1.04-1.77 among HIV-negative women).

While reporting recent transactional sex significantly predicted AI practice among HIV-negative women, it did not predict UAI practice. Although likely depression did not predict AI practice among HIV-positive women, it did slightly increase odds of UAI practice in this group (aOR=1.27; 95% CI: 1.03-1.58).

Table 7.1. Predictors of AI practice over follow-up among women in the WIHS cohort, by HIV-status

		HIV-POSITIVE WOMEN N=2,995, Total visits=49,793					HIV-NEGATIVE WOMEN N=1,081, Total visits=19,129				
		% AI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI	% AI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI
Demographic determinants											
Age	Years, continuous	NA	**0.94*** **	**0.93-0.95**	**0.95*** **	**0.94-0.96**	NA	**0.95*** **	**0.93-0.96**	**0.96*** **	**0.95-0.97**
Race	Black	3.8%	Ref		Ref		5.7%	Ref		Ref	
	Hispanic	5.1%	**1.33***	**1.02-1.72**	**1.62*** **	**1.25-2.11**	7.2%	1.31	0.91-1.89	**1.41***	**1.04-2.06**
	White	5.6%	**1.45***	**1.03-2.05**	**1.63** **	**1.16-2.29**	8.2%	1.54	0.91-2.61	1.32	0.81-2.14
	Other	3.7%	1.04	0.59-1.89	1.05	0.62-1.80	11.0%	**2.04***	**1.03-4.04**	1.69	0.98-2.92
Education	<High school	4.0%	Ref		Ref		5.3%	Ref		Ref	
	High school+	4.6%	1.21	0.96-1.51	**1.35** **	**1.08-1.70**	7.1%	1.37	0.96-1.94	**1.44***	**1.02-2.05**
Married or living with a partner	No	4.3%	Ref		Ref		6.8%	Ref		Ref	
	Yes	4.6%	1.09	0.92-1.3	0.91	0.77-1.08	6.3%	0.91	0.70-1.18	0.92	0.72-1.17
Household annual income	<$12,000	4.2%	Ref		Ref		5.9%	Ref		Ref	
	12,000+	4.5%	1.07	0.91-1.27	1.05	0.89-1.25	7.3%	**1.32***	**1.03-1.69**	**1.32***	**1.03-1.69**
Behavioural determinants											
Alcohol use[2]	<8 drinks/week	4.0 %	Ref		Ref		6.2%	Ref		Ref	
	8+ drinks/week	7.9 %	**2.08*** **	**1.65-2.61**	**1.46*** **	**1.17-1.83**	8.3%	1.31	0.96-1.78	0.96	0.71-1.31
Crack, cocaine or heroin	No	4.0%	Ref		Ref		5.8%	Ref		Ref	
	Yes	7.8%	**2.10*** **	**1.67-2.64**	**1.39** **	**1.08-1.77**	10.6%	**1.86*** **	**1.36-2.55**	**1.58** **	**1.15-2.16**
Transactional sex[3]	No	4.2%	Ref		Ref		6.0%	Ref		Ref	
	Yes	15.3%	**4.20*** **	**3.04-5.81**	0.96	0.66-1.38	20.8%	**3.95*** **	**2.54-6.15**	**1.61***	**1.02-2.55**
Number of male sex partners	0-1	3.5%	Ref		Ref		4.6%	Ref		Ref	
	2+	14.6%	**4.96*** **	**4.19-5.87**	**3.03*** **	**2.52-3.64**	15.5%	**3.69*** **	**2.91-4.68**	**2.20*** **	**1.71-2.84**
Number of female sex partners	0	4.4%	Ref				5.6%	Ref		Ref	
	1+	4.0%	0.94	0.69-1.3	0.84	0.63-1.13	6.0%	1.15	0.78-1.69	1.07	0.75-1.54
Any UVI[4]	No	2.7%	Ref		Ref		3.1%	Ref		Ref	
	Yes	9.3%	**3.52*** **	**3.00-4.14**	**2.64*** **	**2.24-3.11**	9.5%	**3.09*** **	**2.41-3.97**	**2.36*** **	**1.85-3.01**

		HIV-POSITIVE WOMEN N=2,995, Total visits=49,793					HIV-NEGATIVE WOMEN N=1,081, Total visits=19,129				
		% AI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI	% AI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI
Psycho-social determinants											
Likely depression[5]	No	3.9%	Ref		Ref		5.9%	Ref		Ref	
	Yes	5.0%	**1.26****	**1.07-1.5**	1.07	0.91-1.25	7.5%	**1.29***	**1.03-1.61**	**1.29***	**1.02-1.63**

OR=odds ratio, aOR=adjusted odds ratio, 95% CI= 95% confidence interval, Ref=referent. *p-value<0.05, **p-value<0.01, ***<p-value<0.001. All variables were collected over follow-up and measured since the last visit except race and education level, which were measured at baseline. Results in bold indicate that the 95%CI does not include the null value.

Visits for which AI practice data were available and for which the prior visit was no longer than 12 months ago (i.e. maximum one visit skipped), and for which all included co-variates were available, were included in analysis. Among HIV-positive women, 86.2% of visits were retained after applying these criteria; among HIV-negative women 86.7% visits were retained.

[1]Percentage of visits when AI is reported. In total, AI was reported at 4.4% of visits among HIV-positive women and at 6.6% of visits among HIV-negative women. [2]Dichotomised at 8 drinks/week as 8+ drink per week is considered problematic drinking among women (35). [3]Defined as exchanging sex for money or drugs. [4]Reporting never or sometimes versus always using condoms during VI. [5]"Likely depression" was determined by scoring the series of survey items forming the Center for Epidemiologic Studies Depression Scale. Scores of >15 were defined as likely depression (36).

Table 7.2. Predictors of AI unprotected by condoms over follow-up among women in the WIHS cohort, by HIV-status

		HIV-POSITIVE WOMEN N=2,995, Total visits=49,804					HIV-NEGATIVE WOMEN N=1,081, Total visits=19,131				
		% UAI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI	% UAI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI
Demographic determinants											
Age	Years, continuous	NA	**0.94*** **	**0.93-0.95**	**0.95*** **	**0.93-0.96**	NA	**0.95*** **	**0.94-0.97**	**0.95*** **	**0.94-0.97**
Race	Black	2.0%	Ref		Ref		4.1%	Ref		Ref	
	Hispanic	2.5%	1.28	0.93-1.76	**1.47***	**1.06-2.05**	5.9%	1.43	0.97-2.11	1.38	0.92-2.07
	White	2.2%	1.08	0.69-1.7	1.16	0.75-1.79	6.0%	1.46	0.85-2.48	1.20	0.72-2.01
	Other	1.4%	0.71	0.33-1.53	0.69	0.33-1.44	5.9%	1.9	0.94-3.86	1.51	0.78-2.94
Education	<High school	2.0%	Ref		Ref		4.4%	Ref		Ref	
	High school+	2.2%	1.1	0.83-1.45	1.33	1.00-1.76	5.1%	1.18	0.82-1.71	1.26	0.87-1.83
Married or living with a partner	No	2.0%	Ref		Ref		4.6%	Ref		Ref	
	Yes	2.3%	1.15	0.93-1.41	1.21	0.99-1.47	5.5%	1.21	0.92-1.59	**1.35***	**1.04-1.77**
Household annual income	<$12,000	2.3%	Ref		Ref		4.4%	Ref		Ref	
	12,000+	2.0%	0.87	0.69-1.09	0.93	0.74-1.17	5.4%	1.24	0.97-1.60	1.23	0.98-1.56
Behavioural determinants											
Alcohol use[2]	<8 drinks/week	1.9%	Ref		Ref		4.6%	Ref		Ref	
	8+ drinks/week	4.2%	**2.19*** **	**1.67-2.87**	**1.56****	**1.19-2.04**	6.2%	**1.58****	**1.2-2.09**	1.18	0.85-1.63
Crack, cocaine, or heroin	No	1.9%	Ref		Ref		4.5%	Ref		Ref	
	Yes	4.6%	**2.54*** **	**1.92-3.37**	**1.65****	**1.15-2.38**	7.4%	**1.97*** **	**1.45-2.69**	**1.58****	**1.12-2.21**
Transactional sex[3]	No	2.0%	Ref		Ref		4.6%	Ref		Ref	
	Yes	9.0%	**4.79*** **	**3.04-7.56**	1.04	0.58-1.83	12.5%	**3.56*** **	**2.3-5.53**	1.40	0.88-2.24
Number of male sex partners	0-1	1.7%	Ref		Ref		3.8%	Ref		Ref	
	2+	7.5%	**4.76*** **	**3.77-6.01**	**3.31*** **	**2.51-4.35**	10.0%	**3.15*** **	**2.42-4.10**	**2.00*** **	**1.53-2.62**
Number of female sex partners	0	2.1%	Ref				4.8%	Ref		Ref	
	1+	2.2%	1.02	0.68-1.52	0.79	0.54-1.15	5.2%	1.15	0.75-1.76	0.85	0.57-1.29
Psycho-social determinants											
Likely depression[5]	No	1.8%	Ref		Ref		4.5%	Ref		Ref	

	HIV-POSITIVE WOMEN N=2,995, Total visits=49,804					HIV-NEGATIVE WOMEN N=1,081, Total visits=19,131				
	% UAI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI	% UAI visits[1]	Univariate analysis OR	95% CI	Multivariable analysis aOR	95% CI
Yes	2.7%	**1.54*** **	**1.25-1.91**	**1.27***	**1.03-1.58**	5.6%	**1.49****	**1.17-1.89**	**1.18***	**1.05-1.77**

OR=odds ratio, aOR=adjusted odds ratio, 95% CI= 95% confidence interval, Ref=referent. *p-value<0.05, **p-value<0.01, ***<p-value<0.001. All variables were collected over follow-up and measured since the last visit except race and education level, which were measured at baseline. Results in bold indicate that the 95%CI does not include the null value.

Visits for which AI practice data were available and for which the prior visit was no longer than 12 months ago (i.e. maximum one visit skipped), and for which all included co-variates were available, were included in analysis. Among HIV-positive women, 86.2% of visits were retained after applying these criteria; among HIV-negative women 86.7% visits were retained.

[1]Percentage of visits when AI is reported. In total, UAI was reported at 2.2% of visits among HIV-positive women and at 4.9% of visits among HIV-negative women. [2]Dichotomised at 8 drinks/week as 8+ drink per week is considered problematic drinking among women (35). [3]Defined as exchanging sex for money or drugs. [5]"Likely depression" was determined by scoring the series of survey items forming the Center for Epidemiologic Studies Depression Scale. Scores of >15 were defined as likely depression (36)

7.4.3. Supplementary analysis 1: Exploring violence

Adding the violence variables (raped since last visit, severely beaten since last visit and feel afraid of current partner), which have a large proportion of missing values, to the complete case analysis model retained only 44.6% of total visits, compared to 86.4% of visits retained when these three variables were excluded (for HIV-positive and -negative participants combined). Among HIV-positive women, AI practice was reported at 4.1% of visits in this smaller subset of visits, compared to 4.6% of visits when a complete case analysis was conducted using the variables in Table 7.1. and 7.2. Among HIV-negative women, the proportion of visits at which AI was reported reduced from 6.6% to 5.6%. This decrease in reported AI is likely due to the pattern of missing values for violence variables disproportionately removing visits earlier in the cohort study, when participants tended to be younger and more sexually active.

Results of these analyses are displayed in the appendix (Table A7.1 for predictors of AI and Table A7.2 for predictors of UAI). Violence victimisation followed a dose-response pattern in predicting AI and UAI practice, with having been both raped and beaten since the last visit predicting AI and UAI practice with high ORs among both HIV-positive and -negative women (e.g. OR=6.55; 95% CI: 3.10-13.82) for UAI practice among HIV-positive women) and either being raped or beaten having a lower, but still highly significant OR (e.g. OR=3.23; 95% CI: 2.30-4.54). After adjustment in multivariable analysis, this pattern remained for AI and UAI practice among both HIV-positive and negative women; with having been both raped and beaten increasing odds of AI practice approximately two-fold. Reporting feeling afraid of current partner also predicted both AI and UAI practice in univariate analysis among both groups of women (e.g. OR=3.36; 95% CI: 1.67-6.79 among HIV-negative women). After adjustment for confounders, this increased odds of UAI practice only among HIV-negative women.

Patterns among other variables in the supplementary analysis were largely similar to in the main models (Tables 7.1 and 7.2). However, as confidence intervals were in many cases wider, likely due to the smaller number of included visits, some variables no longer significantly predicted AI or UAI practice, despite the OR and aORs being similar.

7.4.4. Supplementary analysis 2: ART as a predictor of AI and UAI practice

Additional supplementary analyses examined whether taking ART or not may be a predictor of AI and UAI practice. Results of these analyses are in Appendix Table A7.3. In univariate analysis, not taking ART was associated with increased odds of both AI and UAI practice (e.g. for AI practice; OR=1.58;

95%CI: 1.29-1.92). These associations disappeared, however, when controlled in multivariable analysis for all covariates included in the main analysis.

7.4.5. Supplementary analysis 3: Predictors of initiating AI practice

In total, 317 women (185 HIV-positive and 132 HIV-negative) reported never having practised AI at baseline, but report AI at least once over follow-up. Baseline characteristics of this sub-group are displayed in Appendix Table A7.4. Briefly, characteristics are similar to those of the whole sample (Chapter 6, Table 6.2.), although a larger proportion of the sub-group were recruited during the first and second recruitment waves, they tended to be younger (median age 31 vs 36 years) and fewer reported ever having had any female sex partner (13.0% vs 25.0%).

Results of the analysis are displayed in the Appendix Table A7.5. Reporting recent multiple male sex partners was the only variable which predicted first AI practice in both univariate and multivariable analysis among both HIV-positive and -negative women (e.g. aOR=1.49, 95% CI: 1.02-2.18 among HIV-negative women).

7.4.6. Supplementary analysis 4: Predictors of AI and UAI practice among each trajectory group

Results by trajectory group among HIV-positive women are shown in Appendix Table A7.6a, and for HIV-negative women in Appendix Table A7.6b. Among both HIV-positive and HIV-negative women, AI practice was reported at too few visits among the least heterosexually active classes (Class 4 and Class 5 among HIV-positive and -negative women, respectively) to conduct the regression models.

Among both HIV-positive and -negative women, predictors of AI practice varied to some extent between trajectory groups. Fewer covariates significantly predicted AI practice within trajectory groups among HIV-negative women compared to HIV-positive women, perhaps partly reflecting that the five-class model used among HIV-negative better characterised AI practice over the life course compared to the four-class model among HIV-positive women.

As in the main model, AI practice decreased significantly with age in all trajectory groups among HIV-positive women. However, among HIV-negative women, age had no association with AI practice among Classes 1 and 3, reflecting that women in these classes report male partners throughout the life

course, in contrast to other classes. White and Hispanic HIV-positive women were more likely to report AI practice over time, compared to Black HIV-positive women in all classes. Race did not significantly predict AI practice within classes among HIV-negative women. Having multiple male partners significantly predicted AI practice across trajectory groups among HIV-positive, but not among HIV-negative women. Reporting recent UVI did not predict AI practice within Class 1 among both HIV-positive and -negative women, perhaps reflecting how comparatively common this practice was in both classes.

7.5. DISCUSSION

This longitudinal analysis of AI found that the practice decreases with age, and is more common over the life course among Hispanic women (and White women among HIV-positive women) compared to Black women and among more educated women. In the short-term, AI practice is predicted by having a higher income (among HIV-negative women only), being a victim of violence, problematic drinking (among HIV-positive women only), drug use, transactional sex (among HIV-negative women only), practicing UVI, reporting multiple male sex partners and being depressed. These findings confirm similar associations with AI practice observed in cross-sectional studies, but indicate for the first time the temporal order of these associations.

With the exception of AI practice being predicted by having a higher level of education and a higher income, the predictors identified suggest a profile of higher risk behaviours and exposures among women who practise AI. Given that a number of studies have found a positive association between lifetime AI practice and higher education, and higher income (9,13,15,32); I had hypothesised during the development of the conceptual framework in Chapter 2, that women with a higher socio-economic status are more likely to experiment with AI, but not to practise on a regular basis. However, this analysis shows higher socio-economic status is predictive of increased likelihood of AI practice throughout the life course. This finding appears contradictory, as all other predictors identified suggest a profile of higher risk behaviours and exposures among women who practise AI. One possible explanation is that better educated women are more likely to accurately report AI.

Some studies have found AI practice to be more common among U.S. women who report sex with both men and women (3,7,18,19). Likewise, members of the trajectory group among HIV-negative women who most commonly practised AI (identified and described in Chapter 6) were more likely to identify

as lesbian or bisexual at baseline, so it is perhaps surprising that reporting a female sex partner was not a predictor in this analysis. It may be that in this sample, phases of having female sex partners do not disproportionately coincide with phases of having male sex partners. Another explanation is that identifying as bisexual or lesbian at baseline reflected past sexual behaviour which did not did not carry over the duration of the cohort study. Indeed, despite being more likely to identify as lesbian or bisexual, having a female sex partner was only reported at 7.7% of visits compared to having a male sex partner being reported at 95.6% of visits over follow-up among members of this AI practising trajectory group.

HIV-positive women in this sample were less likely, in univariate analysis, to practise AI when taking ART at that previous visit. However, even when controlled for age only (data not shown), there was no longer an association, as AI practice decreased with age while taking ART increased with age in this sample. This increased use with age is likely largely a reflection of the improved access to treatment over the duration of the long-running cohort study.

The predictors of AI and UAI practice were similar, with the most notable change being that while AI was not associated with marital status, UAI was predicted by being married or living with a partner among HIV-negative women. This implies that although not more likely to practice AI, when married women do practice AI it is less likely to be condom protected. Physical and sexual violence victimisation predicted both AI and UAI practice, but the magnitude of association with UAI was greater. Also, while feeling afraid of one's partner did not predict AI, it did predict UAI among HIV-negative women. Together, these findings imply that when AI occurs in the context of violence, particularly intimate partner violence, it is more likely to be unprotected by condoms. The association between UAI practice and intimate partner violence has been identified in a number of studies (20,25,28), while others have found that intimate partner violence is associated with using condoms inconsistently, regardless of sex act type (40).

This analysis has a number of limitations. The analysis in this chapter identifies predictors of AI risk, and it is therefore not possible to comment on concurrent clustering of AI practices with other risk behaviours and exposures. The main limitation of this study was the large number of missing values in the violence data over follow-up. This hindered analysis as it was not feasible to include these variables in the main models. The lack of data on violence perpetrators was a further limitation, as I was unable to directly test whether intimate partner violence predicted AI. As discussed in Chapter 6, because data on AI and all other variables was collected using face-to-face interviews, AI practice in particular may be underreported due to social-desirability bias.

The analysis presented in this chapter identifies predictors of AI practice, which, in conjunction with the identification and description in Chapter 6 of trajectory groups who practice AI commonly throughout life, can be used to identify women most likely to practice AI both in the short-term and the long-term.

These findings are useful in improving targeting of safe sex messaging and of prevention services such as HIV pre-exposure prophylaxis (PrEP). However, when AI occurs in the context of violence, as these findings indicate it often does, women are unlikely to be able to insist on condom use, and may also be unable to safely access and take PrEP. As such, the most effective method of reducing the transmission risk posed by AI may be to focus on gender-based violence reduction interventions.

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Chapter 8

Discussion

8.1. SUMMARY

The overarching aim of this thesis was to examine heterosexual AI practice from an epidemiological and public health perspective. Specifically, the thesis sought to describe who is engaging in AI, at what frequency, with whom, whether condoms are used, and whether once initiated, the practice is continued throughout the life course. Over the subsequent paragraphs I briefly address the thesis' findings on each of these aspects in turn. Aims and findings by chapter are summarised in Table 8.1.

Who is engaging in AI?

The various analyses found that AI practice is common, but varied across populations. The systematic reviews and meta-analyses presented in Chapters 3 and 4 found that around a fifth of young people (pooled estimate = 23.4%), South Africans (pooled estimate = 20.5%) and FSW (pooled estimate = 19.6%) reported practising AI in the past three months, with pooled estimates of other recall periods being similar. The data analysis on Swazi FSW in Chapter 5 found AI practice to be very commonly practised in this population, with 44% reporting AI in the past month. AI practice was less commonly practised by the women in the WIHS cohort, presented in Chapter 6 and 7, with 7.1% of HIV-positive and 9.5% of HIV-negative sexually active women reporting AI in the past six months on average over follow-up.

The systematic reviews and meta-analyses found few participant characteristics which explained heterogeneity in pooled AI prevalence estimates. Reported AI prevalence tended to be higher among urban, male and young South Africans. The reviews among young people and South Africans found that AI prevalence tended to increase over time. The main source of heterogeneity in AI prevalence across the reviews emerged to be interview method, with reported AI prevalence higher the more confidential the method employed. This is likely due to AI often being a highly stigmatised behaviour (83,84) leading to social desirability bias in reporting. Therefore, it may be more willingly reported using more confidential interviewing methods (85–87). Both the review among South Africans and among young people found significantly higher prevalence reported using ACASI, followed by SAQ and FTFI, although as articles using ACASI tended to be more recent; this finding may be confounded by an increase in AI prevalence over time. Further supporting this finding; the three studies in the reviews which compared AI prevalence by interview method all found higher prevalence using more confidential methods compared to FTFI (19,34,35). The highest number of AI acts across reviews was recorded among South African FSW completing daily pictorial coital diaries, with the same study finding a substantially lower number reported through daily FTFI and lower again through weekly FTFI (17). Likewise, the few studies using confidential ACASI to collect frequency data in the review among

South Africans found the highest fraction of AI and UAI acts. Together, these findings support the need to use more confidential methods in the reporting of AI practice, but also highlight the importance of using short recall periods (one week or one month, depending on population) to record frequency data. AI practice may be more stigmatised for women than men, so the lower reported prevalence among women may partly be explained by greater social-desirability bias in women reporting stigmatised sexual behaviour (88).

The individual level data analysis in Chapters 5 to 7 allowed a more thorough examination of behaviours and exposures associated with AI practice. In line with the literature-based conceptual framework (Chapter 2) AI practice was found to be more common among the better educated, among victims of rape and physical violence, and those reporting recent unprotected sex in both Swazi FSW and the WIHS cohort participants. AI practice was associated with having fewer new clients among Swazi FSW, whereas women in the WIHS cohort who practice AI most commonly were substantially more likely to report multiple male partners.

The WIHS dataset allowed the identification of predictors of AI behaviour, which were largely in line with the cross-sectional associations identified in the conceptual framework. AI practice was found to be predicted by periods of problematic alcohol use, drug use, being depressed and being a victim of physical and/or sexual violence; indicating for the first time the temporal order of these associations.

At what frequency is AI practised?

AI frequency data was reported in far fewer studies included in the systematic reviews than AI prevalence data. As such, my analysis of AI frequency data was limited to a rudimentary description of results, without meta-analysis. Among young people, the percentage of sex acts that were AI ranged from 3.0 to 24%, among South Africans from 2.4% to 15.9% and among FSW from 0.6% to 29.2%. The percentage of sex acts unprotected by condoms that were UAI tended to be higher, indicating that condoms were used less frequently during AI than during VI, although the numbers of studies reporting these data were very low. Neither the data on Swazi FSW, nor the WIHS cohort collected data on AI frequency.

With whom is AI practised?

