Overestimating HIV infection:
The Construction and Accuracy of Subjective Probabilities of HIV Infection in Rural Malawi

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Introduction

The AIDS epidemic caused a rapid mortality increase in eastern and southern Africa. Periods of rapid mortality change are often characterized by uncertainty about the magnitude of risk (Montgomery, 2000). People living in highly HIV-affected areas may have a reasonable idea of the risk they face from familiar illnesses, such as malaria, but uncertainties are likely to be particularly great when the deaths are due to AIDS, since the long latency period between infection and death makes it difficult to connect the source of infection with deaths a decade or so later. Virtually all living in highly AIDS-affected areas of sub-Saharan Africa know that HIV is sexually transmitted, and some have engaged in what they believe is risky sex or believe their sexual partner has engaged in risky sex. It would not be surprising, then, that many believe that they have already been infected.

In the low and middle-income countries of sub-Saharan Africa, people facing the tide of the epidemic have little alternative but to rely on their subjective assessment. UNAIDS and WHO estimate that in low or middle-income countries only 10% of people at risk of HIV infection have access to voluntary counseling and testing (VCT), (UNAIDS, 2004). The few VCT centers are concentrated in urban areas, making certainty particularly difficult for rural residents. Those who are promoting the expansion of VCT as a weapon in the battle against AIDS believe that it is critical for people to know their status accurately. The assumption is that knowledge of one's status will affect behavior: those who learn they are negative will be motivated to adopt stronger prevention methods, whereas those who learn they are positive will change their behavior so as not to infect others (Holbrooke, 2004). There is little evidence to support these predictions of behavioral change. It is, however, reasonable to believe that in the absence of testing facilities, subjective assessments are likely to drive behavior. As has been said, "If men define situations as real, they are real in their consequences." (Thomas and Thomas, 1928: 572).

In this paper, we use a unique dataset from rural Malawi that includes respondents' HIV status as well as their subjective likelihood of HIV infection. These data show that 10%

of husbands and 18% of wives estimate a medium or high likelihood of currently infection. Actual prevalence was much lower: 6% of men and 9% of women were HIV positive. The difference between the measures of self-assessed and objective HIV status raises an important question: why are so many wrong? This in turn leads to questions about the construction of subjective assessments. We thus begin by asking what are the characteristics of individuals that lead them to believe they are, or are not, already infected. We then evaluate the accuracy of their subjective probabilities against the evidence provided by biomarkers for HIV: what proportion of the respondents accurately identifies their HIV status, either positive or negative? Lastly, we distinguish between those who overestimate their risk and those who underestimate it, and ask what characteristics of individuals are associated with these their error.

We find that both men and women appear to use a set of heuristic rules to formulate probabilities that they are, or are not, infected. These heuristics are gendered, consistent with what researchers know are the primary routes of HIV transmission in the heterosexual epidemic of sub-Saharan Africa. Men rely on their knowledge of their own sexual behavior, but also take into account their perception of the prevalence of AIDS in their community. Women, who as a group are particularly concerned about their husband's behavior, rely on their assessments of his fidelity, as well as being influenced by their social network partners. Both men and women, however, are more likely to overestimate their risk than to underestimate it, and the same heuristics that are their basis for their subjective estimates are also associated with their overestimation of risk.

Background

When many are at risk but few are tested, how do individuals assess risk and likelihood of HIV infection? In one sense, this is a relatively simple exercise: individuals use their knowledge of HIV transmission and apply this knowledge to their past behavior, to arrive at an estimation of their likelihood of HIV infection. A variety of surveys show that respondents in the highly AIDS-affected areas of sub-Saharan Africa know that AIDS is transmitted through sexual contact, they are very worried about becoming infected, and they know infection can be prevented by abstinence before marriage and fidelity after, or by consistent condom use (Kengeya-Kayondo et al, 1999; United Nations, 2002). By combining this knowledge with knowledge of their own behavior, people can estimate their own risk—and, because they are so worried, they do.

Yet the accuracy of subjective probability of HIV infection is questionable for several reasons. Researchers in social psychology and economics have examined the assessment of risk under uncertainty and the influence of these assessments on subsequent decisions (Heimer, 1988; Kahneman, Slovic and Tversky, 1982). This research suggests that individuals use a set of heuristic rules to process judgments and formulate probabilities for uncertain outcomes. Due to biases in the process of probability estimation under circumstances of uncertainty (Montgomery, 2000; Rabin, 1998; Kahneman, Slovic and Tversky, 1982), heuristics used by individuals may lead to an incorrect assessment of probabilities. In addition, human rationality may be biased not only because the cognitive capacity of the individual is limited, but also because reasoning is restricted to the environment from which the individual originates (Simon, 1982).

Some aspects of the epidemiology of HIV magnify uncertainty. Most common infections are characterized by symptoms that occur shortly after infection, thus permitting individuals to link their symptoms to the source of infection. HIV infection is well known to be quite different. Moreover, the invisibility of HIV contributes to uncertainty. In rural Malawi, 92% of women and 95% of men know that a healthy-looking person can still be infected with HIV (see table 1). Furthermore, the length of time between HIV infection and exhibiting symptoms of AIDS makes it difficult for individuals to connect the event when AIDS transmission occurred and the resulting infection.

Although general knowledge of AIDS transmission is widespread, this knowledge is incomplete in three ways relevant for assessing one's own risk. First, 97% of male and 95% of female residents of rural Malawi believe that there is a high or certain likelihood of HIV infection from unprotected sex one time with an infected person (from MDICP survey data- see table 1). The actual likelihood of infection in the absence of an STI is approximately one in a thousand (95% confidence interval: 0.0008–0.0015 per act of intercourse) (Gray et al. 2001). Second, married individuals are likely to know what has been risky about their own behavior, but to know less about the behavior of their spouse. Their observation of their spouse's comings and goings is limited by gendered patterns of work and social interaction; although their social network partners supplement their observation, this information may be imprecise and limited in detail (Clark, 2005; Watkins 2005; Kohler, 1997). Finally, partly because they overestimate the likelihood of HIV transmission in one act of intercourse, Malawians also overestimate the prevalence of HIV in their village.

