

ASSOCIATION OF STI/HIV INFECTION
WITH REPORTED BEHAVIOR CHANGE AND CONCURRENCY
AMONG RURAL YOUTH IN SOUTH AFRICA AND MALAWI

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A dissertation submitted to the faculty of the University of North Carolina at Chapel Hill in
partial fulfillment of the requirements for the degree of Doctor of Philosophy in the
Department of Epidemiology

Chapel Hill
2008

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ABSTRACT

BROOKE AMANDA LEVANDOWSKI: Association of STI/HIV infection with reported behavior change and concurrency among rural youth in South Africa and Malawi
(Under the direction of Frieda M. Behets, PhD, MPH)

HIV prevalence in rural southern Africa is increasing towards urban levels, highlighting intervention needs of rural youth. Being faithful is a common HIV prevention message as concurrency, or having more than one sexual partnership at one time, has been associated with STI transmission. Two surveys concerning sexual behaviors and STI prevalence conducted with youth in South Africa (SA) and Malawi were used. Analyses were stratified by gender and country and restricted to rural, sexually experienced youth 15-24 years old.

We studied the association between reporting behavior change since hearing of HIV and HIV infection. Many youth reported changed behavior, ranging from 48.2% among Malawian females to 70.6% among SA females. HIV prevalence was 19.0% (95%CI 14.9, 23.1), 4.5% (95%CI 2.6, 6.3), 4.7% (95%CI 3.0, 6.5) and 1.9% (95%CI 0.6, 3.1) for SA women, Malawian women, SA men, and Malawian men, respectively. We found little to no association between behavior change and HIV infection among youth. Analyses stratified by specific behavior changes uncovered that some behaviors were protective while others were riskier, leading to an attenuated effect when all behaviors were combined into a single measure. SA women who reported that they changed their behavior to abstinence were 2.90 (95%CI 1.01, 8.38) times more likely to be HIV+ than those who reported another behavior change.

We hypothesized that rural Malawian youth who reported concurrency were more likely to have STIs. Concurrency was reported by women (5.0%) and men (16.0 %). The overall prevalences of STIs and HIV were 10.4% and 4.4% for women and 0.3% and 2.1% for men, respectively. Concurrency was not associated with STIs for either gender or with HIV infection among males. Using multiple imputation methods and controlling for confounders, women reporting concurrency were 6.08 (95% CI 1.23, 30.16) times more likely to be HIV+ than women not reporting concurrency.

The cross sectional data may mask the temporal relationship between behavior change or concurrency and STI infection. Further research needs to focus on better measurement of type and duration of prevention behaviors. Innovative HIV prevention methods, highlighting the risk associated with concurrency, are needed to reach rural youth.

For my mother, Cynthia Marie Levandowski

ACKNOWLEDGEMENTS

This work could not have been completed without the support and encouragement of myriad people. My committee members, especially my Chair Dr. Frieda Behets, have provided timely and thoughtful feedback that has spurred my intellectual growth as both an epidemiologist and researcher. Mentors Dr. Sandra Lane and Dr. Robert Rubinstein have provided unrelenting emotional and professional support since we met. My Dissertation Support Group (Sandi McCoy, Lizzie Torrone, Kim Powers, Jessica Keys) was always present, to discuss an idea, brainstorm a solution, and generally provide both the impetus and faith I needed to succeed.

My dissertation work was supported through several funding sources, including the National Research Service Award Infectious Disease training grant and a very educational and productive research assistantship with Drs. Mike Cohen and Audrey Pettifor through the Center for AIDS Research.

Last, but certainly not least, is my family who has continued to stand by my side as constant sources of support. My sister Andrea was always available for a great joke. My sister Cortney and I spent countless hours on the phone helping each other through daily pitfalls and triumphs. My father Richard generously provided assistance in the most unlikely but necessary situations. Sawyer, Riley, Mason and Ned made me smile and laugh at the times it was most needed and reminded me of life outside of graduate school.

This entire experience would not have been what it was without my biggest cheerleader and supporter, my mother Cyndy. She taught me to dream and reach for the stars. She has always supported my choices and has stood by me while others may have questioned my path. And it is to her that I dedicate this work.

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LIST OF ABBREVIATIONS

AIDS	Acquired immunodeficiency virus
ANC	Antenatal clinic
ASCQ	Assisted self-completion questionnaires
CI	Confidence interval
CLR	Confidence limit ratio
DAG	Directed acyclical graph
EA	Enumeration area
FFQ	Face to face questionnaires
HIV	Human immunodeficiency virus
HPV	Human papillomavirus
HSV-2	Herpes simplex virus type 2
IMB	Information Motivation Behavior model
MAR	Missing at random
MCAR	Missing completely at random
MCMC	Markov Chain Monte Carlo
MDHS	Malawi Demographic and Health Survey
MDICP	Malawi Diffusion and Ideational Change Project
MI	Multiple imputation
NMAR	Not missing at random
OR	Odds ratio
RHRU	Reproductive health research unit
SA	South Africa

SES	Socioeconomic status
STD	Sexually transmitted disease
STI	Sexually transmitted infection
UN	United Nations

CHAPTER ONE

Specific Aims

Worldwide, half of all new HIV infections occur among young people, highlighting the vulnerability and specific prevention needs of this group(1). Adolescents are experiencing multiple biological and emotional changes and testing parental and societal boundaries. Part of this process involves burgeoning romantic relationships in which each individual tries to assert his or her needs and desires within tension and apprehension filled situations, such as one in which safe sexual practices may be negotiated. Unwanted outcomes abound. Among 15-24 year olds in South Africa in 2003, HIV prevalence was almost 5% (4.8%) for men and 15.5% for women and almost half (49.5%) of sexually active females reported ever being pregnant(2). The overall HIV prevalence in the rural KwaZulu-Natal province was 16.5% in 2005 and overall prevalence among antenatal clinic (ANC) attendees grew from 33.5% in 2001 to 39.1% in 2005(3, 4). HIV prevalence in 2005 for Malawian youth aged 15-24 years was estimated at 3.4% for males and 9.7% for females(5). The prevalence of STIs in the general Malawian population has not been reported in the literature, but estimates among high risk populations can be found. In the Thyolo district of Malawi (a rural area in the South), 2.0% of male prison inmates reported urethral discharge(6); genital ulcer disease was found in 47% of men and 27% of women and pelvic inflammatory disease was found in 18% of women attending a sexually transmitted disease (STD) clinic (7). The cause of the majority of these outcomes is clear- unprotected sexual intercourse with an infected partner.

African youth, especially young women living in rural areas, are among some of the most vulnerable to sexually transmitted infections (STI), due to poor access to education, transportation, preventive health care and financial stability. Youth are at high risk of HIV/STI acquisition because they are in the process of developing their sexual behaviors. Adoption or maintenance of faithfulness is especially important as concurrency, having sex with another partner during an existing sexual relationship, is associated with STI infection (8-10). In addition, HIV prevalence is higher in urban populations, highlighting the need to maintain low prevalence in their rural counterparts (11-13).

A nationally representative survey of sexual behavior was conducted in 2003 of 11,904 South African youth aged 15-24 years by the Reproductive Health Research Unit (RHRU) at the University of Witwatersrand, South Africa. The Malawi Diffusion and Ideational Change Project (MDICP) at the University of Pennsylvania has conducted a longitudinal study of rural Malawians, including a non-nationally representative survey of approximately 900 rural adolescents in the districts of Mchinji (in the Center), Rumphi (in the North), and Balaka (in the South) in 2004.

In both countries, participants were asked if they have changed their sexual behavior since hearing of HIV/AIDS. If they answered yes, they were asked to name the behavior(s). In Malawi, individuals were asked if they had sex with another partner during their most recent sexual relationship. Biological outcomes of HIV infection were measured in both countries while gonorrhea, Chlamydia and trichomonas infections were also measured in Malawi.

Understanding how adolescents make decisions about their sexual behavior is a critical factor in producing effective interventions. If young people are empowered to make

safer sexual choices, do these behaviors lead to the desired outcome of STI and pregnancy prevention? To this end, this research seeks to explore two vital concepts. The first is to determine if reporting engaging in HIV preventive behaviors is associated with HIV infection among rural youth in South Africa and Malawi. The second is to see if concurrency reported by Malawian youth is associated with STI/HIV infection.

Specific Aim 1

To compare self-reported HIV prevention behaviors between sexually active rural South African and Malawian youth, aged 15-24 years, and assess internal validity of these constructs.

Specific Aim 1a

To assess internal validity of the unprompted question concerning HIV preventive activities initiated since having heard of HIV/AIDS, with answers to prompted behavioral questions asked at other points in the survey concerning abstinence, being faithful and using condoms.

Specific Aim 1b

To estimate the association between the exposure of HIV preventive behavior change and the outcome of HIV infection for these two rural youth populations separately and compare results.

Rationale

Few studies have described experiences of populations across African countries, especially among adolescents specifically (14-16). While many studies have looked at validity of data within their own questionnaire and of self-reported sexual behavior data in general, few have compared validity of the same or similar question between African countries (15-19).

Further, while many studies include adolescents in the sample, few have restricted any comparisons to rural African youth (14-16, 20, 21). We conducted logistic regression to determine if the exposure of reported behavior change was associated with the outcome of HIV infection. Individuals who responded that they have changed their behavior since hearing of HIV/AIDS were hypothesized to mention that behavior in another part of the survey. Reporting changed behavior since hearing of HIV/AIDS was hypothesized to be associated with HIV infection.

Specific Aim 2

To assess the relationship between reported concurrency and either HIV or STI infection among sexually active Malawian youth aged 15-24 years.

Rationale

Concurrency has been highlighted as a potential explanation for high levels of HIV in African nations as compared to European nations and America, as heterosexual sex is the main mode of transmission in all locales (22-24). Concurrency has been associated with STI infection at individual and partnership levels. Individuals who reported concurrency were more likely to have a STI (8-10). Belief or evidence of a partner's concurrency with another

sexual partner was associated with STI infection (8, 25). Studies conducted to develop syndromic management of STIs in developing countries have established the link between potential markers of infidelity (having a new partner or more than one sexual partner within various time periods (26-29) or high number of sexual partners(30)) and STI infection(26-31). The majority of recent studies focusing on concurrency and STI infection have occurred among high risk, urban, American youth(8-10, 25) whereas few have occurred in developing countries(32, 33) or included estimates for rural populations(34). This study is one of the first to focus on concurrency and both STI and HIV infection among rural African youth.

CHAPTER TWO

Background

Maintaining reproductive health among adolescents and young people is a critical problem that needs immediate attention through targeted interventions.

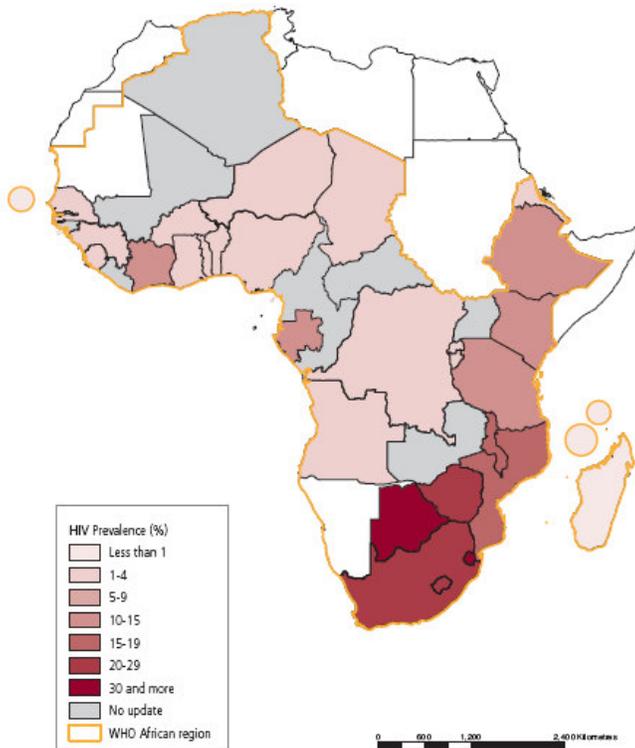
Globally, half of all new HIV infections occur among youth aged 15-24 years old(1). In addition to biological vulnerability, youth are one of the groups at highest risk of HIV/STI infection due to their behaviors. They are at a peak of new sexual experiences that could be perceived as risky or healthy. For example, economic constraints or benefits play an important role in the choice of sexual partners and behaviors, and may lead to age differences between partners and earlier marriage for low income women versus higher income groups (1, 35).

While age and sexual experience mediate reported behavior change, young people are more likely to adopt healthy behaviors. School-based interventions geared towards the adoption of low-risk behaviors among young virgins were more successful than interventions aimed at behavior change among older, sexually active African teens (36). Information about healthy behaviors can be disseminated through school-based programs, mass media or parental education, where culturally appropriate (1, 36).

An important factor to consider in the development of interventions is the background prevalence of HIV in the population, which is, in turn, influenced by the stage of the epidemic. Generalized epidemics are defined by HIV prevalence of more than 5% among

ANC care seeking women and in at least one group of individuals who engage in risky behavior(37). Figure 2.1 indicates that many southern and eastern African countries, including South Africa and Malawi, have a high HIV prevalence among ANC attendees.

Figure 2.1. Median HIV prevalence among women aged 15-49 years attending ANCs by country in the WHO African region, 2003-2004.(38)



Source: WHO HIV/AIDS Epidemiological Surveillance Report for the WHO African Region, 2005 Update

Further evidence indicates that both South Africa and Malawi have generalized epidemics (5, 38-40). In 2004, HIV prevalence reached almost 30% among ANC attendees in South Africa. Half of all self-identified sex workers who tested in 2000 were positive (38). In 2003, approximately 21% of ANC attendees in Malawi were HIV positive. Of women aged 15-24 years who attended ANCs, about 18% were infected with HIV. Testing at STD clinics in seven rural Malawian areas in 1995 yielded 46% HIV infection (40). In

addition, incidence is rapidly increasing among those aged 15-24 years old and in rural areas, closing the gap between lower prevalences found in rural compared to urban areas (12, 13, 37).

For generalized epidemics, prevention research needs to focus on those at risk, better targeting interventions(12). Both specific aims attempt to answer this call to a priority area of research, by describing those rural adolescents who have reported changing their sexual risk taking behavior or have engaged in a risky behavior, and to see if either was associated with infection. The results of this dissertation will serve to inform prevention efforts aimed at rural youth at risk of HIV infection.

Several national and international efforts are geared towards intervention, which could utilize these findings. The United Nations (UN) Millennium Project, the UN Assembly Special Session on HIV/AIDS, and the Behavioral and Social Science Research division of the National Institute of Allergy and Infectious Diseases are all examples of entities focusing on increasing education and decreasing HIV infection among vulnerable youth(1, 41, 42). Efforts such as the 2005 G8 Summit, which cancelled debt and increased aid to developing countries, has provided funding to develop interventions at biological, individual and community levels towards halting and reversing the tremendous effects of HIV infection that has blanketed the African continent(43).

Transmission of STIs, including HIV, is influenced by biology, culture, and individual behavior, particularly in sub-Saharan Africa.

Biologically, HIV transmission is dependent on infectiousness of the HIV positive person and host susceptibility. Infectiousness can increase due to elevated HIV viremia that can

exist during co-infection with an STI (44-49) or acute HIV infection or AIDS(50-52). Co-infection is hypothesized to occur due to genital lesions that can transmit infection (through the absence of a skin barrier), coupled with a decreased immune system that can lead to higher levels of genital shedding of both viruses(44, 49). An example of empirical evidence of co-infection is the association between infection with herpes simplex virus type-2 (HSV-2) and HIV in several cross-sectional studies. In a South African mining town, 64.7% of men and 90.7% of women were co-infected with HSV-2 and HIV (46, 53). Acute HIV infection refers to the first few weeks of infection with the virus, and is characterized by general malaise and increased viral load in both the blood and genital secretions (54). Increased viral load during acute HIV and AIDS increases infectivity (51, 52). Host susceptibility increases in the presence of STIs for both genders and bacterial vaginosis among women; it decreases among circumcised men (44, 55, 56). In four African cities, two each with low and high HIV prevalence, biological factors such as HSV-2 infection and circumcision status were more predictive of HIV infection than sexual behaviors (57). However, biological mechanisms that contribute to HIV infection are influenced by cultural contexts.

The proximate determinants framework can be a useful tool in which to organize cultural influences, as it is constructed by the connections among underlying, proximate and biological determinants(58). Underlying determinants comprise the constellation of influences at the community level. These include socioeconomical, sociocultural and demographic elements (58, 59). In South Africa, examples of underlying determinants include a sexual culture that leads to older males partnering with younger women, reduced sexual power among young women and the existence of a successful HIV prevention and youth empowerment program (2, 60, 61). Underlying determinants influence individual level

factors, or proximate determinants. Factors that are theorized to increase young women's risk for HIV acquisition, such as age, age of partner, age of coital debut, self-reported STIs, number of lifetime partners and condom use are proximate determinates for rural African youth(61). Biological determinants of infectiousness and host susceptibility were described above.

To illustrate how the proximate determinants framework works, we use the example of older male partners. Culturally, women are expected to marry earlier than men and to marry older men, which are underlying determinants of HIV infection. At the individual, proximate determinants level, older men put their young wives at risk by having had more partners, having been more exposed to infection than younger men, and having more power to refuse to use condoms (62, 63). At the biological level, women are more susceptible to infection due to the large vaginal mucosal area (64). These three levels work in concert to increase the risk of HIV infection among young African women who have older male partners. To address the multiple layers of influence illustrated by the proximate determinants framework, HIV education and interventions are common throughout South Africa and Malawi, including in rural communities, to educate youth about the risk of infection from biological and cultural determinants and to influence individual behavior change.

Individual behaviors can be divided into sexual and economic behaviors which work separately and together to influence HIV transmission (1, 12, 46, 65). Individual level sexual behaviors include age of coital debut, number of lifetime partners, and older partners (1, 12, 63, 66). Among urban Zimbabwean women, early coital debut was associated with number of lifetime partners and both were risk factors for HIV(66). Early age of debut is also

associated with riskier partners, including older men partnering with younger women(1). The greater risk associated with women having older partners is more pronounced for younger women than older women. A comparison of the risk of HIV from a partner at least 10 years older compared to 0-4 years older found that those aged 15-19 years in rural Uganda had twice the risk of HIV infection while women aged 20-24 years had only a 24% increased risk(63).

Individual level economic behaviors include sex work, male migration to cities for work, and women with low socioeconomic status (SES) marrying early (1, 12, 46, 63, 66, 67). African women with low SES are more likely to become married at a younger age, receive less education, have access to less information and sexual negotiation skills, and use condoms less frequently(1). A recent review of interventions among youth in developing countries showed that low SES leads to less power, increasing the likelihood that women engaged in transactional sex or were coerced into sex(1). Youth with higher education or that stayed in school were less likely to be HIV infected (46, 66-68). Employed men may be more desirable partners for young women, as they can provide economically for their partners, but may also be at higher risk of infecting their partners than those unemployed (63).

The Information-Motivation-Behavior (IMB) model provided the best framework for this dissertation as it is one of a limited number of behavioral theories or models that specifically focuses on HIV prevention behaviors.

The IMB was developed from an integration of research on HIV prevention and social psychological literature as one of a limited number of HIV prevention models

available(69). This model synthesizes the most important components of HIV prevention, namely that a person needs to have 1) knowledge about behaviors that prevent HIV acquisition, 2) the desire to prevent themselves from being put at risk and 3) the skills necessary to protect themselves, leading to the action of HIV preventive behaviors. Information can be expanded to include knowledge about modes of transmission and methods of prevention, as well as an ability to identify and dispel myths. Motivation includes a person's attitudes towards prevention behaviors, amount of social support surrounding their desire to institute a behavior and perception of risk. Behavioral skills include self-efficacy, the ability to follow through with an action. This could include knowledge about where to purchase condoms, talking to sexual partners about HIV/AIDS, talking to sexual partners about using condoms before, during, and after engaging in sexual intercourse, and getting tested for HIV(69). More studies of the IMB model have shown strong associations between information and motivation, and motivation to behavior, than between information and behavior (70). This model has been applied to condom use in South Africa, showing strong associations between self-efficacy and condom use, irrespective of gender. An increase in belief of stigmas surrounding AIDS led to less knowledge about HIV and less motivation to use condoms, perhaps due to decreased risk perception (71).

*Risk perception is thought to be an intermediate step between
knowledge and behavior change.*

Many health behavior models posit that individuals obtaining information about their potential risk and perceiving that they are at risk are necessary but not sufficient conditions

for behavior change (72-74). In other words, individuals must have knowledge of risk and then feel that they are at risk before they will take any steps to protect themselves. Examples of risk perception leading to protective behavior can be found in Malawi and South Africa. In rural Malawi, men perceived that their girlfriends comprised their greatest source of HIV infection while women perceived their risk came from their husbands (73, 74). Between 1998 and 2001, divorce became a more acceptable way for women to remove themselves from a situation in which they perceived HIV risk in an effort to protect themselves from infection (73). Among South African adolescents, knowing someone who died of HIV increased risk perception (72) and lead to reported behavior change due to HIV(75). Increased access to HIV testing served to disseminate more correct information about the actual HIV prevalence within Malawian communities and reduced overall risk perception and worry about risk(74). However, the empirical evidence concerning risk perception does not provide a clear picture of how it influences behavior and the adoption of behavior change.

Further studies of risk perception in Kenya and Malawi have shown that social networks influenced risk perception and adoption of protective behaviors. Social networks served as a filter for new information concerning HIV and sustained social norms, such as the belief that condoms signal mistrust in a marriage(76). Rural Kenyan women were more influenced by the types and strengths of relationships within their social networks while men were more influenced by the number of people in the network who shared beliefs(77). These studies call attention to the potential of peer-led prevention initiatives to increase and maintain the adoption of prevention behaviors.