The systematic review on FSW found that pooled estimates of AI prevalence did not vary by partner type (Chapters 3 & 4). Likewise, AI practice in the past month did not differ by partner type among Swazi FSW (Chapter 5). Too few studies included in the systematic reviews on young people and South

Africans reported AI practice by partner type to enable analysis, while the WIHS cohort study did not collect data on AI practice by partner type (Chapters 6 & 7). However, the analysis in Chapter 7 did find that having multiple male partners predicted AI practice, suggesting that AI practice is likely more common with casual rather than steady partners in this sample. These findings indicate that AI practice is likely often centrally located within sexual networks, rather than practised only with steady partners on the periphery of networks, and as such, AI practice is positioned to aid the spread of HIV epidemics.

Are condoms used during AI?

The systematic reviews found that pooled estimates of the proportion using condoms inconsistently during AI tended to be higher than for during VI, although this was only significantly different when measured at the last sex act among young people (Chapters 3 & 4). The proportion of Swazi FSW using condoms inconsistently during AI was higher than during VI with each partner type (Chapter 5), although confidence intervals overlapped. The analysis of the WIHS cohort data in Chapter 6 found that the proportion of women who report never consistently using condoms during AI is twofold that during VI. Taken together, this points to a tendency of AI being less often condom protected than VI.

Is AI practise continued once initiated?

The description of AI practice over the life course among the whole sample of U.S. women in Chapter 7 found that while both AI and VI prevalence decreased with age, AI prevalence started decreasing earlier and its decline was faster. The group-based trajectory model (GBTM) identified a small group of HIV-negative women who practise AI consistently throughout life. A substantial minority of women in other trajectory groups also practised AI over follow-up, but their AI practice tended to be intermittent and discontinued with age.

Table 8.1. Summary of thesis aims, findings and limitations

Chapter	Aims	Findings	Limitations and gaps
2	**To review** the literature on demographic, behavioural and structural factors associated with heterosexual AI practice **To develop** a conceptual framework of factors influencing AI practice	AI practice associated with alcohol and drug use, violence and gender power imbalance.	Non-exhaustive and unsystematic literature review Associations with men's heterosexual AI practice little understood due to lack of data
3 & 4	**To establish** how commonly and frequently AI is practised among young people, FSW and South Africans **To identify** how AI practice varies across risk groups, age, partner type, setting and over time.	AI common, but varied among the three populations. Reported AI prevalence higher with more confidential interviewing methods. Practice may be increasing over time	Heterogeneity of recall periods limited analysis. Little data on frequency. Most estimates gathered by FTFI, so pooled estimates are likely affected by social-desirability.
5	**To estimate** AI prevalence among Swazi FSW. **To compare** condom, use during AI and VI **To identify** determinants of AI practice	AI very commonly practiced among Swazi FSW and does vary by partner type Condoms used more inconsistently during AI than VI. AI associated with higher education, fewer clients, unprotected sex, rape and harassment, but also *not* being blackmailed and *not* feeling afraid in public	AI practice likely underreported due to use of face-to-face interviews. AI prevalence varied significantly by interviewer. No data on lubricant use or sex act data.
6	**To describe** AI practice among HIV+ and HIV- U.S. women separately over the life course **To identify** groups with distinct trajectories of AI practice over the life course **To identify** individual baseline characteristics associated with group membership	AI practice decreases with age; faster than VI practice. tends to coincide with reporting multiple male partners and UVI Women in AI practicing trajectory groups report more commonly having multiple male partners and use condoms less consistently during AI and VI. They are more likely to be Hispanic, bisexual, victims of violence; to have ever practised transactional sex, report greater number of male sex partners at baseline, compared to largest trajectory group.	Longitudinal AI practice better characterised by five trajectory group model among HIV- than four group model among HIV+ women. AI practice likely underreported due to use of face-to-face interviews. No sex act data.
7	**To identify** time-varying predictors of AI and UAI practice among U.S. HIV+ and HIV- women	AI practice decreases with age, is more common among more educated women and Hispanic and White women compared to Black women. Short-term predictors are higher income, heavy drinking, drug use, violence victimisation, UVI, multiple male partners and being depressed.	Large number of missing values in violence victimisation data and a lack of data on violence perpetrators limited analysis. AI practice likely underreported due to use of face-to-face interviews. No sex act data.

8.2. LIMITATIONS

The main limitations of the both the analysis of the Swazi data and the WIHS cohort data were the same as that of the majority of studies included in the systematic reviews; namely that data was collected using face-to-face interview and that no data on sex act frequency were gathered. As AI practice is often a stigmatised behaviour, the reliance on data collected via face-to-face interview may have hampered the accuracy of the findings of this thesis. Other limitations specific to each individual analysis are discussed in the relevant chapters.

8.3. IMPLICATIONS FOR RESEARCH

While not practiced by all, it is clear from the analyses presented in this thesis that heterosexual AI is a routine part of sexual practice for many. As such, collecting data on AI practice is indispensable to any survey aiming to capture sexual behaviours among men and women and to understanding transmission risks within a given population. A recurring theme throughout this thesis is that collecting and reporting data on AI must be improved. To address this, I strongly recommend that confidential interview methods be used in order to reduce social-desirability bias. However, to reduce misunderstanding and misreporting, questions must be carefully piloted. The use of unambiguous illustrations may be necessary in some populations.

The meta-analyses found little difference in prevalence by recall period. Likewise, individual cross-sectional studies have found little difference in AI prevalence when AI is reported over both a shorter and a longer recall period (11–14). This might imply either that those who initiate AI continue to practice it, or that it is reported more accurately over shorter recall periods. The longitudinal analysis in Chapter 6 found that only about 8% of women with a male partner reported AI over a six-month period, but a far higher proportion (26%) reported it over the entire follow-up period. This finding supports the latter hypothesis that AI is reported more accurately over shorter recall periods. As such, I recommend that shorter recall periods be used to collect data on AI practice.

We need data that paints a complete picture of AI practice and which allows the proportion of all sex acts that are anal to be estimated. Accurately estimating this proportion is key to estimating the extent to which AI impacts on HIV epidemics. I recommend collecting information on the following dimensions of AI:

- Have you had AI in the past 12 months?
- How many VI acts have you had in the past month with a) regular partner and b) casual partners
- Was a condom used throughout your last VI act with a) regular partner and b) casual partners?
- How many AI acts have you had in the past month with a) regular partner and b) casual partners?
- Was a condom used throughout your last AI act with a) regular partner and b) casual partners

FSW should additionally be asked about AI and VI with clients, and unless client volume is low, sex act data would likely better be captured over the past week, rather than past month.

All analyses presented in this thesis, but particularly the description of AI practice over the life course in Chapter 6, would be valuable to improving mathematical modelling of HIV epidemics; models aiming to inform the extent to which AI practice among women impacts HIV epidemics, as well as models aiming to investigate how AI practice may mitigate the efficacy of interventions such as vaginal microbicides.

8.4 IMPLICATIONS FOR PUBLIC HEALTH

All analyses found that condoms tended to be used less consistently during AI than VI, which may in large part be due to widespread ignorance that AI confers a much higher transmission risk compared to VI (11,13,15–19). AI should therefore be explicitly addressed in safe sex messaging.

As this thesis has confirmed that AI is common across populations, it may be contributing to rectal STI among women, as well as HIV infection. It therefore seems reasonable to recommend that rectal STI screening should be offered to women reporting AI, along with vaginal screening.

Based on the findings of the GBTM of the WIHS data, it appears that AI may be very consistently practised by a small sub-group within a given population of women, who also display other high-risk behaviours. Such sub-groups could benefit from access to PrEP. These sub-groups may to some extent be identified by their reporting of frequent AI, multiple male partners, violence victimisation, by their identification as bisexual, and in the U.S., as being Hispanic. PrEP may be especially suitable for

protecting AI practice among FSW, as they often have a financial incentive to offering UAI (11,16,20–22), so interventions aimed at increasing condom use during AI may be likely to fail.

Again, based on the GBTM, it appears that most AI practice by those not within this higher-risk sub-group mainly practise AI sporadically, which may imply that AI is not planned. In this case, PrEP is unlikely to be the most suitable intervention. A more suitable approach to avoiding HIV transmission during these sporadic episodes of AI practice may to increase condom use during AI through widespread public health messaging; emphasising the importance of condom use during AI, as well as VI.

The limited number of studies included in the systematic reviews in Chapter 3 and 4 which reported on AI frequency data indicated that AI is likely practised with sufficient frequency (estimated to be 5-10% of sex acts being anal) to substantially mitigate the efficiency of vaginal microbicides (23,24). The development of microbicides which can be used in both the vagina and anus would be a great step forward in protecting women from HIV transmission. It may be of particular use to women who practise AI sporadically, as they are unlikely to be suitable candidates for HIV pre-exposure prophylaxis (PrEP).

One approach which may usefully be applied to men and women at high risk of infection through heterosexual AI, may be the harm reduction model, which has been used extensively to effectively reduce infection risk among drug users (IDU)(25). A harm reduction programme could take the approach of emphasising the need for the enthusiastic consent of both parties, as the literature review in Chapter 2 identified that many girls and women practice AI even though they dislike it and often do so under pressure from their male partners. For people who do decide to engage in AI with the mutual enthusiastic consent of their partner(s), then they could be encouraged to use lubricant and condoms. If, however, they do not wish to use condoms, then they should be encouraged to practice AI only with their steady partner, or failing that, with a reduced number of partners.

However, when AI occurs in the context of violence or coercion, women are unlikely to be able to insist on condom use, or use of any possible future rectal / dual compartment microbicide and may also be unable to safely access and take PrEP. Unfortunately, the findings of this thesis point to AI practice all too often being inextricably linked to violence. As such, the most effective method of reducing the transmission of HIV via AI may be to focus on gender-based violence reduction interventions, including violence against FSW.

8.5 FUTURE WORK NEEDED IN FURTHER CHARACTERISING AI PRACTICE

All work in this thesis has explored how people who practise AI differ from those who do not, but heterogeneity within people who practise AI has not been explored. There is some indication that different sub-groups exist within FSW who practise AI. Many studies find that FSW who practice AI are more likely to be in precarious situations, to report other risky sexual behaviour and to be victims of violence. However, others have found AI practice to be more common among those better educated (26) and with higher income (11,16). The analysis in Chapter 5 of AI among Swazi FSW found AI practice to be associated with having been raped and harassed, but AI was also associated with not having been blackmailed and not fearing public places, having fewer clients, and fewer sex acts. The profile of FSW who practise AI may be muddied by the clear financial incentives to practise AI, with several studies finding that FSW charge more for AI than for VI (16,20–22) and that higher earnings are the main reason for its practice (16,21,27,28). Women who charge more for sex tend to be better educated (29), be more experienced in sex work (29,30), be more financially secure and work in less precarious conditions (30–32), to not binge drink (31) and to be more able to negotiate safe sex (32). As AI can be lucrative, women who charge more for sex may also be more likely to practise AI. Higher earning women who practise AI likely differ substantially from women who practise AI in the context of violence or feel unable to refuse, which may explain the mixed results obtained through regression analysis. Regression analysis may therefore be limited in its ability to describe the complex determinants of AI that seem to exist.

Cluster analysis could be used to identify whether distinct sub-groups with homogenous behavioural and risk exposure patterns exist within FSW who practice AI. As individuals are likely to react differently depending on their subgroup identified through cluster analysis, interventions can be adapted and targeted for each subgroup, an approach that has found success in health promotion programmes for lifestyle change (33). For example, this analysis could be used to determine whether UAI practice is concentrated in certain subgroups of FSW in order to better target interventions. Sub-groups may likewise emerge from a similar analysis among non-FSW, and may explain for example, why although AI practice is most often found to be associated with risky behaviours and violence, it is also often associated with higher socio-economic status.

8.6. CONCLUSION

This thesis has characterised heterosexual AI practice among various groups of particular vulnerability to HIV infection using a variety of different epidemiological approaches; conceptual framework, systematic reviews and meta-analyses, and data analysis of cross-sectional and longitudinal data. It has presented the first systematic reviews and meta-analyses of AI practice as well as the first longitudinal analysis of AI practice. It is clear from these analyses that heterosexual AI is an integral part of many people's sexual practice, and that no sexual behaviour survey, nor intervention seeking to mitigate transmission risk of HIV or STI's among people who practise heterosexual sex can afford to ignore AI practice.

8.7. REFERENCES

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APPENDIX: CHAPTER

The appendix is arranged by review population group, with the tables and figures for the review among young people first, followed by tables and figures for the review among South Africans, and lastly those for the review among FSW.

REVIEW ON AI PRACTICE AMONG YOUNG PEOPLE

Table A4.1. Study and participant characteristics of studies included in the review on AI practice among young people.

A. Key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
Outcomes reported	AI prevalence	108	[1–108]	26	[56,109–133]	133[a]
	VI prevalence	94	[1,3–22,24–26,28–33,35–60,62,64–75,77–82,84–86,88,91–98,101–104,106–108]	21	[56,109–111,113–120,122–126,130–133]	114[a]
	AI frequency	10	[21,22,41,42,64,87,90,101,134,135]	3	[110,125,136]	13
AI Recall Period[b]	Lifetime	73	[1,3–7,9–12,14–18,20–22,24–26,29,32,35–41,43–49,52,54,56,57,59,60,62–64,66–70,72,73,75,77–79,82,83,85,88,91–95,97,100–104,106,107]	11	[56,109,112–114,118,119,123,126,128,130]	83[a]
	Current partner	4	[33,65,84,99]	1	[109]	5
	12 Months	8	[2,28,51,53,58,63,86,96]	0	-	8
	6 Months	1	[81]	0	-	1
	3 Months	11	[8,13,19,26,42,71,74,78,87,105,106]	11	[110,117,120,122,124,125,127,128,130,132,133]	22
	2 Months	0	-	1	[116]	1
	1 Month	6	[34,64,73,90,91,98]	1	[111]	7
	First Sex Act	1	[30]	0		1
	Not stated	10	[23,27,31,50,55,61,76,80,89,108]	5	[113,115,121,129,136]	15
Gender	Male & female	38	[1–33,96,99,101,108,135]	6	[109–113,136]	44
	Female only	44	[34–64,91–93,95,97,98,100,102–106,134]	14	[56,114–123,131–133]	57[a]
	Male only	2	[65,66]	3	[124–126]	5
	Mixed only	26	[67–90,94,107]	4	[127–130]	30
Continent[b]	Africa	15	[1–3,30,34,35,65,67–69,77,88,94,108,135]	1	[114]	16
	Asia	6	[5,37,56,70,104,108]	1	[56]	6[a]
	Europe	13	[11,12,16,17,24,28,44,45,49,53,95,96,105]	4	[119,124–126]	17
	Latin America	4	[4,6,36,60]	1	[113]	5
	North America	73	[7–10,13–15,18–23,25–29,31–33,38–43,46–48,50–52,54,55,57–59,62–64,66,71–76,78–87,89–93,97–103,106,107,134]	21	[87,110–112,115–118,120–123,127–133,136]	94
Mean age[b]	<18 years	40	[1,3,6,7,9–11,13–15,19,30,36,39,41–43,49–51,56,57,64,66–69,71,72,74,76,77,83,88,94,95,97,103,105,134]	13	[56,112,113,115–118,120–122,127,128,130]	52[a]
	18-24	71	[2,4,5,8,10,12,14,16–18,20–29,31–35,37,38,40,44–48,52–55,59–63,65,70,73,75,78–82,84–87,89–93,96,98–102,104,106–108,135]	15	[87,109–111,114,119,123–127,129,132,133,136]	86
Survey Year[b]	Pre-2004	64	[8,9,11,18,20–31,36,41,42,44–46,48–50,52–63,65,66,72,75–77,79–84,86,88–92,95,99–102,108,126,135]	17	[56,109–112,117–119,121–124,126–129,136]	80[a]
	2004 onwards	47	[1–7,10,12–17,19,32–35,37–40,43,45,47,51,64,67–71,73,74,85,87,93,94,96–98,103–106,134]	10	[114–116,120,125,129,130,132,133]	57
Study sample[b]	National representative surveys	14	[2,8,10,14,16,17,19,49,63,64,66,96,99,102],	-	-	14
	Community level surveys[d]	19	[1,7,24,33,35,39,42,43,54,57,69,70,72,77,92,101,107,134,135],			19
	Higher Education	43	[4,5,18,20–23,25–29,31,40,45–48,52,53,58–62,65,73,75,78–82,84,86,87,89–91,98,104,106,108]	-	-	43
	Schools	24	[3,6,9,11–13,15,30,36–38,44,51,56,67,68,71,74,76,83,88,94,95,105]	1	[56]	24[a]
	Clinics (non-STI)	10	[32,34,41,50,55,85,93,97,100,103]	-	-	10
	STI or family planning clinics	-	-	13	[109,111,112,116,119,126–129,131–133,136]	13
	Homeless	-	-	5	[56,113,120,121,123]	5

A. Key study characteristics		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
	Pregnant/teen mothers	-	-	2	[117,118]	2
	Roma young people	-	-	2	[124,125]	2
	'At Risk'[e]	-	-	3	[110,114,130]	3
	Prisoners	-	-	2	[115,122]	2
Number lifetime sex partners		29	[4,12,15,17,20–22,25,29,34,36,38,40,42,44–46,53,55,60,62,67,69,70,82,84,96–98]	7	[109,115,117–119,122,126]	36
Age at first VI		32	[1,3–5,12,17,18,21,22,28,29,32,34,38,39,42–46,48,53,58,69,78,79,85,88,89,92,107,134]	10	[52,110–113,117,119,122,123,125]	42
Age at first AI		10	[21,22,33,38,39,43,75,79,85,92]	1	[112]	11
Condom use	During AI	11	[13,39,42,46,50,71,79,86,93,98,101]	11	[109,110,112,119,120,122,123,125,126,130,132]	22
	During VI	25	[11,13,16,17,25,34,35,39,40,42,43,49,50,54,58,70–72,76,78,79,86,93,98,101]	8	[110,117,118,120,122,123,132]	33
Alcohol Use	General use[f]	8	[6,49,61,68,70,72,76,105]	3	[116,118,123]	11
	Use with sex[g]	5	[18,19,45,73,81]	5	[87,111–113,120]	10
B. Study quality and potential for bias		Non-higher risk populations N=110		Higher risk populations N=27		Total N=136
Interview methods[b]	ACASI	18	[3,7,10,13,14,19,42,57,64,69,71,74,85,96,97,103,104,134]	7	[109,110,116,127,130,132,133]	25
	SAQ	73	[1,4–6,9,11,12,15–18,20–32,36,37,39–41,43–49,51–53,55,56,58–62,66–70,73,75,76,78–84,86–89,91,94,95,98,105,106,108,135]	8	[56,112,114,115,117–119,126]	80[a]
	FTFI	17	[2,8,33–35,38,50,54,63,65,72,77,92,93,100,101,107]	12	[111,113,120–125,128,129,131,136]	29
	Telephone	2	[99,102]		-	2
Study Design	Cross-sectional	94	[1–5,7,9–13,15–33,35–37,39,43–56,58–70,72,73,75–84,86–91,94–96,98–104,106–108,134,135]	21	[56,109,111–115,118–126,129,131–133,136]	114[a]
	RCT[c]	8	[6,34,57,71,74,85,92,97]	5	[110,116,127,128,130]	13
	Cohort	7	[8,38,40–42,93,105]	1	[117]	8
Sampling method	CRS	23	[1–3,6,12,13,15,30,37,52,54,63,67,68,71,74,88,91,92,94–96,98]	0	-	23
	SRS	20	[8,10,14,16,17,19,21,28,53,58,64,66,69,70,79,87,99,102,107,122]	1	[122]	21
	Convenience	61	[4,5,7,11,18,20,22–26,31–36,39–51,55,57,59,60,62,65,72,73,75–78,81–86,90,93,97,100,101,103–106,108,134,135]	25	[56,109–121,123,124,126–133,136]	85[a]
	RDS	1	[38]	1	[125]	2
	NS	5	[9,27,61,80,89]	0	-	5
First AI mention	Title	17	[6,10,13,15,17,33,42,43,46,54,57,63,79,85,99,100]	5	[109,110,127,129,131]	22
	Abstract	74	[1,3,4,7–9,11,12,14,18–25,27,29–32,36–41,44,45,47,49–51,55,59–62,66–68,70–78,80,81,83,84,86–89,91–98,102–107,134]	18	[111,112,114–117,119–126,128,130,132,133]	92
	Text	16	[2,5,26,28,34,35,48,52,53,56,64,65,82,90,101,108,135]	4	[56,113,118,136]	19[a]
	Table	2	[58,69]	0	-	2
Survey response rate	≥80%	23	[2,6,8,9,15,30,32,36,45,49,52,55,69,74,76,83,93,94,97,101,105,107,135]	10	[109,112,115,116,119,121,125,126,130,133]	33
	60-79%	14	[10–14,53,54,60,64,82,90,92,102,103]	3	[110,113,114]	17
	<60%	13	[17,19,21,24,27,28,58,75,78,79,96,99,104]	2	[127,128]	15
	NS	59	[1,3–5,7,18,20,22,23,25,26,29,31,33–35,37–44,46–48,50,51,56,57,59,61–63,65–68,70–73,77,80,81,84–89,91,95,98,100,106,108,134]	13	[56,111,117,118,120,122–124,129,131,132,136]	71[a]

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

[a]The sum of some subgroups is greater than total number of included articles because several articles provided AI data in more than one category.

[b]Refers to non-higher risk participants recruited locally through posters, advertisements, from home visits or community venues etc. [c]Three studies recruited 'at risk' young people, which were variously defined as: reporting recent unprotected sex [110,114], having recently been arrested [110], being a crack user, having had multiple sex partners in the past year.