In this paper, we investigate the construction, accuracy, and biases of subjective HIV/AIDS infection probabilities in rural Malawi. First, we identify factors influencing self-assessed likelihood of HIV infection. In assessing their likelihood of HIV infection, we hypothesize that rural Malawians use a set of heuristics based on their own sexual behavior, their understanding of HIV transmission, and the perceived sexual behavior of their spouse. To test the accuracy of subjective likelihood of infection, we then compare these self-assessments with actual HIV infection.

Next, we investigate the reasons for discrepancies between these measures by identifying possible biases in the heuristics identified above. We expect to find that biases in the heuristics identified above lead to inaccurate subjective estimates of HIV infection. For men, infidelity and higher subjective estimates of HIV prevalence in the community will lead to biases in self-assessed probability of infection. These heuristics are important for women, but suspected spousal infidelity and worry about spouse's behavior will be the primary source of bias in heuristics for women. These biases occur because women may suspect that their husbands are unfaithful but are unlikely to know the frequency of infidelity and condom use in the extramarital relationship.

The data for the analysis come from the Malawi Diffusion and Ideational Change (MDICP) Project, a longitudinal survey of ever-married women and their spouses in rural Malawi. These data are unusually appropriate because they are longitudinal, include biomarkers, and offer a variety of measures of risk perception. In comparison, very few available datasets that measure HIV/AIDS risk perception in sub-Saharan Africa also have objective measures of HIV status. Even when HIV status is available, self-assessed HIV infection likelihood is sometimes measured using only one variable, a limitation that is seldom acknowledged (Kengeya-Kayondo et al, 1999)[1]. In addition, most studies are cross-sectional, thus preventing assessments of changes in likelihood of infection over time, and in other attitudes and behaviors related HIV risk.

Setting and Data

When all the countries of the world are ranked by their HIV prevalence, Malawi is the eighth highest, with an estimated national prevalence of 14.6% of adults infected. The epidemic in Africa is predominantly heterosexual, with men most likely to be infected by pre-marital and extramarital partners, and women most likely to be infected by their husbands (de Zousa, Sweat and Denison, 1996; Heise and Elias, 1995; King et al, 1993; McKenna et al., 1997; Bracher, Santow and Watkins 2003). The prevention programs have emphasized the dangers of extramarital partners for men, although they have not yet incorporated the dangers that ordinary wives face from their husbands. It is interesting that women's concern about the impact of her husband on her own HIV status is consistent with findings elsewhere that the greatest actual source of risk of contracting HIV for women in sub-Saharan Africa is their husband or regular partner.

The data for the analysis come from the second and third wave of the Malawi Diffusion and Ideational Change Project, a panel survey that examines the role of social networks in changing attitudes and behavior regarding family size, family planning, and HIV/AIDS in rural Malawi. The first round of the MDICP (MDICP-1) was carried out in the summer of 1998, and interviewed 1541 ever-married women of childbearing age and 1065 husbands of the currently married women in three Malawi districts: Balaka in South, Mchinji in the Center and Rumphi in the North. In 2001 and 2004, the second and third rounds of the survey (MDICP-2 and MDICP-3) re-interviewed the same

[1] Risk perception measured by "Do you think you are at risk of becoming infected with HIV?" with responses of "Yes," "No," "Don't know," and "Already infected." Question comes from a survey conducted in Masaka District, Uganda; funded by the Medical Research Council (UK).

respondents and interviewed all their new spouses, if they had remarried between the two survey waves (more detailed information about fieldwork and sampling procedures can be found at http://malawi.pop.upenn.edu). MDICP-3 also collected biomarkers for HIV/AIDS and sexually transmitted infections for all respondents who agreed to be tested (the testing protocol is described in Bignami-Van Assche et al., 2004).

To identify the factors influencing self-assessed likelihood of HIV infection we use a variety of measures of risk perception from the MDICP-2. We then analyze the predictive power of these measures by comparing self-assessed likelihood of infection in the MDICP-2 with actual HIV infection as measured in the MDICP-3 for the same respondents. The analysis is therefore restricted to respondents who were interviewed in 2001 and tested for HIV in 2004[2]. This requires the exclusion of 397 male and 530 female respondents who were interviewed in 2001 but not tested (e.g. moved, died or refused HIV test) in 2004. The resulting sample size is 899 women and 523 men.

Background characteristics for men and women in the sample are displayed in table 1. MDICP follows ever-married women, so almost all the men in our sample are married to women in the sample (a small number of men were followed after their marriage to a sampled wife ended). Of these women, 92% we currently married in 2001, and 29% were wives of polygamous husbands. For both men and women, most respondents attended school, but left prior to secondary school. For measures of economic status, 9% of both men and women lived in a house with an iron sheet roof, a sign of economic prosperity in rural Malawi, and more than half of the households both owned a bicycle and a radio. The HIV/AIDS prevalence in 2004 for these MDICP respondents is 8.5% for women and 5.9% for men, as shown in table 1.

Methods

Below we describe our methods for addressing the three topics of this paper: 1) the heuristics of subjective likelihood of current HIV infection, 2) the accuracy of self

[2] A small number of respondents (three men, five women) with indeterminate HIV test results were also discarded from this analysis.

assessed likelihood of HIV infection, and 3) biases in the heuristics identified in the first section.

Heuristics of Subjective Likelihood of Current HIV Infection

Here we isolate the components of the heuristics used by rural Malawians to assess their probability of current infection by describing the association between their reported HIV status and their characteristics, including those of their spouses. The dependent variable is "In your opinion, what is the likelihood (chance) that you are infected with HIV/AIDS by now?" Responses for these question are "No Likelihood," "Low," "Medium," "High," and "Don't know." Those responding "Don't know" are deleted from this analysis (see note 1).

We run ordered logistic regressions to identify the determinants of self-assessed probability of infection for respondents in 2001, in order to preserve as much information as possible from the original ordering of the response categories for subjective likelihood of HIV infection (see note 2). Under the proportional odds assumption, the effects of the explanatory variables are always the same regardless of how the dependent variable is dichotomized; any differences between coefficients in different dichotomizations are included in random error. Ordered logistic regression then estimates weighted averages from different dichotomizations as coefficients. In using ordered logistic regression, the dependent variable consists of J ordered categories, represented by 1, 2…J. When the categories are ordered, probabilities are cumulative: modeled as the probability that an individual gives a response in category J or higher. The Jth cumulative odds is then the probability of giving a response in the category J +1 or higher (Allison, 1999).

