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HIV/AIDS-related Expectations and Risky Sexual Behavior in Malawi

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Keywords

AIDS, Anti-retroviral therapy (ART), Disease, HIV, HIV prevalence, HIV transmission, Life expectancy, Malawi, Risk, Risky behavior, Sexual behavior, Sexually transmitted infections, Subjectivity, Sub-Saharan Africa

Disciplines

Demography, Population, and Ecology | Public Health | Social and Behavioral Sciences | Sociology

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Abstract

Subjective expectations are likely to be an important determinant of health-related behaviors in a high-HIV-prevalence environment. We use probabilistic expectations data elicited from survey respondents in rural Malawi to investigate how risky sexual behavior may be influenced by individuals' survival expectations, which in turn depend on the perceived impact of HIV/AIDS on survival; expectations about their own and their partner's HIV status; and expectations about HIV transmission rates. We find that subjective expectations play an important role in determining the decision to have multiple sexual partners. Using our estimated parameters, we simulate the impact of various policies that would influence expectations. An information campaign on mortality risk would decrease risky sexual behavior, while an information campaign on HIV transmission risks, which tend to be overestimated by respondents, would actually increase risky behavior. Also, the expansion of anti-retroviral therapy (ART) treatments to all individuals sick with AIDS would increase risky sexual behavior among HIV-negative individuals or those who have not been tested because individuals are aware that ART increases life expectancy, and thus reduces the cost of becoming HIV-positive.

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1. Introduction

Considerable funding is being dedicated to the support of HIV/AIDS prevention, intervention and treatment. The United States alone dedicated $6.8 billion to fighting the HIV/AIDS pandemic in 2010 (USAID, 2010a). While there is a growing emphasis on biomedical interventions to prevent HIV infections or improve the health of HIV-positive individuals, interventions targeted at behavioural change remain an essential – and arguably indispensible – part of the HIV/AIDS prevention strategy in relatively poor countries with a weak health system (UNAIDS 2010b). Behavioral changes that reduce HIV infection risks depend critically on the information and knowledge of individuals, and their perceptions (or expectations) about their HIV status, survival risks, and transmission risk associated with behaviors such as having multiple sexual partners or not using condoms. Without direct evidence on health-related expectations, the decision processes affecting individual's health can only be poorly understood, thereby limiting the ability to devise effective behavioral interventions. Yet, very little is known about health-related subjective expectations in high-HIV-prevalence environments and how they influence decision-making related to the spread of the disease. In this paper, we fill this knowledge gap by using very rich data on probabilistic beliefs elicited directly from rural Malawi survey respondents to investigate the role of HIV/AIDS-related expectations on the decision to engage in risky sex.

Individuals in developing countries face substantial uncertainty about their own and other family members' health, the relationships between health inputs and health outcomes, and the risk environment affecting the severity of the disease burden. In the context of the HIV/AIDS epidemic, a wide range of subjective expectations is likely to be relevant to health behavior. Within a life-cycle context, mortality expectations are inherently related to the spread of HIV/AIDS. In particular, since becoming infected with HIV means premature death, the expected lifetime utility that is "lost" by becoming infected with HIV depends on how many additional years HIV-negative persons expect to live relative to HIV-positive persons. Given sub-Saharan Africa's high levels of (non-HIV-related) mortality, Oster (2007) and Philipson and Posner (1993) argue that individuals have little motivation to adopt risk-prevention strategies, as these strategies are "costly" in terms of financial expenses (e.g., purchasing condoms) or foregone pleasures (e.g., lower levels of satisfaction as a result of giving up extra-marital partners), but provide only limited gains in terms of longer life expectancy. In places where HIV testing is limited, beliefs about current HIV status may also be an important behavioural determinant (Boozer and Philipson, 2000, Thornton, 2008, Paula et al., 2010). Finally, the perceived risk of becoming infected with HIV conditional on various sexual behaviors is likely to be crucial.

In this paper, we develop a simple two-period theoretical framework highlighting the role of expectations about survival in the decision to engage in risky sexual behavior in a high-HIV-prevalence context. In our model, the difference in subjective survival probability associated with having risky sex versus having safe sex is crucial for decision-making. This difference in probability depends in turn on the perceived impact of HIV/AIDS on survival, on expectations about own and partner's HIV status, and on expectations about HIV transmission rates associated with various sexual behaviors. We use data on all those expectations and data on sexual behavior to estimate our model. Our central finding is that HIV/AIDS-related subjective expectations play an important role in determining the decision to have multiple sexual partners. This suggests that individuals in rural Malawi are forward-looking and take into account mortality risk when making health-related choice.

Using our estimated preference parameters, we simulate the impact of various policies that would influence individual expectations. We find, surprisingly, that an information campaign on HIV transmission risks would have a perverse effect and *increase* the probability of having multiple partners from 20.2% to 24.6% for men and from 2.1% to 4.0% for women. This is because respondents widely over-estimate the relative impact of having multiple partners on the average probability of becoming infected with HIV compared to having one partner. However, providing information on the mortality risk of someone healthy and of someone infected with AIDS would have a positive impact and decrease the average probability of having multiple partners to 19.3% for men and 2.1% for women. This is because individuals under-estimate the magnitude of the negative impact of HIV/AIDS on survival. Also, the expansion of anti-retroviral therapy treatments (ART) to all individuals sick with AIDS would increase the probability of having multiple sexual partners among HIV-negative individuals or those who have not been tested from 20.3% to 21.5% for men and from 2.3% to 2.7% for women: because individuals are aware that ART increases life expectancy, universal treatment reduces the cost of becoming HIV-positive.

While subjective expectations have been increasingly asked of survey respondents in developed countries in the last 20 years (Manski, 2004), the elicitation of probabilistic expectations in developing countries is recent. Delavande et al. (2011) review the existing evidence and conclude that collecting expectations data in developing countries is both feasible and valuable. In this paper, we use data on probabilistic expectations about a wide range of events that we have collected as part of the 2006 wave of the Malawi Longitudinal Study of Families and Health (MLSFH, formerly the Malawi Diffusion and Ideational Change Project) covering more than 3,000 adult respondents in rural Malawi. In Delavande and Kohler (2009), we find that respondents provide meaningful expectations in probabilistic format according to various criteria: most respondents provide probabilities that are consistent with basic properties of probability theory, the subjective expectations are systematically correlated with observable characteristics (such as gender, age, education, and region of residence) in the same way that actual outcomes vary with these variables, and expectations about future events vary across individuals in the same way as individuals' past experience does. Yet, respondents exhibit a lot of heterogeneity in expectations.

The advantage of using expectations data in empirical work is that it mitigates a basic identification problem that researchers face when using data on choices only: observed choices may be consistent with many combinations of expectations and preferences (Manski, 2004). Although expectation data are becoming available, only a limited number of studies have until now employed them to draw inferences on behavior. Recent studies incorporating expectations into econometric models have addressed various decisions such as contraception choice (Delavande, 2008a), portfolio allocation (Delavande and Rohwedder, 2011, Kezdi and Willis, 2009), fertility (Shapira, 2010), college major (Zafar, 2009), teacher career (van der Klaauw, 2011) committing a crime (Lochner, 2007), migration (McKenzie et al. 2007), strategies in games (Nyarko and Schotter, 2002, Bellemare et al., 2008), and the timing of Social Security claiming and retirement (van der Klaauw and Wolpin, 2008, Hurd et al., 2004). We contribute to this line of work that combines choice data with data on subjective expectations to draw inferences on preferences in the context of the HIV/AIDS epidemic. Paula et al. (2011) is most related to our work: they use data on beliefs about HIV status from the MLSFH to evaluate the impact of beliefs about infection on the likelihood of having extra-marital affairs among men. They find that downward revisions in beliefs of being HIV-positive increase risky behavior. We complement their approach by introducing a rich set of expectations that are relevant for decision-making, which allows us to evaluate how other policies such as information campaigns on relative mortality risk and relative transmission risk or the roll-out of ART affect risky sexual behavior.