Table A4.2. Trends over time by continent: subgroup analysis of lifetime prevalence of AI among sexually active youth of all gender groupings

Sub-group	N	Range, %	AI pooled estimates (CI)	I^{2a}
Africa				
<2004	4	7.5-18.8	12.0 (7.3-16.7)	87.9
≥2004	8	1.7-55.7	21.0 (6.4-35.6)	99.6
Asia				
<2004	2	4.2-10.5	7.4 (0.4-14.3)	0.0
≥2004	3	3.1-28.0	16.3 (7.0-25.5)	72.3
Europe				
<2004	7	10.8-27.3	18.2 (14.2-22.3)	90.9
≥2004	3	26.7-39.4	33.7 (28.8-38.6)	83.8
Latin America				
<2004	2	6.2-28.2	17.2 (2.2-32.2)	74.7
≥2004	2	20.4-27.4	23.9 (17.7-30.2)	1.0
North America				
<2004	30	0.0-42.9	20.9 (17.7-24.1)	98.7
≥2004	13	10.9-37.6	25.2 (20.6-29.7)	94.4

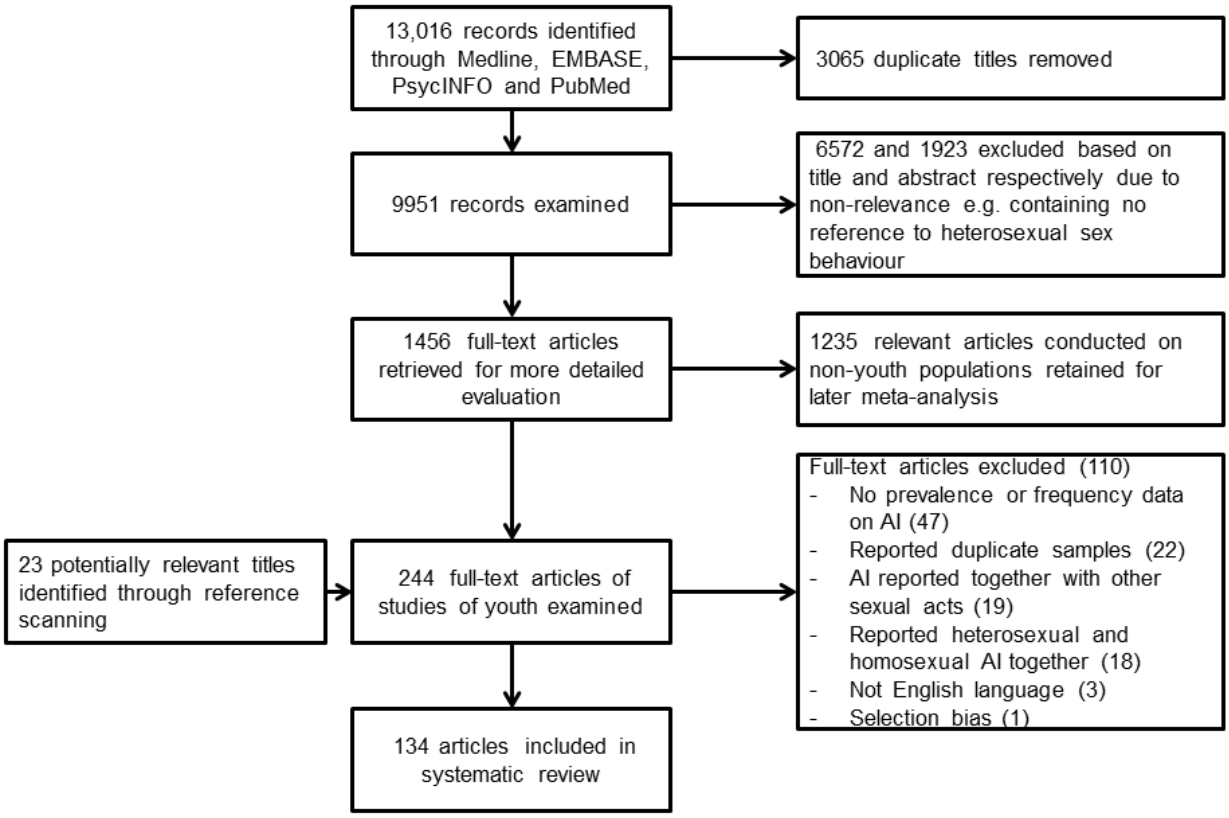
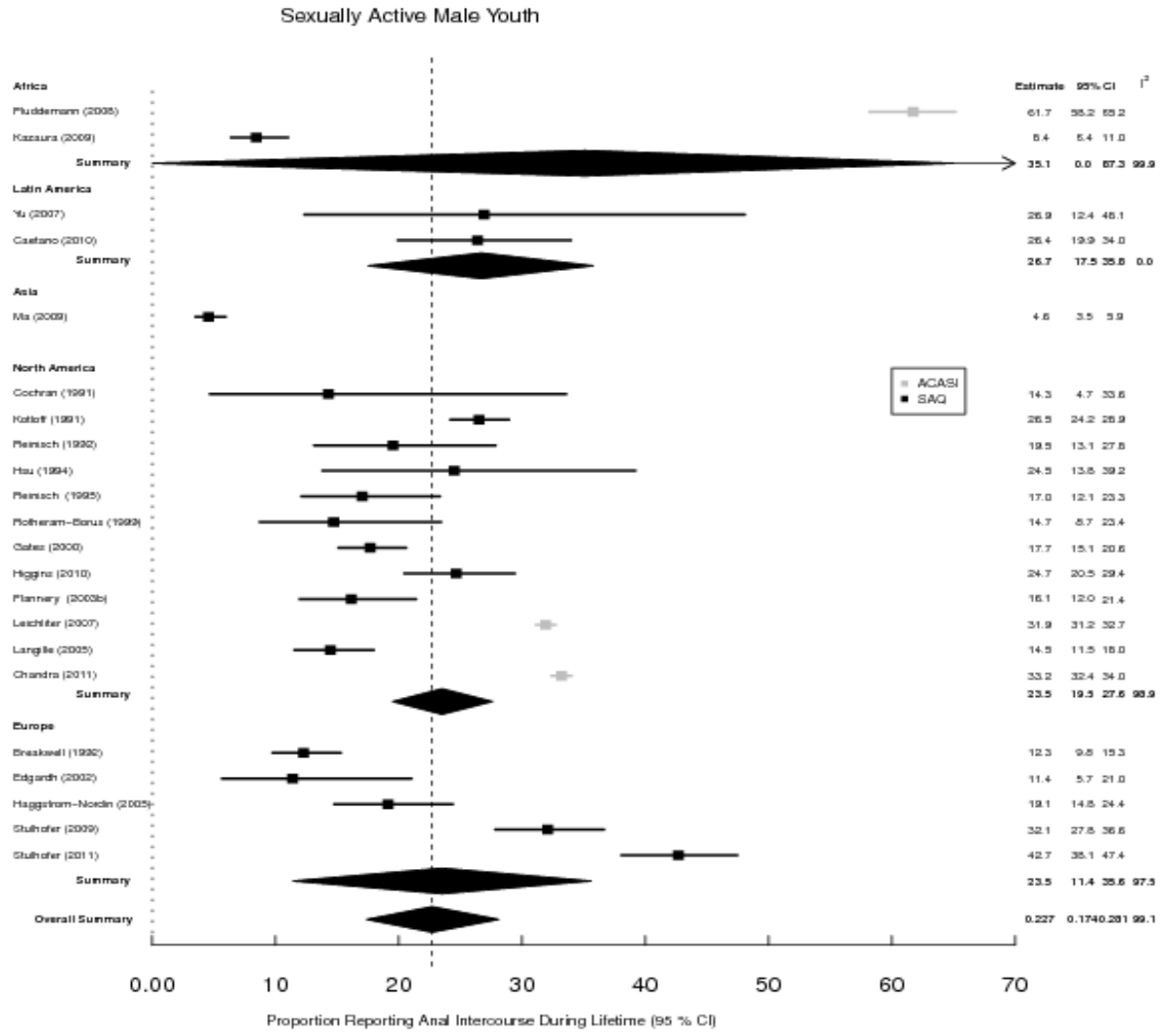
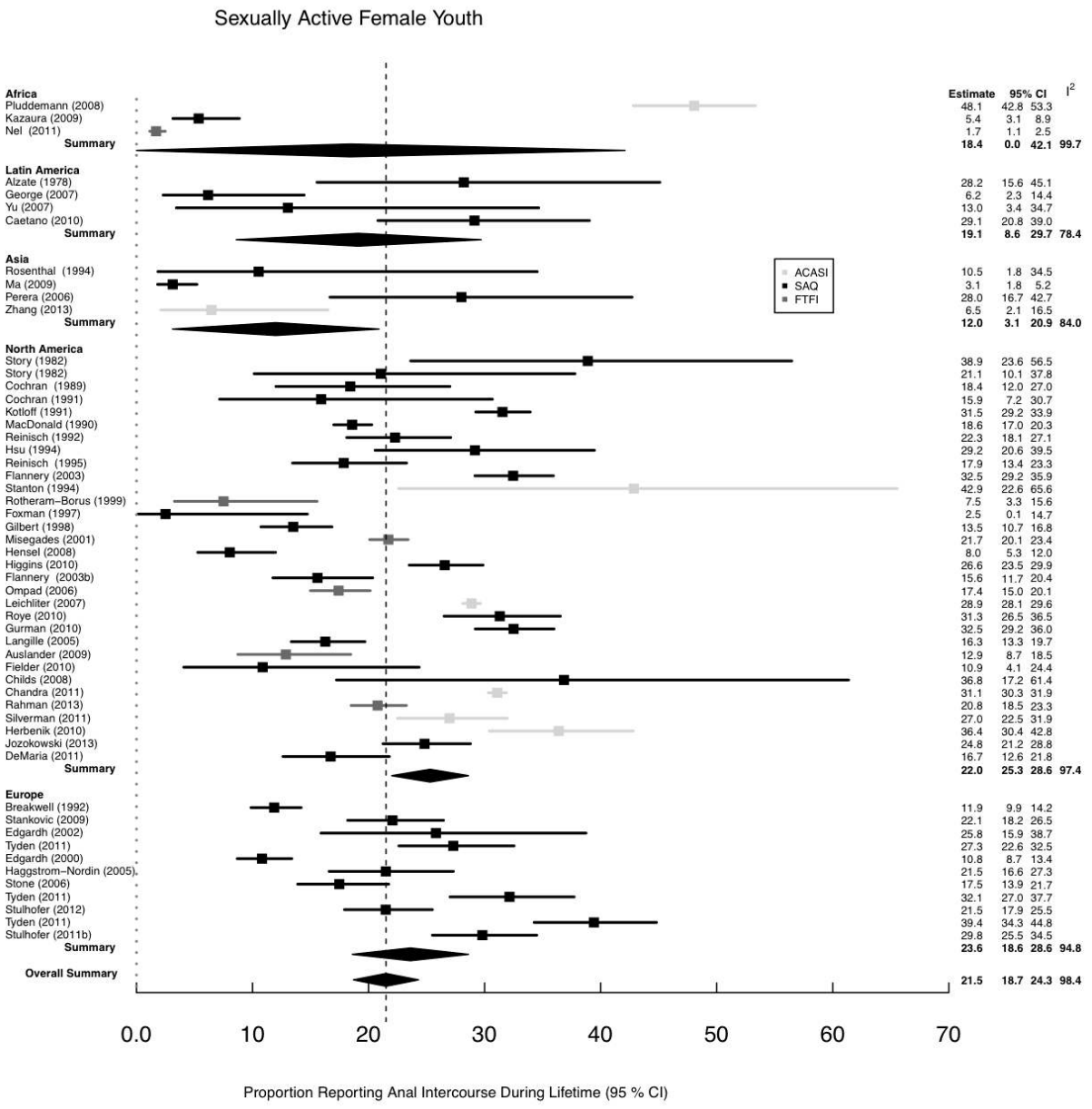


Figure A4.1. Summary of article search and selection, review among young people

a.


Sexually Active Male Youth
Africa
Pluddemann (2005)
Kazaura (2009)
Summary
Latin America
Yu (2007)
Castano (2010)
Summary
Asia
Ma (2009)
North America
Cochran (1991)
Koloff (1991)
Reinisch (1992)
Hsu (1994)
Reinisch (1995)
Rotheram-Borus (1999)
Gates (2000)
Higgins (2010)
Flannery (2003b)
Leichliter (2007)
Langille (2005)
Chandra (2011)
Summary
Europe
Breakwell (1992)
Edgardh (2002)
Haggstrom-Nordin (2005)
Stulhofer (2009)
Stulhofer (2011)
Summary
Overall Summary
ACASI
SAQ
Estimate 95% CI I²
61.7 58.2 65.2
5.4 5.4 11.0
35.1 0.0 87.3 99.9
26.9 12.4 46.1
26.4 19.9 34.0
26.7 17.5 35.8 0.0
4.6 3.5 5.9
14.3 4.7 33.6
26.5 24.2 28.9
19.5 13.1 27.8
24.5 13.8 39.2
17.0 12.1 23.3
14.7 8.7 23.4
17.7 15.1 20.6
24.7 20.5 29.4
16.1 12.0 21.4
31.9 31.2 32.7
14.5 11.5 18.0
33.2 32.4 34.0
23.5 19.3 27.6 98.9
12.3 9.8 15.3
11.4 5.7 21.0
19.1 14.8 24.4
32.1 27.8 36.6
42.7 38.1 47.4
23.5 11.4 35.6 97.5
0.227 0.174 0.281 99.1
0.00 10 20 30 40 50 60 70
Proportion Reporting Anal Intercourse During Lifetime (95 % CI)

b.


Sexually Active Female Youth
Africa
Pluddemann (2008) 48.1 42.8 53.3
Kazaura (2009) 5.4 3.1 8.9
Nel (2011) 1.7 1.1 2.5
Summary 18.4 0.0 42.1 99.7
Latin America
Alzate (1978) 28.2 15.6 45.1
George (2007) 6.2 2.3 14.4
Yu (2007) 13.0 3.4 34.7
Caetano (2010) 29.1 20.8 39.0
Summary 19.1 8.6 29.7 78.4
Asia
Rosenthal (1994) 10.5 1.8 34.5
Ma (2009) 3.1 1.8 5.2
Perera (2006) 28.0 16.7 42.7
Zhang (2013) 6.5 2.1 16.5
Summary 12.0 3.1 20.9 84.0
North America
Story (1982) 38.9 23.6 56.5
Story (1982) 21.1 10.1 37.8
Cochran (1989) 18.4 12.0 27.0
Cochran (1991) 15.9 7.2 30.7
Kotloff (1991) 31.5 29.2 33.9
MacDonald (1990) 18.6 17.0 20.3
Reinisch (1992) 22.3 18.1 27.1
Hsu (1994) 29.2 20.6 39.5
Reinisch (1995) 17.9 13.4 23.3
Flannery (2003) 32.5 29.2 35.9
Stanton (1994) 42.9 22.6 65.6
Rotheram–Borus (1999) 7.5 3.3 15.6
Foxman (1997) 2.5 0.1 14.7
Gilbert (1998) 13.5 10.7 16.8
Misegades (2001) 21.7 20.1 23.4
Hensel (2008) 8.0 5.3 12.0
Higgins (2010) 26.6 23.5 29.9
Flannery (2003b) 15.6 11.7 20.4
Ompad (2006) 17.4 15.0 20.1
Leichliter (2007) 28.9 28.1 29.6
Roye (2010) 31.3 26.5 36.5
Gurman (2010) 32.5 29.2 36.0
Langille (2005) 16.3 13.3 19.7
Auslander (2009) 12.9 8.7 18.5
Fielder (2010) 10.9 4.1 24.4
Childs (2008) 36.8 17.2 61.4
Chandra (2011) 31.1 30.3 31.9
Rahman (2013) 20.8 18.5 23.3
Silverman (2011) 27.0 22.5 31.9
Herbenik (2010) 36.4 30.4 42.8
Jozokowski (2013) 24.8 21.2 28.8
DeMaria (2011) 16.7 12.6 21.8
Summary 22.0 25.3 28.6 97.4
Europe
Breakwell (1992) 11.9 9.9 14.2
Stankovic (2009) 22.1 18.2 26.5
Edgardh (2002) 25.8 15.9 38.7
Tyden (2011) 27.3 22.6 32.5
Edgardh (2000) 10.8 8.7 13.4
Haggstrom–Nordin (2005) 21.5 16.6 27.3
Stone (2006) 17.5 13.9 21.7
Tyden (2011) 32.1 27.0 37.7
Stulhofer (2012) 21.5 17.9 25.5
Tyden (2011) 39.4 34.3 44.8
Stulhofer (2011b) 29.8 25.5 34.5
Summary 23.6 18.6 28.6 94.8
Overall Summary 21.5 18.7 24.3 98.4
ACASI
SAQ
FTFI
Estimate 95% CI I^2
0.0 10 20 30 40 50 60 70
Proportion Reporting Anal Intercourse During Lifetime (95 % CI)

c.

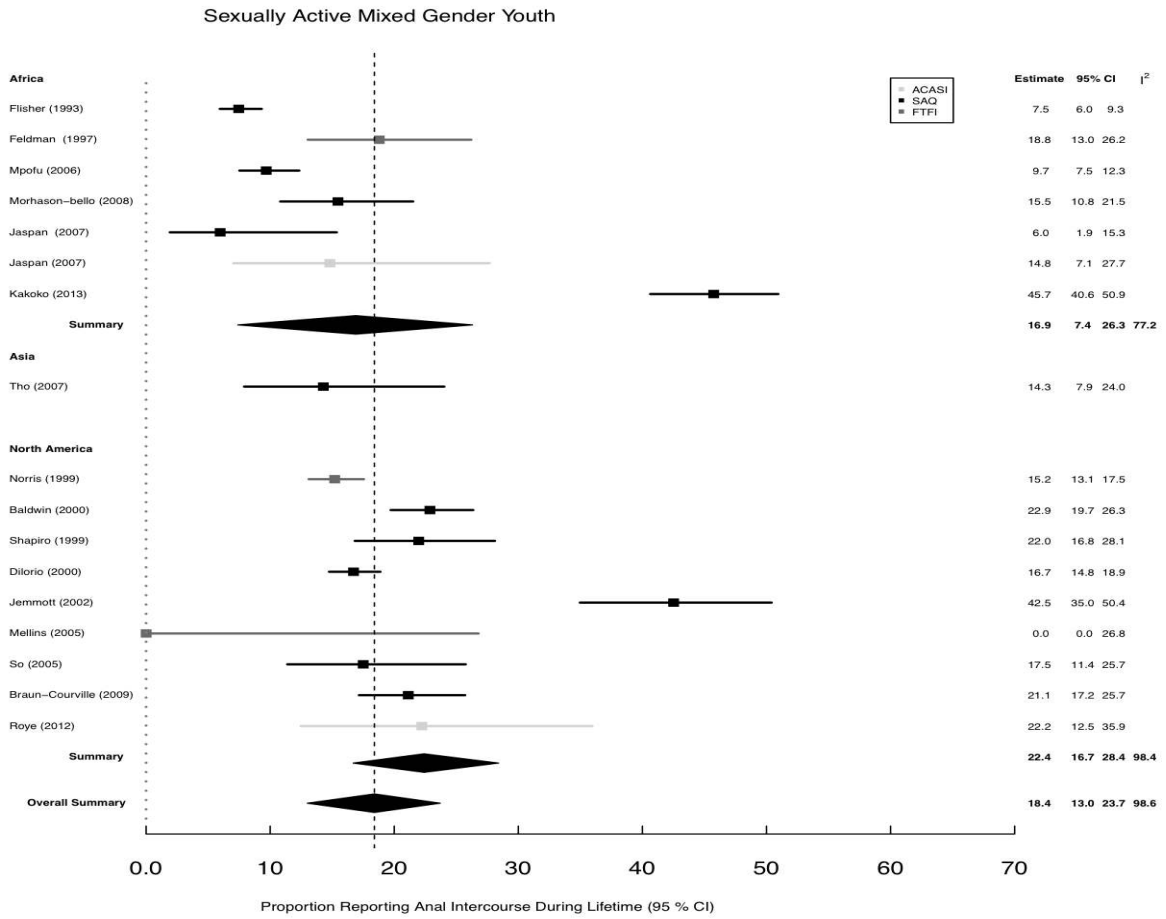


Figure A4.2. Forest plots of lifetime prevalence of AI among non-higher risk (a) sexually active male, (b) female, and (c) mixed gender young people

REVIEW ON AI PRACTICE AMONG SOUTH AFRICANS

Table A4.3. Study and participant characteristics of studies included in the review on AI practice among South Africans

A. Outcomes and key study characteristics		**General risk N=29**		Higher risk N=14		Total N=41
Outcomes reported	AI prevalence	21	[2,3,35,65,68,69,88,108,137–149]	7	[65,150–155]	27[b]
	UAI prevalence only [a]	4	[156–159]	0	-	4
	AI frequency	6	[135,140,156,160–162]	9	[153,155,162–168]	14 [b]
AI prevalence recall period	Lifetime	10	[3,35,68,69,88,138,142–144,146]	2	[154,155]	12
	12 Months	1	[2]	0	-	1
	6 Months	3	[140,145,159]	0	-	3
	3 Months	6	[139,141,144,149,156,158]	0	-	6
	1 Month	3	[137,148,157]	1	[153]	4
	Current partner	1	[65]	1	[65]	1[b]
	General[c]	2	[108,147]	0	-	2
	Not stated	0	-	3	[150–152]	3
AI frequency recall period	6 Months	1	[140]	0	-	1
	3 Months	3	[135,156,162]	3	[162,165,168]	5[b]
	42 Days	0	-	1	[166]	1
	1 Month	2	[160,161]	3	[153,163,167]	5
	1 Week	0	-	2	[155,164]	2
Gender	Male & female	8	[2,3,108,135,144,157,159,160]	0	-	8
	Female only	13	[35,137,138,141,142,145–149,156,158,161]	6	[150,151,153–155,164]	19
	Male only	2	[65,139]	2	[65,152]	3[b]
	Mixed only	6	[68,69,88,140,143,162]	6	[162,163,165–168]	11[b]
Mean age	<25 years	15	[2,3,35,68,69,88,108,135,137,141–144,147,149]	2	[150,154]	17
	25+ years	13	[65,138–140,145,146,148,156–158,160–162]	11	[65,151–153,162–168]	22[b]
	Not stated	1	[159]	1	[155]	2
Study sample	Community	18	[2,35,65,69,135,138,139,141–143,146,148,149,156–159,162]	0	-	18
	Community and shebeen	1	[160]	0	-	1
	Shebeen	2	[157,161]	0	-	2
	University	2	[65,108]	0	-	2
	School	4	[3,68,88,144]			4
	Clinic	3	[137,145,147]	0	-	3
	VCT	1	[140]	0	-	1
	STI clinic patients	0	-	4	[65,162,165,167]	4
	HIV-infected	0	-	3	[163,166,168]	3
	FSW	0	-	5	[150,151,154,155,164]	5
	Clients of FSW	0	-	1	[152]	1
	"High-risk"[d]	0	-	1	[153]	1
Province	Western Cape	11	[3,65,69,88,135,144,156,157,160–162]	4	[162,165–167]	14[b]
	KwaZulu-Natal	4	[137,138,146,147]	8	[65,150–153,155,164,168]	11[b]
	Elsewhere, multiple or not stated	16	[2,35,65,68,108,139–143,145,146,148,149,158,159]	2	[154,163]	18
Urban or rural	Urban	24	[3,65,69,88,135,137–144,146–149,156–162]	11	[65,153–155,162–168]	33[b]
	Rural	6	[35,68,137,138,145,147]	0		6
	Mixed or not stated	3	[2,108,146]	3	[150–152]	5[b]
Survey year	Pre-2005	12	[2,65,68,88,108,135,140,146,147,156,158,162]	9	[65,150–155,162,164]	19[b]
	2005 onwards	17	[3,35,69,137–139,141–145,148,149,157,159–161]	5	[163,165–168]	22

B. Study quality and potential for bias		General risk N=29		Higher risk N=14		Total
Interview method	ACASI	8	[3,69,139,142,146,148,149,161]	3	[163,165,167]	11
	SAQ	9	[68,69,88,108,135,156,157,160,162]	3	[151,152,162]	11[b]
	ACASI or SAQ	1	[144]	0	-	1
	SAQ or FTFI	0		1	[155]	1
	FTFI	13	[2,35,65,137,138,140,141,143,145,147,148,158,159]	5	[65,153,154,164,168]	17[b]
	Coital diary	0	-	1	[164]	1
	Telephone	0	-	1	[166]	1
	Not stated	0	-	1	[150]	1
Study design	Cross-sectional	18	[2,3,35,65,68,69,88,108,135,140,142–145,156,157,160,162]	10	[65,150,152–154,162–164,166,168]	26[b]
	Cohort	2	[147,161]	2	[151,165]	4
	RCT	9	[137–139,141,146,148,149,158,159]	2	[155,167]	11
Sampling method	Convenience	19	[35,65,108,135,137,140,141,143,145–149,156–158,160–162]	12	[65,150–152,154,155,162,163,165–168]	29[b]
	SRS	2	[2,69]	0	-	2
	CRS	5	[3,68,88,139,144]	0	-	5
	RDS	1	[142]	0	-	1
	Not stated	2	[138,159]	2	[153,164]	4
AI first mentioned	Title	2	[2,162]	2	[150,162]	3[b]
	Abstract	5	[3,68,88,144,156]	4	[152,163,164,167]	9
	Text	22	[35,65,69,108,135,137–143,145–149,157–161]	8	[65,151,153–155,165,166,168]	29[b]
Response rate	≥80%	9	[69,135,144,147,156,157,160–162]	2	[152,162]	10[b]
	<80%	0	-	2	[165,167]	2
	Not stated	20	[2,3,35,65,68,88,108,137–143,145,146,148,149,158,159]	10	[65,150,151,153–155,163,164,166,168]	29[b]
Heterosexual only[e]	Yes	5	[65,88,139,143,162]	3	[65,152,162]	6[b]
	No	11	[2,3,68,69,108,135,140,144,157,159,160]	5	[163,165–168]	16
	Not applicable[f]	13	[35,137,138,141,142,145–149,156,158,161]	6	[150,151,153–155,164]	19
Language of survey	Regional lang. only	1	[68]	2	[152,166]	3
	Regional lang. & English	17	[2,3,65,69,135,139–144,148,156,157,160–162]	7	[65,153,162,163,165,167,168]	22[b]
	Not stated	11	[35,88,108,137,138,145–147,149,158,159]	5	[150,151,154,155,164]	16

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

[a]The sum of some subgroups is greater than total number of included articles because several articles provided AI data in more than one category. [b]Refers to non-higher risk participants recruited locally through posters, advertisements, from home visits or community venues etc. [c]Three studies recruited 'at risk' young people, which were variously defined as: reporting recent sex unprotected by condoms, having recently been arrested, being a crack user, having had multiple sex partners in the past year.