Behavioral interventions are working in some contexts, but more information about how and why adolescents make decisions is needed.

Qualitative research can generate contextual clues surrounding adolescent behavior change. In a review of 268 qualitative studies conducted between 1990 and 2004, themes emerged about young people's thoughts on sexual behavior that were found to be independent of country or culture. Specifically: 1) Decisions about a partner being "unclean" or "clean" formed the basis of risk assessment. 2) Partner attributes influenced the couple's behaviors. 3) Advocating the use of condoms was a reflection on the partner that raised the issue and was perceived to indicate mistrust. 4) Gender stereotypes about "promiscuous men" and "prude/pure women" shaped and predicted behavior. 5) Thoughts about how society would penalize actions (such as unwanted pregnancy) and reward others (such as young men having intercourse with their partner) shaped actions. 6) Maintaining a desired reputation from either having or not having had sex was significant to youth. 7) Negotiation around having protected sex was vulnerable to stereotypes and expectations about who should start the conversation and when(78). These foundational beliefs can help to explain young people's behaviors. For example, a young woman knowledgeable about the protective role of condoms may not initiate condom negotiation because it could indicate "uncleanliness" to her partner, may indicate that she does not trust her partner and could also indicate that she has already had many sexual experiences which could subsequently hurt her reputation.

The research described above summarizes the different ways that adolescents described their thought processes surrounding behavior change. Qualitative research in Malawi has indicated that behavior changes have included a myriad of behaviors: abstinence, engaging in spirit-based religion that emphasizes fidelity, being faithful, selecting

extramarital partners based on knowledge of their sexual history and likelihood of HIV infection, divorcing unfaithful spouses and using condoms(79). While many other behavior changes exist, the following discussion will focus on the most commonly described prevention behaviors.

Common HIV prevention behaviors can be categorized into abstinence, being faithful and using condoms.

Components of the common ABC approach to HIV prevention involves Abstaining from sex outside of marriage; or if this is not possible **B**eing faithful to a sexual partner; or if not possible using a **C**ondom. All of these components are interrelated and have an essential role in a comprehensive prevention intervention package(36, 80). For those who have not initiated sex, delay of sexual debut or abstinence may be the most highlighted message, as the adoption of low-risk behaviors have been found to be more effective than changing high risk behaviors(36). For youth who have already had sexual intercourse, public health officials stress monogamy along with condom use for STI, HIV and pregnancy prevention.

Campaigns to disseminate information about HIV/AIDS prevention aim to convey information on ways to protect oneself against infection with the virus and subsequently change behavior to such a magnitude that it is measured as a successful intervention.

Changing the behavior of at-risk individuals is one of the most difficult challenges that public health professionals face. First, increased knowledge doesn't always translate into behavior change, due, for example, to either a lack of initiation of new behaviors, or a lack of agreement on the part of both partners to engage in a new behavior within a relationship.

Males and females in Botswana were found to have similar levels of knowledge about HIV,

but men reported higher levels of condom use(81). Condom use was lower for both sexes when alcohol was involved, and decreased among women with older partners(81), perhaps reflecting a power differential between men and women in the latter example. Even when behavior change occurs, it is difficult to capture since this information is self-reported, and subject to social desirability bias. In spite of these hurdles, successful interventions can be identified.

Interventions that are applicable to the target population in terms of culture and their specific risk factors, and that involve repetition of the message, are most successful in increasing knowledge and self-efficacy, and decreasing risky behaviors (82, 83). Successful interventions often include community gatekeepers, religious organizations, local leaders and village groups at every level of intervention development, implementation and evaluation (22, 82). A review of 73 studies and interventions in the US found that programs targeting risky sexual behaviors through comprehensive classes covering abstinence and contraception and one-on-one discussions with a health care provider in a clinic setting were as effective as service learning programs which sought to enrich the lives of youth by involving them in volunteer activities(84). A review of prevention interventions in developing countries also found an effect of increased knowledge and skills leading to behavior change, but this effect was smaller than that seen in the US (85). However, another review of 11 African school-based interventions showed increased knowledge and some behavior change, mainly through increased communication with peers and partners about condom use, which may serve as a precursor to sustained behavior change(36). Indeed, the largest predictor of inconsistent condom use among South African youth was not discussing condom use with their partner in

the previous 12 months (Adjusted OR 9.32, 95% CI 6.45, 13.48 for males and 16.99, 95%CI 8.40, 34.37 for females) (86).

Abstinence occurs at both the primary and secondary levels, and is more widely adopted in contexts of comprehensive sexual educational programs.

In a study of South African youth, 5.2% of youth aged 15-24 reported primary abstinence “to avoid pregnancy/STI/HIV” and 14.7% reported ‘secondary abstinence’ or not having had sex in the past 12 months(87). A recent review found no association between abstinence-only educational interventions and a reduction in sexual risk behaviors(88). Therefore, these programs are potentially putting disempowered women at greater risk of infection through misinformation or information exclusion(89). In contrast, a recent review of abstinence-plus programs found a reduction in sexual risk behaviors in 59% of trials and no increase in sexual risk behaviors in any trials(90). This suggests that the inclusion of messages about partner number reduction and condom use to an abstinence-based program are beneficial towards reducing risky behaviors overall (90, 91).

Being faithful is a critical behavior as concurrency is suspected to amplify STI/HIV transmission.

Concurrency is defined as having at least one other sexual partner during an existing sexual relationship and has been found in many contexts and social groups. Concurrency can be measured in several ways, either through a direct question about having another sexual partner during a current relationship or by indirect calculation of the overlap of beginning and ending dates of past and current sexual relationships(92). Studies of both measures have

found little agreement between the two when asked of the same participants (9, 92). The direct method was shown to elicit less missing data and more valid responses with less misclassification error than indirect methods (9, 25, 34, 92). However, the direct question may suffer from social desirability bias as well as limit the ability to describe the patterns of concurrency, in terms of overlap length, number of overlapping partnerships, etc. The data on Malawian youth used in this dissertation asked direct questions about concurrent behavior. This section will discuss how concurrency is theorized to amplify HIV infection within sexual networks, summarize studies linking concurrency with STI/HIV infection, and apply concurrency to the context of condom use.

Modeling of partnership formation has shown how concurrency is more efficient at transmitting and amplifying HIV infection than serial monogamy. Morris and Kretzschmar (1997) used mathematical modeling to increase the amount of concurrency in a closed population from zero (all partnerships were serially monogamous) to one in which there was high concurrency over a period of time(65). This seminal paper showed that as concurrency increased, the HIV epidemic increased exponentially in both the number of people infected and the amount of time it took to infect greater numbers of individuals(65). Recent modeling by Doherty et al (2006) explored the relationship between concurrency and mixing (having sex with people like (assortative mixing) or unlike (dissortative mixing) themselves) and showed how the two concepts work together and separately to increase both prevalence and transmission within a population(93).

Concurrency creates a chain of transmission by connecting infected partners with new uninfected partners within shorter time periods that are more likely to include the period of infectiousness(93). As a result, concurrency creates a loose network of connections between

people that facilitates transmission and increases prevalence (65, 93, 94). Concurrency has been associated with STI infection at individual and partnership levels. Individuals who reported concurrency were more likely to have a self-reported STI or test positive for gonorrhea, Chlamydia or trichomonas (8, 9, 95). Belief or evidence of a partner's concurrency was associated with STI infection (8, 25). Concurrency was not found to be associated with HIV infection among adults in urban African cities (32).

Several large sexual network studies involving concepts of concurrency have been conducted in Uganda, Thailand and the United States(94, 96). The majority of recent American studies focusing on concurrency and STI infection have occurred among high risk, urban, American youth(8-10, 25) or have described concurrent relationships resulting from the decreased sex ratio of African Americans (97), especially in the South(98-100). Few have occurred in developing countries(32, 33, 96) or included estimates for rural populations(34).

The preventive behaviors of ABC work both separately and together to either prevent infection or lead to increased risk. Studies have shown how concurrency can lead to reduced condom use in some settings, often due to established trust within partnerships. In a household survey of 18-59 year olds in Chicago, concurrency was measured by overlapping dates of relationships, with long term concurrency defined as an overlap of at least 2 months. More African Americans (24% vs. 74%) than White Americans (8% vs. 55%) reported concurrency in the past year and long term concurrency, respectively(101). Condoms were less likely to be used in long term concurrent relationships, as condom use was perceived as a lack of trust (101). Sex workers in Thailand and their regular partners (≥ 3 encounters) reported less condom use within these partnerships, which are thought to be more secure.

These young men also reported zero condom use with non-sex worker partners, acting as a bridge population to local young women (96). Among Ugandan adults aged 15-49 years, the median number of sex partners was 2 for women and 3 for men, but 40% reported concurrency within the last three partnerships (55% women, 27% men). Over 90% reported two long term partners, and of those, about 90% reported inconsistent condom use with at least one of the partners(96). Together, these studies highlight the important role that concurrency plays in fueling the HIV epidemic. Condom use is the last component of the common ABC prevention tenants to discuss.

Increased condom use would slow the spread of STIs and decrease unwanted pregnancy, but requires a change in behavior at the levels of both the individual and dyad.

Condom use is promoted as a method to prevent STI infection almost universally. However, as the condom provides a physical barrier between the penis shaft and vaginal or anal mucosal surfaces, it does not cover the entire genital area, leaving room for infection from diseases such as herpes or human papillomavirus (HPV) that are commonly transmitted through skin to skin contact(102). Since the Food and Drug Administration's investigation of condom efficacy in 2000, studies have shown that consistent condom use is protective against HIV, gonorrhea, Chlamydia, herpes, HPV and pregnancy(103) and that condom promotion within STD prevention interventions is associated with less subsequent infection(104). It is estimated that consistent condom use can reduce HIV transmission by between 80-90% in discordant couples, couples in which one partner is HIV+ and the other is HIV-(103).

The use of condoms requires action at both the individual and partnership level. At least one individual in a partnership needs to initiate a discussion about condom use and bring condoms to sexual acts (individual level behaviors) and condoms need to be used consistently and correctly during sexual acts (partnership level behaviors). In 2000, over 80% of teens aged 15-19 years and over 90% of youth aged 20-24 in Malawi knew where to buy condoms(1). However, knowledge doesn't always translate into action, especially since condom use negotiation is influenced by both partner's desires and perceptions, subject to the power differential in the relationship (60, 105-109). South African youth reporting low levels of condom self-efficacy felt that condom use was a sign of distrust in a relationship (110, 111). This belief was echoed by married Malawian adults, who indicated that the marital relationship created space to satisfy sexual cravings and to reproduce; condoms could only be used for pregnancy prevention with a spouse. These men also indicated that condom use was acceptable outside of marriage, for STI and STI/pregnancy prevention (112). Another instance of acceptable condom use was found among partnerships of Ugandan adults in which one partner traveled for work. Travelers reported greater knowledge about HIV risk and greater condom use with both non-local and local partners, a finding echoed by their local partners(96).

All of the ABC prevention behaviors have been discussed in detail. The next step is to investigate if changed behavior will lead to decreased infection at the population level.

*An increase in reported behavior change and decreased HIV prevalence
has been linked in several contexts.*

While observation of declining HIV prevalence can be shown through increasing AIDS deaths, studies the epidemic in Kenya, Uganda and Zimbabwe have provided some evidence that declining HIV prevalence may also be the result of changes in sexual behavior.

Evidence from a series of cross-sectional Kenyan studies suggested declining HIV prevalence estimates since the year 2000, as extrapolated from ANC and STD clinics.

Between 1993 and 2003, respondents in national Kenyan surveys reported fewer sexual partners in the previous 12 months, reduced coital frequency in the past month and higher levels of condom use with non-regular partners(113). Rural Ugandan cohort data from 1989 to 1997 showed decreased HIV prevalence particularly among females aged 13-24 and men aged 20-24. Between 1992 and 1997, ever having used a condom was increasingly reported by all age groups of men and women under 35 years and in all marital status categories(114). From 1998 to 2003, HIV prevalence decreased among Zimbabwean men aged 17-29 years and among Zimbabwean women aged 15-24 years. At follow-up, cohort participants reported fewer numbers of new partners in the past 12 months and numbers of casual partners in the past month. Consistent condom use with casual partners remained around 40% for men and increased to 36.5% for women(115).

Another widely cited success is the 100% Condom Use Program in Thailand which has been successful in encouraging condom use at every penetrative sexual act among sex workers throughout the nation. Thailand has managed to increase and sustain condom use to over 90% since 1992 (116). This structural level intervention has also been established country wide in Cambodia. Growing programs in China, Lao People's Democratic Republic,

Mongola, Myanmar/Burma, Philippines and Viet Nam have shown promise that increasing condom use leads to decreasing HIV and STI prevalence.

It should be noted, however, that the evidence of increased reporting of protective behaviors and decreased HIV prevalence does not lead to a conclusive causal link between these two factors. Studies of each factor were conducted separately, and sometimes within different populations, making a direct comparison difficult. In addition, prevalence is a measure of the total number of people infected out of the total population. As deaths from AIDS increases, the prevalence will subsequently decrease. A review of the literature found several commentaries questioning Uganda's results and the strength of the causal link between behavior change and decreased incidence and prevalence in this country (89, 117, 118).

Information about the commonalities and differences of adolescent sexual behavior between African countries, specifically South Africa and Malawi, are limited.

A review of the literature identified comparable samples of youth in South Africa and Malawi, identifying similar patterns of behavior for some constructs (Table 2.1). Youth of both genders in both countries report few lifetime partners. Some level of condom use at last sex act is reported in both countries, but was reported by more South African youth compared to their Malawian counterparts. Married women in both countries report sex in the past month in much higher numbers than single women. HIV testing was more common in South Africa than Malawi, which could indicate greater access to testing facilities (11, 21, 119).

Table 2.1 Sexual behavioral characteristics among South African and Malawian youth (11, 21, 119)

	South Africa		Malawi	
	Females	Males	Females	Males
Sexual partners				
Mean number of lifetime partners	1.1	1.8		
Reporting at least 2 partners in the past year			2%	16%
Condom use at last sex	48%	57%	26%*	23%*
Sex in the past month				
Married women	>70%	--	>70%	--
Single women	40%	--	20%	--
Tested for HIV	25%	15%	7%	7%

*Among those that reported at least 2 sexual partners in the past month

Table adapted from Wellings et. al, 2006; Bankole et. al., 2004; Pettifor et. al., 2004.

The desire to be tested for HIV was quite high in Malawi, ranging from 81% of women to 86% of men(1, 11, 119). When Malawi youth were asked an open-ended question of ways to avoid HIV/AIDS, more identified abstinence or using condoms than having only one partner. While the majority of youth aged 15-24 years in Malawi between 1999 and 2003 knew that a healthy person could have AIDS (84% and 89%, respectively), a more comprehensive knowledge of prevention facts was correctly answered by only a little over a third . High participation in the South African multi-media campaign, loveLife, was found; 85.2% of young women and 84% of young men had seen or heard of the campaign. Participation in at least one loveLife program, all of which focused on increasing knowledge and participation in safe behaviors, was shown to be protective against HIV infection(2). This dialogue, however, compares different groups at different points in time. The first specific aim attempted to clarify the previous discussion of similarities and differences of

sexual behaviors through the evaluation of the same group (rural youth aged 15-24 years) from data collected in South Africa and Malawi a mere year apart.

Moving from behavior change to biological outcome data, HIV prevalence estimates are higher among women than men and in South Africa than in Malawi (5, 39). Studies in a rural area of southern Malawi have reported evidence of genital ulcer disease and pelvic inflammatory disease in STD clinics and urethral discharge among male inmates (6, 7). This evidence indicates that there is a need in the literature for a direct comparison between behaviors and STI outcomes among rural youth in these two countries.

Rural African youth comprise an important subgroup as they are more isolated than urban youth, but have lower HIV prevalence.

While the previous statistics describe the adolescents of each country in general, more needs to be known about rural youth. Youth living in rural areas have poor access to many factors that could protect them from becoming infected with HIV. Rural youth suffer from a decreased access to education. Among sub-Saharan youth aged 15-19 years, 37.9% more urban males and 46.9% more urban females had access to school compared to their rural counterparts(120). Staying in school or the level of schooling completed may be protective; Zambian women aged 15-19 yrs who had some level of education had decreasing prevalence levels compared to women with no education during the 1990s(121).

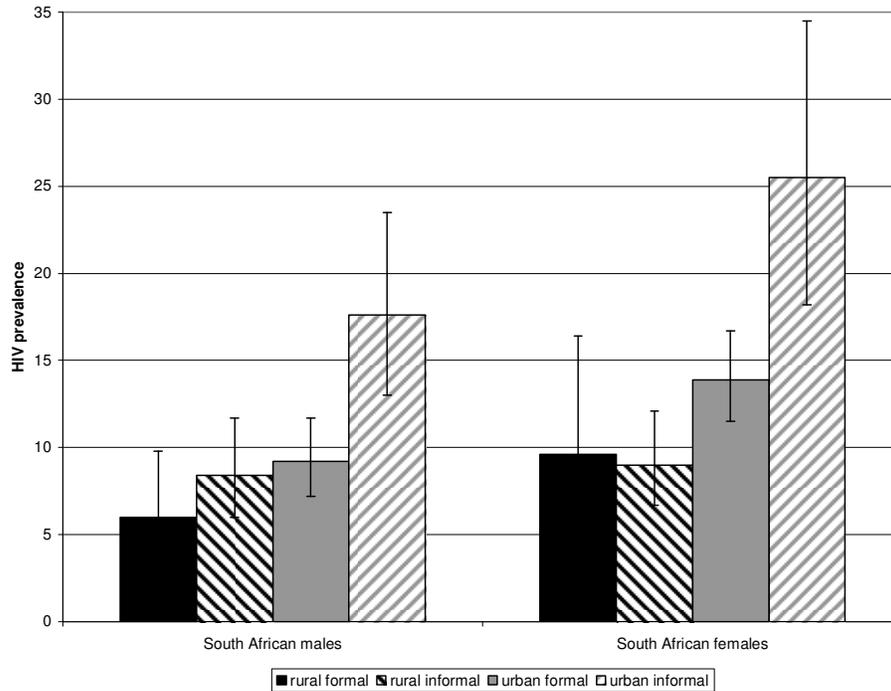
Media campaigns imparting information on HIV and how to protect oneself are likely to be more available in urban areas, where access to television and the radio may be more consistent and dominant than in rural areas where electricity may not be readily available. Information about the benefits of reproductive health care, as well as facilities to provide this

care, is often insufficient in rural areas. In addition, transportation from rural to urban areas is often sporadic and costly, limiting access to information on HIV; health facilities for testing, treatment and care of STIs and HIV; and pharmacies and shops that sell condoms.

Poverty in rural areas is intermingled in all of these points. Access to cash affords access to: radio or television information, health care facilities, the ability to purchase condoms; it can also lead to more power for women to negotiate sexual relationships (37). The financial ability to purchase condoms is particularly salient in this comment made by a 21-25 year old South African female participant in a focus group: “Diseases will not end if they sell condoms to us. People here are very poor; if someone gets five rand they spend it on bread and candles, not condoms.”(111)

This evidence helps to support the conclusion that it is imperative to direct interventions towards rural youth to prevent HIV prevalence in rural areas from reaching the high levels experienced in urban areas. The prevalence of STIs and HIV in rural Malawi is increasing towards levels seen in urban areas, making rural youth an important target population for prevention (13, 122). The overall HIV prevalence in KwaZulu-Natal province, where the majority live in rural areas, was 16.5% in 2005 and prevalence among ANC attendees grew from 36% in 2000 to 39% in 2005(3, 4). Among a population based sample of South Africans, HIV prevalence was higher in urban versus rural areas (Figure 2.2)(123).

Figure 2.2. HIV prevalence among a population based sample of South Africans, 2004



Source: Connolly C et al., Epidemiology of HIV in South Africa- results of a national, community-based survey, 2004.

Note: Rural formal means farms, rural informal means tribal areas, urban formal means urban settlements and urban informal means informal settlements.

Geographic and demographic variations of HIV are found in Malawi, with higher prevalence found in the South (compared to the Center or North) and in urban areas compared to rural areas(122). While HIV prevalence, measured from ANC attendees, declined from 1999 to 2003 in urban areas, it increased in rural areas from 2001-2003. As evidence indicates HIV prevalence is lower in rural compared to urban areas (20, 123, 124); it is imperative to retain low infection numbers among these groups.

Conclusion

Youth are vulnerable to HIV infection and are succumbing to infection at high levels. Rural youth are important to target with interventions to keep their infection levels below those found in urban areas. The ABC components of HIV prevention work together to effect change and there is some evidence that behavior change is associated with decreased HIV prevalence in some areas. Being faithful is an important component of the ABC messages as concurrency has been associated with STI infection. The description of behavior change among rural youth in South Africa and Malawi and the investigation of concurrency and STIs in rural Malawi are both novel and necessary studies.

CHAPTER THREE

Research Design and Methods

Data sources

Study data was drawn from two national surveys, one conducted in South Africa in 2003, and one in Malawi in 2004.