Due to potential endogeneity issues, it is challenging in many empirical applications to evaluate how expectations of events over which individuals have some control *causally* affect their decisions: Unobservable characteristics may influence both the formation of expectations and decision-making. Few papers using expectations data have addressed the endogeneity issue directly (see discussion in van der Klaauw, 2011).[1] To deal with the potential endogeneity arising from the dependence of expectations on past behavior, we estimate a recursive system of equations where beliefs about current HIV status depend on past sexual behavior and observable characteristics, the decision to get tested for HIV is explicitly estimated, and the decision to engage in risky sexual behavior depends on individual HIV/AIDS-related expectations. We find that, in our data, there is no endogeneity issue when estimating the impact of HIV/AIDS-related expectations on having multiple sexual partners.

Our findings derived from the policy simulations build on work evaluating the impact of existing programs on sexual behavior in high-HIV-prevalence environments (e.g., Merson and Dayton, 2002). Dupas (2011) finds that providing information on the relative risk of HIV infection by partner's age decreases pregnancy, an objective proxy for unprotected sex, among teenage girls in Kenya. Goldstein et al. (2010) find that enrolment in HIV care (including free ART) increases self-reported sexual activity and condom use among HIV-positive individuals in Western Kenya. Several papers also evaluate the impact of HIV testing on subsequent sexual behaviors (e.g., Thornton, 2008, Delavande and Kohler, forthcoming, Gong, 2010).

The paper proceeds as follows. Section 2 presents the theoretical framework that motivates the empirical analysis. Section 3 describes the data. Section 4 presents the econometric specification and Section 5 the analytical sample. Section 6 analyzes the role of subjective expectations in the decision to engage in risky sex and considers a series of robustness checks such as misreporting of sexual behavior or HIV testing outside the MLSFH surveys. Section 7 presents the policy simulation results.

[1] De Paula et al. (2011) use a panel data estimator which accommodates unobserved heterogeneity as well as belief endogeneity arising from the dependence of current beliefs on lagged behaviors, Lochner (2007) uses fixed-effect instrumental-variable estimates, and Bellemare et al. (2008) model preferences and beliefs jointly.

2. Theoretical framework

Consider a sexually active individual *i* who has two periods left to live (period 1 and period 2). In period 1, she can choose between 2 different actions: $a_i^1 = 0$, having sex with one partner only; $a_i^1 = 1$, having sex with multiple partners. Her period 1 utility depends on the immediate utility from sex $V(a_i^1)$ associated with action a_i^1. Individual *i* can enjoy period 2 utility $\overline{U}$ only if she survives to period 2. The subjective probability of survival to period 2 depends on whether the individual believes that she will be infected at the end of period 1. She may believe that she was already infected with HIV before period 1 or that she can contract HIV during period 1. The subjective probability is therefore a function of the action taken in period 1 (since period 1 action may influence HIV status) and her subjective beliefs f_i^1 of being infected with HIV at the beginning of period 1. In particular, if the individual believes that she is not infected with HIV at the beginning of period 1 (i.e., f_i^1=0), the subjective probability of surviving to period 2 if the individual takes action a_i^1 in period 1 is given by:

$$p_i^{HIV+}(a_i^1)S_i^{HIV+} + \left(1 - p_i^{HIV+}(a_i^1)\right)S_i^{HIV-},$$

where $p_i^{HIV+}(a_i^1)$ is individual *i*'s subjective probability of becoming HIV+ if she engages in action a_i^1, S_i^{HIV+} is *i*'s subjective probability of surviving to period 2 if she contracts HIV in period 1, and S_i^{HIV-} is *i*'s subjective probability of surviving to period 2 if she does not contract HIV in period 1. So overall, the subjective probability of surviving to period 2 for an individual whose subjective probability of being infected with HIV at the beginning of period 1 is f_i^1 is given by:

$$f_i^1 S_i^{HIV+} + (1 - f_i^1)\left(p_i^{HIV+}(a_i^1)S_i^{HIV+} + \left(1 - p_i^{HIV+}(a_i^1)\right)S_i^{HIV-}\right)$$

We further assume that the utility function depends on a random term $\varepsilon_{ia_i^1}$ that is unobservable to the econometrician and captures heterogeneity in tastes. Individual *i* chooses the action a_i^1 that maximizes her lifetime subjective expected utility, i.e., she solves the following problem:

$$\max_{a_i^1 \in \{0,1\}} V(a_i^1) + \left(f_i^1 S_i^{HIV+} + (1 - f_i^1)\left(p_i^{HIV+}(a_i^1)S_i^{HIV+} + \left(1 - p_i^{HIV+}(a_i^1)\right)S_i^{HIV-}\right)\right)\overline{U} + \varepsilon_{ia_i^1}$$

Overall, a riskier sexual behavior may increase the direct pleasure from sex in period 1 but decreases the (subjective) probability of surviving to period 2 and therefore of enjoying period 2 utility.[3]

3. The data: Malawi Longitudinal Study of Families and Health (MLSFH)

The analyses in this paper are based on the 2006 and 2008 waves of the MLSFH.[4] The MLSFH is a panel survey started in 1998 that collects data in three regions of rural Malawi: Balaka, Mchinji and Rumphi. Balaka district is located in the Southern Region of Malawi, primarily inhabited by Yao-speaking individuals and is predominantly Muslim. Mchinji district is located in the Central Region near the border with Zambia. It is primarily inhabited by Chewa-speaking individuals, with almost equal proportions of Catholics and Protestants. Rumphi district in the Northern Region of the country is inhabited primarily by Tumbuka-speaking individuals who are predominantly Protestant (Trinitapoli and Regnerus, 2006).

In 2006, the MLSFH included more than 3,200 male and female respondents aged 17 to 60 who were asked about a wide range of demographic, health, and socio-economic characteristics. In 2008, slightly more than 4,000 respondents were interviewed, with the additional respondents resulting primarily from a new parent sample that extended the age range from 17 to 92 years by also interviewing parents of earlier MLSFH respondents. Comparisons with the Malawi Demographic and Health Survey showed that the 2006 MLSFH sample population is reasonably representative of the rural Malawi population (Anglewicz et al., 2007).

An innovation of the 2006 and 2008 waves was the inclusion of an *interactive elicitation technique for subjective expectations* that was based on asking respondents to allocate up to ten beans on a plate to express the likelihood that an event will be realized (Delavande and Kohler,

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[3] Note that the specification of the utility function does not allow for consideration of altruism. One possibility is to assume that a spouse's survival would provide utility to an individual. If the belief about transmission of HIV within couples is high –which is the case in our data- and the survival beliefs for spouses are similar, then the probability that the spouse survives is similar to the individual's own survival probability. $\overline{U}$ would then capture second-period direct utility and the utility from having the spouse alive.

[4] Detailed descriptions of MLSFH sample selection, data collection, and data quality are provided on the project website at http://www.malawi.pop.upenn.edu, in a Special Collection of the online journal *Demographic Research* that is devoted to the MLSFH (Watkins et al. 2003), and in a recent working paper that incorporates the 2004 and 2006 MLSFH data (Anglewicz et al. 2007).