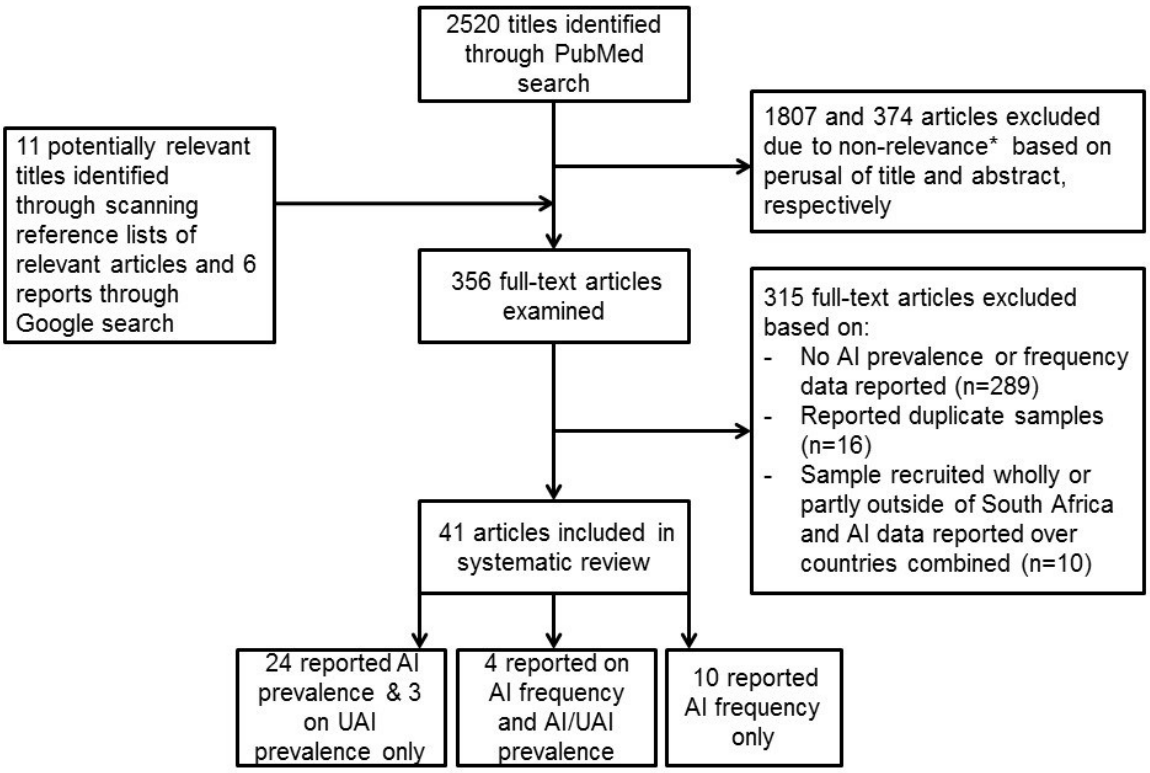


Figure A4.3: Summary of article search and selection.

*Non-relevance included no reference to heterosexual sex behaviour and studies conducted outside of South Africa.

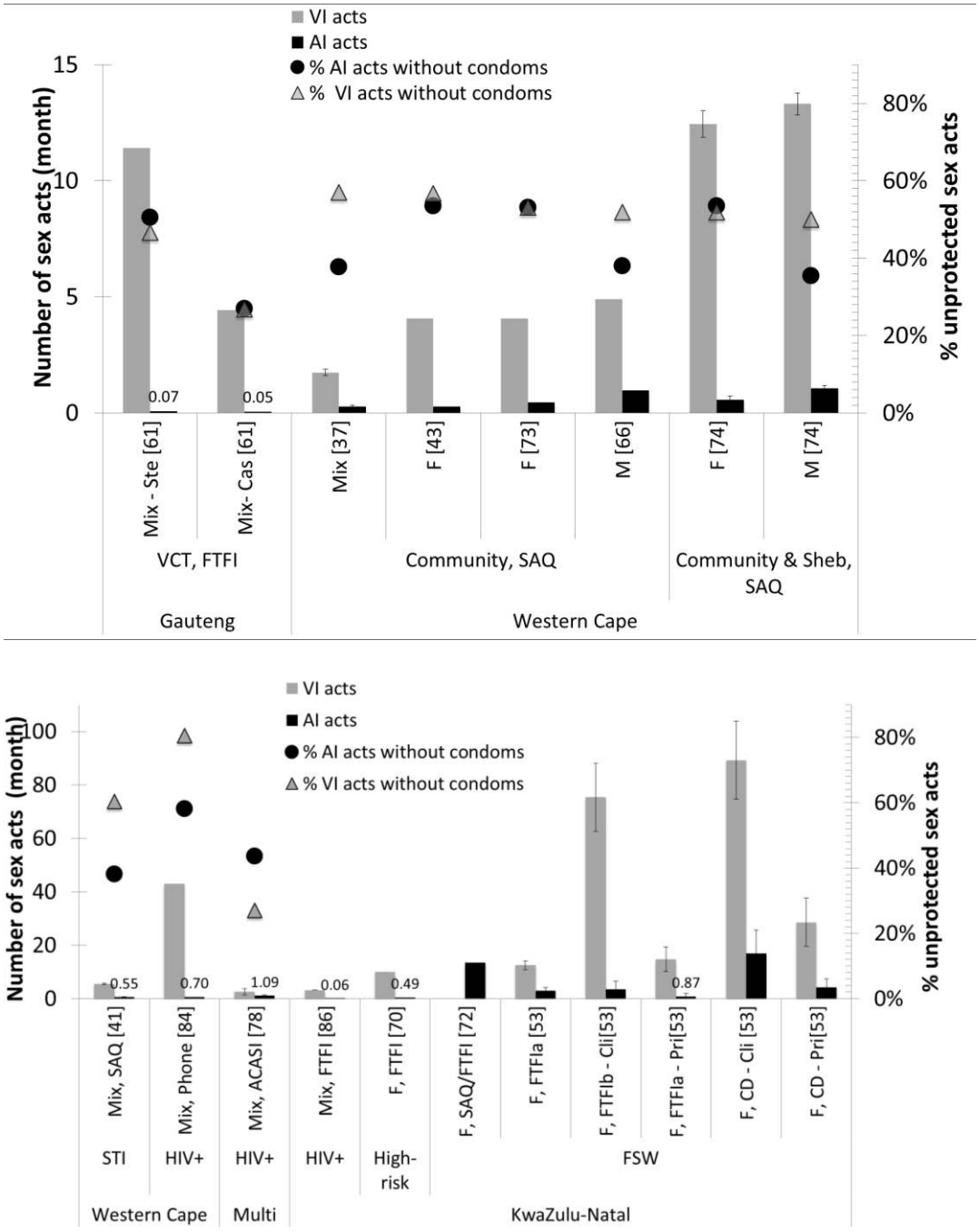
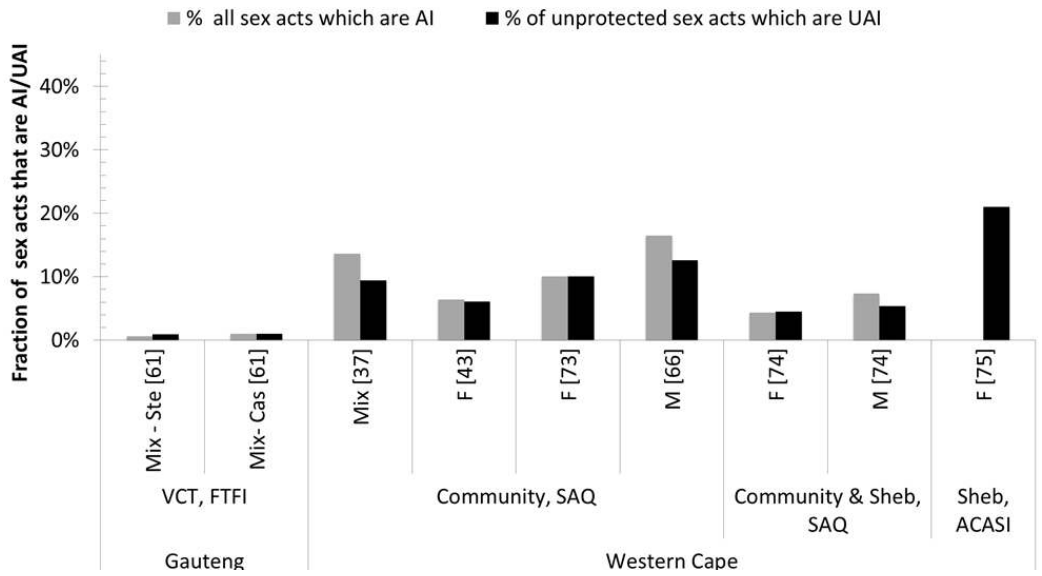


Figure A4.4. Monthly frequency of VI and AI acts and fraction of unprotected sex acts Bar chart of the number of VI and AI acts reported per month and scatter plot of the fraction of AI and VI acts that are unprotected among a) general risk study participants and b) higher risk study participants.

AI=anal intercourse, ACASI=audio computer assisted self-interview, Cas=with casual partners, Cli=with clients, FTFI=face-to-face interview, FTFIa=weekly FTFI, FTFIb=daily FTFI, Mix=data only available for men and women combined; N=sample size; STI clinic=sexually transmitted infections clinic patients, Pri=with primary partner, SAQ=self-administered questionnaire; Ste=with steady partner, VI=vaginal intercourse; Shebeens = informal drinking establishments, VCT=voluntary counselling and testing. Recall period refers to the original period, but the figure shows the number of acts per month.

a.



b.

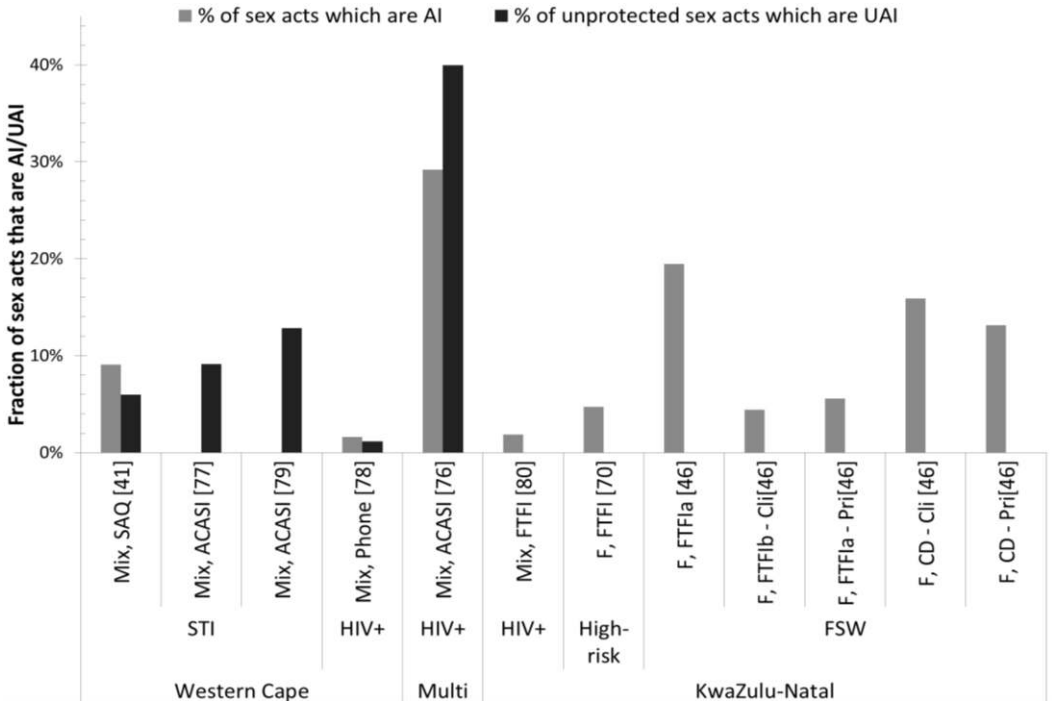


Figure A1.5. Bar chart of fraction of sex acts that are AI and fraction of unprotected acts that are UAI among A) general risk study participants and B) higher risk study participants.

AI=anal intercourse, ACASI=audio computer assisted self-interview, Cas=with casual partners, Cli=with clients F=female, FTFI=face-to-face interview, FSW=female sex workers, High-risk=defined by authors as high-risk of HIV infection, 79% were FSW, M=male, Mix=data available for mixed gender only, N=sample size, Pri=with primary partner, SAQ=self-administered questionnaire, Sheb=Shebeen, which are informal drinking establishments, Ste=with steady partner, STI clinic=sexually transmitted infections clinic patients, VCT=voluntary counselling and testing, UAI=unprotected anal intercourse, VI=vaginal intercourse.

Table A4.4. Summary of a) study and participant characteristics and b) quality of included studies

A. Outcomes and key study characteristics		N=129	Studies
Outcomes reported[a]	AI prevalence	122	[133,150,151,154,155,169–285]
	UAI prevalence only[b]	4	[286–289]
	AI frequency	13	[155,164,172,178,179,184,210,218,256,266,267,290,291]
AI prevalence recall period[a]	Lifetime	30	[154,172,173,175,178–180,183,184,187,188,193,203,208,213,228,232,234,247–250,253,254,257,259,267,268,270,272]
	12 Months	6	[211,216,233,247,266,277]
	6 Months	10	[199,204,207,212,227,237,241,269,279,289]
	3 Months	7	[133,169,170,181,186,275,286]
	2 Months	1	[240]
	1 Month	17	[155,171,182,184,206,209,218,221–223,226,227,263,266,267,274,287]
	15 days	1	[189]
	7 days	8	[192,206,223,235,246,251,255,266]
	1 day	1	[191]
	With last client	1	[285]
	Offer service[c]	35	[150,172,185,194–198,200,202,205,210,214,215,217,220,224,225,236,238,239,242–244,252,258,260,262,264,271,276,280,282,284,288]
	Current primary partner	3	[172,200,244]
	Not stated	20	[151,174,176,177,190,200,201,219,229–231,245,261,262,265,273,278,281–283]
AI practice reported by partner type[a]	With any type	66	[133,151,154,155,164,169,170,173–179,181,184,187,188,190,193,199,201,203,208,211,216,218,219,223,226,228–235,237,240,245,246,250,253,254,256,257,259,261,263,265–268,270,272–274,277–279,281,283,289–291]
	Clients[d]	61	[150,180,182,183,185,186,189,191,192,194–198,200,202,204–207,209,210,212–215,217,220–222,224,225,227,236,238,239,241–244,247–249,251,252,255,258,260,262,264,269,271,275,276,280,282,284–288]
	One-time or new clients	3	[171,172,266]
	Regular clients	3	[171,172,266]
	Primary or non-paying partner(s)	14	[171,172,200,206,207,213,222,227,244,249,262,266,275,282]
Continent[a]	Africa	33	[150,151,154,155,164,169–177,215,232,233,245,246,253,254,256,259,265–267,272,277,281,284,285,290,291]
	Asia	53	[155,178–184,186–189,191–194,196,197,200,207–209,211,214,216,219,221,222,225,226,228,230,231,236–243,247,250–252,261,263,264,271,274,275,278,287]
	Europe	23	[195,198,201–206,210,212,218,220,235,244,248,255,258,262,268,269,276,279,288]
	South America	10	[185,190,213,220,229,249,260,270,273,283]
	North America	13	[133,199,217,223,224,227,234,257,280,282,286,289]
Mean age[ae]	<28 years	71	[133,150,151,154,155,164,170,175–177,180,188–193,195–197,199,205–207,209,212,213,215–217,220,221,224,226,228,231–237,239,240,244–246,250,252–254,256,259–261,263–267,269,271–273,276,277,281,285,289–291]
	28+ years	55	[150,155,169–172,174,178,181–184,186,187,197,198,200–204,208,210,211,214,218–220,222,223,225,227,229,230,238,241–243,247,249,251,255,257,261,264,268,270,275,278,280,282,284,286–289]
	Not stated	6	[173,179,185,194,248,283]
Survey year[e]	Pre-2003	64	[150,151,154,155,164,172,174–177,185,190–194,197–206,214,215,217,219–221,224,229,234,235,240,242,244,246,248,250,252,253,256–264,268–270,276,277,279–283,290]
	2003 onwards	65	[133,169–171,173,178–184,186–189,195–197,207–213,216,218,222,223,225–228,230–233,236–239,243,245,247,249,251,254,255,265–267,271–275,278,284–289,291]
Workplace[a]	Indoors	32	[174,178,180,191,193,196,202,204,209,213,219–221,226,230,231,233,235,236,239,240,257,259–261,263–265,268,271,277,278]
	Outdoors	12	[150,151,155,177,203,220,235,244,248,255,264,280]
	Mixed indoors and outdoors	37	[154,179,181–183,185,187,189,192,195,197,206,211,212,215,217,224,228,229,237,238,241,245,249,250,252,254,261,272–274,281,284,285,289–291]
	Not stated	53	[133,155,164,169–173,175,176,184,186,188,190,194,198–201,205,207,208,210,214,216,218,222,223,225,227,232,234,242,243,246,247,251,253,256,258,262,266,267,269,270,275,276,279,282,283,286–288]
Mean number of clients per week[ae]	<10	44	[169,170,172,175,180,183,184,189,205,207–209,211,215,216,221,224,225,227,228,232,236,239–243,246,247,249–252,254,257,258,271,272,277,279,282,289–291]
	10+	46	[150,151,154,155,164,171,174,176–178,181,182,185–187,190–193,195,198,201,202,204,209,210,212,219,230,231,235,255,256,261–264,266,268,270,273,278,280,283,284,289]
	Not stated	40	(4–6,8,9,11,16,23,25,30,39,45,47,50,51,54,60,61,64,66,68,71,74,78,81,82,87,88,90,94,100,103,107,112,115,117,118,127,129,124)

B. Study quality and potential for bias		N=129	Studies
Interview method[a]	ACASI	9	[133,169,207,212,234,247,267,275,286]
	SAQ	6	[210,217,239,262,276,283]
	SAQ or FTFI[f]	2	[197,205]
	FTFI	110	[150,151,154,164,169–196,198–204,206,208,209,211,213–216,218–222,224–233,235–238,240–246,248–261,263–266,268–274,277–282,284,285,287–289,291]
	Coital diary	4	[155,164,223,290]
	Polling box	1	[287]
Study design	Cross-sectional	114	[133,150,154,164,169,170,172,173,175–177,179–187,189–192,194–198,200–212,215–218,220–245,247–257,259–268,270–288,290,291]
	Cohort[g]	11	[151,171,178,188,193,199,214,246,258,269,289]
	Randomised-controlled trial[g]	4	[155,174,213,219]
Sampling method	Convenience	94	[133,150,151,154,155,164,169–171,173,175–177,181,183,186,189–193,198–206,210,214,215,217–221,223–231,235,237–246,248–264,268–270,273–283,285,286,288–291]
	Simple-randomised sampling	5	[172,194,213,261,265]
	Cluster-randomised sampling	7	[180,184,196,208,209,234,236]
	Respondent-driven sampling	19	[174,182,185,188,195,197,207,212,216,222,232,233,247,266,267,271,272,284,287]
	Time-location sampling	4	[178,179,187,211]
Place in paper where AI is first mentioned	Title	12	[150,170–173,184,207,208,211,266,286]
	Abstract	33	[133,164,169,174,178–183,185–189,191,195–200,209,212,213,217,226,255,259,267,277,285,289]
	Text	84	[151,154,155,175–177,190,192–194,201–206,210,214–216,218–225,227–254,256–258,260–265,268–276,278–284,287,288,290,291]

AI=anal intercourse, ACASI=audio-computer assisted self-interview, FTFI=face-to-face interview, SAQ=self-administered questionnaire, UAI=unprotected anal intercourse.
[a]The sum is greater than the total number of included studies because several studies provided AI data in more than one category. [b]Studies which reported AI prevalence for unprotected AI only. [c]Several studies asked whether participants practiced AI with clients generally, rather than specifying a recall period, which I refer to as offering AI as part of their service. [d]Not stated whether one-off or regular. [e]Numerical variables were dichotomised at the median. [f]Depending on participant preference/ability. [g]Baseline data only extracted.