The South African data

A nationally representative household survey of South African youth aged 15-24 was conducted in 2003 and a multitude of questions were asked, such as knowledge about HIV/AIDS, and information on how youth may have changed their sexual behavior since hearing of HIV/AIDS. Orasure® tests for HIV were conducted (Orasure Technologies, Inc., Bethlehem, Pennsylvania)(125). The sampling design consisted of a three-stage, disproportionate, provincially stratified sample which resulted in sampling of 15-24 year old youth in the nine South African provinces. Primary sampling units were based on census drawn enumeration areas (EA). Random sections of each EA were enumerated by household and one youth per household was chosen for participation by randomization determined by the Kish grid method(2). Of the 11904 adolescents in the survey, 5606 (47.1% unweighted) of the sample were considered from rural South Africa. Of those, 820 lived in rural formal (small farm holdings) and 4786 lived in rural informal (tribal) areas(125). Among those rural youth, 2716 were young men (48.5%) and 2890 (51.5%) were young women. For Specific

Aim 1, the analytic sample included all rural sexually active youth aged 15-24 years old. Appropriate analytic methods were used to analyze a subpopulation while correctly accounting for the complex survey design.

The Malawi data

The Malawi Diffusion and Ideational Change Project (MDICP) at the University of Pennsylvania is a longitudinal study of rural married and adolescent Malawians in the districts of Mchinji (in the Center), Rumphi (in the North), and Balaka (in the South). This study was originally conducted among married females and their partners in 1998 while an adolescent sample of both married and unmarried individuals was added in 2004 to refresh the sample. In the main survey, data was collected in 2004 on demographics, social networks, religion, sexual behavior, and HIV risk perception. Generally within one week of collection of data for the main survey, a nurse visited each participant for a brief STI questionnaire and to collect biomarker samples. Self-collected vaginal swabs from women were tested for Chlamydia, gonorrhea and trichomonas. Urine was collected from men and tested for Chlamydia and gonorrhea. Vaginal samples and urine were tested using Roche PCR. Oral fluid samples were collected for HIV testing using Orasure® (Orasure Technologies, Inc., Bethlehem, Pennsylvania) and positive tests were confirmed through Western Blot.(126)

While this data is not nationally representative, characteristics of the rural population in the Malawi Demographic and Health Survey (MDHS) and those of the sample were quite similar (11, 127). The 2004 MDICP survey and the MDHS survey were comparable and those lost to follow-up in the MDICP were more likely to be HIV positive and to have received their STI/HIV test results(128).

Table 3.1. Characteristics and sampling of three rural districts in Malawi

	Rumphi	Mchinji	Balaka
Geographical location	North	Center	South
Sampling strategy	Randomized three stage sampling design	Randomized three stage sampling design	Villages sampled from baseline survey conducted by GTZ
System of kinship and lineage	Patrilineal	Matrilineal	Relaxed matrilineal
Primary tribe	Tumbukas	Lomwes and Yaos	Chewas
Primary religion	Protestant	Moslem	Catholic and Protestant

Adults in the Mchinji and Rumphi districts were randomly chosen to participate in the study based on a three-stage design in which villages in census EAs were chosen through cluster sampling. Households were enumerated and married women were randomly chosen from these lists. The husband of each woman was also interviewed. About 400 adolescents from each district were randomly chosen from household rosters as well, with the intention to capture equal numbers of males/females, and unmarried/married(17). Sampling of adults and adolescents in the Balaka district was conducted based on villages included in a baseline survey by GTZ, a German aid agency(80, 127).

The analytic sample involved combining datasets from the groups of married men, married women, adolescent men and adolescent women in the age range of 15-24 years. For Specific Aim 1, the analytic sample included all sexually active youth aged 15-24 years old (since the population sample already encompasses only rural youth). For Specific Aim 2, the analytic sample included all sexually active youth aged 15-24 years who answered both the main and STI surveys. Since the sampling in the Balaka district was so different from the

other districts, and the sampling frames of the Mchinji and Rumphi districts mirrored what was done in South Africa, the potential effect of district was explored in the analyses.

Data management

All of the data used for the analyses was deidentified, which included but was not limited to the absence of names, addresses, social security numbers and other identification besides age and race. Each dataset had a unique identifier for each individual which did not correspond to any identifying information. Analyses occurred on a password protected computer with a screen saver that locked the computer after 3 minutes of inactivity.

Statistical Methods Aim One

Specific Aim 1: To compare self-reported HIV prevention behaviors between rural South African and rural Malawian youth, aged 15-24 years, and assess internal validity of these constructs.

Analyzing survey data

Since the South African study was conducted as a nationally representative survey, the design of the survey was accounted for to ensure that appropriate variances and standard errors were calculated. The survey options in STATA were utilized, adjusting for the strata of province, primary sampling unit of the census EA, and weighting using the variable `newbenchwgt3`. Another complexity of the sampling frame involved analyzing a subpopulation of the entire dataset. The subpopulation option in STATA was employed, to properly restrict analyses to the various analytical groups, such as rural, sexually-active

females aged 15-24 years, while maintaining the sampling frame and calculating correct variances and standard error(129-131). Since the MCIDP data on Malawians was not weighted, survey methods were not utilized.

Analytic sample

The purpose of this aim was to capture the desired change in behavior- to delineate those that engaged in protective behaviors from those that were not engaging in protective behaviors. Those individuals who maintained protective behaviors or who were not at risk may not have reported behavior change, leading to misclassification of the exposure. For example, if individuals were already abstinent and remained abstinent after hearing of HIV, then they may not report having changed their behavior. This scenario, and others in which youth were not at risk of HIV infection, would have introduced information bias into the measurement of the exposure variable. In an effort to remove this bias, the analytic sample was restricted to rural youth who were sexually active, since they are the youth at risk for HIV infection.

It should be noted that it was not possible to remove those that remained faithful or were consistent condom users from the analysis, leading to some remaining misclassification of the exposure. However, reported consistent condom use is small among this population. A focus on general behavior change is therefore representative of the majority of the population of interest.

To create a comparison sample of youth between the two surveys, the datasets were restricted to those aged 15-24 years. As sexual experiences, behaviors and attitudes of women and men are quite different, analyses were conducted separately by gender.

Description of main study variables

South Africa

Behavior change since hearing of HIV was asked in a two part question. The first question asked “Since you have heard of HIV/AIDS, have you changed your personal behavior in any way to prevent getting HIV?” If yes, the person was asked to name the specific behavior. The exposure was dichotomized into 0= no behavior change and 1= change in behavior since hearing of HIV.

In sub analyses, the specific behavior change named in the second question was explored. Behaviors that were reported as abstinent, being faithful and using condoms were coded into mutually exclusive categories to compare each behavior change to the other. For each of these variables, reporting the specific behavior change was coded as 1 and everyone else who reported any specific behavior change was coded as 0. Those that answered that they changed their behavior to the first question and did not answer the second question concerning a specific behavior change were coded as missing. Since this was an open ended question, those behaviors that included “abstain or stopped having sex” were coded as abstinence, “being faithful to one partner” was coded as being faithful, and “use condoms” was coded as using condoms. A composite variable of reporting either abstinence, being faithful or using condoms was also created.

The outcome of HIV infection was a dichotomous yes/no variable.

Malawi

Behavior change since hearing of HIV/AIDS was also asked as a two part question in the Malawi questionnaire. The first question asked “Have you personally made any changes in your sexual behavior to avoid getting HIV/AIDS?” If yes, the person was asked to name the

specific behavior. The main exposure centered on the first question of behavior change, a dichotomous yes/no variable where 0= no behavior change and 1= behavior change since hearing of HIV.

In sub analyses, the specific behavior change named in the second question was used and coded into mutually exclusive categories of abstinence, being faithful or using condoms as described for the South African data above.

The outcome of HIV infection was a dichotomous yes/no variable.

Description of other study variables

Other covariates were investigated in this analysis, either as potential effect measure modifiers or potential confounders. Sociodemographic variables included district (Malawi only), age, education level, ever married or ever pregnant (women only). Variables on sexual behavior included age of coital debut, number of lifetime partners, and partner type (coded as casual or steady/spouse), condom use with most recent partner, sex in past 12 months, and current use of family planning (women only).

Analyses for Specific Aim 1a: Assessment of internal validity

Specific Aim 1a: To assess internal validity of the unprompted question concerning HIV preventive activities initiated since having heard of HIV/AIDS, with answers to prompted behavioral questions asked at other points in the survey concerning abstinence, being faithful, and using condoms.

The exposure for the first aim was based on the question of the individual changing their behavior since hearing of HIV/AIDS. If they answered yes, they were asked a follow-up question to name the behavior. There are many obstacles to collecting valid and correct information about sexual behaviors. Validity of the follow-up question was assessed to give credibility to the exposure variable. For example, if an individual answered that they “use[d] condoms” as their behavior change, may be more likely to have mentioned condom use with their most recent partner at another point in the survey when asked directly about condom use.

Kappa scores are used for discrete variables to assess for chance agreement between two separate measures of the same construct. Specifically, the kappa coefficient is:

$$\frac{\text{Observed agreement} - \text{Expected agreement}}{1 - \text{Expected agreement}}$$

and equals 1 when the two measures perfectly agree, 0 when the two measures agree by chance, and -1 when the two measures perfectly disagree. Observed agreement is the agreement found in the survey while expected agreement indicates the amount of agreement expected by chance (132, 133). With an understanding that not all researchers agree on levels of kappa scores that indicate high agreement among constructs(134), an approximate range of ≥ 0.75 was often considered to indicate “excellent” agreement and was used as a reference point for these analyses (133, 135). The kappa coefficient was easily calculated using the PROC FREQ statement in SAS (134).

Using Kappa scores, internal validity or agreement between what respondents answered to the unprompted question about behavior change since hearing of HIV and their

answers to prompted questions concerning those behaviors in other parts of the survey was assessed. Table 3.2 details the specific comparison variables used.

Table 3.2. Comparison variables for kappa coefficient analysis

Responses to the question regarding specific behavior change enacted after hearing of HIV	Malawi data	South Africa data
	Comparison question in another part of the survey	
Abstaining	Have you had sex in the past 12 months?	Have you had sexual intercourse in the last 12 months?
Only sleep with boyfriend/girlfriend/spouse	Were you having sex with other partners during the time you were having sex (with most recent partner)?	Measure of concurrency based on beginning and ending dates of most recent and second most recent partner.
Use condoms	In general, with what frequency did you use a condom with this (most recent) partner?	On average how often do you/did you use condoms with your most recent sexual partner?*

*For coding purposes, using condoms included the possible answers of: at the beginning, sometimes, almost every time and every time; never using condoms was coded as: not using condoms.

(Results of the interval validity analyses are presented in Appendix One.)

Analyses for Specific Aim 1b: Association between behavior change and HIV infection

Specific Aim 1b: To estimate the association between the exposure of HIV preventive behavior change and the outcome of HIV infection for these two rural youth populations separately and compare results.

Univariate analyses

Distributions of the exposure, outcome and covariates were assessed.

Small sample or continuity correction

All Malawian men who were HIV positive reported behavior change. As there were no HIV positive men who reported not changing their behavior, there was a zero in one cell of the 2x2 table of exposure and outcome, making the calculation of odds ratios impossible with common methods. Exact methods are often used when cell sizes range between one and five, but not necessarily when a cell size is zero. To support this convention, when exact methods were used in SAS (136), it did not always generate results (Table 3.3).

A small sample correction (k) can also be used, and k is commonly substituted as 0.5 (137, 138). Other types of k have been suggested, such as the treatment arm k and empirical k, which have both been shown to perform better when used on studies with zero cells that were included in meta-analyses (139). However, the discussion in Sweeting’s article(139) emphasized that as the ratio of exposed to unexposed becomes less balanced, the substitution of 0.5 for k yields more biased ORs than a more balanced ratio. In the data for Malawian men, the ratio of unexposed to exposed ranged from 1:0.3 to 1: 4.7. When compared to Table V on pg 1360(139), this smaller ratio did not yield as biased estimates as larger ratios, thereby supporting use of 0.5 for the small sample correction. Whenever small sample sizes yielded a zero in one cell of a 2 x 2 table, a small sample correction of 0.5 was added to each cell to calculate an odds ratio.

Table 3.3. Calculation of odds ratios (95% CIs) for Malawian men

	Association of behavior change and HIV infection	Association of concurrency and HIV infection	Association of concurrency and STI infection
Exact CIs calculated in SAS	∞ (0.42, ∞)	0.00 (0.00, 3.12)	∞ (0.23, ∞)
Small sample correction, k=0.5	3.68 (0.02, 66.14)	0.36 (0.02, 6.46)	13.29 (0.53, 330.75)

Sensitivity analysis

Unadjusted odds ratios were calculated between the exposure of reported behavior change and the outcome of HIV infection. A sensitivity analysis was conducted to determine if the missing values for the exposure of reported behavior change and outcome of HIV infection affected the resultant associations. The sensitivity analysis involved modeling the association between the exposure and outcome for various scenarios of values the missing data could have taken. For example, all missing values were coded in separate analyses as “yes, changed behavior since hearing of HIV”, “no change in behavior”, “named a protective behavior”, “named a risky behavior change”, and “did not report a specific change in behavior”. Results from the sensitivity analyses were similar to the crude associations in both effect estimates and 95% CIs. As these analyses did not generate very different results, sensitivity analyses were not conducted on more complex models.

Multivariate analyses

Logistic regression was conducted with behavior change as the exposure and HIV status as the outcome.

Assessment of effect measure modification

To test if a variable was an effect measure modifier (EMM) of the exposure-outcome relationship, the relationship between exposure and outcome was assessed for each strata or level of the potential EMM. The Breslow Day test of Homogeneity can be used to determine if the stratified estimates are statistically different from one another. Unfortunately, software that accounts for the sampling frame of the South African data does not support the Breslow

Day test. An additional problem is that non-weighted stratified estimates were different from weighted stratified estimates (Table 3.4).

Table 3.4. Association between behavior change and HIV infection for South African women, stratified by age group

	Accounting for survey weights OR (95%CI)	Without accounting for survey weights OR (95%CI)
15-19 years	0.95 (0.40, 2.27)	1.42 (0.90, 2.23)
20-24 years	1.21 (0.58, 2.50)	0.91 (0.68, 1.22)

OR=odds ratio CI=confidence interval

As Breslow Day tests conducted on non-weighted estimates were invalid, CI overlap was used to assess EMM. Using the example of age as an EMM, an investigation of the overlap of CIs for stratified South African estimates showed the majority had sufficient overlap, indicating the same estimate and no EMM by age (Table 3.5).

Table 3.5. Association between reported types of behavior change and HIV infection for South African and Malawian rural youth, stratified by age group

	South African women OR (95%CI)	South African men OR (95%CI)	Malawian women OR (95%CI)	Malawian men OR (95%CI)
General behavior change				
15-19 years	0.95 (0.40, 2.27)	0.76 (0.20, 2.90)	--*	--*
20-24 years	1.21 (0.58, 2.50)	0.92 (0.34, 2.49)	1.69 (0.60, 4.78)	--*
Specific behavior change				
Change of either A, B, or C				
15-19 years	0.85 (0.36, 2.05)	0.51 (0.16, 1.61)	--*	--*
20-24 years	1.24 (0.46, 3.32)	1.02 (0.45, 2.30)	--*	0.54 (0.06, 4.96)
Change of A				
15-19 years	0.38 (0.11,1.34)†	0.61 (0.10, 3.85)	--*	--*
20-24 years	7.38 (1.22,44.52)	0.67 (0.22, 2.10)	0.97 (0.28, 3.41)	1.31 (0.26, 6.73)
Change of B				
15-19 years	3.82 (1.70,8.55)†	--*	--*	--*
20-24 years	0.38 (0.15, 0.96)	1.01 (0.41, 2.47)	1.16 (0.33, 4.09)	1.13 (0.20, 6.44)

Change of C				
15-19 years	0.39 (0.16, 0.95)	1.09 (0.34, 3.47)	--*	--*
20-24 years	0.42 (0.10, 1.78)	1.17 (0.56, 2.44)	1.20 (0.13,10.78)	--*

OR=odds ratio, CI=confidence interval, A=abstinence, B=being faithful, C=using condoms

*OR not calculated due to zeros in at least one cell

†Effect estimates appear to be different due to a lack of CI overlap

The following variables were tested as potential EMMs: district (Malawi only), age, education, ever married, ever pregnant (women only), most recent partner type, condom use with most recent partner, sex in past 12 months, reported concurrency and current use of family planning (women only).

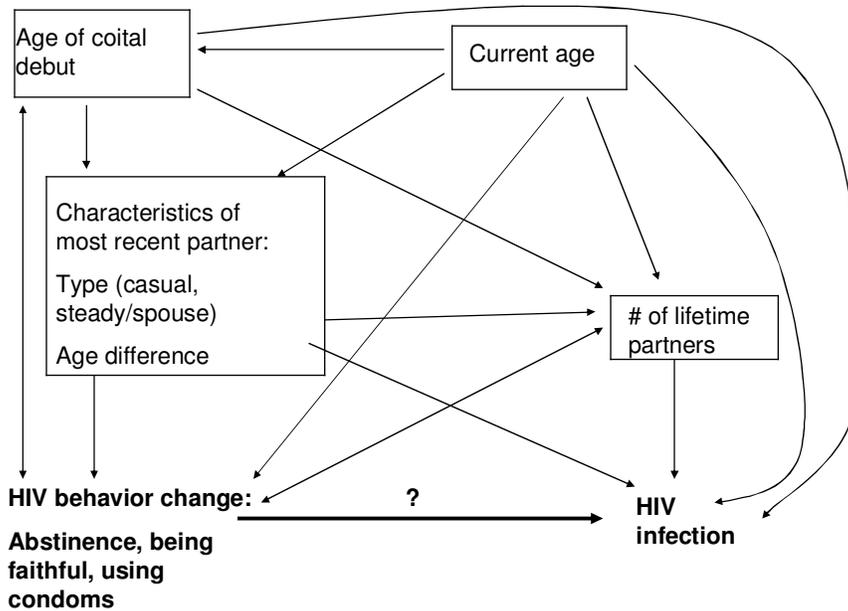
Assessment of confounding

Potential confounders were identified through *a priori* hypothesis/knowledge and creation of a directed acyclic graph (DAG). Current age was controlled for due to *a priori* hypothesis that the ability to change behavior is impacted by age, in that younger individuals may not feel confident or knowledgeable enough to change their behavior (i.e. compared to a 20 year old, a 15 year old female may not feel she has enough power in the relationship to negotiate safer sexual practices).

Figure 3.1 is the full DAG for the potential association between the exposure and outcome, taking into consideration potential confounders of the relationship. There are several limitations to using a DAG in studies of infectious disease, as it assumes that the outcome of each individual is independent of the outcome of other individuals. In the South African dataset, individuals may be sexual partners that have infected one another. The Malawi dataset was originally populated by married women and their spouses, so couples are represented and can be identified. In addition, each arrow in a DAG needs to be unidirectional. Therefore, while other relationships between variables may exist, such as

partner type on age of coital debut, the strongest relationships between variables was highlighted. Regardless of these limitations, DAG analysis is a helpful tool for thinking about potential confounders.

Figure 3.1. Directed acyclic graph for the association of the exposure of behavior change and outcome of HIV infection



Using DAG analysis techniques, those covariates in boxes: current age, age of coital debut, number of lifetime partners, and partner characteristics, were confounders of the relationship between the exposure and outcome and were assessed for confounding in the modeling stage of the analysis. The process of model building utilized backwards elimination, which began with the full model with all covariates. The potential confounder(s) thought to be least likely to change the main exposure- outcome effect estimate, identified by looking at the variable with the highest p-value, was removed first. Subsequent variables were removed in order of highest to lowest p-values. If at least a 10% percent change in the

point estimate between the exposure and outcome was found after each confounder was removed, it remained in the model.

Information Motivation Behavior Model analysis

Components of the IMB model were included in a separate analysis of South African youth to see if their contribution added to the fit of the model. This analysis was not replicated using the Malawi data due to small sample sizes. There are three components of the IMB model: information, motivation and behavior. Information was measured by a composite variable (has correct knowledge, has incorrect knowledge, has no knowledge) created from the following questions: “To the best of your knowledge, is there anything a person can do to avoid HIV, the virus that causes AIDS?” and “If yes, what can a person do to avoid getting HIV, the virus that causes AIDS?” Motivation was measured by a question on risk perception (none, small, moderate, high). The behavior component was represented by a composite variable that combined five questions with Likert-type scales concerning condom self-efficacy, such as “Would you be able to talk about using condoms with your partner?” The composite variable values ranged from 0 to 25 and was dichotomized into a variable representing high and low self-efficacy (110). Logistic regression with backwards elimination was utilized as described above.

(Results from the IMB analysis are presented in Appendix Two.)

Statistical Methods Aim Two

Specific Aim 2: To assess the relationship between reported concurrency and either HIV or STI infection among sexually active Malawian males and females aged 15-24 years.

Analytic sample

The analysis was stratified by gender and restricted to sexually active Malawian youth aged 15-24 years who answered both main and STI questionnaires.

Description of main study variables

The main exposure was reported concurrency with their most recent partner, measured by the question “Were you having sex with other partners during the time you were having sex with this partner?” This variable was coded as 0=no and 1= yes, concurrent.

Two outcomes of STIs were assessed. The first is a compilation variable which =1 if they tested positive for biological markers for gonorrhoea, Chlamydia or trichomonas (for women only) and =0 if did not test positive for any of the mentioned STIs. The second outcome of HIV infection was a dichotomous yes/no variable. While HIV is certainly an STI, the description of STIs for Specific Aim 2 only encompassed the bacterial STIs of gonorrhoea, Chlamydia and trichomonas.

Description of other variables

Other variables of interest in these analyses included district, age, education, ever pregnant (women only), ever married, house and roof material (as measures of SES), general health

status, most recent partner type, ever used condoms with most recent partner, belief partner cheated (measured by responding yes to the question “do you think this partner had other partners during the time you were having sex?” or responding “yes” or “suspect” to the question “do you suspect or know that your husband has had sexual relations with other women apart from you since you were married?”), sex in past 12 months, ever test for HIV, discharge or sores in the past 12 months, talking with partner about HIV, perception they had an STI in the past 12 months, likelihood of current STI infection, belief partner had an STI in the past 12 months and suspicion that spouse is HIV positive.