2009).[5] Interviewers introduced the interactive elicitation technique with a short introduction (see Appendix B). After any clarifying questions, respondents were first asked a training question about the probability of winning in a local board game (Bawo), followed by a series of expectations questions related to economic and health outcomes. They were in particular asked about the probability that they are currently infected with HIV, that their spouse/partner is infected with HIV, and their one-year, 5-year, and 10-year mortality expectations. In addition to these questions about their own mortality, the questionnaire also included several questions about the one-year, 5-year, and 10-year mortality of the following hypothetical individuals: (*i*) a woman/man of the respondent's age who is healthy and does not have HIV; (*ii*) a woman/man of the respondent's age who is sick with AIDS; (*iii*) a woman/man of the respondent's age who is sick with AIDS and is treated with Antiretroviral Therapy (ART). The gender used in the scenarios was the same as that of the respondent. Respondents were also asked the probability that someone of the same gender who was currently healthy would become infected with HIV in the next 12 months if she (a) is married to an HIV-positive spouse, or (b) has several sexual partners in addition to her spouse. Respondents were also asked their perception of the village HIV prevalence (from 0 to 10).

The mortality questions were designed to ensure that respondents provided answers that would allow us to construct well-defined survival curves. In particular, respondents were first asked to pick the number of beans that reflects how likely it is that they will die within a one-year period beginning that day. Then, with the beans of the previous question still on the plate, they were asked to *add* more beans to reflect how likely it is that they would die within a five-year period. The same procedure was followed for the ten-year-period mortality question. This ensured that respondents provided weakly increasing answers when the time horizon increased.

Delavande and Kohler (2009) provide a detailed analysis and evaluation of the probabilistic expectations collected using the above interactive elicitation technique. Key findings from the 2006 data include these: (a) About 99% of the respondents are found to provide beliefs consistent with basic properties of probability theory when asked about nested events; (b) in basically all the considered domains, subjective beliefs vary considerably across individuals; (c) subjective expectations are systematically correlated with observable

[5] In 2008, the expectation module was administered to all respondents who had been interviewed in 2006, and to new respondents below the age of 60.

characteristics – such as gender, age, education, and region of residence – in the same way that actual outcomes vary with these variables (e.g., expectations about infant mortality exhibit regional differences that are similar to actual outcomes, and expectations about economic outcomes vary with socio-economic status in the expected directions); and (d) expectations about future events vary across individuals in the same way as individuals' past experience does.

Another innovative aspect of the MLSFH is the collection of HIV status. As part of a randomized experiment to study the determinants of HIV testing uptake, respondents were offered a free HIV test at the end of the 2004 interview (Thornton, 2008). At the time of testing, respondents were given randomly assigned vouchers redeemable for a sum of money equivalent on average to a day's wage (agricultural labor) upon picking up their HIV test results at local clinics a couple of months after testing. Thornton (2008) finds that learning one's HIV results was highly responsive to the financial incentives.[6] In 2006 and 2008, respondents were re-visited by nurses shortly after completing the interview and were offered a free at-home HIV test with immediate results. There was no financial incentive provided in 2006 and 2008 for learning one's HIV status. In 2006, 93% of the respondents agreed to be tested and 98% of those who were tested learned their HIV status. Overall, 5.2% were HIV+. Fifteen percent of the sample was not found by the team of nurses at the second visit, and were therefore not offered a test.

Finally, the questionnaire asks several questions about sexual behavior. Of particular interest to this paper is the number of sexual partners in the last 12 months, asked in 2008.[7] Figure 1 shows the important aspects of the timeline of the data collection.

4. Econometric specification

Based on section 2, the probability of choosing multiple sexual partners is the probability that action $a_i^1 = 1$ yields higher expected subjective utility than the action $a_i^1 = 0$, i.e.:

[6] In 2004, 91% of the respondents agreed to be tested and among those, 69% went to pick up their test result.

[7] We focus on the number of partners, abstracting from condom use, for several reasons. First, respondents were not asked about condom use in 2008. Second, condoms are relatively infrequently used in Malawi, especially in regular relationships (Chimbiri, 2007) so the number of sexual partners is likely to be the most important margin of behavioural adjustment. Third, women may have limited decision power regarding the use of condom.

$$P(a_i^1 = 1) =$$

$$P\begin{pmatrix} V_i(1) + \left(f_i^1 S_i^{HIV+} + (1-f_i^1)\left(p_i^{HIV+}(1) S_i^{HIV+} + \left(1 - p_i^{HIV+}(1)\right) S_i^{HIV-} \right)\right)\overline{U} + \varepsilon_{i1} \\ \geq V_i(0) + \left(f_i^1 S_i^{HIV+} + (1-f_i^1)\left(p_i^{HIV+}(0) S_i^{HIV+} + \left(1 - p_i^{HIV+}(0)\right) S_i^{HIV-} \right)\right)\overline{U} + \varepsilon_{i0}. \end{pmatrix}$$

$$= P\left(\varepsilon_{i0} - \varepsilon_{i1} \leq V_i(1) - V_i(0) + \Delta P_i \overline{U}\right), \qquad (1)$$

where $\Delta P_i = \left(1 - f_i^1\right)\left(p_i^{HIV+}(1) - p_i^{HIV+}(0)\right)\left(S_i^{HIV+} - S_i^{HIV-}\right)$.

We seek to draw inferences on the structural preference parameter $\overline{U}$ to evaluate whether subjective beliefs are important for decision-making. In particular, we want to evaluate whether individuals are forward-looking and take into account relative survival risk when making decisions. The variable ΔP_i is the *difference* in probability of survival between having multiple partners (action 1) and having one partner (action 0). The estimate of $\overline{U}$ is given by the coefficient associated with ΔP_i.

We use beliefs elicited *in 2006* to explain sexual behavior that occurs *between 2006 and 2008* (see Figure 1). The timing is important because sexual behavior may lead individuals to revise their beliefs (e.g., about current HIV status) subsequently. Therefore, it is critical to use beliefs elicited *prior* to the decision to engage in risky behavior. Yet, there may still be some issues in the estimation of equation (1) due to potential endogeneity of beliefs arising from the dependence of *current* beliefs on *past* behaviors. Unobserved heterogeneity capturing time-invariant preferences for the number of partners or the search cost of having multiple partners may be correlated with the beliefs f_i^1, if for example, beliefs at the beginning of period 1 depend on the prior number of partners, or if this unobserved heterogeneity also influences the decision to get tested for HIV.

To deal with this issue, we estimate a three-equation recursive model. The first equation models the probability f_i^0 of being infected with HIV prior to the 2006 HIV test. It is a reduced-form equation which depends on observable exogenous characteristics and lagged sexual behavior. The second equation models the decision to get tested for HIV in 2006. The propensity to get tested depends on demographic characteristics X_3, on the probability f_i^0 of being infected with HIV prior to the 2006 HIV test, and on sexual behavior prior to the HIV test. The third equation models the propensity to have multiple partners. As defined in equation (1), it will depend on demographic characteristics and lagged sexual behavior (under the assumption that $V_i(1)-V_i(0)=\beta_1 X_1$), on the difference in survival expectations ΔP_i , which in turn depends on the potentially endogenous post-test beliefs f_i^1 (which are equal to the pre-test beliefs f_i^0 if a respondent did not get tested for HIV in 2006 or to the actual 2006 HIV status if the respondent got tested for HIV in 2006) and the exogenous beliefs $\left(p_i^{HIV+}(1)-p_i^{HIV+}(0)\right)\left(S_i^{HIV+}-S_i^{HIV-}\right)$. The system of equations (2) is recursive and given by:

$$\begin{aligned} f_i^0 &= \beta_3 X_3 + u_3 \\ test_i^* &= \beta_2 X_2 + \theta f_i^0 + u_2 \\ a_i^* &= \beta_1 X_1 + \omega\left(\left(1-f_i^1\right)\left(p_i^{HIV+}(1)-p_i^{HIV+}(0)\right)\left(S_i^{HIV+}-S_i^{HIV-}\right)\right)+u_1 \end{aligned} \qquad (2)$$