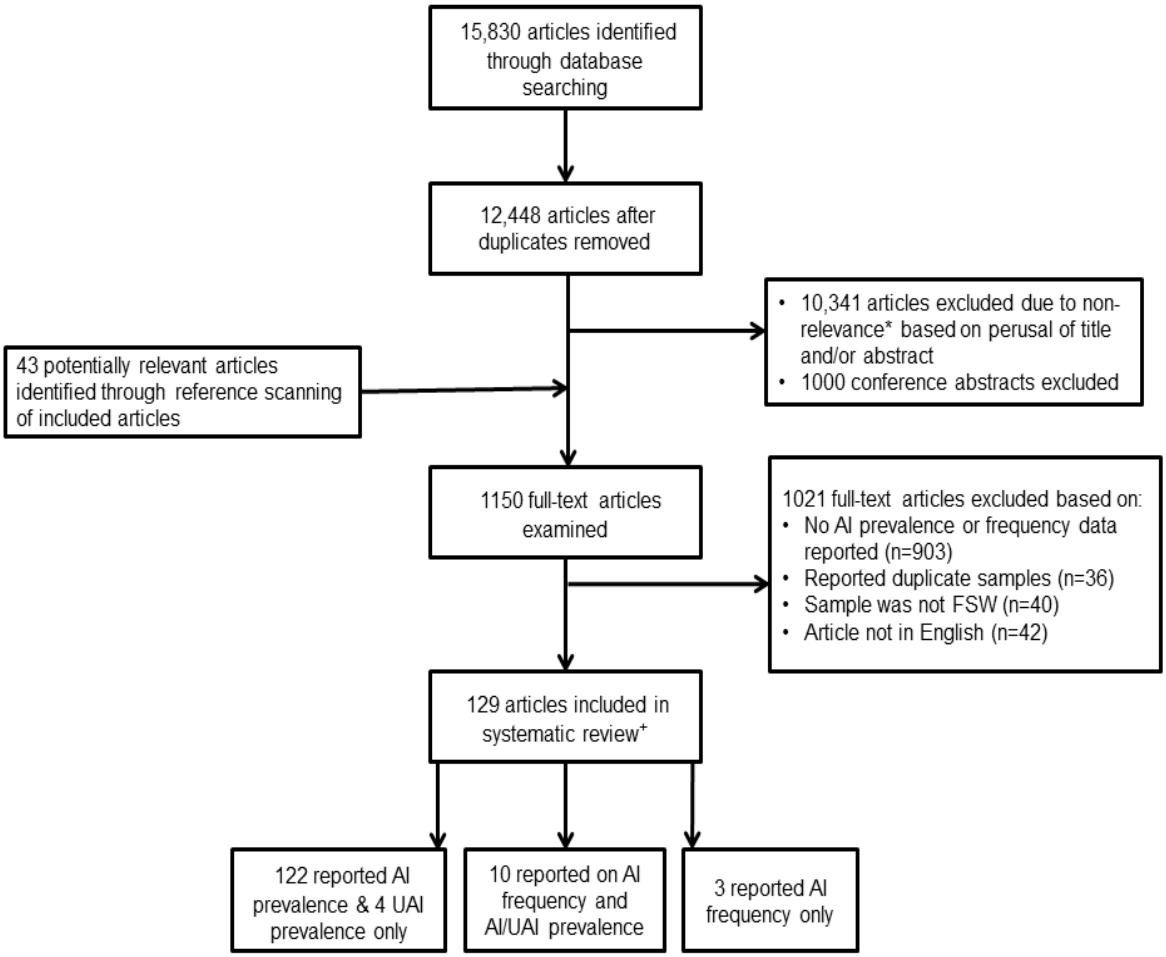
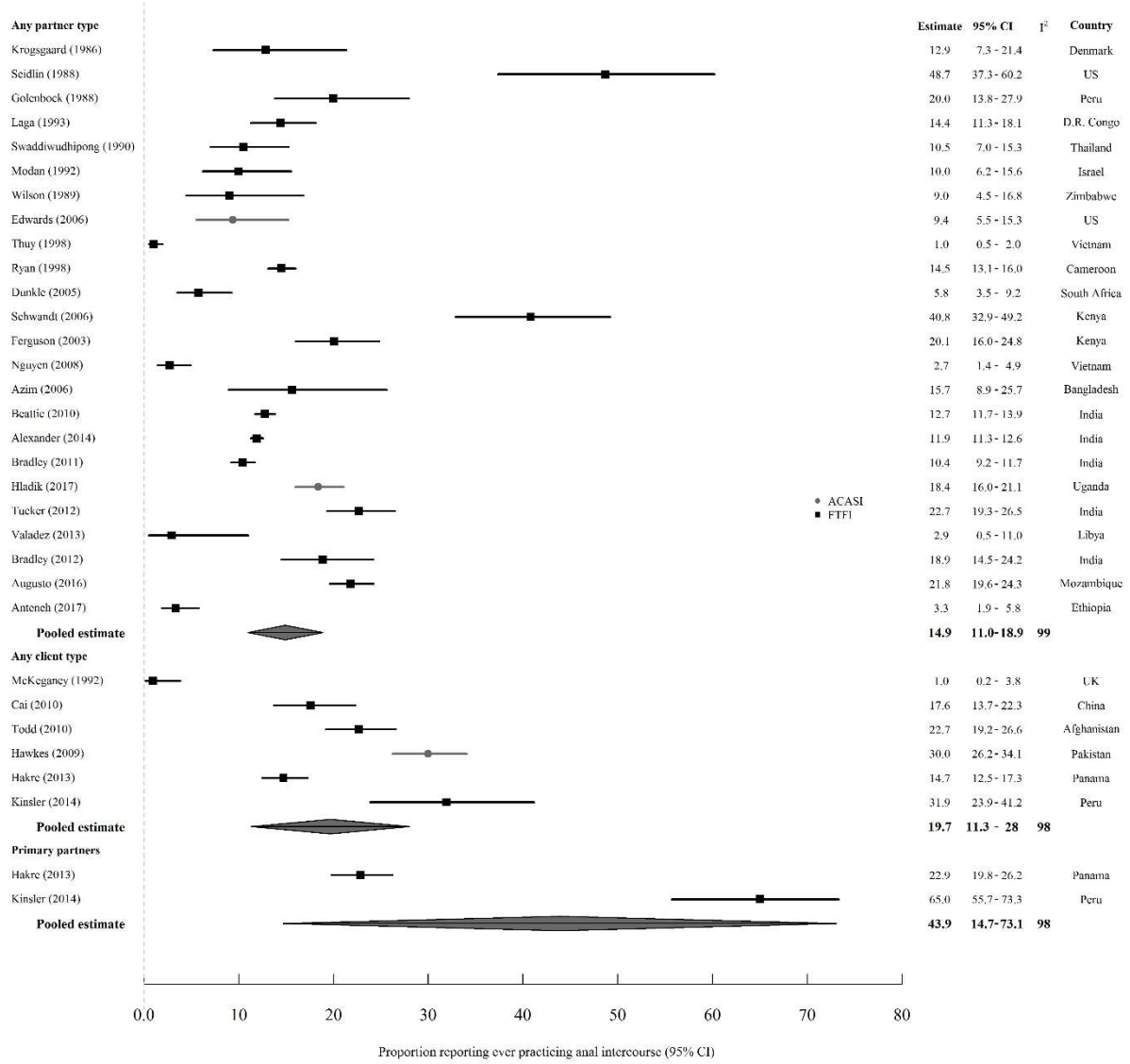
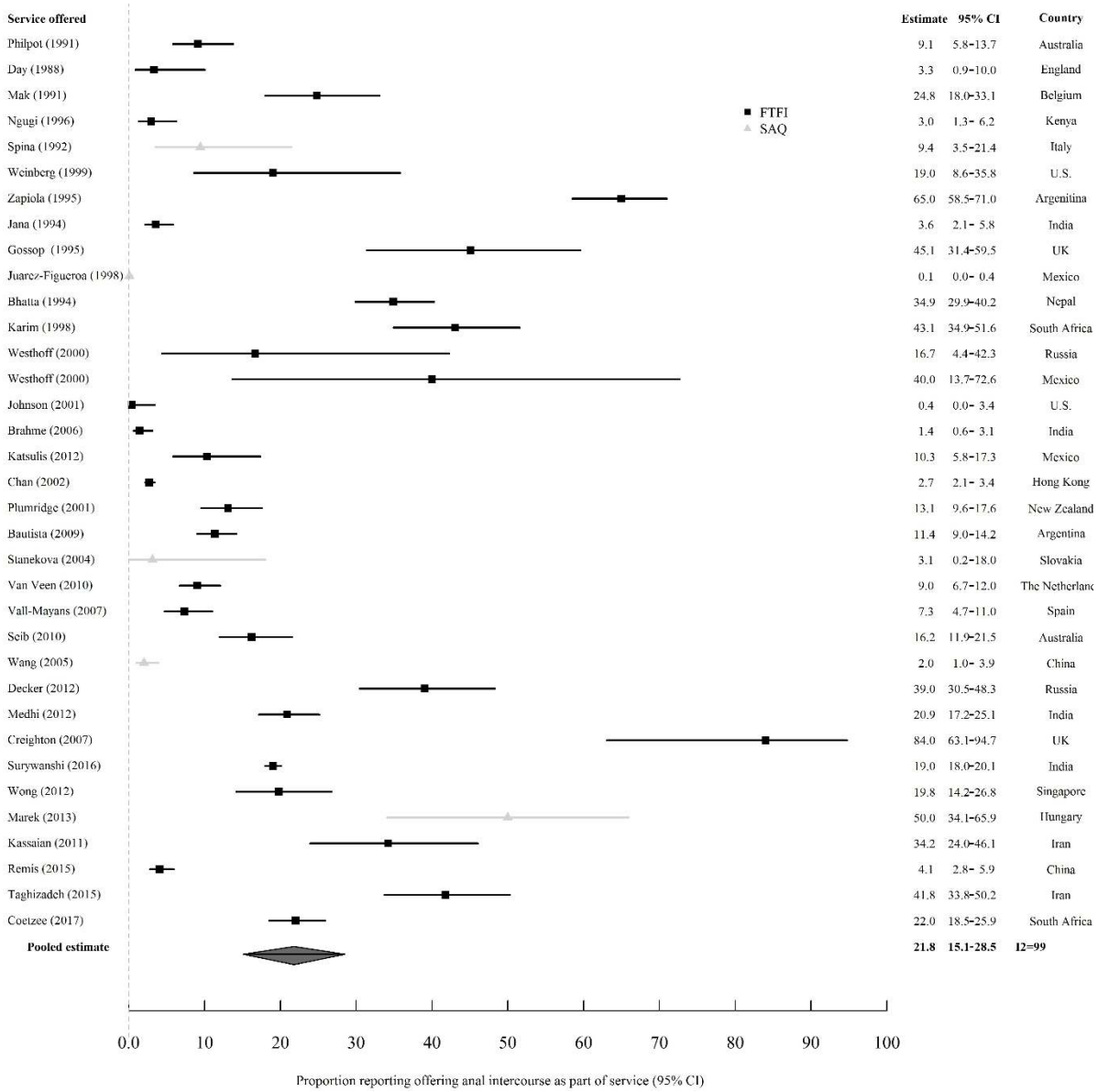


Figure A4.6. Summary of article search and selection.
*Non-relevance was defined as not referring to sexual behaviour among FSW.
+Two of the included studies were identified through reference scanning, with the remainder identified through the database searches.

a


Any partner type
Krogsgaard (1986)
Seidlin (1988)
Golenbock (1988)
Laga (1993)
Swaddiwudhipong (1990)
Modan (1992)
Wilson (1989)
Edwards (2006)
Thuy (1998)
Ryan (1998)
Dunkle (2005)
Schwandt (2006)
Ferguson (2003)
Nguyen (2008)
Azim (2006)
Beattie (2010)
Alexander (2014)
Bradley (2011)
Hladik (2017)
Tucker (2012)
Valadez (2013)
Bradley (2012)
Augusto (2016)
Anteneh (2017)
Pooled estimate
Any client type
McKegancy (1992)
Cai (2010)
Todd (2010)
Hawkes (2009)
Hakre (2013)
Kinsler (2014)
Pooled estimate
Primary partners
Hakre (2013)
Kinsler (2014)
Pooled estimate
ACASI
FTFI
Estimate 95% CI I² Country
12.9 7.3 - 21.4 Denmark
48.7 37.3 - 60.2 US
20.0 13.8 - 27.9 Peru
14.4 11.3 - 18.1 D.R. Congo
10.5 7.0 - 15.3 Thailand
10.0 6.2 - 15.6 Israel
9.0 4.5 - 16.8 Zimbabwe
9.4 5.5 - 15.3 US
1.0 0.5 - 2.0 Vietnam
14.5 13.1 - 16.0 Cameroon
5.8 3.5 - 9.2 South Africa
40.8 32.9 - 49.2 Kenya
20.1 16.0 - 24.8 Kenya
2.7 1.4 - 4.9 Vietnam
15.7 8.9 - 25.7 Bangladesh
12.7 11.7 - 13.9 India
11.9 11.3 - 12.6 India
10.4 9.2 - 11.7 India
18.4 16.0 - 21.1 Uganda
22.7 19.3 - 26.5 India
2.9 0.5 - 11.0 Libya
18.9 14.5 - 24.2 India
21.8 19.6 - 24.3 Mozambique
3.3 1.9 - 5.8 Ethiopia
14.9 11.0 - 18.9 99
1.0 0.2 - 3.8 UK
17.6 13.7 - 22.3 China
22.7 19.2 - 26.6 Afghanistan
30.0 26.2 - 34.1 Pakistan
14.7 12.5 - 17.3 Panama
31.9 23.9 - 41.2 Peru
19.7 11.3 - 28 98
22.9 19.8 - 26.2 Panama
65.0 55.7 - 73.3 Peru
43.9 14.7 - 73.1 98
0.0 10 20 30 40 50 60 70 80
Proportion reporting ever practicing anal intercourse (95% CI)

b


Service offered
Estimate
95% CI
Country
Philpot (1991) 9.1 5.8-13.7 Australia
Day (1988) 3.3 0.9-10.0 England
Mak (1991) 24.8 18.0-33.1 Belgium
Ngugi (1996) 3.0 1.3- 6.2 Kenya
Spina (1992) 9.4 3.5-21.4 Italy
Weinberg (1999) 19.0 8.6-35.8 U.S.
Zapiola (1995) 65.0 58.5-71.0 Argentina
Jana (1994) 3.6 2.1- 5.8 India
Gossop (1995) 45.1 31.4-59.5 UK
Juarez-Figueroa (1998) 0.1 0.0- 0.4 Mexico
Bhatta (1994) 34.9 29.9-40.2 Nepal
Karim (1998) 43.1 34.9-51.6 South Africa
Westhoff (2000) 16.7 4.4-42.3 Russia
Westhoff (2000) 40.0 13.7-72.6 Mexico
Johnson (2001) 0.4 0.0- 3.4 U.S.
Brahme (2006) 1.4 0.6- 3.1 India
Katsulis (2012) 10.3 5.8-17.3 Mexico
Chan (2002) 2.7 2.1- 3.4 Hong Kong
Plumridge (2001) 13.1 9.6-17.6 New Zealand
Bautista (2009) 11.4 9.0-14.2 Argentina
Stanekova (2004) 3.1 0.2-18.0 Slovakia
Van Veen (2010) 9.0 6.7-12.0 The Netherlan
Vall-Mayans (2007) 7.3 4.7-11.0 Spain
Scib (2010) 16.2 11.9-21.5 Australia
Wang (2005) 2.0 1.0- 3.9 China
Decker (2012) 39.0 30.5-48.3 Russia
Medhi (2012) 20.9 17.2-25.1 India
Creighton (2007) 84.0 63.1-94.7 UK
Surywanshi (2016) 19.0 18.0-20.1 India
Wong (2012) 19.8 14.2-26.8 Singapore
Marek (2013) 50.0 34.1-65.9 Hungary
Kassaian (2011) 34.2 24.0-46.1 Iran
Remis (2015) 4.1 2.8- 5.9 China
Taghizadeh (2015) 41.8 33.8-50.2 Iran
Coetzee (2017) 22.0 18.5-25.9 South Africa
Pooled estimate 21.8 15.1-28.5 I2=99
FTFI
SAQ
0.0
10
20
30
40
50
60
70
80
90
100
Proportion reporting offering anal intercourse as part of service (95% CI)

c

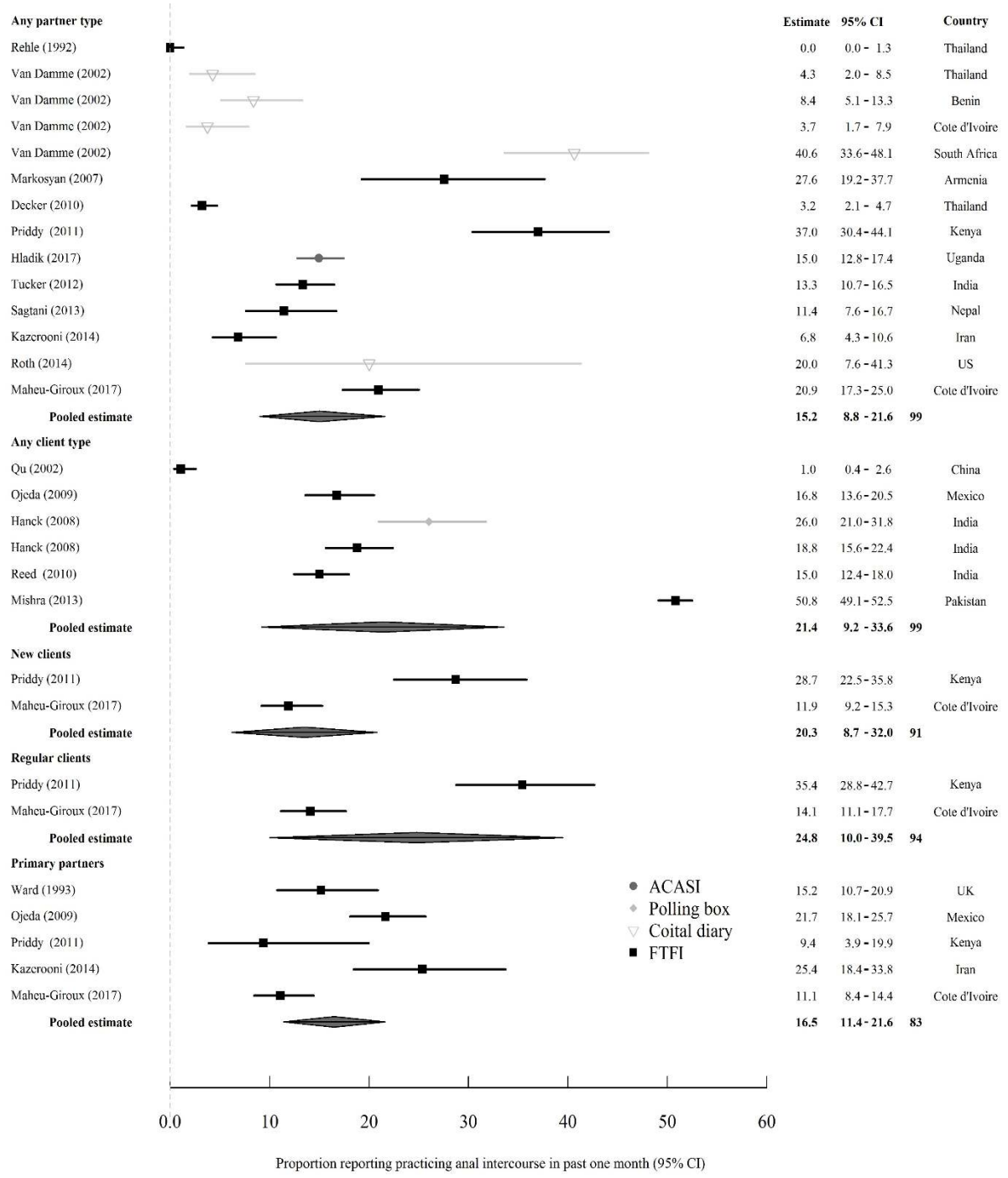
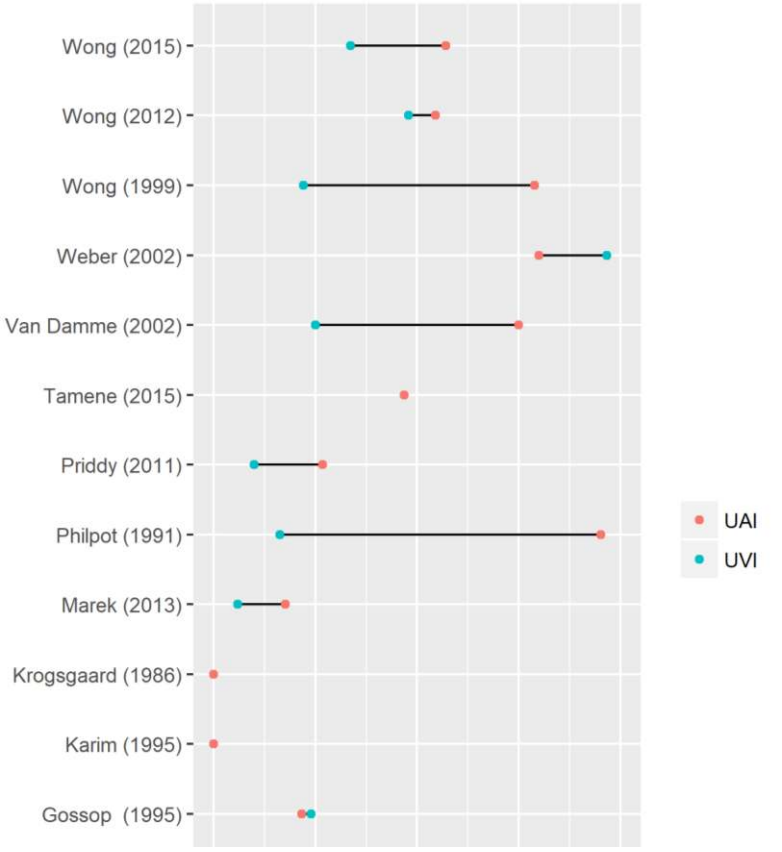


Figure A4.7. Forest plots of the prevalence of anal intercourse over a) lifetime, b) as part of service (i.e. FSW were asked whether they practiced AI with their clients), c) one month. Estimates are ordered by survey year and grouped by partner type.

95%CI=95% confidence interval. ACASI=audio computer assisted self-interview, FTFI=face-to-face interview, SAQ=self-administered questionnaire. I^2 lies between 0 and 100%; 0% indicates no observed heterogeneity and larger values show increasing heterogeneity.