Univariate analyses

Distributions of the exposure, outcomes and covariates were assessed.

Bivariate analyses

The crude odds ratio was assessed for the exposure and outcomes. Descriptive statistics of the females are reported in Table 5.1 including age, education level, ever pregnant, ever married, general health status, most recent partner type, ever used condoms with most recent partner, belief partner cheated, sex in past 12 months, ever test for HIV, discharge or sores in the past 12 months, and belief partner had an STI in the past 12 months.

Only one male was positive for gonorrhoea and he reported concurrency. Only six males were HIV positive and none reported concurrency. Therefore, additional analyses were not conducted with the males.

Multivariate analysis

EMM and confounding was assessed for the relationship between the exposure of concurrency and each outcome of STIs or HIV as described for Specific Aim 1.

DAGs

Figure 3.2 is the full DAG for the potential association between concurrency and STIs, taking into consideration potential confounders of the relationship. Figure 3.3 is the the full DAG for the potential association between concurrency and HIV, taking into consideration potential confounders of the relationship.

Figure 3.2 Directed acyclic graph for the association of the exposure of concurrency and outcome of STI infection

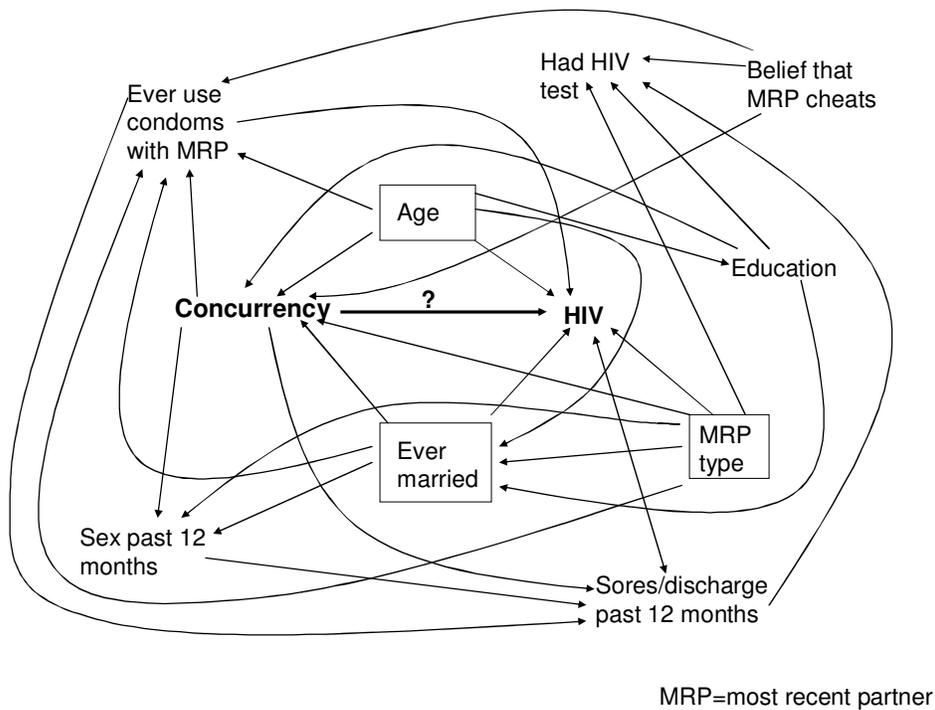
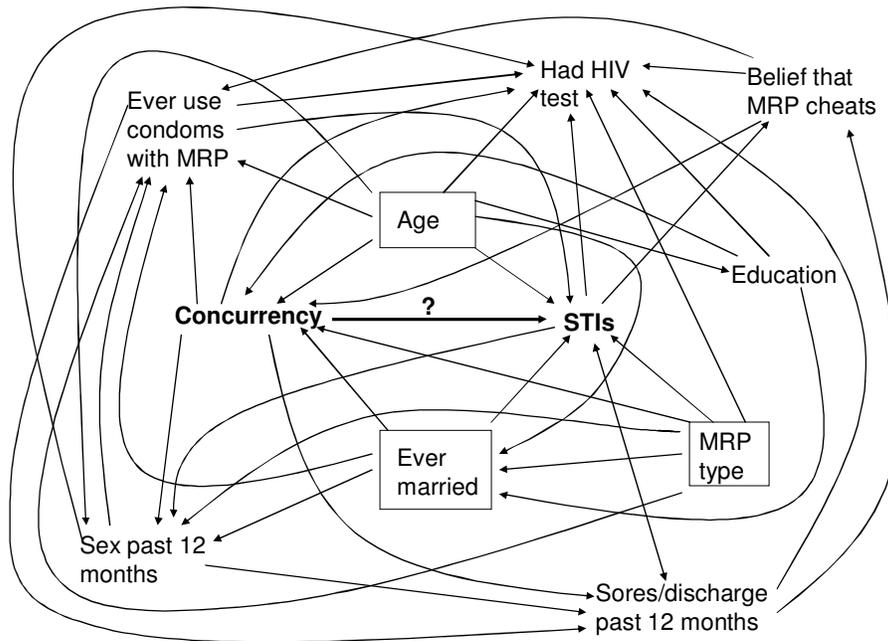


Figure 3.3 Directed acyclic graph for the association of the exposure of concurrency and outcome of HIV infection



MRP=most recent partner

According to DAG analysis, age, ever being married and most recent partner type were confounders of the relationship between exposure and outcomes and were retained in the models. Logistic regression with backwards elimination was used as described above. Unfortunately, less than 70% of the original sample had complete data for all variables of interest (Table 3.6). The high amount of missing data led to the consideration of multiple imputation to optimize the existing data.

Table 3.6. Proportion missing from variables of interest in concurrency analyses

Variable	% missing
Concurrency	11.7
Most recent partner type	11.7
Ever used condoms with most recent partner	9.2
Felt most recent partner cheated	10.7
Discharge in past 12 months	2.7
Genital sores in past 12 months	3.2

Multiple imputation for missing data

Both SAS and Stata conduct complete case analysis when conducting a logistic regression, meaning that the program only analyzes the association between the exposure and outcome for those observations that have complete data for all the variables included in the regression. If there are systematic differences between those individuals who gave complete answers to all questions and those that did not, then the resultant association may be biased. Methods such as multiple imputation have been developed to generate plausible values for the missing data, to produce effect estimates that have less bias and are more precise than a complete case analysis(140-142).

There are three types of missing data. Missing at random (MAR) means that the probability of being missing may be dependent upon the values of other variables, but not on the value that would have been captured, if the data was not missing(143). A more stringent assumption that rarely holds is missing completely at random (MCAR) in which the missingness is not dependent on any factors. If data are truly MCAR, then a complete case analysis would not have any bias. The third category of missing data is not missing at random (NMAR) in which the values that are missing are based on the actual values that

would have been collected(143). If data are MAR, then MI is a helpful tool to fill in probable values for the missing values.

To determine if the missingness of the variables is MCAR, MAR or non-ignorable, I conducted the following investigation:

- 1) Considered probable reasons for the variable to have a high proportion of missing values.
- 2) Explored each variable to see if the data is missing completely at random. The procedure PROC MI in SAS shows the pattern of missing data for the variables of interest. If one or more of the patterns comprised the majority of the missingness, then the data may not be MCAR. In addition, the MCAR assumption is rarely satisfied. Associations were examined between the missingness of each variable and the exposure, outcome and other covariates namely: age, ever married, house type, type of most recent partner, condom use with most recent partner, belief most recent partner ever cheated, and discharge or sores/ulcers in the past 12 months. For example, the association between missingness of discharge (D) and the exposure was assessed as follows:

$$OR = \frac{(\# \text{ missing D among the exposed}) \times (\# \text{ not missing D among the unexposed})}{(\# \text{ missing D among the unexposed}) \times (\# \text{ not missing D among exposed})}$$

where D = discharge, exposed= those who reported discharge in the past 12 months, and unexposed= those who reported no discharge in the past 12 months. If the odds ratio did not equal to 1.0, there was an association between the two variables.

- 3) Appraised the probability that the missing values were dependent on the real value of the variable, and therefore non-ignorable.

MI was conducted using Markov Chain Monte Carlo in SAS and Regression switching in Stata. Answers were compared.

(Results from the multiple imputation are presented in Appendix Three)

CHAPTER FOUR

Results Aim One: HIV Prevention Behaviors Reported By

Rural Youth In South Africa And Malawi:

Untangling The Association With HIV Infection¹

Abstract

Background: HIV prevalence in rural southern Africa is increasing towards urban levels, highlighting rural youth as an important population for intervention.

Objectives: We studied the association between reporting behavior change since hearing of HIV and HIV infection among rural South African and Malawian youth.

Methods: Two surveys concerning sexual behaviors and HIV prevalence conducted with youth in South Africa and Malawi were used. Analyses were stratified by gender and country and restricted to rural, sexually experienced youth 15-24 years old (n=2002 South African females, 471 Malawian females, 1714 South African males, 431 Malawian males).

Results: Many youth reported behavior change since hearing of HIV, ranging from 48.2% among Malawian females to 70.6% among South African females. HIV prevalence was

¹ This chapter has been prepared as a manuscript: Levandowski BA. Pettifor AE. Kohler HP. Ennett ST. Marshall SW. Cohen MS. MacPhail C. Behets FM. HIV prevention behaviors reported by rural youth in South Africa and Malawi: untangling the association with HIV infection.

19.0% (95%CI 14.9, 23.1), 4.5% (95%CI 2.6, 6.3), 4.7% (95%CI 3.0, 6.5) and 1.9% (95%CI 0.6, 3.1) for South African women, Malawian women, South African men, and Malawian men, respectively. We found no association between behavior change and HIV infection among South African youth but some evidence of an association among Malawian women. Analyses stratified by specific behavior changes uncovered that some behaviors were positively associated while others were negatively associated with HIV infection, leading to an attenuated effect when all behaviors were combined in a single variable. South African women who reported that they changed their behavior to abstinence were 2.90 (95%CI 1.01, 8.38) times more likely to be HIV positive than those who reported another behavior change.

Discussion: Based on this cross-sectional data, we see no protective association between behavioral change and HIV. However, youth could have been involved in risky behaviors that led to infection and changed subsequent behavior after hearing of HIV. Innovative HIV prevention methods are needed to reach rural youth. Further research concerning behavior change needs to focus on better measurement of type and duration of behaviors.

Introduction

Worldwide, half of all new HIV infections occur among young people, highlighting the vulnerability and prevention needs of this group(1). Even though youth may engage in sexual experimentation that puts them at risk of HIV infection(144), evidence suggests they may also be amenable to maintaining behaviors protective against HIV infection(87, 119, 145).

Although observation of declining HIV prevalence can be attributed to the result of increasing AIDS deaths, studies of epidemics in Kenya, Uganda and Zimbabwe provide evidence that declining HIV prevalence may also be related to changes in sexual behavior. Evidence from a series of cross-sectional Kenyan studies suggests declining HIV prevalence estimates since the year 2000, as extrapolated from ANC and STI clinics. Between 1993 and 2003, respondents in national Kenyan surveys reported fewer sexual partners in the previous 12 months, reduced coital frequency in the past month and higher levels of condom use with non-regular partners(113). Rural Ugandan cohort data from 1989 to 1997 showed decreased HIV incidence and prevalence particularly among females aged 13-24 and men aged 20-24. Ever having used a condom was increasingly reported by youth between 1992 and 1997 for all age groups of men and women under 35 years and in all marital status categories(114). From 1998 to 2003, HIV prevalence decreased among Zimbabwean men aged 17-29 years and among Zimbabwean women aged 15-24 years. At follow-up, participants reported fewer numbers of new partners in the past 12 months and casual partners in the past month. Consistent condom use with casual partners remained around 40% for men and increased to 36.5% for women(115).

The HIV epidemics in many countries in sub-Saharan Africa, however, have not observed a decline in prevalence including those in South Africa and Malawi. The HIV epidemics in these two countries are linked through the aggressive historical recruitment of young Malawian men to work in South African mines until 1988(146). Miners were geographically and socially isolated in small mining villages, which led to unprotected sex with sex workers, transmission of HIV to the miners and then their partners upon return home(147). Since that time, both countries have seen a transition into generalized

heterosexual HIV epidemics(1, 122, 123). In a worldwide ranking of HIV prevalence among adults from 2007, South Africa ranks #5 and Malawi ranks #8 (148).

The prevalence of STIs and HIV in rural Malawi is increasing towards levels seen in urban areas, making rural youth an important target population for prevention(122). In South Africa in 2003, HIV prevalence among 15-24 year olds was almost 5% for men and 15.5% for women(2). The overall HIV prevalence in KwaZulu-Natal province, where the majority live in rural areas, was 16.5% in 2005 and prevalence among ANC attendees grew from 36% in 2000 to 39% in 2005(3, 4). Rural South African youth reported less access to health services, reproductive and HIV/AIDS health information, and HIV prevention programs than their urban counterparts(119).

Geographic and demographic variations in HIV are found in Malawi, with higher prevalence found in the South, compared to the Center or North, and in urban areas compared to rural areas(122). While HIV prevalence, measured from ANC attendees, declined from 1999 to 2003 in urban areas, it increased in rural areas from 2001 to 2003. HIV prevalence in 2005 for Malawian youth aged 15-24 years was estimated at 3.4% for males and 9.7% for females(5). As evidence indicates HIV prevalence is lower in rural compared to urban areas(20, 123, 124), it is imperative to retain low infection numbers in these areas.

The purpose of this study was to investigate the association between behavior change due to HIV awareness and HIV infection among sexually active rural youth in South Africa and Malawi. We aimed to measure behavior change at the population level, as these youth were not involved in a specific prevention intervention. The availability of data on these

rural adolescents provides a unique opportunity to compare two high-risk populations in countries hardest hit by the HIV pandemic.

Methods

Data sets

We conducted secondary analyses of data collected in two surveys of African youth. One data source was a nationally representative survey of sexual behavior conducted by the RHRU at the University of Witwatersrand in 2003 of 11,904 South African youth aged 15-24 years. The sampling design consisted of a three-stage, disproportionate, provincially stratified sample which resulted in a nationally representative sample of 15-24 year old South African youth(2). Appropriate analytic methods were used to analyze a subpopulation within the data while correctly accounting for the complex survey design.

The second survey was conducted by the University of Pennsylvania as part of the MDICP, a longitudinal study of 4834 rural Malawians which began in 1998. These analyses involve data collected in 2004. The sampling design consisted of a three-stage, disproportionate random sample stratified on sex and age(149). While not nationally representative, characteristics of the rural population in the Malawi Demographic and Health Survey (MDHS) and those of the sample are quite similar (11, 127).

Measures

In both countries, participants were asked about their demographic characteristics, sexual history, details about their most recent sexual relationship, and if they had changed their behavior since hearing of HIV. South African youth were asked “Since you have heard of

HIV/AIDS, have you changed your personal behavior in any way to prevent getting HIV?” while Malawian youth were asked “have you personally made any changes in your sexual behavior to avoid getting HIV/AIDS?” (150) Those individuals who reported behavior change were also asked to name the specific behaviors. Three protective behaviors were coded: those who reported abstinence, being faithful to their partner, or using condoms. In South Africa, youth were asked if they were sexually active in the past 12 months, and if not, why. Orasure® tests for HIV were conducted on both samples (Orasure Technologies, Inc., Bethlehem, Pennsylvania)(119, 151).

Statistical analyses

Analyses were stratified by gender and country and restricted to rural, sexually experienced youth between the ages of 15 and 24 years old (n=2002 for South African females, n=471 for Malawian females, n=1714 for South African males, n=431 for Malawian males). Univariate and bivariate analyses were conducted to determine the association between demographic and relationship variables and the prevalence of HIV. Chi-square tests were conducted to determine a difference in the distribution of HIV prevalence among strata of each covariate. Reported types of specific behavior change were stratified by age to explore trends.

Logistic regression with backwards elimination was used to assess the relationship between the self-reported behavior change variables and HIV infection while controlling for potential confounders. The full model was assessed with all variables. Variables with the highest p-values were removed one at a time and the main effect was assessed. If covariate removal resulted in a >10% change in estimate of the main association, it was retained in the

model. In a separate sub analysis, the association between these specific behaviors and HIV infection was assessed for all youth who said they changed their behavior.

All analyses were completed using Stata version 9.2 (StataCorp, College Station, Texas).

Results

Among rural, sexually active youth, behavior change since hearing of HIV was reported by 70.6% of South African females, 48.2% of Malawian females, 62.1% of South African males, and 63.3% of Malawian males (Table 4.1 and Table 4.2). The prevalence of HIV was 19.0% (95%CI 14.9, 23.1), 4.5% (95%CI 2.6, 6.3), 4.7% (95%CI 3.0, 6.5) and 1.9% (95%CI 0.6, 3.1) among South African women, Malawian women, South African men, and Malawian men, respectively.

Only 13.2% of South African women reported not having had sex in the 12 months prior to the interview; of those, 43% were infected with HIV (Table 4.1). Looking at the main reason that these women reported not having had sex in the past 12 months, 5.5% were waiting for marriage, 19.7% did not have a current partner and 49.9% did not have the opportunity for sexual intercourse. Less than one quarter of South African men reported no sex in the past 12 months. Almost 80% attributed this to a lack of partner or opportunity. Only 11 (4.3%) women and 50 (11.1%) men reported that they did not have sex in the past 12 months because they were worried about getting HIV/AIDS. Of those, three women and two men were HIV positive and four women and nine men reported having been tested for HIV.

Table 4.1. Unweighted counts, weighted proportions and weighted HIV prevalence by sexual characteristics among rural, sexually active South African youth, aged 15-24 years, 2003

Variable	Level	Females (n=2002)			Males (n=1714)		
		n	%	HIV prevalence	n	%	HIV prevalence
EXPOSURE							
Behavior change†	No	683	29.2	18.2	505	37.5	4.6
	Yes	1314	70.6	19.3	1200	62.1	4.8
COVARIATES							
<i>Demographics</i>							
Age	15-19 years	933	42.5	6.9*	889	46.0	1.7*
	20-24 years	1069	57.6	27.8	825	54.0	7.3
Education level‡	HS complete	1109	48.6	10.8*	099	59.3	2.5*
	Not complete	892	51.3	26.7	610	40.2	8.1
Ever married	No	1894	95.2	19.3	1681	97.6	4.4*
	Yes	108	4.8	12.2	33	2.4	16.1
Ever pregnant§	No	932	49.5	19.0	--	--	--
	Yes	1064	50.4	18.9	--	--	--
<i>Relationship characteristics</i>							
Coital debut#	≤14 years	240	9.8	14.3	258	20.9	2.2
	15+ years	1762	90.2	19.3	1454	79.0	5.4
Number of lifetime partners**	1 partner	913	51.6	16.4	486	30.6	2.7
	>1 partners	1088	48.4	21.6	1225	69.3	5.6
Most recent partner type††	Steady	1889	94.8	18.7	1355	79.2	5.0
	Casual	18	0.8	40.7	212	10.9	4.6
Condom use with most recent partner‡‡	Always	366	20.6	8.0*	482	22.2	5.0
	Not always	1539	74.9	22.0	1084	67.7	4.9
Had sex in past 12 months	No	180	13.2	43.0*	259	23.8	1.7*
	Yes	1822	86.8	15.3	1455	76.2	5.7

* Significant difference using a chi-square test and $p < 0.05$

† Missing data: 5 females, 9 males

‡ Missing data: 1 female, 5 males

§ Missing data: 6 females

Missing data: 2 males

** Missing data: 1 female, 3 males

†† Missing data: 95 females, 147 males. Of those, 90 and 142, respectively, did not report having had sex in the past 12 months, and were therefore not asked this question

‡‡Missing data: 97 females, 148 males. Of those, 93 and 142, respectfully, did not report having had sex in the past 12 months, and were therefore not asked this question

Table 4.2. HIV prevalence by sexual characteristics among rural, sexually active Malawian youth, aged 15-24 years, 2004

Variable	Level	Females (n=475)			Males (n=431)		
		n	%	HIV prevalence	n	%	HIV prevalence
EXPOSURE							
Behavior change†	No	187	39.4	4.4	84	19.5	0.0
	Yes	229	48.2	6.5	273	63.3	2.5
COVARIATES							
<i>Demographics</i>							
Age	15-19 years	190	40.0	0.7*	193	44.8	0.0*
	20-24 years	285	60.0	9.1	238	55.2	3.8
Education level§	HS complete	95	20.0	5.3	175	40.6	1.3
	Not complete	339	71.4	5.9	136	31.6	1.7
Ever married	No	98	20.6	2.4	243	56.4	1.4
	Yes	377	79.4	6.6	188	43.6	2.9
Ever pregnant#	No	133	28.0	2.7	--	--	--
	Yes	341	71.8	7.0	--	--	--
<i>Relationship characteristics</i>							
Number of lifetime partners**	1 partner	240	50.5	3.9	81	18.8	2.7
	>1 partners	189	39.8	8.2	278	64.5	1.7
Most recent partner type††	Steady	356	75.6	5.5	205	47.6	2.2
	Casual	35	7.4	3.5	135	31.3	1.8
Condom use with most recent partner‡‡	Always	18	3.8	6.3	30	7.0	0.0
	Not always	95	20.0	7.7	106	24.6	3.3
Had sex in past 12 months§§	No	97	20.4	5.2	113	26.2	3.0
	Yes	327	68.8	6.1	240	55.7	1.5

* Significant difference using a chi-square test and $p < 0.05$

†Missing data: 59 females, 74 males

‡ Missing data: 106 female, 49 males

§ Missing data: 41 females, 120 males

#Missing data: 1 female

**Missing data: 46 females, 72 males

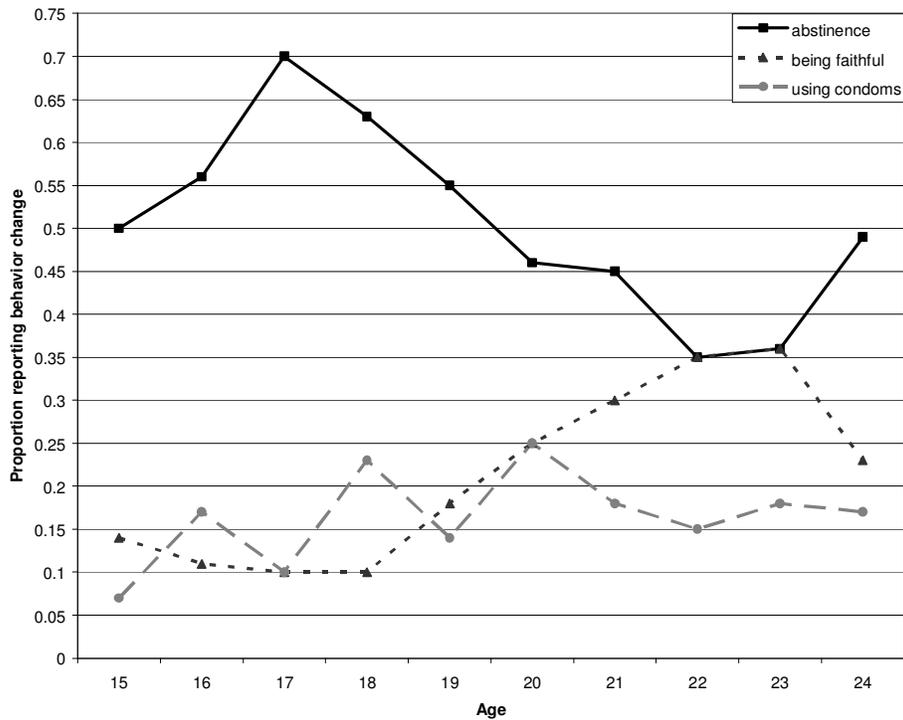
†† Missing data: 80 females, 91 males

‡‡Missing data: 362 females, 295 males

§§ Missing data: 51 females, 78 males

When specific behavior change was stratified by age, younger Malawian men reported abstinence and older men reported that they changed their behavior to be faithful to their partner. Less than one quarter reported condom use at any age (Figure 4.1). Overall, almost 30% of South African men reported condom use but half of men aged 18 reported condom use. From 15-18 years, more South African men reported abstinence, but from age 19-24 more reported concurrency. At least 40% of Malawian women at each age reported abstinence and as age increased, the percentage that reported being faithful increased and condom use decreased. No pattern was found among South African women. Compared to all youth in the subpopulations reporting condom use as their behavior change, Malawian women reported the least condom use and males reported more condom use than their female counterparts.