To examine the respondents' characteristics that associated with his or her report of current HIV status, we consider five categories of independent variables (Table 1). First are demographic variables: age, region of residence, level of education, marital status (men are assumed to be married), if the respondent is a polygamist husband or one of several wives, and measures of economic status (presence of a bicycle or radio in the household, and the material of the respondent's roof).

The ability to assess the probability of current AIDS infection requires basic knowledge of HIV/AIDS transmission. Therefore, three measures of AIDS transmission knowledge represent the second category of variables included in the regressions: "Can you get AIDS if you have sex with someone who looks perfectly healthy?" "Does having an STD increase, decrease, or not affect a person's chance of getting AIDS?", and "If you have sex only one time with a person infected with the AIDS virus, what are the chances that you will get AIDS from her/him?"

As expected, rural Malawians generally have a good understanding of HIV/AIDS transmission (table 1). More than 90% of men and women in MDICP realize that AIDS can be transmitted by someone who appears to be healthy, and more than 80% of both men and women know that having an STI increases the likelihood of AIDS transmission through sex. However, as stated above, more than 95% of MDICP respondents inaccurately believe that AIDS will be transmitted in one act of unprotected sex with an infected person.

The respondent's own reported behavior is included. First, reported infidelity is included. More than 20% of men report having been unfaithful to their current wife, and only 4% of women report being unfaithful. To measure approximately how long the respondent has been sexually active, age of first intercourse is included. When controlling for the respondent marrying their first sexual partner, this variable measures the duration of sexual activity. Younger age of sexual debut is associated with greater likelihood of marital infidelity (White, Cleland, and Carel, 2000). For age at first sex, respondents are broken into five groups: less than 15 years old, 15 or 16 years old, 17 or 18 years old, greater than 18 years old, and "don't know". Since respondents perceive that having an STI can increase the chance of becoming infected with HIV, we include self reports of STIs (syphilis, gonorrhea, genital warts, chalmydia), or symptoms of an STI (lower abdominal pain, foul-smelling discharge, genital sores/ulcers, genital warts, burning pain on urination, redness/inflammation in genital area, itching in genital area), (this set of questions was not asked for women in the survey).

The next set of variables measures spouse's or cohabiting partner's perceived sexual activity. The literature shows that men are the primary source of HIV infection within marriage (Heise and Elias, 1995; King et al, 1993; Serwadda et al, 1995). This is consistent with our survey reports of married women, who in 2001 considered their spouse to be their primary source of risk. Men also shared the view that they are the primary source of infection in their marriage: they reported "other partners" as their primary source of risk (Clark, 2005; Smith and Watkins, 2005). Variables measuring spouse's behavior include "During your time together, did you suspect or know that your current wife/husband had sexual relations with other men/women apart from you?" The responses for this variable are dichotomized into 1) know or suspect infidelity 2) can't, don't know, or probably not. More than one quarter of women in MDICP suspect or know that their husband is unfaithful, and only 5% of men say the same about their wife. The greatest source of concern for HIV infection is included, with response categories of 1) wife/husband, 2) other partners, and 3) other (transfusions, needle/injections). The respondent's opinion of the acceptability of condom use in marriage is also included. We include a variable indicating whether the husband usually resides outside of the village of wife's residence, since MDICP qualitative data show that it is expected that when migration separates the spouses, the men will take another sexual partner, although wives are ideally more faithful, it is acknowledged that some will also seek another partner. Finally, a dummy variable is included for the respondent answering that one of the best ways to protect themselves from AIDS is to "Advise spouse to take care" (from a list of options including condom use, avoiding sex, prayer and other options).

The MDICP asked respondents with whom they had talked about AIDS. These social network partners people with whom have been shown to influence the extent to which respondents are worried about contracting AIDS (Helleringer and Kohler, 2005; Smith, 2001; Watkins, Kohler and Behrman, 2000). Thus, characteristics of social network partners are also included in the regression. First, the number of people spoken to about AIDS is included. Also, a variable is created for having at least one network partner (out of up to five partners listed) reporting a high level of worry of contracting HIV/AIDS. In addition, the average level of worry among the network partners was calculated. It is likely that subjective risk assessments may be influenced not only by network partners, but by perceptions of the prevalence of AIDS in the respondent's community: presumably, the more a person perceives that others are infected, the more he or she will feel at risk. We thus include the respondent's of the number of people known to have died of AIDS in the past 12 months are also included, as well as the number of funerals attended. Although the absence of testing means that respondents do not know for sure whether someone has died of AIDS, the MDICP qualitative data show that people in the communities diagnose cause of death using much the same heuristics that we hypothesize influence their own subjective risk assessment, indicators of physical illness and local knowledge of the sexual behavior of their past partners (Watkins and Swidler 2005).

<u>The accuracy of self-assessed likelihood of current HIV infection</u>

Once the heuristics used by rural Malawian men and women to assess their likelihood of current HIV/AIDS infection have been identified, we proceed to an examination of the accuracy of these subjective assessments by comparing the subjective assessment with the results of the MDICP HIV testing. We are interested first in the accuracy of the assessment, and then in whether respondents over-or under-estimate their risk.

Although survey data from 2004 is not yet prepared for analysis, 2004 biomarkers for MDICP respondents are available. Therefore, we link 2004 biomarkers with 2001 survey data for the same respondents. Note that self-assessed likelihood of HIV infection and HIV biomarker are not collected during the same year.

Using self assessed probability of current infection and objective HIV status from different waves of MDICP requires several assumptions. If the subjective assessment of current HIV infection is calculated partly based on previous behaviors, testing the accuracy of 2001 subjective assessments with 2004 biomarkers requires the assumption that there were no dramatic changes in behavior between 2001 and 2004. In other words, we are assuming that respondents who reported a low likelihood of current HIV infection in 2001 did not begin to engage in risky activities that would increase the likelihood of

HIV infection between 2001 and 2004, and therefore invalidate their 2001 assessment. Similar assumptions are made for the other variables measured against 2004 objective HIV status. In addition, we assume that there is homogeneity in the biological susceptibility of HIV infection among male and female respondents. Additional assumptions are identified and tested later in this section.