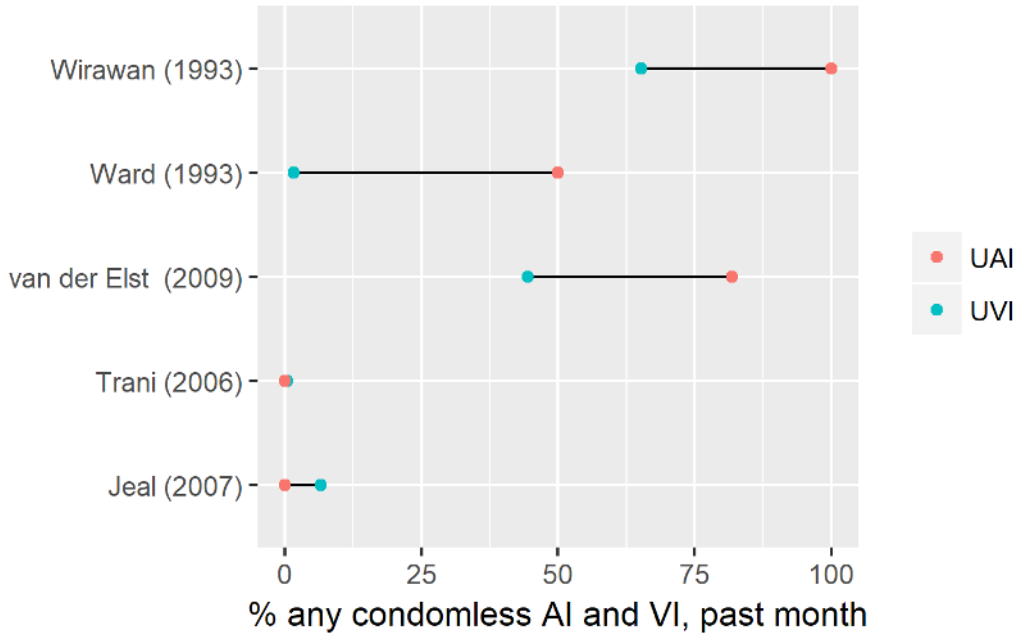
a


Wong (2015)
Wong (2012)
Wong (1999)
Weber (2002)
Van Damme (2002)
Tamene (2015)
Priddy (2011)
Philpot (1991)
Marek (2013)
Krogsgaard (1986)
Karim (1995)
Gossop (1995)
UAI
UVI

b


Roth (2014)
Markosyan (2007)
Maheu-Giroux (2017)
Kinsler (2014)
Kazerooni (2014)
Beattie (2010)
0
25
50
75
100
% any condomless AI and VI, past month
UAI
UVI

c



d

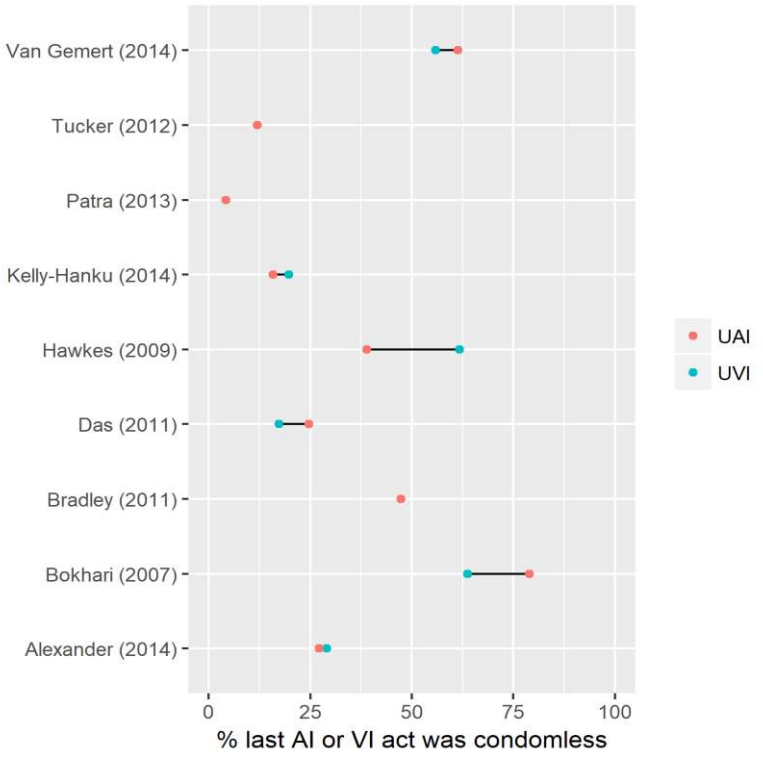


Figure A4.8. Individual study estimates the percentage reporting any AI and VI unprotected by condoms over the most common recall periods. Dot plots of the percentage of FSW reporting any AI unprotected by condoms among those who report practicing AI, a) generally (i.e. reporting ´sometimes or ´never´ using condoms during AI, b) in the past month, c) in the past week and d) at last sex act. The equivalent available estimates for VI of also plotted. The bars joining the UVI and UAI estimates are to visually aid comparison.

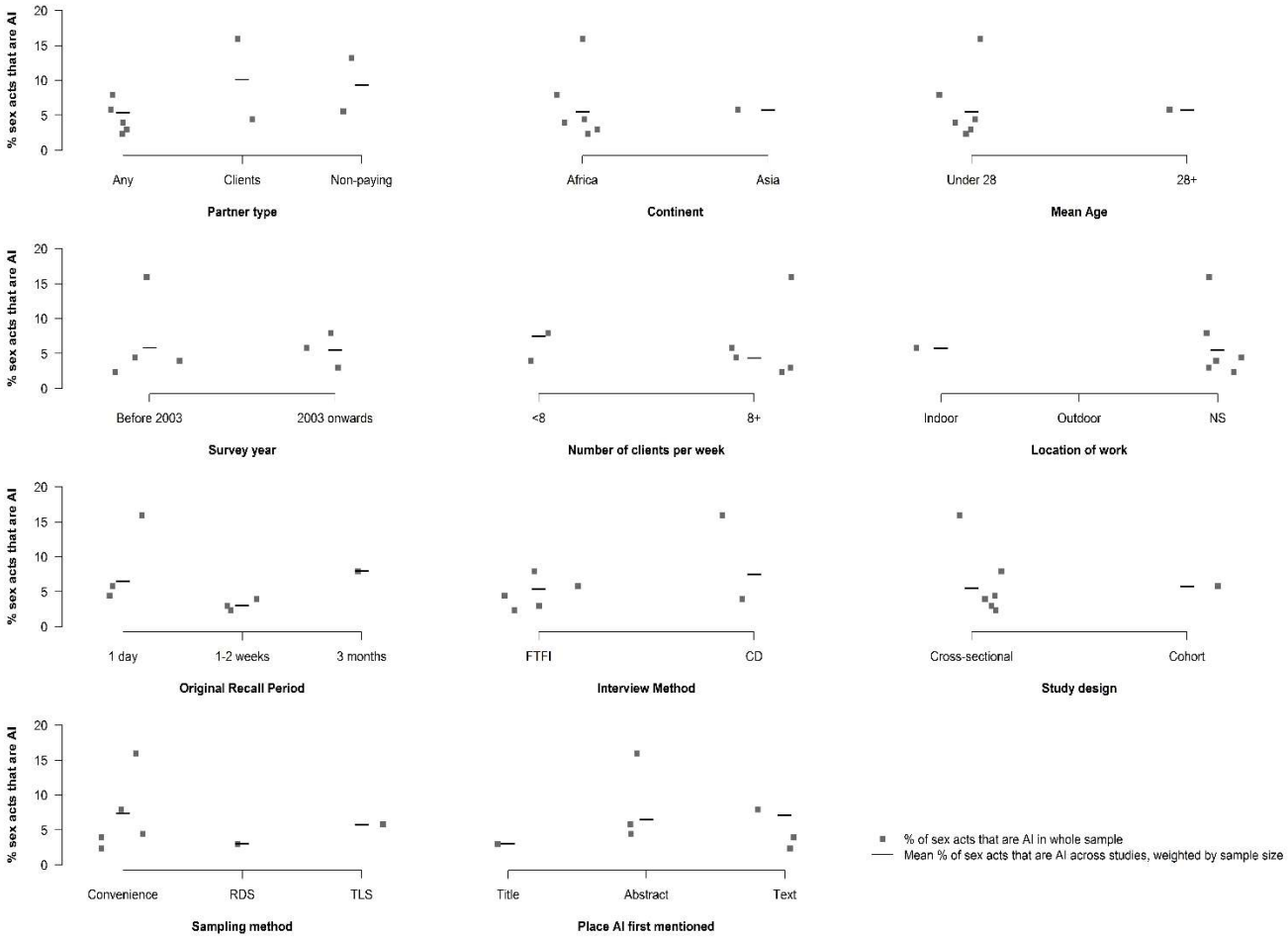


Figure A4.9. Proportion of sex acts that are anal by selected study and participant characteristics. Scatter plots of the proportion of sex acts that are anal among the whole sample (i.e. including those reporting no AI) participant characteristics and study characteristics.

ACASI=audio computer assisted self-interview, CD=coital diary, CRS=cluster-randomised sampling, FTFI=face-to-face interview, Mix=data only available for men and women combined, NS=not stated, RCT=randomised controlled trial, RDS=respondent-driven sampling, SAQ=self-administered questionnaire, SRS=simple randomised sampling, TLS= Time-location sampling.

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CHAPTER 5 APPENDIX

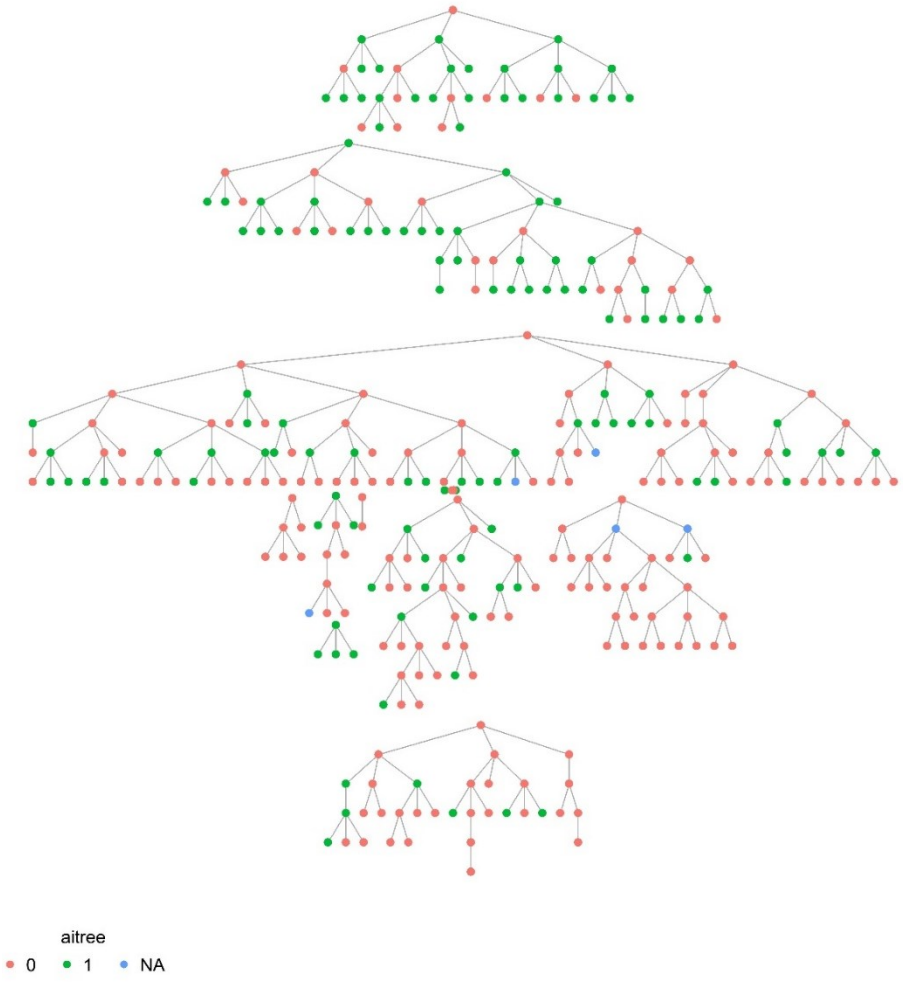

Figure A5.1. RDS recruitment network tree.

Dots which are unconnected to dots above represent seeds. Nine of 14 total seeds recruited other FSW. FSW reporting AI practice in the past month are represented by green dots, FSW who report no AI practice by red dots. FSW with missing values for AI practice are represented by blue dots

Table A5.1. Characteristics and behaviours included in the multivariable analysis, stratified by interviewer. The intraclass correlation coefficient (ICC) was used to measure potential interviewer effects between responses to individual interviewers

Variable	Category	N	Interviewer 1 N=86 Male, 30, HIV management n	%	Interviewer 2 N=57 Male, 31, HIV management n	%	Interviewer 3 N= 89 Female, 25, psychology n	%	Interviewer 4 N= 88 Female, 27, psychology n	%	ICC†
Outcomes											
Any AI in past month	No	191	34	40%	33	58%	56	63%	68	77%	0.096
	Yes	129	52	61%	24	42%	33	37%	20	23%	
Any AI with inconsistent condom use in past month¶	No	214	37	44%	43	77%	59	66%	75	85%	0.140
	Yes	104	48	57%	13	23%	30	34%	13	15%	
Personal characteristics											
Age	<26 years	167	55	64%	24	42%	46	52%	42	48%	0.007
	26+	153	31	36%	33	58%	43	48%	46	52%	
Highest level of education	Primary or lower	104	28	33%	20	35%	23	26%	33	38%	0.000
	Some secondary or higher	216	58	67%	37	65%	66	74%	55	63%	
Grew up	Urban	157	45	54%	33	59%	47	53%	32	36%	0.000
	Rural	148	39	46%	22	39%	39	44%	48	55%	
	Foreign country	12	0	0%	1	2%	3	3%	8	9%	
Number of dependents supported by sex work	0-2	153	48	56%	26	46%	39	44%	40	45%	0.001
	3+	167	38	44%	31	54%	50	56%	48	55%	
Individual behaviour											
Number of sex acts/week	<5	162	50	60%	33	61%	44	50%	35	40%	0.026
	5+	152	34	41%	21	39%	44	50%	53	60%	
Condom use at last sex with new or regular client‡	Condom used	242	71	84%	39	71%	68	76%	64	73%	0.000
	Condomless	75	14	17%	16	29%	21	24%	24	27%	
Number of new clients/month	<5	183	45	58%	40	74%	51	59%	47	53%	0.015
	5+	123	33	42%	14	26%	35	41%	41	47%	
	<7	184	40	48%	37	65%	59	68%	48	55%	0.026

Variable	Category	N	Interviewer 1 N=86 Male, 30, HIV management n	%	Interviewer 2 N=57 Male, 31, HIV management n	%	Interviewer 3 N= 89 Female, 25, psychology n	%	Interviewer 4 N= 88 Female, 27, psychology n	%	ICC†
Number of regular clients/month (5 NAs)	7+	131	43	52%	20	35%	28	32%	40	45%	
Number of non-paying partners/month	0 or 1	206	47	55%	40	70%	60	67%	59	67%	0.006
	2+	113	38	45%	17	30%	29	33%	29	33%	
Any drug use/year	No	207	55	64%	40	70%	54	64%	58	66%	0.028
	Yes	108	31	36%	17	30%	30	36%	30	34%	
Social discrimination/violence											
Ever blackmailed	No	210	53	62%	43	75%	63	71%	51	58%	0.014
	Yes	110	33	38%	14	25%	26	29%	37	42%	
Ever physically or verbally harassed	No	125	48	56%	24	42%	31	35%	22	25%	0.069
	Yes	195	38	44%	33	58%	58	65%	66	75%	
Ever raped since age 18	No	180	51	63%	31	54%	48	58%	50	61%	0.009
	Yes	123	30	37%	26	46%	35	42%	32	39%	
Ever afraid to access health services	No	180	48	56%	34	60%	55	62%	43	49%	0.001
	Yes	140	38	44%	23	40%	34	38%	45	51%	
Ever afraid to walk in public places	No	167	51	59%	30	53%	50	56%	36	41%	0.016
	Yes	153	35	41%	27	47%	39	44%	52	59%	
Social cohesion score§	High	157	35	47%	21	39%	51	61%	34	39%	0.034
	Low	141	39	53%	33	61%	32	39%	53	61%	
Knowledge and information access											
Knowledge of type of sex with highest transmission risk	Anal	34	13	15%	6	11%	6	7%	9	10%	0.001
	Other	286	73	85%	51	90%	83	93%	79	90%	
Tested for STIs/year	No	232	54	63%	50	88%	67	75%	61	69%	0.035
	Yes	88	32	37%	7	12%	22	25%	27	31%	
	No	45	15	18%	8	14%	18	21%	4	5%	0.031

Variable	Category	N	Interviewer 1 N=86 Male, 30, HIV management n	%	Interviewer 2 N=57 Male, 31, HIV management n	%	Interviewer 3 N= 89 Female, 25, psychology n	%	Interviewer 4 N= 88 Female, 27, psychology n	%	ICC[†]
Received information on HIV prevention/year	Yes	272	70	82%	49	86%	70	80%	83	95%	

AI=anal intercourse, ICC=intraclass correlation coefficient, STI=sexually transmitted infection. There were three pieces of information available on each interviewer: sex, age and educational background. 'HIV management' refers to having a qualification in the social management of the eSwatini's HIV/AIDS crisis.

[†]The ICC measures the percentage of the total variance for a particular question that is attributable to the interviewer. A zero value represents no interviewer effect, but as some variation across interviewers is to be expected, acceptable values are considered to be <0.07, with values above implying that respondents' answers were influenced by characteristics or behaviours of the interviewer when answering a survey question[30]. Two variables which were to be entered into the multivariable model were removed as the ICC indicated substantial interviewer effects (ICC>0.15) although they were not stigmatised topics (condom negotiation and social participation), which suggests that they were badly measured. The ICC measures differences between each individual interviewer.

[¶]AI practice with inconsistent condom use is defined as reporting having used condoms 'most of the time', 'sometimes', 'rarely' or 'never' during AI in the past month.

[‡]Condomless last sex with new or regular client was derived from two questions on condom use at last sex with new and regular clients separately, with condomless sex defined as reporting no condom use with either or both of these client types.

[§]The social cohesion score comprises of a series of questions on relationship with other FSW and was measured using a scale developed for use among FSW in Brazil[63]. Participants were asked to rate their agreement or disagreement with nine statements relating to mutual aid, support and trust among their peers, such as being able to count on colleagues to support the use of condoms and to help deal with violent or difficult clients. For analysis, the nine items were summed and the scores dichotomised at the median.

Table A5.2. Demographic, behavioural and structural determinants of practising anal intercourse with inconsistent condom use in the past month with any partner, among the whole sample of Swazi female sex workers (stratified by practice of AI with inconsistent condom use, and univariate and multivariable logistic regression with clustered standard errors). Stratified analysis shows crude data, logistic regression results are from models with imputed missing data.

			AI with inconsistent condom use/past month¶		No AI with inconsistent condom use/past month		Univariate		Multivariable†	
Variable	Categories	N	n	%	n	%	OR	95% CI	aOR	95% CI
Personal characteristics										
Age	<26 years	145	48	46	97	45	Ref	-	Ref	-
	26+	173	56	54	117	55	0.91	0.56-1.5	1.06	0.57-1.98
Highest level of education	Primary or lower	104	35	28	69	36	Ref	-	Ref	-
	Some secondary or higher	214	92	72	122	64	1.49	0.87-2.56	1.87*	1.01-3.47
Grew up	Urban	155	47	45	108	51	Ref	-	Ref	-
	Rural	148	52	50	96	46	1.31	0.83-2.09	1.94*	1.12-3.38
	Foreign country	12	5	5	7	3	1.66	0.54-5.07	7.11**	1.71-29.49
Number of dependents supported by sex work	0-2	152	52	50	114	53	Ref	-	Ref	
	3+	166	52	50	100	47	0.88	0.55-1.40	0.75	0.43-1.32
Individual behaviour										
Number of sex acts/week (5 NAs)	<5	199	77	76	122	58	Ref	-	Ref	-
	5+	114	25	25	89	42	0.45**	0.26-0.77	0.66	0.34-1.28
Number of new clients/month	<5	182	73	75	109	52	Ref	-	Ref	-
	5+	123	24	25	99	48	0.34***	0.20-0.58	0.31**	0.15-0.67
Number of regular clients/month	<7	183	63	62	120	57	Ref	-	-	
	7+	130	39	38	91	43	0.88	0.56-1.37	1.37	0.75-2.42
Number of non-paying partners/month	0 or 1	204	58	56	146	68	Ref	-	Ref	-
	2+	113	45	44	68	32	1.66*	1.04-2.64	1.45	0.80-2.63
Any drug use/year	No	205	61	60	144	68	Ref	-	Ref	-
	Yes	108	41	40	67	32	1.39	0.85-2.27	1.43	0.79-2.59
Social discrimination/violence										

Variable	Categories	N	AI with inconsistent condom use/past month¶ n	%	No AI with inconsistent condom use/past month n	%	Univariate OR	95% CI	Multivariable† aOR	95% CI
Ever blackmailed	No	208	73	51	135	63	Ref	-	-	
	Yes	110	31	49	79	37	0.74	0.45-1.23	0.70	0.34-1.46
Ever physically or verbally harassed	No	123	39	38	84	39	Ref	-	Ref	-
	Yes	195	65	63	130	61	1.08	0.67-1.72	1.86*	1.02-3.64
Ever raped since age 18	No	179	49	51	130	63	Ref	-	Ref	-
	Yes	122	47	49	75	37	1.70*	1.01-2.88	1.94	0.93-2.06
Ever afraid to access health services	No	178	50	48	128	60	Ref	-	Ref	-
	Yes	140	54	52	86	40	1.61	0.95-2.58	2.18**	1.16-4.10
Ever afraid to walk public places	No	165	63	61	102	48	Ref	-	Ref	-
	Yes	153	41	39	112	52	0.59*	0.37-0.97	0.46*	0.21-0.99
Social cohesion score§	No	140	46	50	94	46	Ref	-	Ref	-
	Yes	156	47	50	109	54	0.85	0.52-1.40	0.80	0.43-1.49
Knowledge, information and services access										
Knowledge of type of sex with highest transmission risk	Anal	33	13	13	20	9	Ref	-	Ref	-
	Other	285	91	88	194	91	0.72	0.34-1.52	0.53	0.20-1.38
Tested for STI/past year	Yes	232	76	73	58	27	Ref	-	Ref	-
	No	86	28	27	156	73	0.96	0.58-1.60	1.68	0.90-3.13
Received information on HIV prevention/past year	Yes	270	87	84	183	86	Ref	-	Ref	-
	No	45	16	16	29	14	1.16	0.59-2.28	1.20	0.55-2.15

AI=anal intercourse, aOR=adjusted odds ratio, OR=odds ratio, STI=sexually transmitted infection, 95%CI=95% confidence interval, Ref=reference level. *p<0.05, **p<0.01, ***p<0.001.

† Multivariable results are mutually adjusted for all variables listed in this table. In addition to the variables listed, interviewer was entered into the model as a dummy variable in order to control for its potential confounding effect.

¶ Practice of AI with inconsistent condom use is defined as reporting anything other than 'always' having used condoms during AI in the past month with any partner type (i.e. using condoms most of the time, sometimes, rarely or never).

‡Condom use at most recent sex with new or regular clients was derived from two questions on condom use at last sex with new and regular clients separately, with condomless sex defined as reporting no condom use during AI or VI with either or both of these client types.

§ Social cohesion is an index comprised of a series of questions on relationship with other FSW. For more information, see Table A4.1 footnotes.