Figure 4.1. Proportion of Malawian men aged 15-24 who reported a specific behavior change since hearing of HIV, stratified by age.



Reported behavior change since hearing of HIV suggested a possible association with increased risk of HIV infection among Malawian women (unadjusted OR 1.51, 95%CI 0.55, 4.14) but was not associated with HIV infection among South Africans (unadjusted OR 1.08, 95%CI 0.70, 1.65 for South African women, 1.04, 95%CI 0.39, 2.73 for South African men). All Malawian men who were HIV positive reported behavior change, limiting the ability to model the association between exposure and outcome for this group. When a small sample correction of 0.5 was added to the data for Malawian men(137, 139), an unadjusted odds ratio (OR) of 3.68 (0.20, 66.14) was obtained.

The ORs were adjusted for age, education, partner type and having had sex in the past 12 months using multivariate logistic regression. Results did not change substantially from the crude estimates. Those who reported behavior changes were no more or less likely to be

HIV positive compared to their counterparts who reported not changing their behavior, controlling for confounders.

Results from the sub analysis of specific reported behavior changes are presented in Table 4.3. Among South African women reporting behavior change, the prevalences of reporting abstinence, being faithful and using condoms were 17.3%, 18.2%, 20.2%, respectively. Out of all Malawian females who reported behavior change, the prevalences of reporting abstinence, being faithful and using condoms were 46.4%, 37.2%, and 10.9%, respectively. More South African men reported condom use (23.0%) compared to those who reported abstinence or being faithful (8.7%) In contrast, more Malawian men reported abstinence (49.6%) compared to those who reported being faithful (22.4%) or using condoms (17.3%). In these populations, some behaviors appeared to be associated with a higher or lower likelihood of infection (Table 4.3). The strongest evidence of association was found among South African women where reporting abstinence was associated with a higher likelihood of HIV infection (OR 2.90, 95% CI 1.01, 8.38) while using condoms was associated with a lower likelihood of infection (OR 0.46, 95%CI 0.21, 1.01) (Figure 4.2).

Table 4.3. Behavior changes and HIV infection among rural, sexually active South African and Malawian youth who reported changing their behavior to either abstinence, being faithful or using condoms

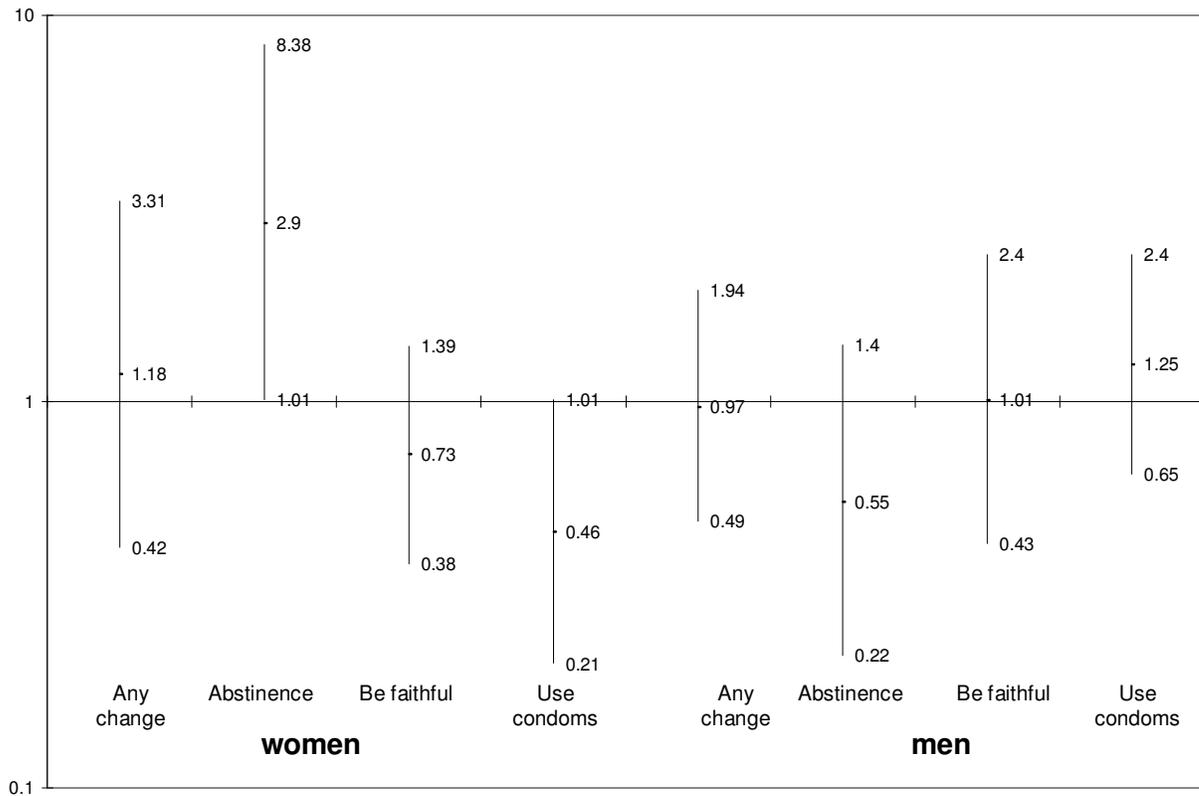
	Any behavior change* OR (95%CI)	Abstinence OR (95%CI)	Being faithful OR (95%CI)	Using condoms OR (95%CI)
South Africa				
Women	1.18 (0.42, 3.31)	2.90 (1.01, 8.38)	0.73 (0.38, 1.39)	0.46 (0.21, 1.01)
Men	0.97 (0.49, 1.94)	0.55 (0.22, 1.40)	1.01 (0.43, 2.40)	1.25 (0.65, 2.40)
Malawi				
Women	1.63 (0.09, 29.39)†	0.81 (0.25, 2.66)	1.76 (0.54, 5.69)	0.73 (0.09, 5.95)
Men	0.62 (0.07, 5.48)	1.03 (0.20, 5.18)	1.69 (0.30, 9.50)	0.38 (0.02, 6.79)†

OR= Unadjusted odds ratio, CI= Confidence interval

*Reporting either abstinence, being faithful or using condoms

†Used small sample correction of 0.5 added to each cell

Figure 4.2. Association of specific behavior change and HIV infection among South African youth reporting a specific behavior change since hearing of HIV



Of additional interest is the group of youth who reported that they changed their behavior since hearing of HIV but did not provide a specific behavior changed in the follow-up question. Failing to mention a specific behavior change was not associated with HIV infection [unadjusted OR 0.84 (95% CI 0.41, 1.73)] among South African women (n=99). No other youth missing specific behavior change information (2 Malawian women, 23 South African men, 2 Malawian men) were HIV positive.

Discussion

HIV prevalence was higher for South African youth compared to Malawian youth and higher among women compared to men as found in other studies in the region (5, 15, 119). Many

rural youth reported changing their behavior since hearing of HIV which could indicate that some youth were actively trying to protect themselves against HIV infection. However, self-reported behavior change was not associated with HIV infection among South African youth, and was weakly associated with more HIV infection among Malawian females. The cross-sectional data make it impossible to determine if behavior change occurred due to suspected risk or knowledge of HIV status.

While a high proportion of each group indicated behavior change, South African women reported the highest level of behavior change (70.6%) and had the highest HIV prevalence, potentially indicating these women are responding to perceived risk of infection. Many health behavior models posit that individuals obtaining information about their potential risk and perceiving that they are at risk are necessary but not sufficient conditions for behavior change(72-74). Social networks were shown to influence risk perception and adoption of protective behaviors in Kenya and Malawi(73, 76, 77), calling attention to the potential of peer-led prevention initiatives to increase and maintain the adoption of prevention behaviors.

While we found no association overall between reported behavior change and HIV infection, analyses stratified by specific behavior changes yielded more informative results. South African women who reported abstinence as their behavior change were more likely to be HIV infected. Due to the cross-sectional nature of the data, it's unclear if youth were abstinent and then became sexually active at a later time (primary abstinence) or stopped having sex after losing their virginity (secondary abstinence). The reporting of secondary abstinence by youth has increased in the literature(152, 153). In a similar study of South African youth, 5.2% of youth aged 15-24 reported primary abstinence "to avoid

pregnancy/STI/HIV” and comparable percentages reported ‘secondary abstinence’ or not having had sex in the past 12 months (14.7% compared to 13.2% in this study)(87).

A weak positive association was indicated between being faithful and HIV infection among Malawian youth, of whom almost 80% of women and less than half of men were married. Many studies have found that concurrent sexual relationships are strongly associated with HIV infection across different cultural groups(98, 124, 154). In reality, one can only be confident of one’s own fidelity; many people don’t know if their partner is faithful to them. Relationships in which both partners are HIV negative and mutually monogamous can offer protection against HIV infection(16).

Using condoms was associated with less HIV infection among South African women and more HIV infection among South African men, but few rural youth reported consistent condom use within steady partnerships across gender and country. In other analyses of South African youth, higher condom use was reported. Condom use at last sex was reported by 57% of males and 48% of females(155) and 33.5% of sexually active youth reported condom use consistency with their most recent partner(86). This could indicate that these rural youth are reporting less condom use than their urban counterparts.

While reported condom use was low among Malawian youth of both genders, there were more married Malawian youth and condoms aren’t very accepted within marital relationships(112). However, there is some evidence that condom acceptance has increased in Malawi under certain circumstances. Malawian men reported an increase in condom use between 1992 and 2000 among casual partners for STI, HIV and pregnancy prevention while condom use within a marriage decreased and was mainly attributed to pregnancy prevention (112).

Our findings have implications for prevention. Components of the common ABC approach to HIV prevention involve **A**bstaining from sex outside of marriage; **B**eing faithful to an uninfected partner; or using a **C**ondom. All of these components are interrelated and each have an essential role in a comprehensive prevention intervention package(36, 80). One recent review found no association between abstinence-only educational interventions and a reduction in sexual risk behaviors(88). In contrast, a recent review of abstinence-plus programs found a reduction in sexual risk behaviors in 59% of trials and no increase in sexual risk behaviors among any trials(90), suggesting that the inclusion of messages about reducing the number of sex partners and condom use are beneficial towards reducing risky behaviors(90, 91). Our findings support the need for a comprehensive approach to risk reduction that involves both primary and secondary abstinence along with condom use and partner number reduction. By promoting an array of behavior change options one might increase the likelihood that a person might adopt at least one desirable behavior, potentially increasing uptake of preventive behaviors overall.

One way to reach youth to increase their education about sexual health, and motivation and skills to enact protective behaviors, is through the school system. Youth who complete high school have been shown to delay coital debut and report higher levels of contraception and condom use (124, 156, 157). However, rural youth suffer from a decreased access to education. Among sub-Saharan African youth aged 15-19 years, 37.9% more urban males and 46.9% more urban females had access to school compared to their rural counterparts(120). This trend is seen in these analyses as well, shown by low percentages of high school completion ranging from a high of 59.5% among South African males to a low of 20.0% among Malawian females. In a review paper, school-based interventions were

highlighted as easy to implement, due to the structure of school and the availability of a captive audience(36). Keeping youth in school is helpful for many reasons, including the probability of their exposure to risk reduction interventions, potentially leading to subsequent behavior change.

There are several limitations to this study, such as the reliability of self reported sexual behavior(19, 158, 159), social desirability bias (159), and small sample sizes leading to less precise estimates of effect. The 2000 MDHR found that “99% of women and 100% of men report[ed] having heard of AIDS” (122) , which could have influenced the reporting of behaviors that are thought to be socially acceptable during the interview. This bias could be shown through number of lifetime partners (higher for men, lower for women)(158), over reporting condom use and abstinence, and under reporting concurrent sexual partnerships.

In addition, the cross-sectional nature of these data makes it impossible to tease apart the temporality surrounding reported behavior change and infection. Ubiquitous knowledge of AIDS in 2000 in Malawi(122) indicates that behavior could have been changed anytime in at least the four years prior to this survey. Youth may have engaged in risky behaviors, subsequently became infected, later heard about HIV and then changed their behavior, which could explain part of the null effects. Alternatively, youth engaging in many risky sexual behaviors may have changed only one behavior. All Malawian men who were HIV positive reported behavior change which may reflect a decreased risk to their partners, especially if these men either knew or suspected their status.

Our study results can serve as a proxy for the type of knowledge and behavior change that occurred in the general rural adolescent populations of South Africa and Malawi. Further research needs to determine the context surrounding reported behavior change and

the specifics of changed behavior, such as duration and timing of change in relation to infection. The special needs of rural youth need to be considered in the development of interventions that are contextually and culturally specific. Innovative methods are needed to reach rural youth before their prevalence levels reach those found in urban African centers.

CHAPTER FIVE

Results Aim Two: The Link Between Concurrency And Sexually Transmitted Infections Among Rural Malawian Youth²

Abstract

Background: Concurrency, or having more than one sexual partnership at one time, has been associated with the transmission of STIs in several populations.

Objectives: We hypothesized that rural Malawian youth were more likely to be infected with an STI/HIV if they reported concurrency.

Methods: Data from a 2004 survey of sexual behavior and STI/HIV biomarkers among rural Malawians were used. Analyses were restricted to sexually active females (n=412) and males (n=376) aged 15-24 years with reported concurrency in their most recent partnership as exposure and outcomes of STI infection (trichomonas (females only), Chlamydia and/or gonorrhea) and HIV infection. Logistic regression with backwards elimination was used to assess the relationship between concurrency and outcomes. Evaluated confounders included age, partner type, ever being married and belief of partner's concurrency. To optimize the available dataset and address missing data, two multiple imputation (MI) methods were compared in which plausible values were pulled from the distribution of real values, creating

² This chapter has been prepared as a manuscript: Levandowski BA. Marshall SW. Kohler HP. Pettifor AE. Ennett ST. Cohen MS. Behets FM. The link between concurrency and sexually transmitted infections among rural Malawian youth.

25 complete datasets. Summary effect estimates were generated from analysis of each imputed dataset.

Results: Five percent of women and 16% of men reported they had sex with another partner during their most recent sexual relationship. The overall prevalence of STIs and HIV was 10.4% and 4.4% for women and 0.3 and 2.1% for males, respectively. Concurrency was not associated with STI or HIV infection among males or STI infection among females [OR 0.69, (95%CI 0.09, 5.57)]. For females, approximately 71% of the 421 records had complete data for all variables. Using MI and controlling for confounders, women reporting concurrency were 5.65 (95% CI 1.37, 23.31) times more likely to be HIV positive than women not reporting concurrency.

Discussion: Concurrency was not common among rural young women in Malawi but was associated with HIV infection. Youth, including those in rural areas, need to understand the risks associated with concurrency.

Introduction

Concurrency is defined as having at least one other sexual partner during an existing sexual relationship. It has been highlighted as a potential explanation for high levels of HIV in African nations as compared to European nations and America, as heterosexual sex is the main mode of transmission in all locales (22-24). Concurrency has been hypothesized to be the “main driver of HIV infection”(23) in generalized epidemics.

Modeling of partnership formation has shown how concurrency is more efficient at transmitting and amplifying HIV infection than serial monogamy. Morris and Kretzschmar

(1997) used mathematical modeling to increase the amount of concurrency in a closed population from zero (all partnerships were serially monogamous) to one in which there was high concurrency over a period of time(65). This seminal paper showed that as concurrency increased, the HIV epidemic increased exponentially in both the number of people infected and the amount of time it took to infect greater numbers of individuals(65). Recent modeling by Doherty et al (2006) explored the relationship between concurrency and mixing (having sex with people like (assortative mixing) or unlike (dissortative mixing) themselves) and showed how the two concepts work together and separately to increase both prevalence and transmission within a population(93).

Concurrency creates a chain of transmission by connecting infected partners with new uninfected partners within shorter time periods that are more likely to include the period of infectiousness(93). As a result, concurrency creates a loose network of connections between people that facilitates transmission and increases prevalence (65, 93, 94). Concurrency has been associated with STI infection at individual and partnership levels. Individuals who reported concurrency were more likely to have a self-reported STI or test positive for gonorrhea, Chlamydia or trichomonas (8, 9, 95). Belief or evidence of a partner's concurrency was associated with STI infection (8, 25). However, concurrency was not found to be associated with HIV infection among adults in urban African cities (32).

Several large sexual network studies involving concepts of concurrency have been conducted in Uganda, Thailand and the US(94, 96). The majority of recent American studies focusing on concurrency and STI infection have occurred among high risk, urban, American youth(8-10, 25) or have described concurrent relationships resulting from the decreased sex

ratio of African Americans (97), especially in the South(98-100). Few have occurred in developing countries(32, 33, 96) or included estimates for rural populations(34).

This study is one of the first to focus on concurrency and both STI and HIV infection among rural youth; it is placed in Malawi. We hypothesized that youth who reported concurrency were more likely to be infected with an STI or HIV than youth who did not report concurrency.

Methods

Data set

Data are from the MDICP, a longitudinal study of 4834 rural Malawians conducted by the University of Pennsylvania. Data was collected from three districts: Rumphi in the north, Mchinji in the center, and Balaka in the south. Sampling consisted of a three-stage design in which adults were randomly chosen to participate after selection based on census EAs, villages and households. In 2004, the sample was refreshed with adolescents chosen from household rosters with the intention to capture equal numbers of each gender and single/married(160, 161). These analyses involved cross sectional data collected in 2004. While not a nationally representative sample of Malawians, this sample shared characteristics with the MDHS (11, 127).

Information on demographics and sexual relationships was collected through one-on-one interviews conducted in the language of the participant, referred to as the main survey. Concurrency with the most recent partner was measured by the question, “Were you having sex with other partners during the time you were having sex with this partner?” Participants were visited a second time by a nurse, often within one week, who asked a very brief sexual behavior questionnaire and collected biomarker samples, referred to as the STI survey. Oral

fluid samples were collected for HIV testing using Orasure® (Orasure Technologies, Inc., Bethlehem, Pennsylvania) and positive tests were confirmed through Western Blot. Self-collected vaginal swabs were tested for gonorrhea, Chlamydia and trichomonas and males' urine was tested for gonorrhea and Chlamydia using Roche PCR(126). The outcome of STI infection was coded as 'yes' if the participant had at least one infection with either gonorrhea, Chlamydia or trichomonas for women and either gonorrhea or Chlamydia for men.

Data analysis

Analyses were restricted to sexually active females (n=412) and males (n=376) aged 15-24 years who completed both the main and STI surveys. Univariate and bivariate analyses were conducted. Chi square tests were performed to detect differences in distributions in bivariate analysis. Exact chi square tests were used when cell sizes were less than five.