Where $D\begin{pmatrix} u_1 \\ u_2 \\ u_3 \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & r_{12} & r_{31} \\ r_{12} & 1 & r_{23} \\ r_{31} & r_{23} & r_{33} \end{pmatrix}\right)$

$$test_i = \begin{cases} 1 & if \quad test_i^* > 0 \\ 0 & if \quad test_i^* \le 0 \end{cases}$$

$$a_i^1 = \begin{cases} 1 & if \quad a_i^* > 0 \\ 0 & otherwise \end{cases}$$

Identification requires at least one variable in X_3 not included in X_2 (Maddala, 1983). Note that the system is logically consistent (Maddala 1983, Wilde 2001). We will estimate the system of equations (2) by maximum likelihood.[8]

5. Analytic sample and definition of the variables

5.1. Analytic sample

[8] We use the cmp Stata command developed by Roodman (2009).

We restrict our analysis to respondents sexually active in the 12 months prior to the survey.[9] We also exclude 202 men who are in a polygamous marriage and have therefore multiple sexual partners within marriage. Note that different samples are used to estimate the various equations of the system (2). Since X_2 and X_3 include lagged sexual behavior, the sample for estimating the first two equations is restricted to respondents who were sexually active in 2006 (independently of whether they were interviewed in 2008). Eighty-eight percent of the 3,240 2006 MLSFH respondents report having at least one sexual partner in the preceding 12 months. For the third equation of system (2), we focus on respondents who were sexually active in both 2006 and 2008. Table 1 presents basic characteristics of the respondents who were sexually active in 2006, excluding men in a polygamous marriage.

Our empirical strategy relies on estimating whether sexual behavior in the last 12 months reported in 2008 is influenced by elicited beliefs reported in 2006. However, 23% of the 2006 respondents could not be resurveyed in 2008, so their behavior cannot be used to infer $\overline{U}$. Note that those respondents are however used in the regressions determining beliefs formation and testing decisions since those rely exclusively on variables elicited in 2006. We investigate whether the probability of attrition between 2006 and 2008 is associated with 2006 beliefs and 2006 sexual behavior (Table A1) and find that the difference in probability of survival ΔP_i and past sexual behavior are not correlated with the probability of attrition.

5.2. Definition of variables

We describe the dependent variables in the system of equations (2). Table 2 presents their descriptive statistics.

- *2006 pre-test probability of being currently infected with HIV*. The variable f_i^0 is the respondent's answer about the likelihood of being currently infected with HIV, elicited in 2006 (and re-scaled from zero to 1 by dividing the number of beans by 10). The average belief is 0.11. However, the distribution is skewed: 66 percent of the respondents report a probability of zero of being currently infected with HIV.
- *HIV testing*. We define the variable $test_i = 1$ if the respondent learned his HIV status at the

[9] We focus on respondents who ever had sex because the initiation of sexual activity may be different from the decisions we study.

end of the 2006 interview, and 0 otherwise. Respondents who did not learn their status include respondents who did not get tested because the nurses did not find them or because they refused to be tested, and respondents who got tested but did not want to learn their status. Overall, 78 percent of our analytical sample learned their HIV status in 2006.

- *Having multiple partners in 2008.* The variable a_i^1 is equal to 1 if the respondent reports in 2008 having had more than 1 sexual partner in the last 12 months, and zero if the respondent reports having had only one sexual partner in the last 12 months. Table 2 shows that among respondents who were sexually active in both 2008 and 2006, 10 percent had more than one sexual partner. Note however that there is a large difference by gender: this percentage is 21 percent among males compared to 2 percent among females.

We now describe how we compute the individual-specific difference in survival probability associated with having multiple partners and having one partner $\Delta P_i = \left(1 - f_i^1\right)\left(p_i^{HIV+}(1) - p_i^{HIV+}(0)\right)\left(S_i^{HIV+} - S_i^{HIV-}\right)$. Table 3 presents the descriptive statistics of the various relevant expectations for respondents who were sexually active in 2006 and 2008.

- *2006 post-test probability of being currently infected with HIV,* f_i^1. We define the variable f_i^1 as follows:

$$f_i^1 = \begin{cases} 0 & \text{if the respondent learned that s/he was HIV-negative in 2006 HIV test} \\ 1 & \text{if the respondent learned that s/he was HIV-positive in 2006 HIV test} \\ f_i^0 & \text{if the respondent did not learn his/her HIV status in 2006} \end{cases}$$

The underlying assumption is that individuals revised their belief upon learning their HIV status. Table 3 shows that the average belief is equal to 0.05 and is thus lower than the pre-test belief, due to the fact that a large number of respondents who were tested found out that they were HIV-negative.

- *Survival expectations,* S_i^{HIV+} *and* S_i^{HIV-}. We use the 2006 elicited 10-year mortality rate conditional on being infected with AIDS to determine S_i^{HIV+} and the 2006 elicited 10-year mortality rate conditional on being currently healthy to determine S_i^{HIV-}.[10,11] Table 3 shows that on average respondents think that there is a 41 percent chance of being alive in 10 years conditional on being healthy, compared to only a 1 percent chance of being alive in 10 years conditional on being infected with AIDS. This shows that individuals are aware that being infected with HIV/AIDS reduce life expectancy in the long run. Table A2 in the appendix show the average survival beliefs by age group for someone healthy, infected with AIDS, and infected with AIDS but treated with anti-retroviral therapy (ART). It shows a gradient of survival expectations by age: younger people expect to live longer. It also shows that for all age groups, individuals are aware that being infected with AIDS will shorten life expectancy substantially, and that being on ART will mitigate this.

- *Subjective probability of infection associated with having multiple partners,* $p_i^{HIV+}(1)$. We use the 2006 elicited expectations about the likelihood that a hypothetical individual of the respondent's gender would become infected with HIV in the next 12 months if s/he was having several sexual partners in addition to a spouse. Respondents believe on average that there is an 81 percent chance of becoming infected with HIV conditional on having multiple partners (Table 3).
- *Subjective probability of infection associated with having one partner,* $p_i^{HIV+}(0)$. This probability is again individual-specific and depends on respondents' belief about the status of their main partner. It is defined as $p_i^{HIV+}(0) = \Pi_i^{HIV+} \times f_{pi}^{\,1}$, where Π_i^{HIV+} is person *i*'s perceived likelihood of becoming infected with HIV during the next 12 months for someone who is married to an HIV+ individual and $f_{pi}^{\,1}$ is *i*'s subjective beliefs about her partner's HIV status after the 2006 HIV test and before engaging in action a_i^1. Note that a respondent may not know the test result of her spouse if the latter did not share the results. We assume that a respondent learned the status of her spouse after the 2006 HIV test if, in 2008, she

[10] We use the survival probability conditional on being infected with AIDS because people tend to think that the duration from infection to AIDS symptoms is much shorter than it is (Santow et al. 2008).