APPENDIX: CHAPTER 6

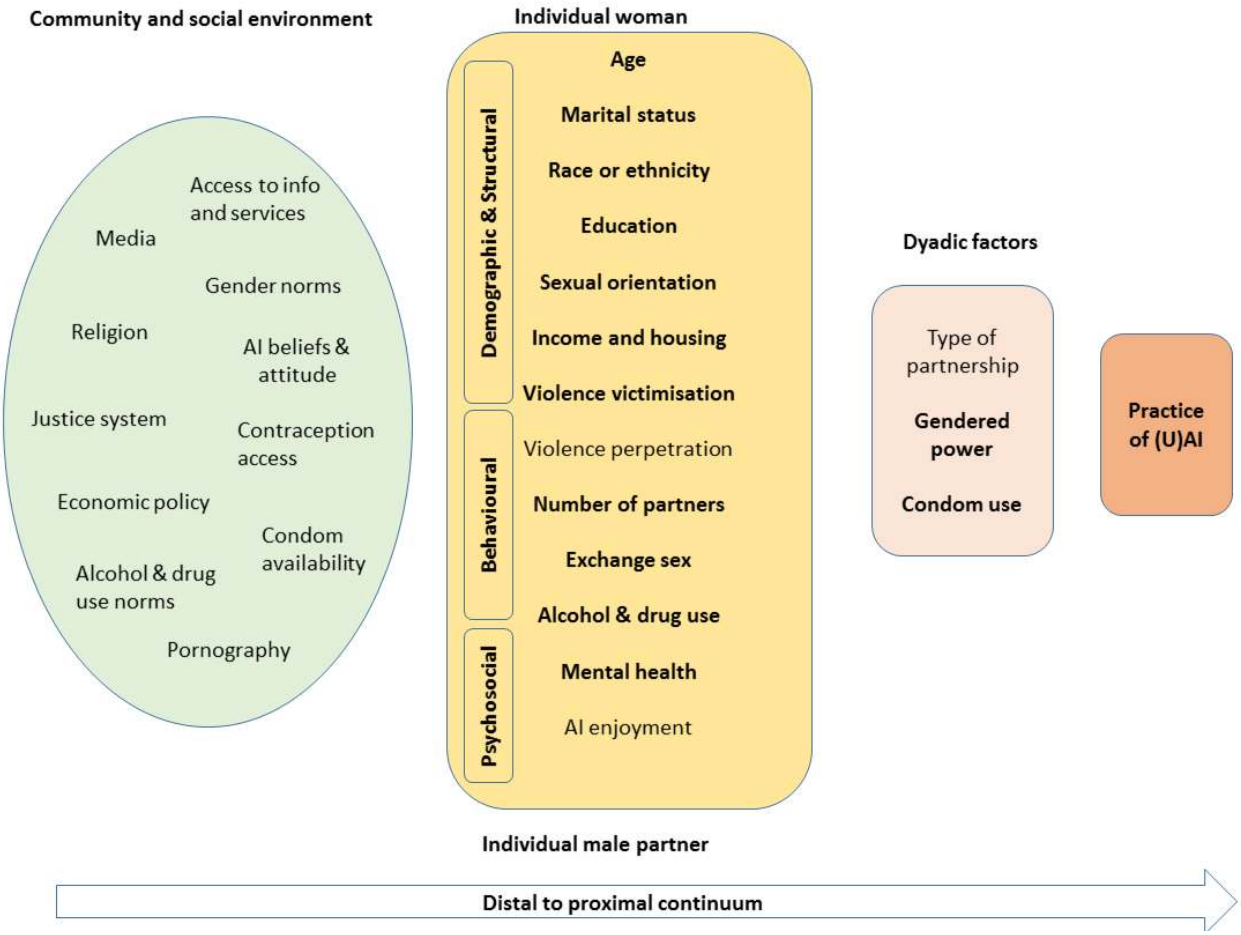

Figure A6.1. A conceptual framework of anal intercourse practice among women in the U.S.

Bold font indicates covariates of interest for which data were available in the WIHS dataset. AI - anal intercourse, UAI - unprotected anal intercourse, exchange sex-sex in exchange for money, drugs, goods or services.

Table A6.1. Baseline characteristics by recruitment wave

	First, 1994 N (%) or median (IQR)	Second, 2001-02 N (%) or median (IQR)	Third, 2011-12 N (%) or median (IQR)	Fourth, 2013 N (%) or median (IQR)
HIV status (NA=0)				
HIV-seronegative	445 (22.0%)	354 (35.5%)	81 (25.6%)	205 (27.1%)
HIV-seropositive	1577 (78.0%)	642 (64.5%)	235 (74.4%)	551 (72.9%)
Site (NA=0)				
Atlanta	-	-	-	243 (32.1%)
Birmingham	-	-	-	102 (13.5%)
Bronx	428 (21.2%)	201 (20.2%)	38 (12.0%)	-
Brooklyn	314 (15.5%)	199 (20.0%)	35 (11.1%)	-
Chapel Hill	-	-	-	180 (23.8%)
Chicago	259 (12.8%)	129 (13.0%)	94 (29.7%)	-
District of Columbia	293 (14.5%)	135 (13.6%)	55 (17.4%)	-
Los Angeles	382 (18.9%)	189 (19.0%)	14 (4.4%)	-
Miami	-	-	-	126 (16.7%)
Mississippi	-	-	-	105 (13.9%)
San Francisco	1346 (17.1%)	143 (14.4%)	80 (25.3%)	-
Median (IQR) years age (NA=0)				
	36.0 (30.0-41.0)	31.0 (26.0-37.0)	45.0 (39.0-49.0)	44.0 (36.0-51.0)
Median (IQR) years of follow-up (NA=0)				
	18.0 (8.5-22.5)	15.0 (10.5-15.5)	5.5 (5.0-6.0%)	3.0 (2.5-3.1)
Race or ethnicity (NA=0)				
Black	1131 (55.9%)	573 (57.5%)	245 (77.5%)	631 (83.5%)
Hispanic	492 (24.3%)	303 (30.4%)	36 (11.4%)	46 (6.1%)
Non-Hispanic White	344 (17.0%)	75 (7.5%)	15 (4.8%)	67 (8.9%)
Other	55 (2.7%)	45 (4.5%)	20 (6.3%)	12 (1.6%)
Sexual orientation (NA=50)				
Heterosexual	1725 (86.6%)	865 (87.6%)	276 (88.5%)	682 (91.2%)
Bisexual	165 (8.3%)	83 (8.4%)	26 (8.3%)	55 (7.4%)
Lesbian	103 (5.2%)	39 (4.0%)	10 (3.2%)	11 (1.5%)
Education (NA=6)				
High school+	1295 (64.0%)	601 (60.7%)	200 (63.3%)	523 (69.2%)
<High school	727 (36.0%)	389 (39.3%)	116 (36.7%)	233 (30.8%)
Marital status (NA=12)				
Married or partnered[1]	758 (37.5%)	346 (34.8%)	90 (28.9%)	245 (32.5%)
Not married or partnered	1261 (62.5%)	649 (65.2%)	221 (71.1%)	508 (67.5%)

	First, 1994 N (%) or median (IQR)	Second, 2001-02 N (%) or median (IQR)	Third, 2011-12 N (%) or median (IQR)	Fourth, 2013 N (%) or median (IQR)
Household income (NA=133)				
<$12,000/year	1223 (63.2%)	515 (52.3%)	208 (67.8%)	32 (44.7%)
$12,000+/year	713 (36.8%)	470 (47.7%)	99 (32.2%)	403 (55.3%)
Employed (NA=9)				
Yes	487 (24.1%)	359 (36.1%)	78 (24.8%)	241 (32.0%)
No	1530 (75.9%)	636 (63.9%)	237 (75.2%)	513 (68.0%)
Injection drug use/ ever (NA=1)				
Yes	781 (38.6%)	110 (11.1%)	45 (14.2%)	51 (6.8%)
No	1241 (38.6%)	885 (88.9%)	271 (85.8%)	705 (93.3%)
Median (IQR) number of male sex partners/ ever (NA=71)	12.0 (5.0-50.0)	10.0 (4.0-25.0)	12.0 (6.0-30.0)	11.0 (6.0-30.0)
Any female sex partners/ever (NA=18)				
Yes	487 (24.2%)	234 (23.5%)	92 (29.3%)	209 (27.7%)
No	1522 (75.8%)	760 (76.5%)	222 (70.7%)	546 (72.3%)
Anal intercourse/ever[2] NA=631				
Yes	606 (43.3%)	436 (44.0%)	159 (50.6%)	304 (40.3%)
No	792 (56.7%)	556 (56.0%)	155 (49.4%)	451 (59.7%)
Transactional sex/ever (NA=12)				
Yes	760 (37.8%)	274 (27.6%)	126 (39.9%)	277 (36.6%)
No	1252 (37.8%)	720 (72.4%)	190 (63.1%)	4 79 (63.4%)

1. “Partnered” refers to living with a partner.

2.The majority of NAs are because at the baseline visit of the first recruitment wave, women reporting no sex partner in the past 6 months were not asked whether they had ever practised AI. In subsequent waves, all women were asked whether they had ever practised AI. When using only data from women who reported a male sex partner in the past 6 months at baseline (i.e. applying the criteria for being asked about lifetime AI practice in Wave 1 to subsequent waves) to calculate the proportion reporting ever practising AI at each wave, the proportion was consistently slightly higher in Wave 2=45.2 vs 44.0%, 3=52.9 vs 50.6% and 4=43.9% vs 40.3%, implying that the baseline estimate for lifetime AI practice for the whole sample would be only slightly higher had data from all recruits in the first wave been collected.

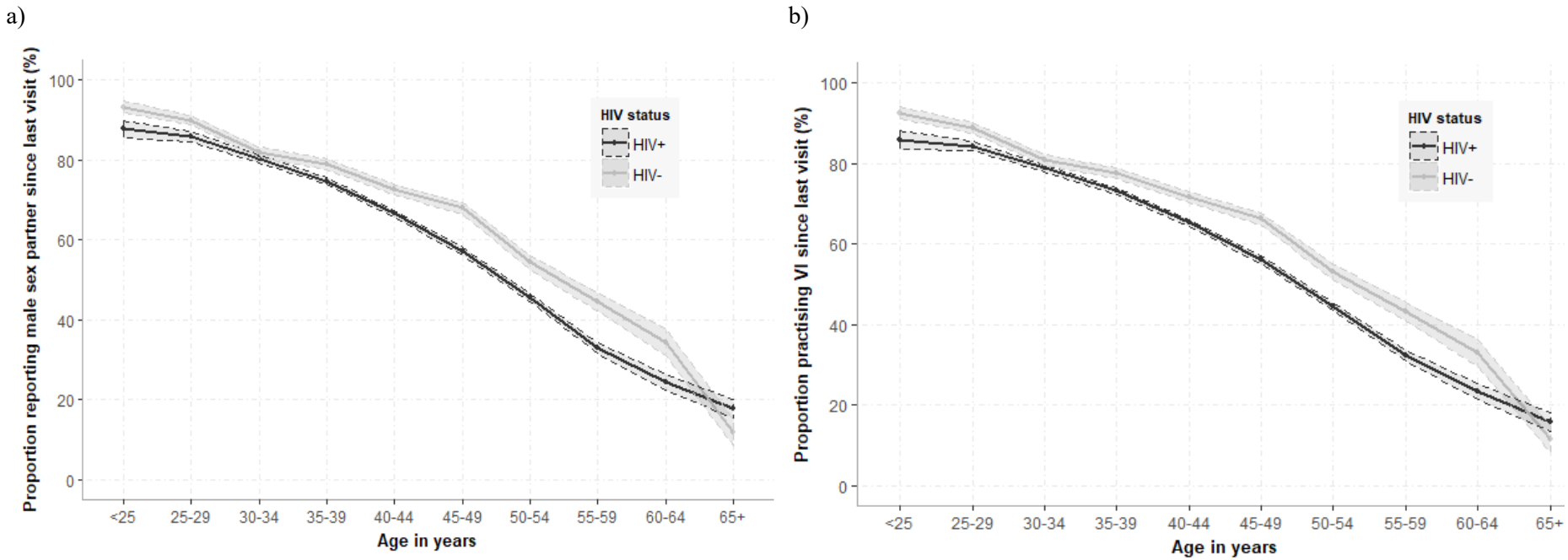

Figure A6.2. The proportion of women reporting a) having a male sex partner since the last visit and b) VI since the last visit, by age. Shaded areas represent 95% confidence intervals.

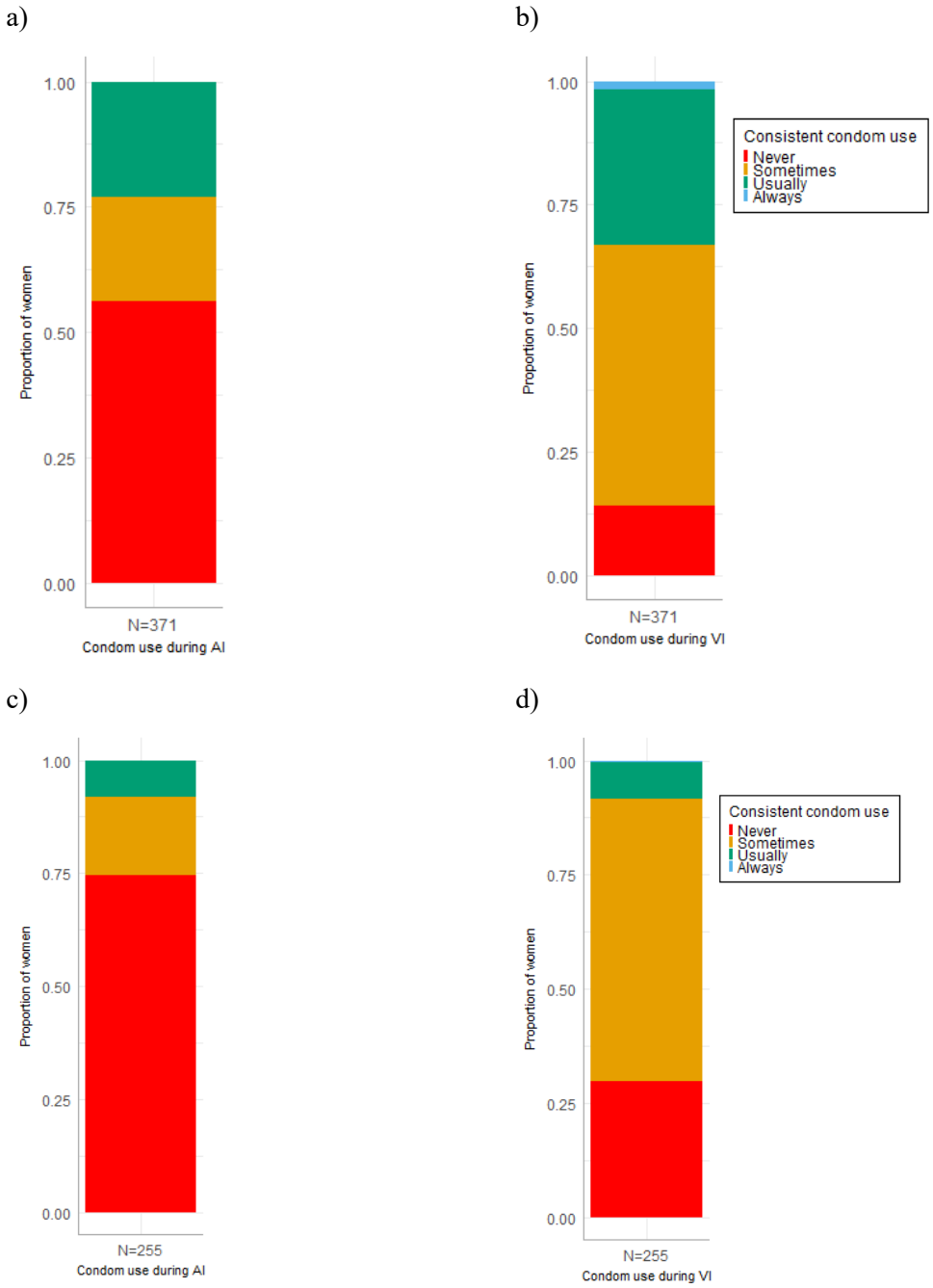

Figure A6.3. Comparative condom use during a) AI and b) VI among the subset of women reporting any AI unprotected by condoms over follow-up. Figures c and d) display the equivalent data for HIV sero-negative women.

Reporting any AI unprotected by condoms was defined as ever reporting over follow-up that condoms had been used sometimes or never during AI since the last visits. Consistent condom use was defined as reporting always using condoms during AI since the last visit.

Never=consistent condom use during since the last visits at 0% of visits, sometimes=consistent condom use during AI at 1-49% of visits with AI, usually=consistent condom use during AI at 50-99% of visits with AI, always=consistent condom use during at100 of visits with AI. Equivalent measures and categorisations were used for condom use during VI

APPENDIX CHAPTER 7

Table A7.1. Predictors of AI practice over follow-up, by HIV status. Complete case analysis including violence variables

		HIV-SEROPOSITIVE N=2,400, Total visits=29,225					HIV-SERONEGATIVE N=899, Total visits=11,325				
		% AI visits	Univariate analysis		Multivariable analysis		% AI visits	Univariate analysis		Multivariable analysis	
			OR	95% CI	aOR	95% CI		OR	95% CI	aOR	95% CI
Demographic and structural determinants											
Age	Years, continuous	NA	**0.94*** **	**0.93-0.95**	**0.95*** **	**0.94-0.96**	NA	**0.94*** **	**0.93-0.96**	**0.96*** **	**0.94-0-97**
Race/ethnicity	Black	3.7%	Ref		Ref		4.9%	Ref		Ref	
	Hispanic	5.3%	**1.49***	**1.09-2.05**	**1.82*** **	**1.34-2.49**	7.0%	1.46	0.97-2.21	**1.72***	**1.12-2.62**
	White	5.0%	1.38	0.9-2.11	**1.61***	**1.02-2.55**	7.1%	1.48	0.82-2.67	1.4	0.78-2.53
	Other	2.9%	0.85	0.45-1.6	0.93	0.49-1.76	8.3%	1.75	0.78-3.93	**2.04***	**1.04-3.99**
Education	<High school	3.9%	Ref		Ref		5.0%	Ref		Ref	
	High school+	4.2%	1.12	0.89-1.35	1.14	0.91-1.27	5.9%	1.07	0.82-1.39	1.09	0.86-1.37
Married or living with a partner	No	3.8%	Ref		Ref		5.5%	Ref		Ref	
	Yes	4.8%	**1.24***	**1.01-1.52**	0.99	0.80-1.24	5.7%	1.03	0.77-1.38	0.90	0.68-1.19
Household annual income	<$12,000	4.0%	Ref		Ref		6.2%	Ref		Ref	
	$12,000+	4.3%	1.09	0.90-1.32	1.11	0.91-1.36	4.9%	1.15	0.94-1.46	1.16	0.86-1.47
Violence victimisation	No violence	3.9%	Ref		Ref		5.6%	Ref		Ref	
	Either raped or severely beaten	10.3%	**2.84*** **	**2.13-3.80**	**1.53***	**1.15-2.04**	12.8%	**2.77*** **	**1.88-4.07**	**1.47***	**1.01-2.16**
	Both raped and beaten	16.6%	**4.95*** **	**2.59-9.45**	**2.63***	**1.19-5.83**	21.4%	**5.49*** **	**1.97-15.33**	**1.58***	**1.07-3.72**
Behavioural determinants											
Alcohol use	<8 drinks/week	3.17%	Ref		Ref		5.4%	Ref		Ref	
	8+ drinks/week	8.3%	**2.18*** **	**1.69-2.80**	**1.66** **	**1.29-2.15**	6.8%	1.28	0.94-1.74	1.12	0.81-1.54
Crack, cocaine or heroin use	No	3.8%	Ref		Ref		5.3%	Ref		Ref	
	Yes	8.2%	**2.17*** **	**1.67-2.81**	1.32	0.98-1.77	8.0%	**1.57***	**1.07-2.30**	1.39	0.90-2.14
	No	4.0%	Ref		Ref		5.4%	Ref		Ref	

		HIV-SEROPOSITIVE N=2,400, Total visits=29,225					HIV-SERONEGATIVE N=899, Total visits=11,325				
		% AI visits	Univariate analysis		Multivariable analysis		% AI visits	Univariate analysis		Multivariable analysis	
			OR	95% CI	aOR	95% CI		OR	95% CI	aOR	95% CI
Transactional sex	Yes	16.5%	**4.1*** **	**2.89-5.83**	1.07	0.69-1.54	15.9%	**3.32*** **	**1.97-5.62**	1.17	0.67-2.04
Number of male sex partners	0-1	3.4%	Ref		Ref		4.3%	Ref		Ref	
	2+	15.1%	**4.53*** **	**3.71-5.52**	**2.74*** **	**2.14-3.49**	14.1%	**3.61*** **	**2.73-4.80**	**2.19*** **	**1.58-3.03**
Number of female sex partners	0	4.1%	Ref		Ref		5.6%	Ref		Ref	
	1+	3.7%	0.97	0.68-1.4	0.77	0.52-1.23	6.0%	1.09	0.67-1.77	1.09	0.67-1.76
Any UVI	No	2.6%	Ref		Ref		2.6%	Ref		Ref	
	Yes	9.2%	**3.58*** **	**2.97-4.31**	**2.74*** **	**2.22-3.38**	8.5%	**3.48*** **	**2.52-4.81**	**2.66*** **	**1.88-3.74**
Likely depression	No	3.6%	Ref		Ref		5.2%	Ref		Ref	
	Yes	5.0%	**1.38***	**1.13-1.68**	1.11	0.94-1.40	6.5%	1.25	0.95-1.65	1.20	0.88-1.64
Feel afraid of partner	No	4.1%			Ref		5.4%	Ref		Ref	
	Yes	10.0%	**2.62*** **	**1.63-4.22**	1.05	0.63-1.74	16.2%	**3.36*** **	**1.67-6.79**	1.55	0.87-2.77

OR=odds ratio, aOR=adjusted odds ratio, 95% CI= 95% confidence interval, Ref=referent. *p-value<0.05, **p-value<0.01, ***<p-value<0.001.

This is a complete case analysis including all variables in the full model (Table 7.1) as well as violence variables (raped since last visit, beaten since last visit and felt afraid of partner since last visit), marked in red. These variables contain a large proportion of missing values. Including all these variables retains only 44.6% of visits, compared to 86.4% of visits retained when violence variables are not included. Variables in red were added to the variables included in the main analysis, which are in black. All variables were collected over follow-up and measured since the last visit except race and education level, which were measured at baseline. Results in bold indicate that the 95%CI does not include the null value.

[1]Percentage of visits when AI is reported. In total, AI was reported at 4.1% of visits among HIV-positive women and at 5.6% of visits among HIV-negative women. [2]Dichotomised at 8 drinks/week as 8+ drink per week is considered problematic drinking among women (35). [3]Defined as exchanging sex for money or drugs. [4]Reporting never or sometimes versus always using condoms during VI. [5]"Likely depression" was determined by scoring the series of survey items forming the Center for Epidemiologic Studies Depression Scale. Scores of >15 were defined as likely depression (36).