Multivariate logistic regression was completed with the exposure of concurrency and outcomes of both STI and HIV infection. Confounders of the relationship between exposure and outcome were 1) either believed to be confounders due to a priori knowledge or 2) had significance in bivariate analyses and generated a greater than 10% change in the effect estimate when removed from the model. Statistical packages only analyze observations that have data for all variables used in an analysis. Observations missing one or more data points are dropped from the model, leading to reduced sample size and precision of the estimated effect measures. This analysis is referred to as "complete case analysis". CLRs (upper confidence limit/lower confidence limit) were calculated to give a measure of precision.

Multiple imputation for missing data

As less than 70% of participants had complete data for all variables of interest, MI was employed to address missing data and optimize the dataset. The main assumption of MI is that data are MAR. MAR indicates the reason that data are missing could be related to other variables in the dataset but is not related to the actual value that is missing(143).

In an attempt to assess the validity of the MAR assumption, each variable was checked to see if the missingness of the variable was associated with the exposure, STI/HIV outcome, age group and ever being married variables both in the entire dataset and within the subpopulation of interest. All variables, including symptoms of and biological markers for STIs, were associated with at least one other variable, indicating that the variables could be MAR.

MI involved several steps: 1) choice of the imputation model which produced imputed datasets; 2) analysis of the imputed datasets; and 3) creation of summary statistics from the analyses(143). This paper will compare the use of the Markov Chain Monte Carlo (MCMC) method in SAS and regression switching in Stata for MI highlighting the former method first.

The MCMC method was conducted in SAS (version 9.1, SAS Institute, Inc., Cary, North Carolina) to fill in missing values to create 25 complete datasets(162). All variables were imputed as a continuous variable. Values for the outcome variables were rounded to either 0 or 1 before analysis to generate a dichotomous outcome for logistic regression. Imputed datasets were analyzed with the same logistic regression model as the complete case analysis and summary statistics were generated.

Regression switching was conducted in Stata (version 9.2, StataCorp, College Station, Texas). The first step conducted the specified regression, generating predictive values of the effect of exposure and covariates on the outcome. Based on closeness to predictive values, it then chose values for the missing data from a posterior distribution of existing values of the variables. The 25 complete datasets were created simultaneously and analyzed to generate summary measures(163).

Results

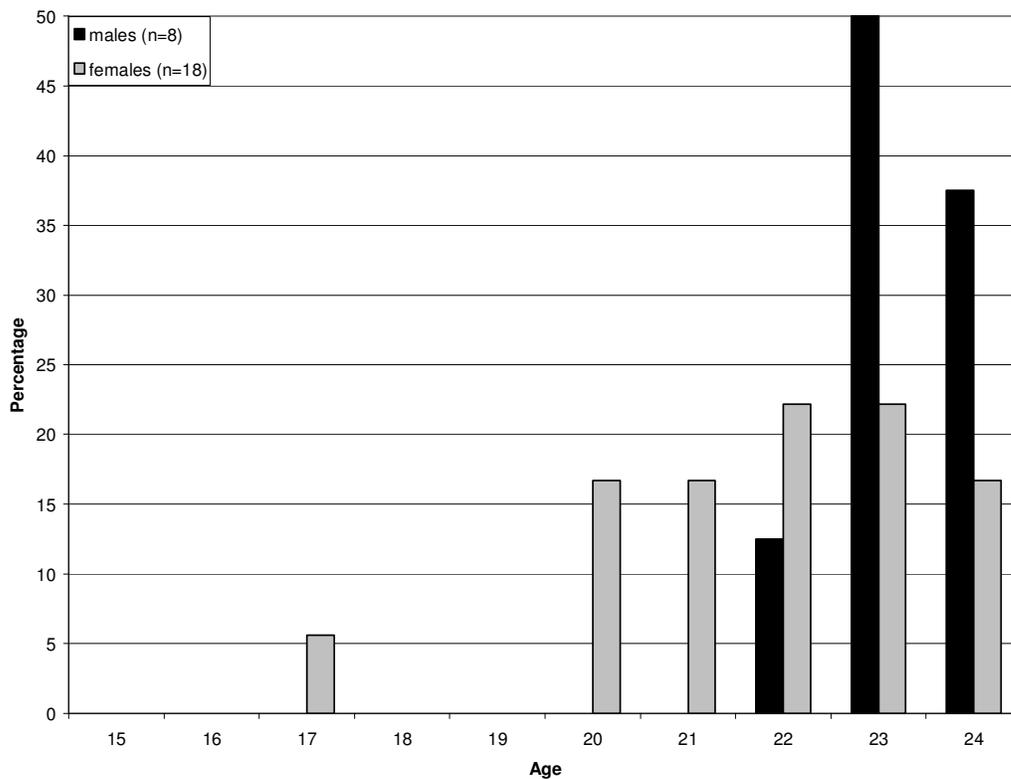
Males

Among males, 16.0% reported concurrency during their most recent relationship and 22.6% reported concurrency within their two most recent partnerships. Only one male tested positive for gonorrhea and eight were HIV positive, resulting in STI and HIV prevalences of 0.3% (95%CI -0.3, 0.8) and 2.1% (95%CI 0.7, 3.6), respectively. More males reported their most recent partner was steady (56.4%) versus casual (34.6%) (with 9.0% missing data). While 8.8% reported discharge and 4.5% reported genital sores or ulcers in the past 12 months, only 1.6% reported they thought they had an STI in the same time period. Almost 36% of males reported having used a condom with their most recent partner.

Of the 46.3% of males who felt their partner had concurrent sexual behavior, 56.7% also reported concurrency. Almost 52% of women felt that their most recent partner had another partner and two thirds (66.7%) of women who reported concurrency reported their partner was also concurrent. However, reporting concurrency was not strongly associated with a belief that their partner was also concurrent (male OR: 1.50, 95%CI 0.85, 2.65, female OR: 2.02, 95%CI 0.81, 5.00).

There was little to no overlap between concurrency and either STI or HIV infection among men. Only one man reporting concurrency had an STI and none were HIV positive. Since there was such a low prevalence of HIV among men, the distribution of HIV and age was explored for both men and women. Only men aged 22-24 were HIV positive and the male with gonorrhoea was 19 years old (Figure 5.1). As concurrency was not associated with either STI or HIV infection among men, further analyses were not conducted for this subpopulation.

Figure 5.1. Distribution of age and HIV infection among the sample of 15-24 year old sexually active Malawian females and males.



Females

Five percent of females reported that they had sex with another partner during their most recent relationship, compared to 6.6% who reported concurrency with either their most

recent or next most recent relationship (Table 5.1). The prevalences of STIs and HIV were 6.6% (95%CI 4.2, 9.0) and 4.4% (95%CI 2.4, 6.4), respectively. Only four women had more than one STI; two had gonorrhoea and HIV and the other two had gonorrhoea and trichomonas. STI infection was distributed throughout the ages of women, but the majority of HIV infection was restricted to those aged 20-24 years (Figure 5.1). Of those reporting concurrency, 5.6% were STI positive and 23.5% were HIV positive.

Table 5.1. Counts, proportions, STI and HIV prevalence among levels of demographic and sexual characteristics of 412 rural, sexually active Malawian females, aged 15-24 years, 2004.

Variable	Level	n	%	STI prevalence [†]	HIV prevalence
Demographics					
District	Balaka	151	36.7	10.9	6.4
	Mchinji	146	35.4	9.3	3.6
	Rumphi	115	27.9	4.3	5.7
Age	15-19 years	165	40.1	11.2	0.7
	20-24 years	247	60.0	6.4	8.5*
Completed high school	No	316	76.7	7.0	5.4
	Yes	94	22.8	13.0	4.8
	Missing	2	0.5	--	--
Ever pregnant	No	96	23.3	13.8	1.2
	Yes	315	76.5	6.6*	6.6
	Missing	1	0.2	--	--
Ever married	No	103	25.0	12.2	2.2
	Yes	309	75.0	7.1	6.4
General health status	Excellent	157	38.1	9.5	1.6
	Very good	84	20.4	8.7	7.3
	Good	115	27.9	7.5	5.8
	Fair/poor	42	10.2	8.1	12.8*
	Missing	14	3.4	--	--
Characteristics of most recent partner					
Partner type	Steady	330	80.1	7.9	5.1
	Casual	34	8.3	7.1	3.2

	Missing	48	11.7	--	--
Ever used condoms with most recent partner	No	266	64.6	6.4	4.2
	Yes	103	25.0	12.1	6.6
	Missing	38	9.2	--	--
Felt that most recent sexual partner has ever cheated or spouse has been unfaithful	No	184	44.7	8.2	1.9
	Yes or suspect	213	51.7	8.6	8.0*
	Missing	15	3.6	--	--
Sexual experience					
Had sex in the past 12 months	No	95	23.1	8.9	4.9
	Yes	301	73.1	7.9	5.7
	Missing	16	3.9	--	--
Ever tested for HIV	No	342	83.0	8.8	5.7
	Yes	64	15.5	7.1	1.7
	Missing	6	1.5	--	--
Discharge from vagina in past 12 months	No	367	89.1	7.4	4.2
	Yes	34	8.3	14.7	15.6*
	Missing	11	2.7	--	--
Sores/ulcers around genitals in past 12 months	No	384	93.2	8.9	4.6
	Yes	15	3.6	0.0	25.0*
	Missing	13	3.2	--	--
Suspects/knows spouse/partner had STI in past 12 months	Know or suspect	30	7.3	8.0	14.8
	Can't know what they do	41	10.0	8.6	11.4
	Probably not	200	48.5	9.2	3.5
	No current spouse/ partner	66	16.0	0.0	5.1
	Don't know	61	14.8	7.3	2.3
	Missing	14	3.4	--	--

*Significant difference using a chi-square test and $p < 0.05$

†Includes biological tests for gonorrhea, trichomonas, Chlamydia

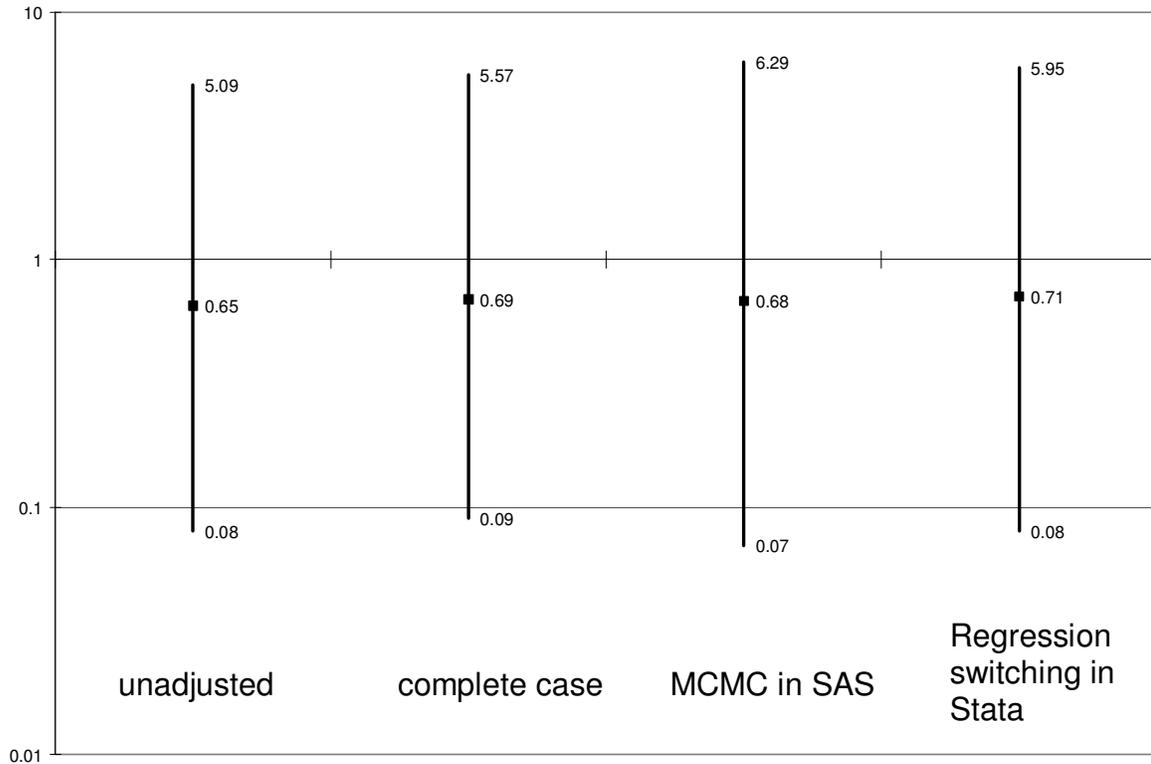
Only one percent of women reported current discharge. Of the 2.9% who reported current sores or ulcers around their genitals, 20.0% tested HIV positive. Concern or worry about contracting an STI or HIV was essentially the same, although they were measured by

separate questions. Of those who reported not being worried about STI infection, 71.6% also reported not being worried about HIV infection. Of those who reported being worried a lot about STI infection, 74.0% reported being worried a lot about HIV infection.

Women who reported concurrency with their most recent partner were seven times (95%CI 2.01, 25.06) more likely to be infected with HIV than women who didn't report concurrency. Women who reported a belief their most recent partner has been concurrent were 4.38 times (95%CI 1.23, 15.54) more likely to be HIV positive than those who reported partner faithfulness.

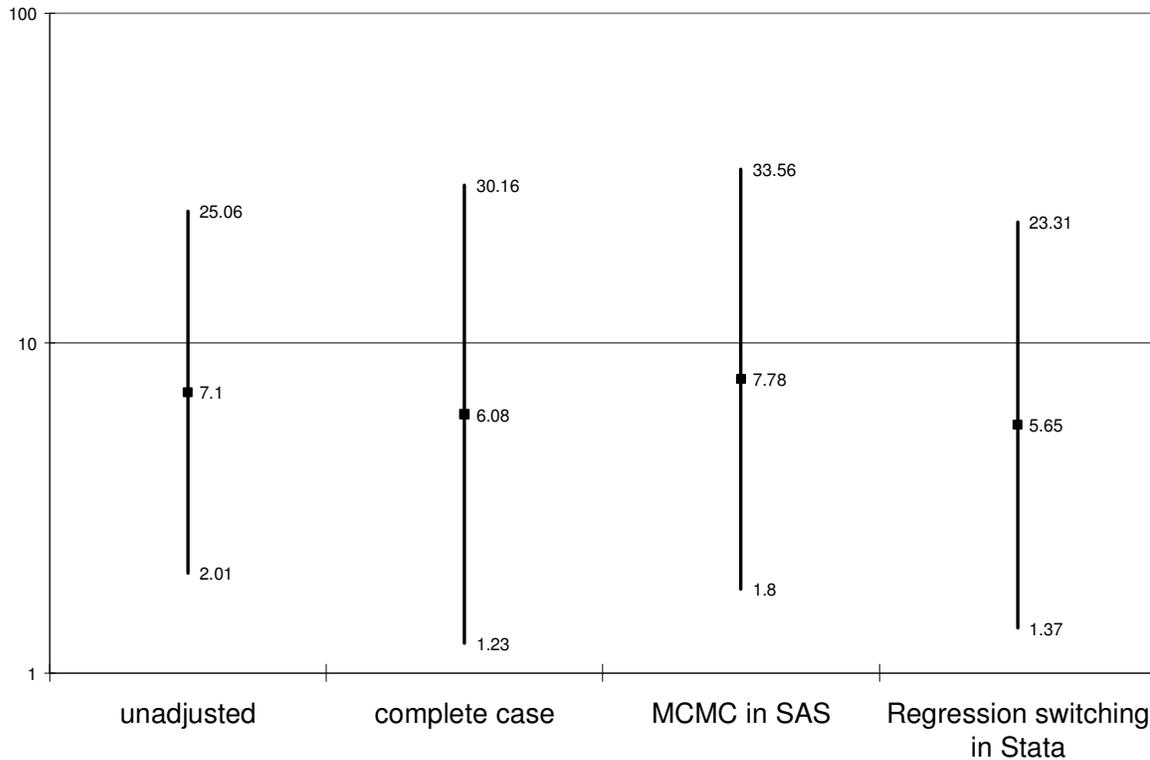
Age, ever being married, most recent partner type and belief that partner was concurrent were all confounders of the relationships between concurrency and STI or HIV infection for women and were controlled for in multivariable models. Concurrency was not associated with STI infection for women (OR 0.69, 95%CI 0.09, 5.57). A comparison of CLRs indicated that multiple imputation methods yielded less precise estimates of effect measures than complete case analysis (Figure 5.2).

Figure 5.2. Logistic regression results for the association between concurrency and STI infection among rural Malawian females aged 15-24 years for complete case analysis (n=273) and using multiple imputation (n=412) methods



Using complete case analysis and controlling for other covariates, women who reported concurrency were 6.08 times (95%CI 1.23, 30.16) more likely to be HIV positive than women not reporting concurrency. Using MI methodology and controlling for other covariates, a comparable but more precise estimate was obtained (Figure 5.3).

Figure 5.3. Logistic regression results for the association between concurrency and HIV infection among rural Malawian females aged 15-24 years for complete case analysis (n=296) and using multiple imputation (n=412) methods



Discussion

This study found that concurrency was associated with HIV infection among females but was not associated with STI infection among either gender or HIV infection among males. Other studies of American youth have found associations between concurrency and STI outcomes for each gender (9, 25).

This analysis may be influenced by measurement bias and social desirability bias. Concurrency can be measured in several ways, either through a direct question about having another sexual partner during a current relationship or by indirect calculation of the overlap of beginning and ending dates of past and current relationships(92). Studies of both

measures have found little agreement between the two when asked of the same participants (9, 92). In this population, concurrency was measured using a direct question asking if the participant had another sexual partner. As with other studies (9, 25, 34, 92), the direct method is seen to elicit less missing data and more valid responses with less misclassification due to recall error in remembering dates. However, such a direct admission of concurrency may have suffered from social desirability bias as well. It also limits the ability to describe the patterns of concurrency, in terms of overlap length, number of overlapping partnerships, etc.

The effect of social desirability bias may be manifest in the low percentage of reported concurrency (less than 7%) among females. Other studies of concurrency have found much higher levels of reported concurrency, from 16% of Botswanian females aged 15-49(34) and 17.7% of urban American females aged 18-39 years(9) to 58% of a nationally representative sample of US females aged 13-17 years(164). Other reasons for low reported concurrency among females could have included cultural norms surrounding relationships. There may be less opportunity for young rural Malawian women to engage in concurrent relationships.

While there is evidence that concurrency occurs in rural Malawi, it may be more common among men or more commonly reported by men. Of rural Malawian males aged 15-24, 16% reported concurrency with their most recent partner. Of all respondents answering the questionnaire in Malawi, aged 11-77 years, only 5.2% reported concurrency; of those 9.3% were male and 1.6% were female. These numbers can be compared to 31.4% of Botswanian males and 22.6% of rural Botsawians aged 15-49 years who reported concurrency(34). While only 9.3% of males and 11.7% of females of the sample of interest

had missing data for the question of concurrency, 45.1% of all participants (aged 11-77) did not answer the concurrency question, indicating much room for underreporting. It should be noted that this question was asked of all sexually active participants who reported at least one sexual partner. Another analysis of primarily married adults in the MDICP data found that while low numbers of participants admitted adultery, 18% of women and 26% of male respondents reported that their best friends were unfaithful in the past year(73).

MI yielded more precise estimates for those models with HIV, but not for the STI models. MI methods generated summary statistics and confidence intervals that accounted for the variability inherent in choosing values to substitute for missing data. As the amount of missingness in a dataset increases, more data is imputed and the variability around resultant effect estimates is increased (143). One reason for the increased imprecision of the MI models for the STI data could be the amount of missingness in the dataset overall. Overall missingness is composed of both the amount of missingness in each variable and for each participant in the dataset. In other MI exercises conducted with this data (not shown), more complete initial data yielded more precise CIs after MI.

Conducting MI with both SAS and Stata yielded similar results. An examination of the CLRs of all variables in each regression found comparable precision between results for each program and for each outcome (data not shown). Means and standard errors of imputed datasets were comparable between methods. These results are promising as researchers generally prefer one statistical program over the other. In conjunction with an earlier study comparing earlier versions of the programs(165), this analysis supports the use of either program to conduct MI.

As with other cross-sectional studies, it is difficult to determine how temporality influences the results. Due to the long infectious period of HIV, a measure of HIV prevalence in a population can not approximate incidence. Infection could have occurred through contact with any sexual partner, not necessarily the most recent or concurrent partner. However, the infectious period of STIs is quite different from HIV.

The lack of association between concurrency and STIs could be attributed to the period of infectivity and timing of questionnaire in relation to the concurrent acts. Gonorrhea has a short incubation period of 24-48 hours and symptoms commonly occur one week after exposure, though asymptomatic infections can occur in up to 10% of those infected. The incubation period for Chlamydia is much longer, ranging from one to two weeks, with asymptomatic infection estimated to occur among 30% of patients. Risk factors for both diseases include multiple sexual partners and a recent new sexual partner(64). If previous STI infection was the result of concurrency, short incubation periods could have led to an inability of the survey to capture all infections. In addition, current STI infection may have occurred by the partner bringing an STI into the relationship. Since concurrency was asked through a direct method, the period of overlap between partnerships cannot be determined to shed more light on the history of infection.

Another clear reason for the lack of association between concurrency and STI infection among men is the low prevalence of disease found among the 15-24 year olds. Several studies of African youth have shown females reporting older male partners (60, 62, 66). Future studies could incorporate the suggestion of Zaba's(59) call for comparing younger women with older men, to account for these age differences in partnerships. Other

studies also have focused on a wider age range of participants, indicating that more participants in a wider age range could have yielded different results.