To assess the accuracy of current and future self-assessed likelihood of HIV infection, we first create tables of the percent HIV infected by self-assessed probability of infection, dichotomized into 1) respondents reporting no or low likelihood, and 2) those answering medium or high. In addition to self-assessed probability of current infection, we also test the accuracy of responses to "In your opinion, what is the likelihood (chance) that you will become infected with AIDS in the future?" and "How worried are you that you might catch AIDS?" To verify the results for these tables by controlling for possible spurious factors in the self-assessed probabilities and level of worry, we run logistic regressions with demographic characteristics such as age, education, region of residence in Malawi, knowledge of AIDS transmission, and economic status of the household.

<u>Biases in heuristics</u>

Finally, we use the heuristics identified in section one to identify factors that influence the accuracy of self-assessed HIV infection likelihood. By identifying characteristics that differ by the accuracy of subjective assessment, we address the question: why are some respondents incorrect in their subjective assessment?

According to Tversky and Kahneman (1992), heuristics used to assess probabilities are subject to biases that frequently lead to inaccurate estimation. For example, using the "availability" heuristic, people assess probability of an event by the ease with which instances or occurrences can be recalled. Tversky and Kahneman discover biases in availability due to the fact that the ability for an event to be imagined does not always represent its frequency or probability. AIDS funerals may be events that are easy to recall in rural Malawi, which can lead to an inaccurate assessment of AIDS prevalence and biased subjective infection likelihood.

Also, the "adjustments and anchoring" heuristic refers to the initial point of an estimation that is adjusted for a final prediction. A starting point is often estimated in the process of evaluating the risk or problem, and is then adjusted in the calculation of one's risk likelihood. Incorrect starting points can bias this heuristic. For example, the assessment of HIV infection risk for an individual may first depend on their estimate of the prevalence of HIV in the community. If one overestimates the likelihood of HIV transmission in one act of sexual intercourse with an infected person, their subjective likelihood of HIV infection will be biased upward.

To identify factors that influence the accuracy of subjective HIV infection likelihood, we conduct three analyses. First, we examine the determinants of the overall level of accuracy regardless of the direction of bias. Second, we examine the determinants of over-estimation and under-estimation separately. Because the number of HIV infected men and women are small, this analysis yields very large standard errors and some cases of quasi-complete separation for variables in the analysis. This assessment may be possible with 2004 survey data, but we have not conducted this analysis with 2001 survey data. Finally, we analyze the determinants of overestimation of current HIV infection. We consider only HIV uninfected respondents, and distinguish the HIV uninfected by 1) respondents who correctly assessed their likelihood of current infection as low, and 2) uninfected respondents who incorrectly assessed their current likelihood of HIV infection as high. We then run logistic regressions to identify the differences in reporting characteristics for these two groups, in order to find out why some respondents found themselves at high risk of HIV infection in 2001 but were found uninfected in 2004.

Results

Heuristics of Subjective Probability of HIV Infection- Results

Table 2 shows that, as expected, rural Malawians combine their knowledge of the main sources of infection in a heterosexually transmitted infection with their knowledge of their own past behavior and that of their spouse. Because male and female sexual behavior is perceived to differ, the components of the heuristics used to estimate subjective probabilities of infection are gendered.

Even a cursory glance at Table 2 shows gendered patterns of the components of heuristics used to assess the likelihood of infection. For men, their own reported infidelity is highly significant in the model, with unfaithful men 2.4 times more likely to be in a higher category of perceived likelihood than male respondents reporting fidelity to current wife or partner. Monogamous men are not worried about the behavior of their wife (or, if they are, they do not report it), but polygamous men perceive themselves to be at great risk, probably because their wives do not live in the same compound, and thus their behavior is more difficult to observe and control. Men are also influenced by their perception of the prevalence of AIDS in their community. It is likely that if the respondent perceives a higher prevalence, he concludes that his outside partners are more likely to be infected as well, and thus he himself is more likely to be infected. Age also matters for men, with older men reporting themselves as at lower risk. This is likely because respondents become less sexually active at older ages, and older MDICP respondents would have been most sexually active during times of lower HIV prevalence.

In contrast, the heuristics that women use to assess their likelihood of infection feature the behavior of their husband rather than their own behavior (although this is probably under-reported). Women who reported that they knew or suspected their husband of infidelity are 82% more likely to be in a higher category of self-assessment, a highly significant variable in the model. Other measures of the husband's perceived behavior—her perception that her husband is the greatest potential source of her infection, and his polygamy—are also components of women's risk assessment. It is interesting that women who are willing to use a condom in marriage to avoid AIDS are more likely to be in a higher category of self-assessed probability of current infection: here, the direction is undoubtedly from the wife's fear of infection by her spouse to her willingness to use condoms in marriage, suggesting the possibility of an oncoming change in the acceptability of condom use in marriage. Whereas the heuristics used by men are influenced by their estimates of HIV prevalence in their community, wives are influenced by their social network partners, most of who are friends and relatives. Women with at least one network partner who is highly worried about HIV are more likely to think they are infected.

The components of the heuristics used by men and women to assess their risk are consistent with research findings that show that indeed men's greatest risk is from extramarital partners, and women's greatest risk is from their husbands, suggesting that both men and women would be accurate in assessing their current HIV status.

<u>Accuracy of Subjective Probability of HIV Infection- Results</u>

Table 3 shows the percentages of respondents who are HIV-positive in 2004 by the subjective probability of current infection in 2001. Again, we see differences by gender. All respondents in this table are infected, but men are more likely to correctly believe they are infected than are women. 8% of female respondents who report a low likelihood of current HIV infection are, in fact, HIV positive in 2004, but 10% who report a high likelihood of current infection in 2001 are infected in 2004. In contrast, only 5% of men who report they are not infected are, whereas 16% of respondents who report a high likelihood of HIV infection are correct. Only small percentages of infected men and women accurately report their likelihood of current HIV infection. When they are wrong, it is often because they think they are infected when they are not.