Table A7.2. Predictors of UAI practice over follow-up, by HIV status. Complete case analysis including violence variables

		HIV-SEROPOSITIVE N=2,400, Total visits=29,232					HIV-SERONEGATIVE N=899, Total visits=11,326				
		% UAI visits	Univariate analysis		Multivariable analysis		% AI visits	Univariate analysis		Multivariable analysis	
		2.1	OR	95% CI	aOR	95% CI	4.4	OR	95% CI	aOR	95% CI
Demographic and structural determinants											
Age	Years, continuous	NA	**0.94*** **	**0.93-0.96**	**0.95*** **	**0.93-0.97**	NA	**0.94*** **	**0.93-0.96**	**0.95*** **	**0.93-0-96**
Race/ethnicity	Black	2.0	Ref		Ref		3.8	Ref		Ref	
	Hispanic	2.6	1.30	0.88-1.92	1.44	0.98-2.11	5.8	1.55	0.97-2.48	**1.57**	**0.96-2.54**
	White	1.5	0.75	0.44-1.27	0.80	0.47-1.36	5.6	1.51	0.81-2.77	1.28	0.69-2.40
	Other	1.2	0.58	0.44-1.27	0.60	0.24-1.49	7.5	2.06	0.91-4.68	**2.96**	**0.91-4.22**
Education	High school+	2.2	Ref		Ref		4.3	Ref		Ref	
	<High school	2.0	0.93	0.67-1.29	1.14	0.81-1.60	4.5	1.06	0.68-1.65	1.26	0.81-1.96
Married or living with a partner	No	1.9	Ref		Ref		4.0	Ref		Ref	
	Yes	2.4	1.24	0.95-1.61	1.21	0.93-1.57	5.2	1.33	0.98-1.82	1.33	0.98-1.81
Household annual income	<$12,000	2.2	Ref		Ref		4.1	Ref		Ref	
	$12,000+	1.9	0.89	0.69-1.14	1.02	0.78-1.33	4.7	1.16	0.87-1.56	1.04	0.79-1.37
Violence victimisation	No violence	1.9	Ref		Ref		4.1	Ref		Ref	
	Either raped or severely beaten	5.9	**3.23*** **	**2.30-4.54**	**1.63 ***	**1.13-2.35**	11.1	**2.93*** **	**1.90-4.53**	**1.71***	**1.12-2.60**
	Both raped and beaten	11.3	**6.55*** **	**3.10-13.82**	**3.07***	**1.22-7.70**	22.0	**6.58*** **	**2.18-19.87**	**2.15***	**1.09-4.93**
Behavioural determinants											
Alcohol use	<8 drinks/week	1.9	Ref		Ref		4.2	Ref		Ref	
	8+ drinks/week	4.1	**2.26*** **	**1.63-3.14**	**1.68** **	**1.17-2.41**	5.7	1.36	0.97-1.91	1.34	0.95-1.88
Crack, cocaine or heroin use	No	1.9	Ref		Ref		4.2	Ref		Ref	
	Yes	4.2	**2.26*** **	**1.63-3.12**	1.30	0.87-1.93	5.9	1.42	0.92-2.19	1.29	0.84-1.97
Transactional sex	No	2.0	Ref		Ref		4.3	Ref		Ref	
	Yes	8.2	**4.35*** **	**2.53-7.48**	0.90	0.40-1.63	10.8	**2.70** **	**1.38-5.30**	1.12	0.58-2.19
	0-1	1.7	Ref		Ref		3.7	Ref		Ref	

		HIV-SEROPOSITIVE N=2,400, Total visits=29,232					HIV-SERONEGATIVE N=899, Total visits=11,326				
		% UAI visits	Univariate analysis		Multivariable analysis		% AI visits	Univariate analysis		Multivariable analysis	
		2.1	OR	95% CI	aOR	95% CI	4.4	OR	95% CI	aOR	95% CI
Number of male sex partners	2+	7.8	**4.91*** **	**3.67-6.55**	**3.21*** **	**2.24-4.60**	9.4	**3.61*** **	**2.73-4.80**	**1.94*** **	**1.35-2.79**
Number of female sex partners	0	2.1	Ref		Ref		4.4	Ref		Ref	
	1+	1.6	0.77	0.47-1.27	0.56*	0.34-0.92	4.6	1.03	0.59-1.80	0.77	0.44-1.33
Likely depression	No	1.7	Ref		Ref		4.2	Ref		Ref	
	Yes	2.7	**1.63*** **	**1.28-2.07**	1.29	1.00-1.66	5.1	1.24	0.92-1.68	1.09	0.81-1.47
Feel afraid of partner	No	2.0			Ref		4.3	Ref		Ref	
	Yes	7.1	**3.70*** **	**1.97-6.94**	1.55	0.78-3.11	15.6	**4.14*** **	**1.95-8.82**	**1.95***	**1.03-3.70**

OR=odds ratio, aOR=adjusted odds ratio, 95% CI= 95% confidence interval, Ref=referent. *p-value<0.05, **p-value<0.01, ***<p-value<0.001.

This is a complete case analysis including all variables in the full model (Table 7.2) as well as violence variables (raped since last visit, beaten since last visit and felt afraid of partner since last visit), marked in red. These variables contain a large proportion of missing values. Including all these variables retains only 44.6% of visits, compared to 86.4% of visits retained when violence variables are not included. Variables in red were added to the variables included in the main analysis, which are in black. All variables were collected over follow-up and measured since the last visit except race and education level, which were measured at baseline. Results in bold indicate that the 95%CI does not include the null value.

[1]Percentage of visits when AI is reported. In total, AI was reported at 4.1% of visits among HIV-positive women and at 5.6% of visits among HIV-negative women. [2]Dichotomised at 8 drinks/week as 8+ drink per week is considered problematic drinking among women (35). [3]Defined as exchanging sex for money or drugs. [5]"Likely depression" was determined by scoring the series of survey items forming the Center for Epidemiologic Studies Depression Scale. Scores of >15 were defined as likely depression (36).

Table A7.3. Univariate and multivariate analysis of AI and UAI practice among HIV-seropositive women, including taking ART.

		AI practice					UAI practice				
		% AI visits	Univariate analysis		Multivariable analysis		% UAI visits	Univariate analysis		Multivariable analysis	
			OR	95% CI	aOR	95% CI		OR	95% CI	aOR	95% CI
Demographic determinants											
Age	Years, continuous	NA	**0.94*** **	**0.93-0.95**	**0.95*** **	**0.93-0.96**	NA	**0.94*** **	**0.93-0.95**	**0.95*** **	**0.93-0.96**
Race	Black	3.8	Ref		Ref		2.0	Ref		Ref	
	Hispanic	5.1	**1.33***	**1.02-1.72**	**1.62*** **	**1.25-2.11**	2.5	1.28	0.93-1.76	**1.48***	**1.06-2.05**
	White	5.6	**1.45***	**1.03-2.05**	**1.63****	**1.16-2.29**	2.2	1.08	0.69-1.7	1.15	0.75-1.76
	Other	3.7	1.04	0.59-1.89	1.07	0.62-1.82	1.4	0.71	0.33-1.53	0.68	0.35-1.33
Education	<High school	4.0	Ref		Ref		2.0	Ref		Ref	
	High school+	4.6	1.21	0.96-1.51	**1.34***	**1.07-1.68**	2.2	1.1	0.83-1.45	**1.36***	**1.02-1.81**
Married or living with a partner	No	4.3	Ref		Ref		2.0	Ref		Ref	
	Yes	4.6	1.09	0.92-1.3	0.91	0.77-1.08	2.3	1.15	0.93-1.41	1.17	0.96-1.43
Household annual income	<$12,000	4.2	Ref		Ref		2.3	Ref		Ref	
	12,000+	4.5	1.07	0.91-1.27	1.05	0.89-1.25	2.0	0.87	0.69-1.09	0.91	0.73-1.14
Behavioural determinants											
Alcohol use[2]	<8 drinks/week	4.0	Ref		Ref		1.9	Ref		Ref	
	8+ drinks/week	7.9	**2.08*** **	**1.65-2.61**	**1.46****	**1.17-1.83**	4.2	**2.19*** **	**1.67-2.87**	**1.54***	**1.18-2.02**
Crack, cocaine or heroin	No	4.0	Ref		Ref		1.9	Ref		Ref	
	Yes	7.8	**2.1*** **	**1.67-2.64**	**1.38****	**1.07-1.77**	4.6	**2.54*** **	**1.92-3.37**	**1.71****	**1.17-2.48**
Transactional sex[3]	No	4.2	Ref		Ref		2.0	Ref		Ref	
	Yes	15.3	**4.2*** **	**3.04-5.81**	0.98	0.68-1.42	9.0	**4.79*** **	**3.04-7.56**	1.11	0.64-1.92
Number of male sex partners	0-1	3.5	Ref		Ref		1.7	Ref		Ref	
	2+	14.6	**4.96*** **	**4.19-5.87**	**3.04*** **	**2.52-3.66**	7.5	**4.76*** **	**3.77-6.01**	**3.3*** **	**2.51-4.35**
Number of female sex partners	0	4.4	Ref		Ref		2.1	Ref		Ref	
	1+	4.0	0.94	0.69-1.3	0.83	0.62-1.12	2.2	1.02	0.68-1.52	0.77	0.53-1.12
Any UVI[4]	No	2.7	Ref		Ref		0.7	Not included in model			
	Yes	9.3	**3.52*** **	**3.00-4.14**	**2.58*** **	**2.18-3.04**	6.6				

		AI practice					UAI practice				
		% AI visits	Univariate analysis		Multivariable analysis		% UAI visits	Univariate analysis		Multivariable analysis	
			OR	95% CI	aOR	95% CI		OR	95% CI	aOR	95% CI
Psycho-social determinants											
Likely depression[5]	No	3.9	Ref		Ref		1.8	Ref		Ref	
	Yes	5.0	**1.26****	**1.07-1.5**	1.07	0.92-1.25	2.7	**1.54*****	**1.25-1.91**	**1.26***	**1.02-1.55**
Medical factors											
ART	Taking ART & viral load <50 or undectable[1]	3.6	**Ref**		Ref		1.9	**Ref**		**Ref**	
	Taking ART & viral load 50+	4.3	1.18	0.99-1.40	0.93	0.78-1.10	1.7	0.93	0.75-1.16	0.76	0.53-1.04
	Not taking ART	5.6	**1.58*****	**1.29-1.92**	1.01	0.83-1.23	3.1	**1.69*****	**1.33-2.14**	0.98	0.77-1.27

The models for AI and UAI practice are identical to those presented in Table 7.1 and 7.2, with the addition of taking ART, marked in red. ART use is categorised as reporting taking ART or not since last visit, with viral load used as a measure of adherence. [1]The threshold at which viral load became undetectable decreased as the tests improved over the course of the cohort study. As a result, some viral loads in this category may be above 50. Variables in red were added to the variables included in the main analysis, which are in black. For all other footnotes, see Table 7.1.

Table A7.4. Baseline characteristics of the sub-group of WIHS participants reporting never having had AI at baseline, but reporting AI during follow-up

		Total N (%) or median (IQR)	**HIV seropositive** N (%) or median (IQR)	**HIV seronegative** N (%) or median (IQR)
	Total study participants	317	185	132
Years of follow-up	Median (IQR)	15.5 (10.5-22.5)	15.5 (10.5-22.5)	15.5 (11.0-22.5)
Recruitment wave	First (1994)	171 (53.9%)	112 (60.5%)	59 (44.7%)
	Second (2001-02)	130 (41.0%)	63 (34.1%)	67(50.8%)
	Third (2011-12)	4 (1.2%)	1 (0.5%)	3 (2.3%)
	Fourth (2013)	12 (3.8%)	49(4.9%)	3 (2.3%)
Age in years	Median (IQR)	31.0 (24.0-35.0)	31.0 (26.0-35.0)	29.0 (22.0-35.0)
Race	Black	199 (62.8%)	111 (60.0%)	88 (66.7%)
	Hispanic	82 (25.9%)	51 (27.6%)	31 (23.5%)
	White	26 (8.2%)	16 (8.7%)	122 (7.6%)
	Other	10 (3.2%)	7 (3.8%)	3 (2.3%)
Sexual orientation	Heterosexual	285 (89.9%)	169 (91.4%	116 (87.9%)
	Bisexual	25 (7.9%)	12 (6.5%)	13 (9.9%)
	Lesbian	4 (1.3%)	2 (1.0%)	2 (1.5%)
	Missing	3 (0.9%)	2 (1.0%)	1 (0.7%)
Education	High school or more	184 (58.0%)	97 (52.4%)	87 (65.9%)
	Less than high school	131 (41.3%)	88 (47.6%)	43 (32.6%)
	Missing	2 (0.6%)	0	2 (1.5%)
Marital status	Married or partnered[1]	121 (38.2%)	69 (37.3%)	52 (39.4%)
	Not married or partnered[1]	195 (61.5%)	115 (62.2%)	80 (60.6%)
	Missing	1 (0.3%)	1 (0.5)	0 (0.0%)
Household annual income	<$12,000	193 (60.9%)	120 (64.9%)	73 (55.3%)
	$12,000+	112 (35.3%)	56 (30.3%)	56 (42.4%)
	Missing	12 (3.8%)	9 (4.9%)	3 (2.3%)
Employed	Yes	77 (24.3%)	28 (15.1%)	49 (37.1%)
	No	240 (75.7%)	157 (84.9%)	83 (62.9%)
Injection drug use/ ever	Yes	54 (17.0%)	35 (18.9%)	19 (14.4%)
	No	263 (83.0%)	150 (81.1%)	113 (85.6%)
Number of male sex partners/ever	Median (IQR) *Missing=2*	10.0 (5.0-28.5)	8.0 (5.0-20.0)	10.5 (5.0-31.5%)
Any female sex partners/ever	1+	42 (13.2%)	20 (10.8%)	22 (16.7%)
	0	275 (86.8%)	165 (89.2%)	110 (83.3%)
Transactional sex/ever	Yes	96 (30.3%)	59 (31.9%)	37 (28.0%)
	No	220 (69.4%)	125 (67.6%)	95 (72.0%)
	Missing	1 (0.3%)	1 (0.5%)	0 (0.0%)

NA=missing value, IQR= interquartile range. [1]"Partnered" refers to living with a partner. For covariates where there is no "missing" class, then there were no missing entries.

Table A7.5. Predictors of first AI practice over follow-up among women reporting never having had AI at baseline, by HIV status

		HIV-SEROPOSITIVE, N=143				HIV-SERONEGATIVE, N=109			
		Univariate analysis		Multivariable analysis		Univariate analysis		Multivariable analysis	
		OR	95% CI	aOR	95% CI	OR	95% CI		95% CI
Married or living with a partner	No	Ref		Ref		Ref		Ref	
	Yes	0.78	0.56-1.10	0.72	0.49-1.04	0.94	0.61-1.46	1.00	0.63-1.57
Household annual income	<$12,000	Ref		Ref		Ref		Ref	
	$12,000+	1.79	0.55-1.12	1.39	0.95-2.02	0.79	0.52-1.18	0.89	0.58-1.37
Alcohol use	<8 drinks/week	Ref		Ref		Ref		Ref	
	8+ drinks/week	1.35	0.75-2.46	1.44	0.75-2.77	1.06	0.60-1.87	0.97	0.55-1.70
Crack, cocaine or heroin	No	Ref		Ref		Ref		Ref	
	Yes	1.25	0.80-1.95	1.14	0.66-1.97	0.78	0.47-1.36	0.68	0.52-1.47
Transactional sex	No	Ref		Ref		Ref		Ref	
	Yes	1.14	0.27-4.87	0.72	0.14-3.60	0.64	0.18-2.37	0.84	0.21-3.45
Number of male sex partners	0-1	Ref		Ref		Ref		Ref	
	2+	**1.69***	**1.13-2.52**	**1.75***	**1.08-2.82**	**1.52***	**1.01-2.31**	**1.49***	**1.02-2.18**
Number of female sex partners	0	Ref		Ref		Ref		Ref	
	1+	1.58	0.75-3.34	1.54	0.75-3.16	1.25	0.56-2.77	0.79	0.33-1.89
Any UVI	No	Ref		Ref		Ref		Ref	
	Yes	0.87	0.60-1.25	0.81	0.55-1.20	1.09	0.75-1.58	1.03	0.69-1.54
Likely depression	No	Ref		Ref		Ref		Ref	
	Yes	0.94	0.67-1.32	0.89	0.62-1.27	1.21	0.79-1.85	1.37	0.85-2.22

The model was additionally controlled for race and education level. For other details, see Table 7.2 footnotes.

Table A7.6. Predictors of AI practice over follow-up, by trajectory group membership among A) HIV-seropositive women and B) HIV-seronegative women

A		Group 1 N=269, PY follow-up=3,328			Group 2 N=1,362, PY follow-up=14,790			Group 3 N=813, PY follow-up=10,172			Group 4[1] N=551	
		% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR
Total		23.5			3.2			1.5			0.1	
Age	Years, continuous	NA	**0.92*** **	**0.91-0.94**	NA	**0.95*** **	**0.94-0.96**	NA	**0.91*** **	**0.88-0.94**	NA	NA
Race	Black	20.3	Ref		2.8	Ref		1.1	Ref		0.1	
	Hispanic	28.7	**1.48***	**1.06-2.06**	3.6	**1.56****	**1.11-2.2**	1.8	**1.8***	**1.05-3.08**	0.2	NA
	White	30.7	**1.99***	**1.09-3.36**	4.4	**1.77****	**1.18-2.64**	2.0	**2.1***	**1.13-3.89**	0.1	
	Other	15.8	0.75	0.21-2.66	4.2	**1.77***	**1.03-3.05**	2.5	1.54	0.59-4.03	0	
Education	<High school	22.7	Ref		3.3	Ref		1.5	Ref		0.1	NA
	High school+	23.9	**1.35***	**1.01-1.81**	3.1	1.17	0.87-1.58	1.3	1.35	0.82-2.22	0.2	
Married or partnered	No	27.1	Ref		3.7	Ref		1.4	Ref		0.1	NA
	Yes	19.3	**0.69****	**0.53-0.89**	2.5	**0.61*** **	**0.47-0.79**	1.5	0.68	0.45-1.02	0.1	
Household annual income	<$12,000	22.9	Ref		3.1	Ref		1.6	Ref		0.1	NA
	$12,000+	24.1	1.02	0.80-1.29	3.3	0.99	0.79-1.23	1.4	1.08	0.73-1.60	0.2	
Alcohol use	<8 drinks/week	22.5	Ref		3.1	Ref		1.40	Ref		0.1	NA
	8+ drinks/week	29.4	1.28	0.95-1.72	4.6	1.27	0.92-1.76	2.20	1.26	0.71-2.21	0	
Crack, cocaine or heroin	No	22.5	Ref		3.1	Ref		1.4	Ref		0.1	NA
	Yes	28.3	1.04	0.73-1.48	4.6	1.31	0.93-1.86	1.7	0.81	0.46-1.41	0.2	
Transactional sex	No	23.1	Ref		3.2	Ref		1.4	Ref		0.1	NA
	Yes	30.9	0.68	0.42-1.01	6.6	0.69	0.39-1.25	6.1	1.88	0.69-5.46	0	
Number of male sex partners	0-1	20.5	Ref		2.7	Ref		1.2	Ref		0.1	NA
	2+	35.8	**1.62*** **	**1.25-2.09**	7.9	**2.13*** **	**1.69-2.76**	6.3	**2.17****	**1.20-3.90**	0	
Number of female sex partners	0	23.4	Ref		3.1	Ref		1.4	Ref		0.01	NA
	1+	29.8	0.94	0.63-1.13	9.4	**2.23*** **	**1.39-2.58**	3.8	**2.4****	**1.33-4.34**	0.2	
Any UVI	No	20.9	Ref		2.5	Ref		1.0	Ref		0.1	NA
	Yes	26.2	1.22	0.95-1.57	4.8	**1.81*** **	**1.47-2.23**	4.0	**2.30*** **	**1.55-3.43**	0	

A		Group 1 N=269, PY follow-up=3,328			Group 2 N=1,362, PY follow-up=14,790			Group 3 N=813, PY follow-up=10,172			Group 4[1] N=551	
		% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR
Likely depression	No	21.0	Ref		2.9	Ref		1.3	Ref		0.1	NA
	Yes	28.0	1.10	0.88-1.38	3.8	1.18	0.96-1.47	1.7	1.20	0.84-1.71	0.1	

B		Group 1 N=74, PY follow-up=925			Group 2 N=164, PY follow-up=2,410			Group 3 N=547, PY follow-up=5,892			Group 4 N=164, PY follow-up=2408			Group 5[2]: N=124	
		% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR
Total		46.5			6.6			3.7			1.7			0.3	NA
Age	Continuous	NA	0.98	0.96-1.01	NA	**0.85*** **	**0.82-0.87**	NA	0.98	0.96-1.01	NA	**0.87*** **	**0.83-0.92**	NA	NA
Race	Black	44.5	Ref		5.4	Ref		3.2	Ref		1.7	Ref		0.3	NA
	Hispanic	46.5	1.03	0.67-1.57	8.4	1.18	0.63-2.22	4.9	**1.76***	**1.07-2.91**	1.3	0.86	0.35-2.14	0.2	
	White	47.8	1.29	0.74-2.24	9.6	1.05	0.46-2.38	5.1	1.46	0.85-2.49	1.6	0.71	0.24-2.08	0.3	
	Other	56.7	0.89	0.54-1.47	10.1	0.7	0.3-1.63	1.2	**0.39***	**0.16-0.97**	3.7	1.95	0.68-5.56	1.5	
Education	<High school	47.8	Ref		7.9	Ref		3.9	Ref		2.0	Ref		0.3	NA
	High school+	43.6	0.99	0.65-1.49	4.4	1.39	0.65-2.98	3.3	1.43	0.96-2.13	1.0	2.16	0.84-5.54	0.4	
Married or partnered	No	48.2	Ref		7	Ref		4.2	Ref		1.8	Ref		0.2	NA
	Yes	43.5	0.91	0.66-1.26	5.8	0.63	0.39-1.03	2.8	0.72	0.53-1.00	1.6	0.92	0.42-1.99	0.4	
Household annual income	<$12,000	49.3	Ref		7.3	Ref		3.5	Ref		1.9	Ref		0.2	NA
	$12,000+	42.5	1.33	0.96-1.83	6.0	1.18	0.76-1.84	3.9	1.03	0.72-1.49	1.4	1.39	0.72-2.72	0.4	
Alcohol use	<8 drinks/week	47.1	Ref		6.60	Ref		3.4	Ref		1.6	Ref		0.2	NA
	8+ drinks/week	44.4	0.81	0.57-1.15	6.70	0.97	0.55-1.7	4.9	1.26	0.87-1.87	2.0	1.54	0.52-4.56	1.1	
Crack, cocaine or heroin	No	45.2	Ref		6.1	Ref		3.5	Ref		1.6	Ref		0.4	NA
	Yes	50.8	1.39	0.87-2.24	9.1	**1.87***	**1.06-3.47**	5.0	1.17	0.72-1.89	2.3	1.63	0.58-4.52	0.0	
Transactional sex	No	46.3	Ref		6.2	Ref		3.5	Ref		1.6	Ref		0.2	
	Yes	48.0	0.84	0.45-1.55	22.3	1.88	0.65-5.42	7.7	1.36	0.61-3-01	6.1	**5.52***	**1.21-25.17**	7.7	

B		Group 1 N=74, PY follow-up=925			Group 2 N=164, PY follow-up=2,410			Group 3 N=547, PY follow-up=5,892			Group 4 N=164, PY follow-up=2408			Group 5[2]: N=124	
		% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR	95% CI	% AI visits	aOR
Number of male sex partners	0-1	42.4	Ref		4.5	Ref		3.1	Ref		1.6	Ref		0.3	NA
	2+	52.5	1.43	0.97-2.15	8	1.29	0.8-2.07	5.6	1.38	0.99-1.91	2.7	0.61	0.37-1.12	1.8	
Number of female sex partners	0	43.0	Ref		5.0	Ref		3.1	Ref		1.5	Ref		0.2	NA
	1+	54.4	1.42	0.78-2.61	10.2	1.79	0.64-4.98	9.5	1.48	0.83-2.63	1.9	1.03	0.41-2.59	0.4	
Any UVI	No	46.5	Ref		2.7	Ref		3.1	Ref		1.2	Ref		0.2	NA
	Yes	46.5	1.01	0.65-1.56	10.6	1.64*	1.12-2.44	3.9	1.31	0.94-1.84	2.7	0.9	0.49-1.66	1.7	
Likely depression	No	46.8	Ref		6.5	Ref		3.1	Ref		1.7	Ref		0.2	NA
	Yes	46.1	0.98	0.69-1.38	6.8	1.31	0.88-1.96	5.1	**1.63****	**1.19-2.23**	1.6	1.19	0.58-2.41	0.6	

Given the very small number of visits during which AI was reported by Group 4 members among HIV-seropositive women (10 out of 7963) and Group 5 members among HIV-seronegative women (7 out of 2158 total visits), it was not possible to conduct regression models with these groups. [1]Person years follow-up=5,578 [2]Person years follow-up=1,499. For all other details, see Table 7.2 footnotes