[11] With respect to the model, the definition of the survival probability variables implies that our empirical analysis focuses on the following trade-off: direct utility from sex now versus higher chance of survival in 10 years. Ideally, one would analyze a model with more than two periods, but we do not have the data to estimate it. We thus focus on a time-frame in which there are large differences in survival by HIV status.

reports that the last time her spouse got tested, he shared his test results with her, and if the last time occurred during the 2006 MLSFH data collection period. So we define f_{pi}^{1} as follows:

$$f_{pi}^{1} = \begin{cases} 0 & \text{if the spouse learned that s/he was HIV-negative in the 2006 HIV test and the respondent reports that the spouse shared test results} \\ 1 & \text{if the spouse learned that s/he was HIV-positive in the 2006 HIV test and the respondent reports that the spouse shared test results} \\ \text{2006 elicited beliefs about current infection status} & \text{if the spouse did not learn his/her HIV status in 2006 or the respondent reports that the spouse did not share} \\ \text{Village prevalence} & \text{if the respondent did not report having a main partner in 2006} \end{cases}$$

Respondents believe on average that there is a 93 percent chance of becoming infected with HIV within 12 months if one is married to an HIV-positive spouse, while the average partner's infection probability is 8 percent. Overall, the average subjective probability of becoming infected with HIV within 12 months, conditional on having sex with one partner, is 8 percent, which is about one-tenth the perceived chance of becoming infected conditional on having multiple partners. So, overall, respondents believe that having multiple partners puts them at a substantially greater risk of becoming infected with HIV.

Note that our analysis used beliefs regarding the transmission of HIV $p_i^{HIV+}(1)$ and Π_i^{HIV+} that were elicited in 2006 *before* respondents had the opportunity to get tested and learned their HIV status. Potentially, upon learning their status, respondents could have updated not only their beliefs about their own HIV status but also their beliefs about the transmission of HIV associated with various behaviors. This would be problematic only for respondents who are HIV-negative (as those transmission risk expectations would not enter the decision problem of individuals who found out that they are HIV-positive). In Delavande and Kohler (forthcoming), we investigate the causal impact of learning HIV status in 2004 on elicited 2006 HIV/AIDS-related expectations using an instrumental-variable approach. We find that, among HIV-negative individuals, learning one's status had no impact on expectations about transmission risk. This suggests that 2006 beliefs about transmission risk are unlikely to have been revised after the 2006 HIV test by respondents who found out that they were HIV-negative.

Finally, we include in all equations basic demographic characteristics (e.g., marital status, education, region) and an indicator for whether the respondents report having multiple sexual partners in the 2006 interview (8% of the respondents did, see Table 1), as those are thought to influence sexual behavior, the testing decision, and pre-test beliefs about HIV status. We also include indicators for religion, as religion may influence risky behavior and risk perceptions (e.g., Trinitapoli and Regnerus, 2006).

As pointed out in Section 4, identification requires at least one variable included in X_3 but not in X_2. For that variable, we used the financial incentives (equal on average to 102 Kwacha, which corresponds approximately to a day's agricultural labor wage) that were provided for learning one's HIV status in 2004. The idea is that individuals provided with a larger financial incentive were more likely to learn their HIV status in 2004 (Thornton, 2008), which would influence their 2006 beliefs about whether they are infected with HIV. However, those incentives provided in 2004 should not influence the decision to get tested in 2006. Note however that 28 percent of the respondents did not participate in the 2004 HIV test (Table 1). Among those who were offered the test, only 9 percent refused to get tested. The other 19 percent were not eligible, not found at the time of the 2004 HIV test or not interviewed in 2004. We also include the 2006 elicited expectations about the likelihood that a hypothetical individual of the respondent's gender would become infected with HIV in the next 12 months if s/he was having several sexual partners in addition to the spouse $p_i^{HIV+}(1)$ and the likelihood of becoming infected with HIV during the next 12 months for someone who is married to an HIV+ individual Π_i^{HIV+} as variables that influence the respondent's belief about whether s/he is currently infected with HIV but do not influence the testing decision.

In the HIV testing equation, we include an indicator for whether the respondents know someone on anti-retroviral therapy (ART), as this may increase the motivation to get tested. Finally, when estimating the propensity to have multiple partners, we include an indicator for whether the respondent was rated as more or much more attractive than average by the interviewer, as it may be easier for more attractive individuals to find additional sex partners. Thirty-three percent of the respondents fit in that category.

6. Empirical Results

6.1. Estimation of the system of equations (2)

Because men are much more likely to have multiple sexual partners, we conduct separate regressions by genders. Tables 4 and 5 present the maximum-likelihood estimation results of equation (2) for women and men respectively. In the first column of Tables 4 and 5, where the indicator for having multiple partners is used as a dependent variable, we find that the coefficient associated with the difference in survival probability ΔP_i, which estimates the parameter $\overline{U}$ in the utility function, is positive and statistically significant at 5% for both women and men. The marginal effect on the predicted probability is large and equal to 0.038 for women and 0.150 for men when all the variables are evaluated at the mean. This provides evidence that individuals are forward-looking and take into consideration subjective expectations about relative mortality risk, HIV status, and transmission rates when making decisions related to sexual behavior.

Focusing on women, we can note that only being married and the difference in survival probability ΔP_i have predictive power to explain having multiple partners. For both men and women, married respondents are less likely to have multiple partners. For men, the coefficient associated with lagged sexual behavior is the largest in absolute value and statistically significant at 1%. This shows that men who had multiple partners in the past keep having multiple partners, either because past behavior reflects heterogeneity in preferences or a smaller cost for searching for new partners. Attractive men are also more likely to have had multiple sexual partners in the last 12 months, while Christians other than Catholics and those belonging to indigenous churches are less likely to have had multiple partners than Catholics.

The second column of Tables 4 and 5 presents the estimates for second equation of the system (2), which looks at the HIV testing decision. There are interesting differences between men and women. Men who believe they have a smaller probability of being infected with HIV and those who have had multiple sexual partners in the past are less likely to be tested, while the reverse is true for women.

Finally, the third column of Tables 4 and 5 present the estimates for the first equation of system (2), which looks at pre-HIV-test beliefs about infection status. For both men and women, having multiple partners is associated with a higher perceived probability of being currently infected with HIV. Women aged 30-39 believe that there is a higher chance that they are infected compared to younger women, while men who are more than 50 years old report a lower probability of being infected than men who are less than 29.

The bottom panel of Tables 4 and 5 shows estimates of the variances and covariances of the random terms. For both men and women, we find that r_{23} is statistically significantly different from zero at 5%, suggesting that there is a correlation between the random terms of the infection expectation equation and the testing equation. This estimate of the covariance is positive for men and negative for women. However, the covariance between the random term u_1 of the equation estimating the propensity to have multiple sex partners and the other equations is not statistically significantly different from zero, suggesting that, in this context, there is no endogeneity issue when estimating the impact of survival expectations on having multiple sexual partners.