While concurrency is seen as a risky behavior, population prevalence is a major factor in whether or not sexual behaviors will lead to infection(59). Infection needs to exist at some point in the sexual network to sustain subsequent infection. Analysis of data at the partnership level and the location of each partnership within a sexual network(166) would provide the best data on the risk of STI infection inherent in unprotected sex within that partnership. As partnerships are formed close together in time (such as through serial monogamy), the same risk of infection may be found as within concurrent relationships, if the STI incubation period straddles sexual relations within both relationships. This study helps to support the part that concurrency plays in high HIV prevalence among rural African females.

CHAPTER SIX

Discussion

Summary of findings

This dissertation investigated HIV prevention behaviors among sexually active, rural South African and Malawian youth. The first paper found that, among South African women, reporting abstinence was associated with a greater likelihood of HIV infection (OR 2.90, 95% CI 1.01, 8.38) and reporting condom use was associated with a reduced likelihood of HIV infection (OR 0.46, 95% CI 0.21, 1.01). There was no clear association between behavior change since hearing of HIV for Malawian women or South African men. All Malawian men who were HIV positive reported changing their behavior since hearing of HIV which may indicate protection for future partners of these men. The second paper found no association between concurrency and STI infection for Malawian men or women or between concurrency and HIV infection for Malawian men. However, reporting concurrency was associated with HIV (OR 6.08, 95% CI 0.09, 5.57) among Malawian women.

Interpretation of findings

We hypothesized that behavior change since hearing of HIV was associated with HIV infection and were surprised by the lack of association for either gender of sexually active youth in South Africa or Malawi. If youth changed their behavior, they were asked to name

the specific behavior changed. When stratified by this information, it appeared that the lack of association was due to the differing effects of each behavior change, which varied for each group of youth. The clearest example of this is seen among South African women, where reported abstinence was associated with a greater likelihood of HIV infection [OR 2.90, (95%CI 1.01, 8.38)] and reported condom use was associated with less likelihood of HIV infection [OR 0.46, (95%CI 0.21, 1.01)]. Due to small sample sizes and a lack of precision, these relationships are less clear among the other groups (Table 4.3).

The lack of strong associations makes it difficult to draw conclusions. Reporting abstinence could have been riskier for South African women if they were unprepared to negotiate condom use during an unplanned sexual encounter. South African men could be using condoms with riskier partners, but inconsistently, leading to more infection. Malawian youth were more likely to be married and condom use is not culturally acceptable within the marital unit(112). Therefore, faithfulness to a spouse could lead to more infection if the other spouse is not faithful.

We hypothesized that concurrency would be associated with STI and HIV infection among rural youth in Malawi, but only found an association between reported concurrency and HIV infection (OR 6.08, 95% CI 0.09, 5.57) among Malawian women. Despite the low prevalence of STI infection among both men and women and the small proportion of reported concurrency among women, we did find an association between concurrency and HIV infection among women. More men reported concurrency than women, but the overall reporting of concurrency was lower in this group than in other populations of American and Botswanaian youth (9, 34, 164).

Strengths and Limitations

The first specific aim described sexual behavior changes in the generalized rural population among youth in South Africa and Malawi. Very few comparison papers are found in the literature, and among them, even fewer focus on youth or rural populations (14-16, 20). Since both of these studies were population based, household interviews, they provided comparable data for investigation. This focus on rural youth helped to elucidate the differences in impact of HIV on these marginalized and vulnerable groups. Behavior change is usually investigated in light of evaluation for a specific intervention. However, knowledge about HIV prevention comes from multiple sources such as media outlets, specific interventions, and school-based programs. This aim may serve as a proxy to an investigation of how that knowledge, regardless of source, affected behavior change and if it was helpful in providing protection against HIV acquisition. In addition, this study looked at prevailing behavior patterns among young people and may be more reflective of behaviors in the general public than results from specific interventions.

The second aim was one of the first papers to investigate concurrency and HIV infection among rural youth in developing countries. While the literature concerning syndromic management of STIs in developing countries has established the link between potential markers of infidelity and STI infection(26-31), this study expanded that data to include HIV infection. The addition of MI methods provided stability to the estimates while optimizing the small sample size.

The majority of studies that are conducted on risk factors and sexual behavior are cross-sectional and cannot show temporality or give support towards determining causality(67). In addition, cross-sectional studies can only give estimates of HIV prevalence

in the population, which lacks information on when the person was infected(66). Issues of temporality were found in both studies. In the first study, it was impossible to determine when the behavior change occurred in relation to infection. Youth may have been involved in risky behaviors and became infected, heard of HIV and changed their behavior, but the change was too late. South African women reporting abstinence could have adopted secondary abstinence since hearing of HIV and were either infected in initial relationships or ended their secondary abstinence with a relationship that resulted in infection. In the second study, it is not possible to determine if the concurrent relationship or a past relationship resulted in HIV infection among Malawian women. Also, the short incubation period of STIs would not have captured STI infections that occurred due to concurrency but had resolved at the time of biomarker collection.

There are general limitations to comparing data from several studies. Limitations for the comparison of studies can include type of interview format, participant age group, setting of interview, age and sex of interviewer, confidentiality, wording and language of questionnaire, how behavior is measured, sampling frame, type of study, consistency of findings, and stratification variables (124, 159). In both countries, the questionnaire was conducted by a face-to-face interview with young people aged 15-24 years in a private setting in their own home. The level of privacy within each setting and how that affected the participants' ability to feel comfortable is unknown, both between and within countries. As the age and gender of the interviewer could have led to information bias, attempts were made to match interviewers by both variables. In South Africa, females were allowed to interview males, but only females interviewed other females(125). In Malawi, different gender interviews only occurred in a situation in which a mixed gender interview pair was faced

with a female-only household(127). The combination of setting and interviewer characteristics could have influenced how rapport was established within the interview and how confident the interviewee felt confidentiality would be maintained (159).

Words have different meanings in different contexts and languages. The South African questionnaire was translated into eight languages besides English, such as Zulu, Twana, Xhosa and Afrikaans. It was back translated and piloted(125). The Malawi questionnaire was conducted in English, Yao, Chichewa and Tumbuka(127). Although effort was made to ensure consistency between versions, there is always room for misunderstanding of questions and what type of response to give to each question. In addition, how concepts were measured varied between countries. In regards to transactional sex for example, in South Africa, youth were asked if they ever “have sex with them so that they would give you material or other kind of support, such as money, presents, alcohol, food, clothes, better grades, transportation, etc.... in exchange”. In comparison, Malawian females were asked “The last time you had sex with this partner, did he give you money or gifts for sex”. It is not clear if these two questions are asking about the same concept and can be directly related.

As described in Chapter Two, the samples were arrived at through different routes. The South African data reflects a complex sampling design to produce a nationally-representative sample. The Malawi data is not nationally representative, but does exhibit similar characteristics of data from the nationally representative MDHS. These differences in sampling could help to explain potential variation in results, but as previously mentioned, these samples of rural youth are quite comparable.

There are several additional limitations of the research. Self-reported sexual behavior is inherently unreliable due to social desirability bias; this is a huge limitation of any study in this field. Recall bias is present throughout an interview, especially when asked an open ended versus a close ended question. Youth who have never had sex may remain abstinent to protect themselves against HIV; they conceivably would not report having changed their behavior, since they maintained the same behavior. The analyses were restricted to sexually active youth to reduce complications by the abstaining group. However, it would have been difficult to tease apart those youth who have maintained the behavior of being faithful and/or using condoms and therefore did not report behavior change. The inability to separate out these youth is an additional limitation of Specific Aim 1.

A loss of power was observed when the complete case analyses were conducted. The small sample sizes of Malawian youth often lead to imprecise estimates that covered the null and made an association difficult to interpret. Due to missing data, MI was used to arrive at a more precise point estimate, which was realized for the HIV models in the second aim.

Future research directions

The context surrounding behavior change needs to be investigated more thoroughly, ideally through the involvement of mixed methods and longitudinal data. Qualitative interviews in rural Malawi found that men reported increased condom use for pregnancy and STI infection among casual partners only and that condom use within a marriage was unacceptable(112). A network study of Thailand young men and sex workers also found that condom use was context specific. Steady relationships (having ≥ 3 sex acts with the same worker) were established between young men and sex workers in which condom use was very low. In

turn, these men did not use condoms with non-sex worker partners(96). These two studies highlight the need to delve deeper into the context surrounding behavior change. The type of behavior change, characteristics of partners, timing and duration of change are all details that would help to elucidate the context surrounding change and may give insight on how to sustain it.

Concurrency is a difficult concept to measure due to social desirability and measurement biases. Further studies should attempt to capture more information to shed light on the context surrounding concurrency. It can be measured in several ways, either through a direct question asking if a person has had sex with another individual during a current sexual relationship, or through an indirect method of determining partnership overlap through the collection of beginning and ending dates of past and current relationships. Studies of both methods have found little overlap in reporting when asking the same population about their behavior using both methods (9, 92), but utilizing both methods may help to address underreporting. In addition, studies of concurrency should elicit more information about partnerships. Asking participants if they expect to have sex with a partner in the future (96) may help to tease out continued or future concurrent behavior.

Both studies involve data at the individual level; future research should involve partnership data analyzed at the level of the partnership. Knowledge about risky behaviors and perception of risk are necessary but not sufficient conditions for behavior change(72-74). In addition, a decision about changing behavior, self-efficacy in discussing the change with a partner and agreement at the partnership level (166) are all components in the adoption of behavior change. Analysis of data at the partnership level and the location of each partnership with a sexual network(166) would provide the best data on the risk of STI

infection inherent in unprotected sex within that partnership. As partnerships are formed close together in time (such as through serial monogamy), the same risk of infection may be found as within concurrent relationships, if the STI incubation period straddles sexual relations within both relationships.

Caution needs to be taken in the development of partnership level studies as issues of sampling, confidentiality, and controlling for dependency in the analysis exist (166). In addition, it's necessary to clearly detail how the investigators define relationships, in terms of casual, non-casual, main partnership, etc. to reduce misclassification of participant responses (94, 167). Timing of relationships, while subject to recall bias, can be elucidated by detailing beginning and end dates, length of time between partnerships, and (as captured in the Malawi data), a measure of their concurrency and their belief that their partner is having other relationships outside of their partnership (94).

Public health significance

The investigation of behavior change and HIV infection highlights the need to capture behavior change measurements in a more informative manner. Timing and duration of behavior change, details surrounding what the change entailed and characteristics of the partnership are critical elements that would help to better inform effective interventions. It is helpful to note that youth reported engaging in protective behaviors outside of specific interventions. This could indicate that general HIV prevention messages are being recognized and internalized, protecting youth from infection.

The investigation of concurrency and STI/HIV infection highlights the risk of engaging in multiple sexual relationships, even among rural youth. It also indicates the utility of MI, in both SAS and Stata programs, to optimize missing data.

APPENDIX ONE

Analysis of Internal Validity

Introduction

The exposure for Specific Aim 1 is based on the question of the individual changing their behavior since hearing of HIV/AIDS. If they answered yes, they were asked a follow-up question to name the behavior. As mentioned, there are many obstacles to collecting valid and correct information about sexual behaviors. Assessing the validity of the follow-up question may give credibility to the exposure variable. For example, if an individual answered that they “use condoms” as their behavior change, then they may be more likely to have mentioned condom use with their most recent partner at another point in the survey when asked directly about condom use. Kappa scores are used for discrete variables to assess for chance agreement between two separate measures of the same construct.

Specifically, the kappa coefficient is:

$$\frac{\text{Observed agreement} - \text{Expected agreement}}{1 - \text{Expected agreement}}$$

and equals 1 when the two measures perfectly agree, 0 when the two measures agree by chance, and -1 when the two measures perfectly disagree. Observed agreement is the agreement found among the measures in the survey and expected agreement is the agreement expected by chance (132, 133). With an understanding that not all researchers agree on levels of kappa scores that indicate high agreement among constructs(134), an approximate range of ≥ 75 is often considered to indicate “excellent” agreement and was used as a reference point for these analyses (133, 135). The kappa coefficient was easily calculated using the PROC FREQ statement in SAS (134). Although the South African data was

weighted and the rest of the analyses account for this weighing, this investigation of validity attempted to determine if youth, regardless of stratification variables, answered the same response to each companion question. Therefore, the analyses conducted on South African youth were not weighted.

Methods

Using Kappa scores, internal validity or agreement between what respondents answered to the unprompted question about behavior change since hearing of HIV and their answers to prompted questions concerning those behaviors in other parts of the survey was assessed. A specific example of this using the Malawi data is as follows: answers to questions about “only sleep[ing] with boyfriend/girlfriend” were checked against answers to “were you having sex with other partners during the time you were having sex with this partner?”. See Table 3.2 for specific comparison variables.

Results

Results are reported by country.

Analysis on Malawi data

The kappa coefficients for the Malawi data range from a high of 0.29 for men reporting a behavior change of abstinence and not having sex in the last 12 months to a low of 0.01 for men reporting a behavior change of condom use and any condom use with their most recent partner (Table A1.1). As mentioned above, a kappa of 0.75 would have indicated excellent agreement and zero indicates agreement by chance; these values are indicative of poor agreement between the two measures of abstinence, being faithful or using condoms.

Table A1.1 Kappa scores for Malawi dataset where all women, all men and all youth involve those who self-report ever having had sex and the ages of 15-24 years old.

	All women n=451	All men n=432	All youth n=903	Entire dataset n=4834
Abstinence	0.17 n=219	0.29 n=266	0.23 n=485	0.21 n=1548
Being faithful	0.02 n=199	0.03 n=263	0.04 n=462	0.05 N=1402
Using condoms	0.02 n=65	0.01 n=113	0.01 n=178	0.02 n=402

Analysis on South Africa data

The kappa coefficients for the South African data were slightly higher but did not reach a level of excellent agreement between measures (Table A1.2). For agreement between behavior change of abstinence and not having had sex in the past 12 months, kappa coefficients ranged from 0.45 among women to 0.58 among men, which indicated moderate agreement of the two measures. For a behavior change of using condoms and reporting any condom use with their most recent partner, the values ranged from 0.31 for the entire dataset

to 0.40 for all sexually active, rural youth, which indicated fair agreement. This data shows very poor agreement between the two constructs of being faithful, however.

Table A1.2. Kappa scores for South Africa dataset where all women, all men and all youth involve those who self-report ever having had sex and the ages of 15-24 years old.

	All women n=2002	All men n=1714	All youth n=3716	Entire dataset n=11904
Abstinence	0.45 n=1319	0.58 n=1209	0.52 n=2528	0.48 n=5467
Being faithful	0.09 n=662	0.17 n=768	0.18 n=1430	0.15 n=3263
Using condoms	0.39 n=1244	0.39 n=1101	0.40 n=2345	0.31 n=4983

In addition to the kappa coefficients shown above, a generalized kappa was calculated using composite variables. The questions in the other part of the survey were combined to create a variable for having abstained from sex in the last 12 months, were faithful to their partner or had used condoms with their most recent partner (anyABC). Another composite variable was used for naming the behavior change of either abstinence, being faithful or using condoms from the behavior change question (anychange). Kappa statistics were calculated for the agreement between anyABC and anychange, which ranged from 0 among Malawian women to 0.2 among Malawian and South African men. In addition, anyABC was compared to agreement with the question about changing behavior since hearing of HIV, which generated kappa coefficients that ranged from 0 among Malawian women and everyone in the Malawi dataset to 0.2 among South African men and all rural, sexually active youth aged 15-24 years. All of these comparisons had poor agreement.

Discussion

There are several plausible reasons for a low kappa coefficient.

Mechanical

A low kappa coefficient could have resulted due to a weak correlation between the two measures.

Prevalence and missing data

Kappa scores are dependent upon the prevalence of the construct being validated. If the action is common, then a higher agreement of Kappa will be needed to overcome the commonality of the response(168). For example, if few people reported condom use in the open ended question, then fewer opportunities existed to match this response to condom use asked about later on in the questionnaire. This situation certainly applies to the Malawi data. The highest total number of individuals compared was 1553 for the entire dataset in reference to abstinence or having had sex in the last 12 months. However, this decreased to only 65 women in the sample of interest who responded to both condom use questions. When looking at the kappa statistics overall, the lowest kappa scores were for condom use agreement in the Malawi dataset. Kappa scores ranged from 0.01 among sexually active men aged 15-24 years to 0.02 for the entire dataset. Interestingly enough, missing data for these statistics ranged from 74% missing data among the men to 92% missing data in the whole dataset. Therefore, missing data could have driven these results more than a lack of agreement between responses.

Theoretical

Unprompted vs. prompted questions

In the South Africa dataset, the question about behavior change was open ended. Therefore, this question also measured knowledge about HIV, as participants would have needed to indicate a behavior change and then recall a behavior that would be protective against HIV.

In the Malawi dataset, the question about behavior change was multiple choice so respondents would have chosen a provided answer. Looking at the pattern of answering the question, the majority of respondents chose the first or second choice of responses.

Table A1.3. Proportions of responses to the prompted question about behavior change stated after hearing about HIV, Malawi

Answer position	Answer choice	Women, 15-24, sexually active	Men, 15-24, sexually active	All youth, 15-24, sexually active	Everyone in dataset
1	Abstain	44.9%	49.1%	47.2%	41.4%
2	Only sleep with spouse/partner	38.8%	22.6%	29.9%	43.7%

This response pattern could have been due to reporting actual behavior or for reasons that dealt with the way that people answer questions. When faced with a large list of items, participants often choose the first or last response choice because it is easier to remember than an item in the middle of a list. If they are tired, perhaps due to survey length, they may just hear a few options and choose one of the first ones, to avoid listening to the entire list. What is interesting about the proportions above is the amount of abstinence choice among people who reported being sexually active.

It is unlikely that people who are married reported that they have not had sex in the last 12 months and that they would choose to protect themselves from getting HIV through abstinence, as that would be a difficult choice to operationalize. Therefore, a further analysis for the abstinence construct was conducted, stratified by marital status for those rural youth, aged 15-24 years and sexually active. For the Malawi data, where the overall kappa was 0.23, about half were married (kappa =0.10) and the other half were single (kappa =0.24). There was not much agreement in either group, though it was lower in the married group. This could indicate that participants chose to be abstinent and then married within the previous year, leading to discordance in responses to the two questions. In terms of South Africa, the majority were single (96.6%) and had a kappa coefficient of 0.518, which drove the final kappa of the same number. For those that were married, 82 out of 85 did not choose abstinence and also reported not having sex in the last 12 months. Married participants reporting not having sex in the past 12 months is unusual. Perhaps mobility of this younger group, in which husbands moved to larger cities for work, could explain this response.

Question order

For the Malawi data, the questions about behavior change since hearing of HIV are on page 19 of a 27 page survey. For a person with one sexual partner and two other people in the home, these questions would be about the 247th and 248th questions to be asked. This could obviously lead to fatigue or boredom from the survey leading to some misclassification of answers.

For the South Africa data, question order is more favorable. Questions about behavior change since hearing of HIV are on page 16 of a 32 page survey. For a person with

one sexual partner and any number of other people in the home, these questions would be about the 90th and 91st questions to be asked.

Same construct not measured

The kappa tests were based on agreement of two questions that attempted to measure the same construct. However, it can certainly be argued that the two questions were not measuring the same construct for abstinence, being faithful or using condoms. As shown in Table 3.2, these questions measure essentially, but not exactly, the same construct as the options for changing their behavior. For people who are already sexually active, not having sex in the past 12 months may be a poor comparison question for reporting abstinence as their behavior change. Perhaps they were sexually active, then heard of HIV/AIDS and decided to stay abstinent until marriage. If they married in the last 12 months, then they most likely would have answered yes to having had sex in the last 12 months and their answers between the two questions would have been discordant. In terms of condom use, a person could have been sexually active and not used condoms. Since the end of their relationship, they heard about HIV/AIDS and decided to use condoms. If they had not yet entered into a sexual relationship after this decision, then their condom use with their most recent partner would be measured before their behavior change decision and counted as discordant.

For both datasets, low agreement was found between reporting being faithful as a behavior change and reporting having concurrent sexual relationships in another part of the survey. In Malawi, respondents were asked if they were having sex with other partners during the time they were having sex with their most recent partner. The response to this question is not socially desirable and therefore few people responded yes (5.5% of women,

17.1% of men, 12.1% of all sexually active youth and 12.6% of everyone surveyed). The low prevalence of the response led to decreased opportunity to match and potentially lead to a smaller measure of agreement. In the South African data, concurrency was measured using overlapping months and years of first and last sex with their first, most recent and second most recent sexual partner, as applicable. This construct was heavily influenced by recall bias of beginning and ending dates of sexual relationships, which could have lead to misclassification, in turn affecting agreement between the two measures.

Social desirability

The bias of social desirability can also be illustrated using the same example of being faithful, as detailed above. For the Malawi questionnaire, reporting having more than one sexual relationship at one time may not be socially desirable, which could indicate a high sensitivity and a low specificity for this question. If answering the question to match the actual behavior is indicative of the true result, then this question would have a high sensitivity, as people who report they did have more than one sexual relationship probably really did have more than one partner, as they reported a less socially desirably response. If individuals were monogamous than they were more likely to report monogamy, so they are true negatives, an indication of low specificity. For South Africa, social desirability does not create such as obvious bias in terms of measuring concurrency, as this construct was generated from a series of other questions. For both groups, it is desirable to report condom use of any frequency, which could have increased agreement between the two condom questions.

Temporal order of behavior change and other measures

Since these questions were asked in the same questionnaire, then temporal order cannot be established. The comparison question could have been measured before or after the person decided to change their behavior. As mentioned above, condom use with their most recent partner could be measured before they decided to use condoms to prevent HIV infection. Abstaining from sex in the past 12 months could have been measured after they decided to be abstinent for a period of time (such as until marriage). In addition, respondents could have heard of HIV, decided to change their behavior for a period of time and then may have reverted to their previous behaviors due to changing circumstances (getting married and trying to conceive would reduce or eliminate condom use).