Table 4 reports similar results for the subjective likelihood of HIV infection in the future. Women are slightly more accurate in assessing their likelihood of HIV infection in the future than their current HIV infection. 93% of women who report a low likelihood of HIV infection in the future are uninfected in 2004, and 11% of women who subjectively assess a high likelihood of infection in the future are infected in 2004. These figures show a slight improvement in accuracy in assessing HIV status for both women and men; again, however, the uninfected are more likely to be wrong than the infected.

As seen in table 6, another measure of risk perception, the level of worry of contracting HIV, is also not a reliable indicator of HIV infection: far more were worried that they would be infected than were. Only 9% of women who are “worried a lot” about contracting HIV are HIV positive in 2004, compared with 8% of women who are not worried about contracting HIV. Similarly for men, only 6% of highly worried men are infected, and 5% of men who are not worried are HIV positive. While it has been demonstrated that social networks influence worry (Helleringer and Kohler, 2005; Smith, 2001), and that worry can also be used to measure behavior change (Smith and Watkins, 2005), worry does not accurately measure HIV infection among respondents

Are the mistakes in predicting HIV status influenced by age, education, or understanding of AIDS transmission? For example, perhaps older respondents are less likely to be infected and also to report a high likelihood of current or future HIV infection because they know that they have been less sexually active in recent years and have fewer sexually active years ahead of them. In addition, respondents with little education could have a poor understanding of how HIV is transmitted and rate themselves as not being at risk. Alternatively, since education is related to both economic status and migration rural Malawi (the more educated men are more likely to go to the cities for higher-paying work) education may proxy the ability to afford the transaction costs associated with extramarital partners, and the opportunity to have partners without the knowledge of the wife. In order to evaluate the self-assessed current and future likelihood of HIV infection while taking these concerns into consideration, we run logistic regressions on HIV infection in 2004, and check the effect of self-assessment on infection while controlling for basic demographic features as well as variables measuring the basic understanding of HIV transmission among respondents. In addition to current and future self-assessed probabilities of HIV infection, variables in this regression include age, region of residence, level of education, measures of AIDS transmission knowledge, and measures of economic status.

Table 7 shows that, when controlling for the above characteristics and understanding of HIV transmission, my previous results are reinforced. Men who report a high likelihood of being currently infected are 4.4 times more likely to be HIV infected than those reporting a low likelihood of current HIV infection, and the odds ratio is highly significant. For women, a high self-assessed probability of being currently infected does not have a statistically significant effect on 2004 infection status[3].

With the assessment of current risk in a class statement, those men responding "medium" or "high" likelihood are significantly more likely to be HIV infected in 2004. The level of significance and value of the odds ratio are generally the same for these two levels. In contrast, the effect of "low" likelihood for men is close to the same level as the reference category, "no likelihood." Like men, female respondents answering "medium" and "high" likelihood of current infection are more likely to be infected, but neither category is significant in this regression.

One potential bias that arises from using 2001 self-assessments and 2004 status is the possibility that a disproportionate number of respondents who estimated a high likelihood of current infection were indeed infected and died between waves. If these respondents were had the symptoms of AIDS in 2001 and survived to 2004, they would surely be accurate in assessing their status. To investigate this possible bias, we use field logs from the MDICP survey team in 2004 to identify respondents who were interviewed in 2001 but were reported as having died by 2004. If these respondents died prior to age 60, we make the assumption that the respondent died from AIDS. From these field logs, there are 24 women and 19 men who fit this description and have estimations of current HIV infection likelihood.

Subjective current likelihood of HIV infection estimates for respondents dying between 2001 and 2004, compared to respondents who were tested in 2004, are shown in table 9 for men and table 10 for women, with Chi^2 tests of the differences. For men, the loss to the sample of those who died between waves does not have a significant effect: for women, the attrition through death matters- a much larger percentage of female

[3] For the male regression, the two AIDS transmission knowledge variables missing on table 7 were omitted from the regression due to complete separation. Although these variables were measured on an ordinal scale, they behaved as dichotomous variables, as shown in table 8.

respondents who already considered themselves at medium or high probability of infection had died than those who had considered themselves uninfected

Because the infection status of respondents dying between waves cannot be confirmed, we do not include them as HIV positive respondents in the further analysis. Nonetheless, this indicates that for women, deaths between waves bias the accuracy of 2001 self-assessed probability of HIV infection. Using survey and biomarker data from 2004 will eliminate this bias and can provide a more accurate assessment of subjective HIV infection estimates.

Overall, these results reveal that for men, there is a difference in HIV status prediction accuracy between respondents who self-assess a low and high likelihood of HIV infection. In general, respondents overestimate their risk, but the heuristics used by respondents work better for the infected than the uninfected. Again, we see a difference by gender. Women are less accurate than men. They also overestimate, but compared to the men, larger percentages of both uninfected infected are inaccurately assessing their current HIV status.

Biases in Heuristics- Results

Table 11 displays the percentages of men and women reporting low or high probability of infection by 2004 biomarker result. We can see that 9% of uninfected men and 18% of uninfected women overestimate their likelihood of current infection. Because most men and women in rural Malawi know how HIV is transmitted and have a good understanding of the sources of their greatest risk—other partners for men, husbands for women, it is surprising that relatively large numbers believed they were already infected in 2001 but were not infected three years later. What are the reasons for this discrepancy between subjective probability of infection and actual infection status?

First, Table 12 shows results for respondents' correct assessment, including both HIV infected and uninfected. Again, as in the earlier analysis of the components of the heuristics of risk assessment, correct estimation is influenced by behavioral and social factors. My next question is why the uninfected overestimate their risk. To examine this, the analysis is of the uninfected: what leads them to think they are infected when they are not? The results are shown in table 13 (seen note 3).

To a considerable degree, the same heuristics that individuals use to estimate their subjective probabilities of infection also lead them to overestimate their infection status. Uninfected men reporting infidelity were more than five times more likely to think they were infected when they were not than were men who do not report infidelity.