6.2. Potential endogeneity of the HIV transmission expectations

Our estimation strategy deals with endogeneity of beliefs about infection status arising from the dependence of current beliefs on past behaviors (lagged sexual behavior or HIV testing). Another concern might be that unobservable traits also influence HIV transmission expectations as well as the decision to engage in risky sex. For example, the HIV transmission expectations may depend on other behaviors, such as condom use or frequency of intercourse, which may be related to unobservable characteristics that also influence the decision of having multiple partners. This concern is mitigated by the fact that those expectations are asked about *hypothetical* individuals (see Appendix B). Yet, as a robustness check, we augment the system of equations estimated above by two equations predicting the transmission rates that are relevant for the decision-making process. We assume that the probabilities of contracting HIV conditional on having multiple partners and conditional on being married to an HIV+ spouse depends on exogenous characteristics X_4. The system of 5 equations we estimate is:

$$\begin{aligned}
&\Pi_i^{HIV+} = \beta_5 X_4 + u_5 \\
&p_i^{HIV+}(1) = \beta_4 X_4 + u_4 \\
&f_i^0 = \beta_3 X_3 + \lambda p_i^{HIV+}(1) + \delta \Pi_i^{HIV+} + u_3 \\
&test_i^* = \beta_2 X_2 + \theta f_i^0 + u_2 \\
&a_i* = \beta_1 X_1 + \omega\left(\left(1 - f_i^1\right)\left(p_i^{HIV+}(1) - p_i^{HIV+}(0)\right)\left(S_i^{HIV+} - S_i^{HIV-}\right)\right) + u_1
\end{aligned} \qquad (3)$$

where $D\begin{pmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \\ 0 \\ 0 \\ \end{pmatrix}, \begin{pmatrix} 1 & r_{12} & r_{13} & r_{14} & r_{15} \\ r_{12} & 1 & r_{23} & r_{24} & r_{25} \\ r_{13} & r_{23} & r_{33} & r_{34} & r_{35} \\ r_{14} & r_{24} & r_{34} & r_{44} & r_{45} \\ r_{15} & r_{25} & r_{35} & r_{45} & r_{55} \end{pmatrix}\right)$,

and the dependent variables are defined as previously. Identification requires X_4 to include variables not included in X_3, and X_3 to include variables not included in X_2. We still use the financial incentives that were provided for learning one's HIV status in 2004 and the HIV transmission expectations Π_i^{HIV+} and $p_i^{HIV+}(1)$ as variables included in X_3 but not in X_2. We use knowledge questions about non-sexual HIV transmission (whether the respondent knows that a pregnant woman can transmit the AIDS virus to her unborn child and that a woman can transmit the AIDS virus through breast milk) and the number of known people the respondent suspects to be sick with AIDS as variables that influence the transmission expectations without directly influencing the beliefs about current HIV status as variable included in X_4 but not in X_3. The motivation for using knowledge for non-sexual transmission as excluded variable is that those are likely correlated with overall knowledge of HIV transmission, including sexual mode of transmission. However, since those beliefs are about mother-to-child transmission, they should not directly influence beliefs about current HIV status once we control for beliefs due to sexual transmission.

The first two columns of Tables 6 show the estimation results for women and men respectively for the equation using the indicator for having multiple partners as dependent variables. Tables A3 and A4 in Appendix A show the complete estimation results for all the equations. As before, the coefficient associated with the difference in survival probability ΔP_i, which estimates the utility parameter $\overline{U}$, is positive and statistically significant at 5% for both women and men. It is actually larger in absolute value than in the results based on the system of equations (2). The marginal effect on the predicted probability is large and equal to 0.045 for women and 0.160 for men when all the variables are evaluated at the mean.

The coefficients associated with the other independent variables in the equations for having multiple partners, testing and pre-test beliefs are similar to those in the system of equations (2). One difference is that with this new specification, we find that the HIV transmission expectations are predictors of beliefs about current HIV status for women. Female respondents who report a higher probability of becoming infected if one has several sexual partners also report a higher probability of being currently infected with HIV. Those however who report a higher probability of becoming infected if married to an HIV+ spouse report a lower probability of being infected.

For both men and women, we find as earlier that the estimates of the covariance r_{23} is statistically significantly different from zero at 5%. For women, we also find that r_{35} and r_{45}, which estimate the covariances of the random terms in the subjective probabilities, are statistically significantly different from zero at 5%. For men, only the covariance of the random terms of the two HIV transmission expectation equations is statistically significantly different from zero. As before, the covariance between the random term u_1 of the equation estimating the propensity to have multiple sex partners and those of the other equations is not statistically significantly different from zero, suggesting that again there is no endogeneity issue when estimating the impact of survival expectations on having multiple sexual partners.

6.3. Robustness check: HIV testing between 2006 and 2008

So far, we have assumed that the only way to get tested was through the MLSFH survey. However, HIV testing is becoming more common in Malawi, and some respondents reported that they had been tested between the 2006 and the 2008 waves. Among respondents who were sexually active in 2006, 12.3% of those who did not learn their HIV status as part of the 2006 MLSFH HIV testing report in 2008 that they have been tested for HIV between the 2006 interview and December 2007. In addition, 13.9% of those who had learned their HIV status in 2006 also report having been tested between the 2006 interview and December 2007. We therefore may have measurement error in beliefs about current infection for those who got tested outside of the MLSFH. To deal with this, we assume that the HIV status that they learned in between the 2006 MLSFH testing and December 2007 is the same as the results of the 2008 MLSFH HIV test.[12]

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[12] This is accurate for those who tested negative in 2008, but may potentially be a strong assumption for those who tested positive in 2008, as some may have sero-converted after their latest test. Among those who did learn their HIV status in 2006 and report being tested after the 2006 interview, 15.9% tested positive in 2008 and 11.1% refused to get tested. For the latter group (7 observations), we use the 2006 elicited beliefs about current infected

We re-estimate the system of equation (3) based on those assumptions. The 3rd and 4th columns of Table 6 presents the results of the equation with having multiple sexual partners as the dependent variable and shows that the results are very similar to those of Columns 1 and 2.

6.4. Subjective expectations vs. historical frequencies

We find that subjective expectations are predictive of sexual behavior. However, one may wonder if we would get similar results by using "objective" probabilities, i.e. historical frequencies about transmission rates and life tables. To investigate the value-added of collecting expectations data, we assume that the probabilities of survival conditional on being healthy are as given in the UN life tables for Malawi without AIDS (United Nations, 2008). We take the probabilities of survival conditional on being infected as equal to those in Todd et al. (2007), who measured survival since sero-conversion based on 4 East African population cohort studies before the availability of ART (two studies in Uganda, one in Tanzania, and one in Rwanda). We also assume that the probability of becoming infected with HIV within one year if married to an HIV+ spouse is 5.17% for men and 10.55% for women based on Ugandan data from Carpenter et al. (1999). Finally, we assume that the probability of becoming infected within one year conditional on having multiple partners is 0.67%, which is half the two-year sero-conversion rate between 2006 and 2008 in the MLSFH among those who report having had multiple partners in 2008.[13] Finally, we set the village prevalence equal to the MLSFH regional prevalence (which is relevant for respondents who did not report beliefs about a main partner's HIV status). We still use the pre and post beliefs about HIV status as defined above. We estimate the system of equations (3). The last two columns of Table 6 show the results of the equations using the indicator for having multiple partners as dependent variables. We see that the coefficient

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status as the beliefs used for decision-making. Among those who got tested as part of the 2006 MLSFH and got re-tested before December 2007, 1% changed sero-status and tested positive in the 2008 MLSFH.

[13] Five percent of the respondents who tested HIV-negative in 2006 and who report having multiple partners in 2008 refused to get tested in 2008. We assume that HIV incidence was the same among those who refused to get tested and those who agreed to get tested. If all those who refused to get tested actually sero-converted, yearly incidence would be at 3.1%. Using 3.1% as "objective probability" does not change the qualitative results of Table 6: the coefficient associated with ΔP_i is negative and imprecisely estimated for both men and women. Note that yearly incidence among those who report in 2008 having only one sexual partner in the last 12 months and who agreed to be tested for HIV is 0.4%.

associated with the "objective" probabilities is negative for women and men and very imprecisely estimated. This suggests that eliciting subjective expectations from survey respondents to understand choice behavior is useful in this context.