This analysis shows that there is moderate agreement for reporting a behavior change of abstinence and fair agreement for behavior change of condom use in the South Africa data. For the other constructs, poor agreement was found. There are many reasons that the kappa coefficient could be reduced, such as missing data, a lack of compatibility between constructs, question order and/or social desirability in the responses. However, this was a helpful exercise to learn more about the datasets and quality of the data collected.

APPENDIX TWO

Analysis of Information Motivation Behavior Model

Introduction

The IMB model synthesizes the most important components of HIV prevention, namely that a person needs to have 1) knowledge about behaviors that prevent HIV acquisition, 2) the desire to prevent themselves from being put at risk and 3) the skills necessary to protect themselves, leading to the action of HIV preventive behaviors. Information can be expanded to include knowledge about modes of transmission and methods of prevention, as well as an ability to identify and dispel myths. Motivation includes a person's attitudes towards prevention behaviors, amount of social support surrounding their desire to institute a behavior, and perception of risk. Behavioral skills include self-efficacy, the ability to follow through with an action. This could include knowledge about where to purchase condoms, talking to sexual partners about HIV/AIDS, talking to sexual partners about using condoms before, during, and after engaging in sexual intercourse, and getting tested for HIV(69).

Methods

Components of the IMB model were included in a separate analysis of South African youth to see if their contribution added to the fit of the model between the exposure of behavior change and the outcome of HIV infection. This analysis was not replicated using the Malawi data due to small sample sizes. Information was measured by a composite variable (has correct knowledge, has incorrect knowledge, has no knowledge) created from the following questions: "To the best of your knowledge, is there anything a person can do to avoid HIV, the virus that causes AIDS?" and "If yes, what can a person do to avoid getting HIV, the

virus that causes AIDS?” Motivation was measured by a question on risk perception (none, small, moderate, high). The Behavior component was represented by a composite variable that combined five questions with Likert-type scales concerning condom self-efficacy, such as “Would you be able to talk about using condoms with your partner?” The composite variable values ranged from 0 to 25 and was dichotomized into a variable representing high and low self-efficacy(110). These constructs are well represented by the questions used, although certainly conducting this analysis post-data collection has limitations. Figures A2.1 and A2.2 indicate how the constructs of the IMB model are present in the South African and Malawian datasets.

Figure A2.1. Information –Motivation-Behavioral Skills model for HIV prevention among young South Africans

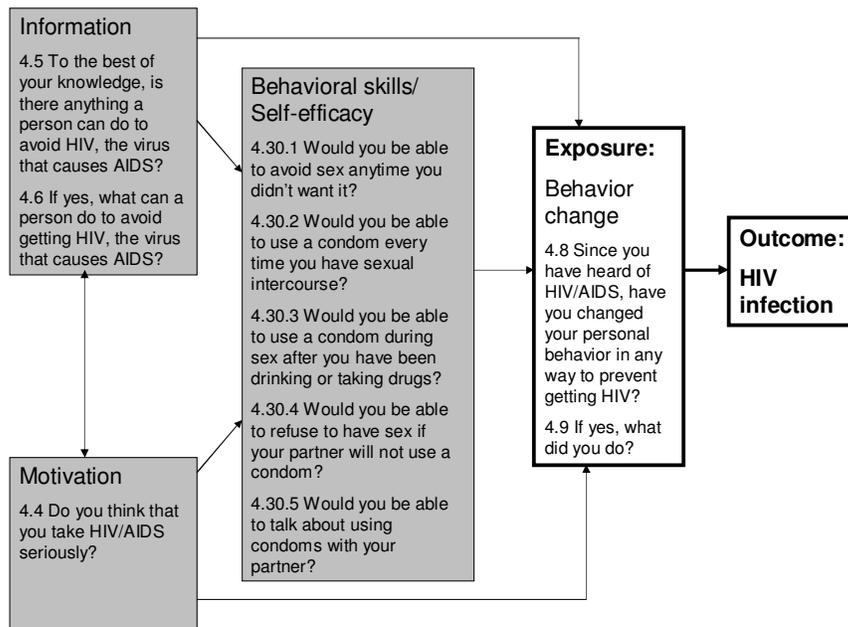
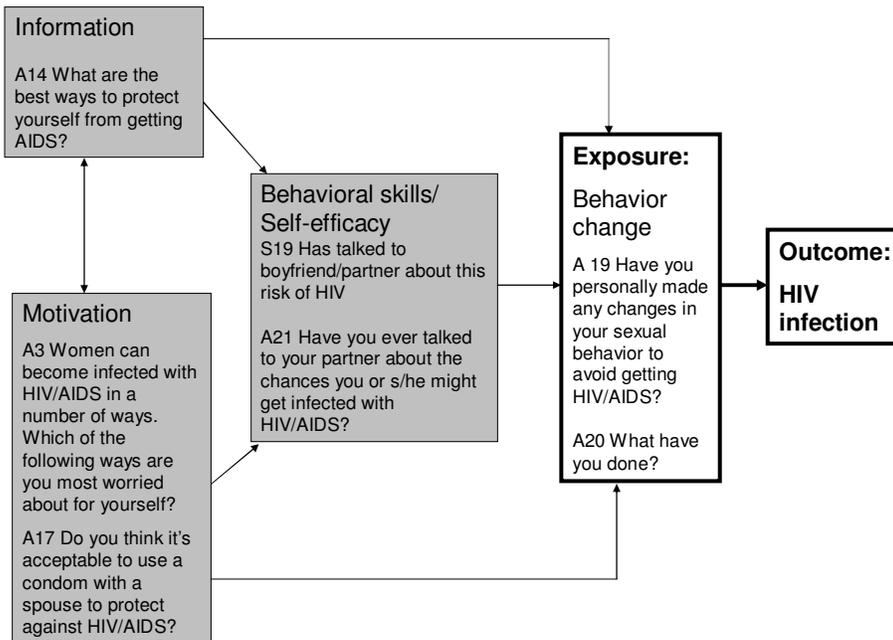


Figure A2.2. Information –Motivation-Behavioral Skills model for HIV prevention among young Malawians



Two different analyses using the IMB variables were conducted. The first analysis compared results from three different models in which the exposure was behavior change and the outcome was HIV infection. A fully adjusted model with all confounders and all IMB variables was created. Backwards elimination, as described in Chapter Three, was conducted on the fully adjusted model. The third model results are brought from the analysis conducted in Chapter Four in which the exposure/outcome relationship is assessed without any IMB variables. The second analyses assessed the association of the IMB variables as an exposure with an outcome of behavior change.

Results

In the fully adjusted model, behavior change and HIV infection are not associated for either men or women. In the second model using backwards elimination, the variables for

information and motivation were retained in the model for women and no IMB variables were retained in the model for men. There is little difference in the effect estimates between the three models for either gender and the CIs almost completely overlap between models (Table A2.1).

Table A2.1. Logistic regression of the association between behavior change and HIV infection for South African youth

	Controlling for all variables of interest plus all IMB variables* OR (95%CI)	Reduced model after backwards elimination was conducted† OR (95%CI)	Reduced model without any IMB variables‡ OR (95%CI)
Women	0.68 (0.41, 1.15)	0.70 (0.42, 1.16)	0.82 (0.51, 1.32)
Men	0.73 (0.34, 1.55)	0.78 (0.37, 1.65)	0.78 (0.37, 1.65)

*For women, controlling for age, ever married, ever pregnant, most recent partner type, sex in past 12 months, education plus IMB variables; for men, controlling for age, ever married, sex in past 12 months, education plus IMB variables

†For women, information and motivation variables remained in the model; for men, all IMB variables dropped out of the model

‡For both women and men, controlling for all variables in first column minus the IMB variables

Table A2.2 compares the IMB constructs to the outcome of behavior change. From this analysis, it appears that youth reporting correct knowledge about ways to avoid HIV were much less likely to report behavior change (women OR: 0.24 (95%CI 0.12, 0.46), men OR: 0.10 (95%CI 0.04, 0.25)) than those that report they don't know of any way to avoid HIV. It does not appear that risk perception is related to behavior change, but having high condom use self-efficacy was associated with almost half (95%CI 0.29, 0.95) the odds of women reporting behavior change than those reporting low condom self-efficacy.

Table A2.2. Logistic regression of the association between IMB variables and behavior change for South African youth

	Bivariate association OR (95%CI)	Multivariate association* OR (95%CI)
Women		
Information on ways to avoid HIV		
Incorrect information vs no information	0.74 (0.23, 2.39)	0.77 (0.22, 2.66)
Correct information vs no information	0.24 (0.12, 0.46)	0.27 (0.14, 0.53)
Motivation: risk perception		
Small vs none	2.02 (0.85, 4.79)	1.90 (0.90, 4.00)
Moderate vs none	0.98 (0.53, 1.80)	0.98 (0.53, 1.83)
High vs none	1.23 (0.75, 1.99)	1.42 (0.77, 2.63)
Behavior: condom use self-efficacy		
High vs low	0.53 (0.29, 0.95)	0.56 (0.32, 1.00)
Men		
Information on ways to avoid HIV		
Incorrect information vs no information	1.38 (0.25, 7.71)	1.27 (0.22, 7.38)
Correct information vs no information	0.10 (0.04, 0.25)	0.12 (0.05, 0.29)
Motivation: risk perception		
Small vs none	0.84 (0.61, 1.18)	0.79 (0.58, 1.06)
Moderate vs none	0.28 (0.12, 0.66)	0.43 (0.21, 0.86)
High vs none	1.00 (0.48, 2.09)	1.02 (0.58, 1.79)
Behavior: condom use self-efficacy		
High vs low	0.83 (0.50, 1.37)	1.09 (0.47, 2.52)

*controlling for all IMB variables in the same model with the outcome of behavior change

Discussion

Adding the IMB variables to the model did not generate a huge change in effect. This analysis indicated that controlling for information, motivation or behavior did not add more information about the relationship between behavior change and HIV infection among South African youth.

There are limitations when applying models to available data, in that survey questions may not always measure a construct in the best manner. The questions concerning knowledge about HIV/AIDS and behavioral skills appear to be straight-forward. In the

datasets used, however, questions that could measure motivation are varied and measure different ideas. It's not clear if a measure of motivation should have been included in the modeling conducted in this dissertation, as it may not have adequately reflected the model constructs. Since the model was applied to existing data, the model was not tested to see if the associations between the constructs and each other (i.e. the association between information and motivation) existed.

The analyses concerning IMB variables and behavior change may support the use of information and behavior variables in the models. However, putting the IMB variables in the same model as the exposure of behavior change and outcome of HIV may not have added more information about the association between exposure and outcome (as originally proposed) but could have lead to a situation in which the models were over controlled.

APPENDIX THREE

Multiple Imputation for Missing Data

Introduction

MI is a common statistical analysis used to handle missing data. While MI methods have existed since the late 1970s, the application of these methods has not yet entered mainstream analysis, which are generally limited to complete case analysis, or analysis of cases that have data for all covariates of interest (141). MI involves several steps: 1) choice of the imputation model which produces imputed datasets; 2) analysis of the imputed datasets; and 3) creation of summary statistics from the analyses. In the creation of imputed datasets, plausible values for the missing value are drawn from distributions of the existing data, taking account of the variability in choosing one of those values used to fill in the missing value(140). Each of the imputed datasets is analyzed in the same method, using the same variables, as the complete case analysis (Figure A3.1). When the summary statistics are generated, the variance reflects the uncertainty in choosing imputed values (140, 141, 169, 170).

Figure A3.1. The process of MI, following five participants who have data on five variables, named X1 to X5.

Subject	X1	X2	X3	X4	X5
1					
2					
3					
4					
5					

The original dataset. Missing values indicated by shaded boxes.

Subject	X1	X2	X3	X4	X5
1					
3					
5					

Complete case analysis will only analyze those cases with complete data for each variable. Forty percent of data is missing.

Subject	X1	X2	X3	X4	X5
1					
2					
3					
4					
5					

Data is arbitrarily missing, indicating the value of using MCMC to impute values.

Imputation 1.

Subject	X1	X2	X3	X4	X5
1					
2					
3					
4					
5					

Imputation 2.

Subject	X1	X2	X3	X4	X5
1					
2					
3					
4					
5					

Imputation 3.

Subject	X1	X2	X3	X4	X5
1					
2					
3					
4					
5					

Several complete datasets are generated with imputed values inserted in the missing spaces.



Results from analysis of Imputation 1 data

Results from analysis of Imputation 2 data

Results from analysis of Imputation 3 data

Summary results combining all results from analyses of imputed datasets, accounting for variance.

Steps 2 & 3: Analyses of each imputed dataset and creation of summary statistics

Missing data can arise from various mechanisms, such as through errors in the interviewer recording responses, data entry errors, or refusal of the interviewee to answer the question. These types of missingness have been grouped into three categories, MCAR, non-ignorable and MAR. MCAR is a special case of MAR in which the probability of an observation being missing is constant across all subjects, and is not based on any other variables. Since the data is missing completely at random, the existence of MCAR does not introduce bias into subsequent analyses. Power may be reduced due to a smaller sample size, but a complete case analysis (of all cases with complete data) is appropriate. Non-ignorable missing data indicates that the probability of being missing is dependent on the actual value that is unobserved. An example of this is that overweight people are less likely to report their weight. Non-ignorable missing data has a great potential for bias in analyses and methods are still being developed to deal with this problem. The third type of missing data is MAR, meaning that the probability of an observation being missing can vary between subjects and may be related to the values of other similar variables, but independent of the value of the missing response. For example, if a person answered 3 out of 4 questions about condom use, their response to the missing question is related to the responses on the other questions, but is likely not dependant on the actual question that has missing data(140, 141).

If data is MAR, then multiple imputation is a helpful tool to fill in probable values for missing values of variables. Multiple imputation is a process that involves several steps. 1) Multiple datasets are generated in which data from complete cases and other variables are used to fill in probable values for the missing value. 2) Each of these imputed datasets is analyzed for the association of interest. 3) The resulting values of the regressions are then averaged to provide a summary measure of the association (141). If the assumptions inherent

in the modeling conducted above are correct, then this process results in an effect estimate that is more precise and has less bias from missing data than a complete case analysis.

Besides the type, missing data is also distinguished by pattern. Univariate missing data has complete data on all variables except for one. Monotone missing data is an extension of univariate missing in which subsequent variables are missing more data, which often occurs when questions are answered through filters. For example: if respondent was aged 15-24, then they were asked question 2. If respondent answered yes to question 2, then s/he was asked question 2a. If not, s/he was asked question 3. Arbitrarily missing data describes data that has no pattern to the missingness. For example, five people didn't answer question 2 and five different people didn't answer question 3 (143, 169).

Methods

Multiple imputation for missing data

The analysis of missing data concentrated on the exposure, STI and HIV outcomes and those variables thought to be confounders of the relationship between these variables, namely: age, ever married, house type, type of most recent partner, condom use with most recent partner, thought most recent partner ever cheated, and discharge or sores/ulcers in the past 12 months.

For each variable, we hypothesized reasons for missing data and conducted diagnostic tests to determine the type and pattern of missingness. Missing STI outcomes could have been non-ignorable, as respondents may have refused to be tested if they knew their status or were symptomatic. Respondents may have refused to answer questions about discharge or sores in the past 12 months because they had those symptoms, which could also have indicated non-ignorable missing data. To gain information about variables missing at

random (MAR), each variable was checked to see if the missingness of the variable was associated with the exposure, STI/HIV outcome, age group and ever being married variables both in the entire dataset and within the subpopulation of interest. All variables, including symptoms of and biological markers for STIs, were associated with at least one other variable, indicating that the variables could be MAR. Variables concerning the most recent partner (concurrency, partner type, condom use and thoughts about partner cheating) had a pattern of monotone missing data as those questions were only asked of participants reporting having had sex in the past 12 months. Remaining variables had an arbitrary missing data pattern.

While Horton and Lipsitz (2001) compared MI in several statistical packages(165), options in SAS have been updated(162) and Stata has added the MICE and ICE macros(171, 172). Due to the common use of both of these statistical packages, this section compares the use of SAS and Stata methods for MI highlighting the former statistical package first.

MCMC (SAS version 9.1)

As the majority of variables were missing arbitrarily, the MCMC method was used to fill in missing values to create 25 complete datasets. The MCMC method pulls probable values for the missing data from the posterior distribution of values not missing (162). As the dichotomous outcome variables were imputed as a continuous variable, these values were rounded to either 0 or 1 before analysis. Imputed datasets were analyzed with the same logistic regression as the complete case analysis and summary statistics were generated.

Regression switching (Stata version 9.2)

Regression switching was used to fill in missing values to create 25 complete datasets. This method conducts a regression and generates predictive values for the outcome for each individual based on their characteristics. It then pulls imputed values from the posterior distribution of plausible values based on closeness to predictive values generated from modeling(163) . Imputed datasets were analyzed with the same logistic regression as the complete case analysis and summary statistics were generated.

Confidence limit ratios (CLR) were calculated by dividing the upper CI by the lower CI and used to obtain a measure of precision for the estimate.

Results

Several diagnostic features in SAS supported the conclusion that the MCMC MI ran correctly. The model converged. Autocorrelation plots indicated statistic independence. The means from the original and imputed datasets were comparable (Table A3.1). The imputed datasets were not missing values for any of the variables of interest. In SAS, the relative efficiency ranged from 0.988 to 0.998 with 25 imputations. The resulting effect estimates and their 95% CIs were comparable to the complete case analysis but had better precision for the HIV estimate, as shown through the CLR.

Table A3.1. Descriptive statistics for several variables comparing multiply imputed datasets through SAS and Stata

		Original dataset	MCMC-SAS	Regression switching-Stata
Concurrency with most recent partner	Mean (std*)	0.06 (0.23)	0.05 (0.23)	0.06 (0.23)
	Range	0, 1	-0.83, 1.00	0, 1
STI outcome	Mean (std*)	0.08 (0.28)	0.09 (0.28)	0.09 (0.28)
	Range	0, 1	-0.97, 1.04	0, 1
HIV outcome	Mean (std*)	0.05 (0.22)	0.05 (0.22)	0.05 (0.22)
	Range	0, 1	-0.72, 1.00	0, 1
Age	Mean (std*)	0.60 (0.49)	0.60 (0.49)	0.60 (0.49)
	Range	0, 1	0, 1	0, 1
Partner type	Mean (std*)	0.09 (0.29)	0.10 (0.29)	0.10 (0.30)
	Range	0, 1	-0.88, 1.11	0, 1
Ever married	Mean (std*)	0.76 (0.43)	0.76 (0.43)	0.76 (0.43)
	Range	0, 1	-0.52, 1.46	0, 1

*std= standard deviation

As expected, the same effect estimates and CIs were obtained in the complete case analysis for both SAS and Stata. MI methods generated similar estimates and CLRs using regression switching as with MCMC in SAS (Table A3.2).

Using complete case analysis and controlling for other covariates, women who report concurrency were no more likely to have an STI infection (95%CI 0.09, 5.57) than women not reporting concurrency. MI methods did not greatly change this affect. Using complete case analysis and controlling for other covariates, women who report concurrency were 6.08 times (95%CI 1.23, 30.16) more likely to be HIV positive than women not reporting concurrency. Using MI methodology and controlling for other covariates, a comparable but more precise estimate was obtained (Table A3.2).

Table A3.2. Odds ratios and confidence limit ratios for the effect of concurrency and outcomes of STI and HIV infection for several methods

	Outcome: STI infection		Outcome: HIV infection	
	OR (95%CI)	CLR	OR (95%CI)	CLR
Unadjusted	0.65 (0.08, 5.09)	62.0	7.10 (2.01, 25.06)	12.5
Complete case analysis	0.69 (0.09, 5.57)	64.7	6.08 (1.23, 30.16)	24.6
Multiple imputation in SAS	0.68 (0.07, 6.29)	84.5	7.78 (1.80, 33.56)	18.6
Multiple imputation in Stata	0.71 (0.08, 5.95)	71.1	5.65 (1.37, 23.31)	17.0

OR= odds ratio, CI= confidence interval, CLR= confidence limit ratio

Discussion

Comparing the methods of SAS and Stata

Both SAS and Stata had very accessible documentation to learning the various coding for each multiple imputation method. The learning curve for reading the documentation, writing the code and getting the code to run correctly was quite different for the two methods. Since the data was missing arbitrarily, the SAS manual gave several different ways to generate the imputed datasets. It took about 20 hours to create a SAS program that ran correctly. In contrast, it took about 4 hours to generate Stata code that ran correctly. Once the code was written, it took both programs under two minutes to run the programs and create summarized output. This computation time could increase as the dataset size increases.

To further compare the methods, descriptive statistics for the original dataset and imputed datasets for several variables were computed. Both methods yielded imputed datasets that were quite close to the original dataset in terms of mean, standard deviation and ranges of imputed variables. The MCMC method in SAS assumed that variables are continuous, and imputed plausible ranges of values into the imputed datasets. Stata imputed discrete values which created dichotomous variables in the imputed datasets. For the

outcome of HIV infection, both imputation programs generated effect estimates with greater precision than the complete case analysis, as shown through the CLRs.

Support of the MAR assumption

MI is based on the assumption that the data is MAR. This assumption can not be tested without additional information on why the data is missing. However, an attempt to test this assumption was conducted by assessing whether or not the missingness of several variables was associated with the exposure, outcomes and other covariates. An association was found between missingness and other variables, indicating that the MAR assumption may be valid. If not completely valid, the evidence indicates that departure from the MAR assumption is quite small and may not have much of an effect on the resultant estimates of effect and error.

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