And women who report that their husband is the greatest potential source of infection are particularly prone to overestimate their vulnerability. Similar to the results of the determinants of perceived risk presented earlier, women overestimate their risk when they have network partners who are very worried about HIV, and men overestimate their risk when they know many who have died of AIDS. There are two interesting difference between these estimates and the previous analysis of the determinants of subjective risk. Here it is not only women but also men who are influenced by their perception of their spouse's infidelity, and here polygamy influences only husband's accuracy, not that of their wives.

Region of residence is also associated with overestimating the likelihood of infection Possible explanations for this are beyond the scope of this paper, but Helleringer and Kohler (2005) describe important demographic and cultural differences between regions in Malawi, and some of these may contribute to the greater likelihood of overestimation in Rumphi.

The results in this section reinforce the hypothesized biases in heuristics used by rural Malawians to assess their likelihood of HIV infection. As seen from the above, men are more likely to overestimate their probability of HIV infection if they report infidelity and perceive a higher prevalence of HIV in the community. Women who are report infidelity or concern about the behavior of their spouse are more likely to overestimate their likelihood of HIV infection. This reinforces other research findings that women do not have accurate knowledge of their husband's possible infidelity, and social networks do not necessarily improve the accuracy of this knowledge for women (Clark, 2005).

Discussion and Conclusion

The results above indicate that, in the absence of VCT, men and women are nonetheless assessing the likelihood that they are infected or not. To do this, they heuristics that are consistent with what we know are the primary ways through which AIDS is transmitted in sub-Saharan Africa: the husband becomes infected from an extramarital partner and then passes the infection on to his wife. Our analyses of the determinants of these heuristics show that these are important for rural men and women in Malawi, and important for understanding the discrepancies between subjective and actual HIV status.

The discrepancies are gendered and systematic: women and men use different heuristics, and they both are more likely to overestimate than to underestimate risk. Men may be correct than an extramarital partner is infected, and women may be correct that their husband is, or soon will be, infected. What they do not assess correctly, however, is the transmission probabilities of HIV. As shown in table 1, more than 95% of both men and women believe AIDS is certain to be transmitted from one act of unprotected intercourse with an infected person. It is likely that this overestimate of transmission probabilities underlies the overestimation of infection.

There are potentially dangerous implications of these inaccurate estimates on the spread of HIV. Just as previous behavior influences the assessed likelihood of contracting HIV, some evidence indicates that these assessments are used to decide future sexual behavior. For example, Kaler (2003) describes sexually active men in rural Malawi, who believe they are already infected with HIV and use this unverified assumption to justify risky sexual activity. In contrast, some adolescents reportedly feel invulnerable to HIV infection and engage in risky activity as a result (Gage, 1998). Particular to HIV/AIDS, economic models of decision-making regarding sexual behavior include a component of self-assessed probability of infection that influences the decision to engage in risky sexual activity (Philippson and Posner, 1993).

Recent research also describes increasing efforts by individuals to lower their likelihood of HIV infection by assessing the probability of infection of potential sexual partners. For example, Smith and Watkins (2005) and Reniers (2005) describe divorce as a method of protection for women who fear HIV infection from their promiscuous husbands. Similarly, partner selection in sexual activity or marriage (Messersmith et al, 2000; Reniers, 2005; Watkins, 2004) also involves an assessment of the potential partner's likelihood of infection. These phenomenons implicitly involve a self-assessed likelihood of infection; if one is infected already, there is no reason for this caution.

This research emphasizes the importance of testing in high HIV prevalence areas of sub-Saharan Africa. If people indeed act based on their perceived likelihood of infection, and these assessments can be inaccurate, rational action regarding the decision to engage in unprotected sex can potentially spread HIV. Access to testing prevents individuals from these discrepancies between actual and subjective HIV status.

Table 1: Background Characteristics of Respondents from MDICP 2001 Survey Also Tested for HIV in 2004		
	Men **N=523**	**Women** **N=899**
	Percentages	
HIV Prevalence	6	9
1. Demographic Characteristics		
Marriage		
Married	----	92
Polygamous Husband or Wife	13	29
Schooling		
None	17	33
Attended Primary School	70	61
Attended Secondary School or More	13	6
Region of Residence		
Balaka	29	36
Rumphi	38	34
Mchinji	33	30
Economic Variables		
Iron Sheet Roof	9	9
Bicycle	62	56
Radio	72	64
2. AIDS Knowledge		
Can get AIDS from someone who looks healthy	95	92
Having and STD increases chance of getting AIDS	89	85
Can get AIDS from sex once with infected person	97	95
3. Own Behaviors		
Unfaithful to current spouse	21	4
Had STI	15	----
Experienced symptom of STI	11	----
Age at first sex:		
Before age 15	6	11

Age 15 or 16	16	17
Age 17 or 18	24	30
Age 19 or older	17	25
Don't know	37	17
Married first sexual partner	35	66
4. Spouse's Behavior		
Believes spouse is unfaithful	5	26
Spouse (respondent if male) stays outside of village	2	8
Most worried about infection from:		
Spouse	24	50
Other partners	37	21
Any other source	39	29
Condom is acceptable with spouse to prevent AIDS	25	29
Best way to protect from AIDS is to advise spouse to take care	33	35
5. Community/Social Characteristics		
Knows:		
No people who have died of AIDS in last 12 months	10	13
Between 1 and 4 died of AIDS in last 12 months	55	58
Five or more died of AIDS in last 12 months	30	26
Doesn't t know number died from AIDS in last 12 months	3	3
Average Number of people chatted with about AIDS (SD)	7.4 (7.3)	5.7 (5.5)
Average number of funerals attended in last 12 months (SD)	1.7 (0.5)	1.7 (0.6)
Hase one network partner very worried about AIDS	55	57
Average level of worry for network partners (SD)	1.8 (0.9)	1.7 (0.8)
(1=not worried at all; 2=Worried a Little; 3=Worried a Lot)		