6.5. Misreporting of sexual behavior

Table 2 shows a large difference in reported sexual behavior by gender. This difference by gender is typical of many surveys done in sub-Saharan Africa. Dinkelman and Lam (2009) for example indicate that in 9 recent African Demographic and Health Surveys, men report between 10% and 80% more sexual partners than women. They point out that the in a closed population without misreporting and with everyone sampled, the average number of partners of men and women should balance. In our analytical sample, the average number of partners is 1.37 and 1.02 for men and women respectively. However, Dinkelman and Lam (2009) also highlight that a disequilibrium of partner reports may occur without misreporting when there is undersampling of sex workers. Yet, because sexual behavior is a sensitive topic, misreporting is a legitimate concern. To evaluate the robustness of our results to misreporting, we follow Hausman et al. (1998), who correct for misclassification and estimate its prevalence. We assume that individuals report truthfully when they do not have multiple partners and misreport about having multiple partners. This probability of misreporting is assumed to depend on the true sexual behavior value $\tilde{a}_i^1$, but is otherwise independent of other observable characteristics. In particular, it is given by:

$$\alpha_1 = P\left(a_i^1 = 0 \mid \tilde{a}_i^1 = 1\right).$$

With this misreporting probability, we have:

$$E\left(a_i^1 \mid X_1, \Delta P\right)^* = \left(1-\alpha_1\right)\Phi\left(\beta_1 X + \alpha \Delta P\right).$$

We estimate a simple probit regression allowing for misreporting of sexual behavior. We find that males do misreport extensively their sexual behavior (α_1 =0.344, standard error=0.111). we also find that, even with misreporting, the coefficient associated with the difference in survival probability ΔP_i is equal to 0.879 (therefore of similar magnitude as the one of Tables 5 or 6) and is statistically significant at 5% (standard error=0.429). For females, while the parameter α_1 is identified in theory, we were unable to recover it in practice. We therefore re-estimate a simple probit equation for various values of α_1. The results are presented in Appendix Table A5. It shows that the coefficient associated with the difference in survival probability ΔP_i are similar for various values of female misreporting.

7. Simulation of hypothetical policies

We now investigate how sexual behavior would change in response to various policy experiments. The first two policies we consider are information campaigns. For those, we explore two alternative outcomes. First, we assume that the information campaign is fully successful at educating people who fully revise their beliefs by aligning them to the information provided (fully updated beliefs scenario). Second, we assume that individuals take into account both their prior beliefs and the information provided by the campaign to revise their beliefs, and that the resulting beliefs are a simple weighted average of the two (partially updated beliefs scenario).[15] We consider the three following policies:

(i) *Information campaign on mortality risk*: We assume that individuals would be provided the life table estimates of males and females uninfected with HIV and of males and females sick with AIDS. For example, for the fully updated belief scenario, we set the subjective probability of survival of a healthy individual equal to the appropriate probability from the UN life table estimates for Malawi without AIDS (United Nations, 2008), and we set the survival probability of an individual infected with AIDS to the Todd et al. (2007) probabilities (note that these may under-estimate the actual mortality risk since Todd et al. (2007) look at individual survival since sero-conversion). See Table A1 in Appendix A for those mortality rates.

(ii) *Information campaign on transmission risk*: We assume that individuals would be provided accurate information about transmission risk. For example, for the fully updated beliefs scenario, we set the probability of becoming infected with HIV within one year if married to someone who is HIV-positive to 5.17% for men and 10.55% for women (Carpenter et al. 1999), and we set the probability of becoming infected within one year if one has multiple partners to 0.67% (see discussion in Section 6.4), and the village prevalence to the MLSFH regional prevalence.

[15] It is unclear how individuals would process this information. Delavande (2008b) shows that educated women in the U.S. exhibit considerable heterogeneity in their revision of beliefs when provided with statistical information. For simplification, we just therefore consider the weighted average.

(iii) *Extension of ART to all people sick with AIDS*: We replace the survival probability of an individual infected with AIDS with the individual-specific subjective survival probability for an individual infected with AIDS who is on ART. We focus on the effect of such a campaign on individuals who know they are HIV-negative or who have not been tested for HIV. Lakdawalla et al. (2006) find that the introduction of ART increases the sexual activity of HIV-positive people in the U.S. Goldstein et al. (2010) find that enrollment in AIDS treatment programs increases the frequency of sex but also condom use.

Table 7 shows the mean and the 25th, 50th and 75th percentiles of the predicted probabilities of having multiple partners using the coefficients of the first two columns of Tables 6 under these three policy scenario. An information campaign on mortality that would lead to full revision of beliefs would be beneficial and decrease the average predicted probability of having multiple partners from 20.2% to 19.3% for men and from 2.5% to 2.1% for women. Respondents are very pessimistic regarding their survival conditional on being healthy and conditional on being sick with AIDS, compared with available statistics (see Table A1). However, what matters for risk-taking behavior is the difference in perceived survival probabilities with and without HIV infection $\left(S_i^{HIV+} - S_i^{HIV-}\right)$. Despite being pessimistic regarding their survival rates, respondents on average underestimate the impact of AIDS on survival. The average $\left(S_i^{HIV+} - S_i^{HIV-}\right)$ based on subjective beliefs is -0.40 in the sample, compared to an average of -0.46 based on available statistics. This is why providing information on mortality risk reduces risky sexual behavior. The effect would still be beneficial, though smaller, if individuals only partially update their beliefs in light of the new information. Under the assumption that the revised beliefs would be the weighted average of the prior beliefs and the provided information, the average predicted probability of having multiple partners would decrease to 19.8% for men and to 2.2% for women.

Table 7 shows that an information campaign on transmission risk would actually have an undesirable effect: the average predicted probability of having multiple partners actually increase to 24.6% for men and 4.0% for women under this policy and the fully updated beliefs scenario. This is because respondents over-estimate the relative impact that having multiple partners has on the probability of becoming infected with HIV. Table 3 shows that respondents are overall very pessimistic regarding HIV transmission risks. While the yearly incidence in sero-discordant couples is estimated to be 5.17% for men and 10.55% for women (Carpenter et al., 1999), the average subjective probability of becoming infected with HIV conditional on being married to an HIV+ spouse is 93.9% for men and 92.6% for women. Similarly, while the probability of becoming infected within one year if one has multiple partners is 0.67% in the MLSFH, the average subjective probability is 81%. What matters for decision-making is the relative subjective risk of becoming infected under these conditions $\left(p_i^{HIV+}(1) - \Pi_i^{HIV+} \times f_{pi}^{\,1} \right)$. This average subjective difference in risk is 0.709 for men and 0.680 for women. If we use the statistics from existing studies (but still use the beliefs about the partner's HIV status $f_{pi}^{\,1}$), the difference in risk is much smaller: 0.004 for men and 0.100 for women. This explains why providing information on transmission risk actually increases risky behavior. Under the partially update beliefs scenario, risky behavior would also increase, though less than under the fully updated beliefs scenario.

Finally, the extension of ART to all infected people decreases the "cost" of becoming infected with HIV by increasing survival probability, and as a result, increases risky behavior. Excluding individuals who know they are HIV-positive, the average predicted probability of having multiple partners increases from 20.3% to 21.5% for men and from 2.3% to 2.7% for women.

Conclusion

About 6.1% of the adults living in Sub-Saharan Africa are estimated to be infected with HIV, with HIV prevalence reaching 30% in some countries (UNAIDS, 2006, 2008). Because the epidemic has become generalized, heterosexual intercourse among low-risk individuals is the most common pathway of infection for rural populations (Gouws et al. 2005). Behavioral change with respect to sexual relationships is therefore crucial for all efforts targeted at curtailing the disease (Aggleton et al. 1994; Cerwonka, Isbell, and Hansen 2000). Subjective expectations about HIV/AIDS-related events are likely to be important determinants of behavior. In this paper, we use probabilistic expectations data elicited from survey respondents in rural Malawi to investigate how individuals' expectations about survival, about HIV status, and about HIV transmission rates affect risky sexual behavior. We find that subjective expectations play an important role in determining the decision to have multiple sexual partners.