Table 2: Determinants of Subjective HIV Infection for Men and Women

	Men N=521	Women N=896
	Odds Ratios	
Age	0.96**	1.00
		-
Marriage		
Married	----	0.98
Polygamous Husband or Wife	1.90*	1.54**
Schooling		
None	----	----
Attended Primary School	1.02	1.00
Attended Secondary School or More	0.84	0.68
Region of Residence		
Balaka	1.25	0.74
Rumphi	----	----
Mchinji	0.15**	0.42**
Economic Variables		
Iron Sheet Roof	0.60	0.94
Bicycle	1.46	0.86
Radio	0.78	0.91
AIDS Education		
Can get AIDS from someone who looks healthy	0.52	2.08*
Does having and STD increase chance of getting AIDS	1.40	1.17
Can get AIDS from one time sex with infected person	0.49	0.61
Reported Behaviors		
Unfaithful to current spouse	2.39**	1.66
Have had and STI	1.59	----
Have had symptom of STI	1.12	----
First had sex before age 15	----	----
First had sex at age 15 or 16	0.97	1.20
First had sex at age 17 or 18	0.93	1.12
First had sex at age 19 or older	1.35	1.37
Don't know age at first sex	0.62	1.45
Married first sexual partner	1.19	0.80

Spouse Behavior		
Spouse unfaithful	2.07	1.82**
Spouse (respondent if male) stays outside of village	0.75	1.08
Most worried to contract AIDS from spouse	1.30	2.29**
Most worried to contract AIDS from other partners	----	----
Most worried to contract AIDS from other source	0.95	1.62*
Condom is acceptable with spouse to prevent AIDS	1.25	1.31#
Best way to protect from AIDS is to advise spouse to take care	0.72	0.77#
Community/Social Characteristics		
No people have died of AIDS in last 12 months	----	----
Between 1 and 4 died of AIDS in last 12 months	1.99#	1.11
Five or more died of AIDS in last 12 months	2.40*	1.57
Don't know number died from AIDS in last 12 months	2.98#	1.19
Number of people chatted with about AIDS (SD)	0.97#	1.00
Number of funerals attended in last 12 months (SD)	1.39	1.07
Have one network partner very worried about AIDS	1.49	2.00**
Level of worry for network partner	1.20	1.17
(1=not worried at all; 2=Worried a Little; 3=Worried a Lot)		
#Significant <.10 * significant < .05 ** significant < .01		

Table 3: Percentages HIV Infected by Self Assessment of Current Infection Likelihood and Gender

Gender	Percentage HIV Positive (Number) Self Assessment	
	Low	High
Women	8% (60)	10% (16)
Men	5% (23)	16% (8)

Table 4: Percentages HIV Infected by Self Assessment of Future Infection Likelihood and Gender

Gender	Percentage HIV Positive (Number) Self Assessment	
	Low	High
Women	7% (37)	11% (34)
Men	4% (18)	11% (10)

Table 6: Percentages HIV Infected by Level of HIV Worry and Gender

Gender	Percentages HIV Positive (Number) **Level of Worry**		
	Not Worried	Worried A Little	Worried a Lot
Women	8% (23)	7% (15)	9% (38)
Men	5% (12)	7% (7)	6% (12)

Table 7- Logistic Regression Results for Subjective Current HIV Infection		
	Men N= 521	Women N=896
	Odds Ratio	
High Likelihood of Current HIV Infection	4.43**	1.38
Age	1.00	0.97*
Marital Status	----	0.27**
Polygamous Husband or Wife	1.65	1.26
Bicycle	0.47	0.85
Radio	1.29	1.51
Roof	0.97	1.41
No Schooling	----	----
Attended Primary School	1.50	1.21
Attended Secondary School	1.47	1.36
Balaka	----	----
Rumphi	0.36	0.31**
Mchinji	1.34	0.60
Can contract HIV from someone who looks healthy	----	1.38
Having an STI increases the likelihood of contracting HIV	0.54	0.93
Certain likelihood of contracting HIV from sex once with an infected person	----	1.20

* significant < .05 ** significant < .01

Table 8- Logistic Regression Results for Subjective Current HIV Infection (Class Statement)		
	Men N= 521	Women N=896
	Odds Ratio	
Low Likelihood of Current HIV Infection	1.07	0.91
Medium Likelihood of Current HIV Infection	4.34**	1.21
High Likelihood of Current HIV Infection	4.82**	1.47
Age	1.00	0.97*
Marital Status	----	0.27**
Polygamous Husband or Wife	1.66	1.27
Bicycle	0.47	0.85
Radio	1.30	1.51
Roof	0.98	1.40
No Schooling	----	----
Attended Primary School	1.50	1.21
Attended Secondary School	1.48	1.34
Balaka	----	----
Rumphi	0.36	0.31**
Mchinji	1.36	0.59
Can contract HIV from someone who looks healthy	----	1.41
Having an STI increases the likelihood of contracting HIV	0.54	0.93
Certain likelihood of contracting HIV from sex once with an infected person	----	1.19

* significant < .05 ** significant < .01

Table 9: Subjective Likelihood of Current HIV Infection by Respondents Tested in 2004 and Respondents Dying Between 2001 and 2004 for Men

Subjective Likelihood	Percentage (Number) Tested 2004	Dying 2001-2004
No Likelihood	74 (398)	58 (11)
Low	16 (88)	21 (4)
Medium	6 (30)	10 (2)
High	4 (22)	10 (2)

Pearson chi2(3) = 3.4390 Pr = 0.329

Table 10: Subjective Likelihood of Current HIV Infection by Respondents Tested in 2004 and Respondents Dying Between 2001 and 2004 for Women

Subjective Likelihood	Percentage (Number) Tested 2004	Dying 2001-2004
No Likelihood	61 (561)	37 (9)
Low	21 (193)	16 (4)
Medium	7 (75)	12 (3)
High	10 (91)	33 (8)

Pearson chi2(4) = 17.7294 Pr = 0.001

Table 11: Percentages of Self Assessed Likelihood of Current HIV Infection by Infection Status and Gender

Likelihood of HIV Infection	Percentage (Number) Infection Status: HIV Negative	HIV Positive
Women		
Low Likelihood	82 (677)	78 (60)
High Likelihood	18 (146)	21 (16)
Men		
Low Likelihood	91 (449)	74 (23)
High Likelihood	9 (43)	26 (8)

Table 12: Determinants of Incorrect Prediction of HIV Status Among All Respondents		
	Men **N=521**	**Women** **N=896**
	Odds Ratio	
Age	0.98	0.99
Marriage		
Married	----	0.93
Polygamous Husband or Wife	2.65*	1.35
Schooling		
None		
Attended Primary School	1.13	1.58#
Attended Secondary School or More	0.71	1.23
Region of Residence		
Balaka	1.33	0.80
Rumphi		
Mchinji	0.47#	0.49**
Economic Variables		
Iron Sheet Roof	0.47	1.25
Bicycle	1.11	0.82
AIDS Education		
Can get AIDS from someone who looks healthy	0.37#	2.09#
Does having and STD increase chance of getting AIDS	1.02	0.73
Can get AIDS from one time sex with infected person	1.11	1.15
Reported Behaviors		
Unfaithful to current spouse	2.55*	1.06
Have had and STI	2.53*	----
Have had symptom of STI	0.70	----
First had sex before age 15	----	----
First had sex at age 15 or 16	0.70	1.25
First had sex at age 17 or 18	0.73	1.49
First had sex at age 19 or older	1.82	1.20
Don't know age at first sex	0.83	1.79
Married first sexual partner	1.22	0.66*

Spouse Behavior		
Spouse unfaithful	2.94#	1.78**
Spouse (respondent if male) stays outside of village	0.60	0.85
Most worried to contract AIDS from spouse	1.72	2.14**
Most worried to contract AIDS from other partners	----	----
Most worried to contract AIDS from other source	1.42	1.13
Condom is acceptable with spouse to prevent AIDS	0.58	1.02**
Best way to protect from AIDS is to advise spouse to take care	0.52#	0.87
Community/Social Characteristics		
No people have died of AIDS in last 12 months	----	----
Between 1 and 4 died of AIDS in last 12 months	0.93	0.75
Five or more died of AIDS in last 12 months	1.87	1.09
Don't know number died from AIDS in last 12 months	2.63	1.26
Number of people chatted with about AIDS (SD)	1.03	1.02
Number of funerals attended in last 12 months (SD)	0.95	0.93
Have one network partner very worried about AIDS	4.33**	2.29**
Level of worry for network partner	0.79	1.18
(1=not worried at all; 2=Worried a Little; 3=Worried a Lot)		
#significant <.10 * significant < .05 ** significant < .01		

Table 13: Determinants of Incorrect Prediction of HIV Status Among HIV Uninfected Respondents

	Men N=490	Women N=820
	Odds Ratio	
Age	0.96*	1.00
Marriage		
Married	----	1.82
Polygamous Husband or Wife	4.64**	1.32
Schooling		
None		
Attended Primary School	0.64	1.83#
Attended Secondary School or More	0.50	1.23
Region of Residence		
Balaka	1.34	0.49*
Rumphi	----	----
Mchinji	0.03**	0.31**
Economic Variables		
Iron Sheet Roof	0.41	1.05
Bicycle	1.84	0.83
AIDS Education		
Can get AIDS from someone who looks healthy	0.30#	2.37#
Does having and STD increase chance of getting AIDS	3.23	0.80
Can get AIDS from one time sex with infected person	0.63	0.83
Reported Behaviors		
Unfaithful to current spouse	5.28**	1.42
Have had and STI	1.44	----
Have had symptom of STI	0.56	----
First had sex before age 15	----	----
First had sex at age 15 or 16	6.29	1.08
First had sex at age 17 or 18	4.72	1.33
First had sex at age 19 or older	11.06#	1.50
Don't know age at first sex	4.46	1.70
Married first sexual partner	1.95	0.67

Spouse Behavior		
Spouse unfaithful	14.47**	2.24**
Spouse (respondent if male) stays outside of village	0.30	0.79
Most worried to contract AIDS from spouse	1.83	2.44**
Most worried to contract AIDS from other partners	----	----
Most worried to contract AIDS from other source	1.46	1.16
Condom is acceptable with spouse to prevent AIDS	0.44#	1.03**
Best way to protect from AIDS is to advise spouse to take care	0.45#	0.67#
Community/Social Characteristics		
No people have died of AIDS in last 12 months	----	----
Between 1 and 4 died of AIDS in last 12 months	1.32	0.52#
Five or more died of AIDS in last 12 months	4.09#	0.76
Don't know number died from AIDS in last 12 months	5.12	0.66
Number of people chatted with about AIDS (SD)	0.95	1.01
Number of funerals attended in last 12 months (SD)	1.14	0.90
Have one network partner very worried about AIDS	21.06**	3.59**
Level of worry for network partner	0.69	1.21
(1=not worried at all; 2=Worried a Little; 3=Worried a Lot)		

#significant <.10 * significant < .05 ** significant < .01

Notes

1. We omit the respondents who "don't know" their likelihood of current HIV infection after confirming that the percentage of HIV infected among men and women who do not know their likelihood of infection are approximately the same as the rest of the sample. In addition, we run logistic regressions in table 8, with the "don't know" responses included, and found that this category is not significant, and its inclusion does not change the significance (or dramatically change the coefficients) of other categories of current infection assessment.

2. For this assessment, we chose to use ordered logistic regression instead of binary logistic regression, ordinary least squares regression, or multinomial logit. As mentioned above, we prefer ordered logistic regression to binary logistic regression to retain as much information as possible from the ordering of variables in the variable. We do not use OLS regression because, although the scale between "no likelihood" and "high" likelihood of infection could be assumed to be continuous, the nature of the dependent variable is categorized. Therefore, we find the interpretation of odds ratios in ordered logistic regression to be more suitable. However, we later claim that the distance between all response categories is not the same, which violates the proportional odds assumption of ordered logistic regression. In other words, the difference between "low" and "medium" likelihood of current infection may not be the same as between "no likelihood" and "low." Therefore, multinomial logistic regression should be the best option for this regression. After running a multinomial regression, we find that the values (and level of significance) of odds ratios for independent variables are very close between ordered and multinomial regressions. Because the interpretation of multinomial regression results is unnecessarily complex, for easier interpretation I use ordered logistic regression.

3. Uninfected male respondents who incorrectly estimate a high likelihood of infection are few, which causes to high standard errors for some variables. When

these regressions are run with 2004 survey results, we expect that the sample size for men will be larger and the standard errors smaller.

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