Using our estimated preference parameters, we simulate the impact of various policies that would influence expectations. Our results suggest that information campaigns focusing on providing information on the transmission of the disease are likely to have limited impact on behavior. Actually, providing information on transmission risk may have a perverse effect and increases the likelihood that people engage in risky sex. Rather, we suggest a new type of information campaign that would decrease the prevalence of risky behavior: information on the survival rate of healthy and infected individuals, or on relative survival rate.

We also find that the expansion of ART to all individuals sick with AIDS would increase risky sexual behavior among HIV-negative individuals or those who have not been tested because individuals are aware that ART increases life expectancy, and thus reduces the cost of becoming HIV-positive. This suggests that expansion of ART should not be done in isolation, but rather combined with behavioral interventions to mitigate the effects of the roll-out of ART on HIV-negative individuals.

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Figure 1: Timeline of data collection

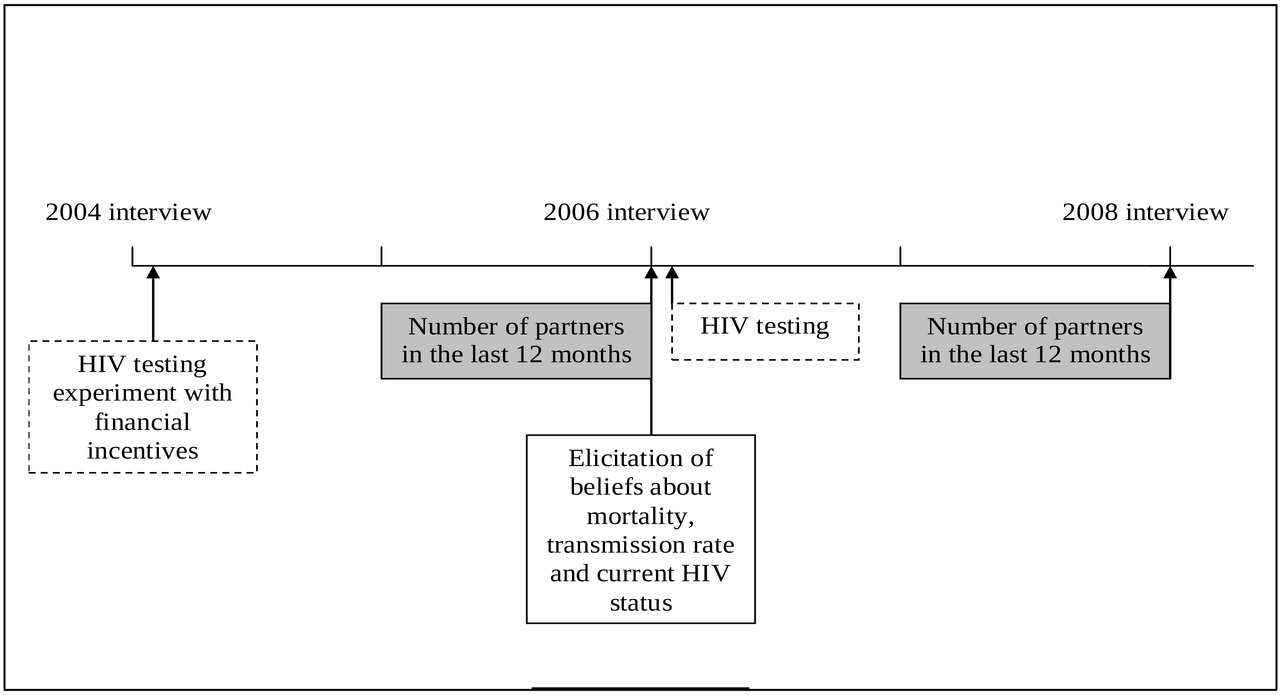

Table 1: Characteristics of respondents who are sexually active in 2006

	2006	2008
N	2,651	2,071
Female	56.9	58.7
Age		
less than 29	42.2	33.6
30 to 39	24.4	26.5
40 to 49	18.2	21.9
50+	14.6	18.1
Missing	0.6	0.0
Education		
No School	21.2	22.4
Primary level	66.4	65.3
Secondary level +	12.3	12.3
Missing	0.2	0.0
married/living together	89.1	90.4
Religion		
Catholic	17.0	16.2
Muslim	25.3	24.8
Indigenous Christian /African Independent Churches	15.3	13.3
Other Christian	35.9	33.4
Other religions	6.0	11.5
No religion	0.5	0.9
Region		
Central region	33.7	32.5
Southern region	35.8	36.0
Northern region	30.5	31.5
HIV test results		
Negative	75.1	74.6
Positive	3.8	3.4
Indeterminate	0.3	0.0
Refuse test	6.8	5.9
Not found on day of test	14.0	16.1
Had multiple sex partners	7.7	9.6
Know any people on ARV	40.6	N/A

Number of known people suspected to be sick with AIDS	2.0	3.2
Financial incentive to learn HIV status in 2004 among participants (in Kwacha)	103	101
Did not participate in the 2004 HIV test	28.7	32.1
Reported that a pregnant woman can transmit the AIDS virus to her unborn child	91.7	N/A
Reported that a woman can transmit the AIDS virus to her child through her breast milk	97.0	
Rated much more or more attractive than average by interviewer	N/A	33.9

Table 2: Descriptive statistics of dependent variables for respondents who were sexually active in 2006

	Mean	SD
Had multiple partners in the last 12 months in 2008 conditional on being sexually active in 2008 and having non-missing beliefs		
All	9.74	
Males	20.64	
Females	1.84	
Learned HIV status in 2006		
All	77.75	
Males	75.44	
Females	79.52	
2006 pre-test probability of being currently infected with HIV		
All	0.11	0.20
Males	0.08	0.17
Females	0.13	0.22

Table 3: Descriptive statistics of subjective probabilities for respondents who were sexually active in 2006 and 2008

		Mean	SD
Subjective probability (from 0 to 1) that:			
Respondent is currently infected with HIV (post 2006 HIV test)	f_i^1	0.05	0.19
Someone of respondent's age and gender who is currently healthy will survive for 10 years	S_i^{HIV-}	0.41	0.22
Someone of respondent's age and gender who is currently infected with AIDS will survive for 10 years	S_i^{HIV+}	0.01	0.04
Someone of respondent's gender now healthy will become infected with HIV in the next 12 months if married to someone who is infected with HIV/AIDS	Π_i^{HIV+}	0.93	0.14
Spouse/romantic partner is currently infected with HIV status (post 2006 HIV test)	$f_{pi}^{\ 1}$	0.08	0.19
One will become infected with HIV in the next 12 months if having sex with spouse only	$p_i^{HIV+}(0) = \Pi_i^{HIV+} \times f_{pi}^{\ 1}$	0.08	0.18
Someone of respondent's gender now healthy will become infected with HIV in the next 12 months if has several sexual partners in addition to spouse	$p_i^{HIV+}(1)$	0.81	0.18
Difference between probabilities of survival in the next 10 years with multiple partners and with one partner	$\Delta P_i = \left(1 - f_i^1\right)\left(p_i^{HIV+}(1) - p_i^{HIV+}(0)\right) \times \left(S_i^{HIV+} - S_i^{HIV-}\right)$	-0.27	0.19

Table 4: The impact of subjective beliefs on sexual behavior for females (system of equations 2)

	Had multiple partners in the last 12 months in 2008 conditional on being sexually active	Learned HIV status in 2006	2006 pre-test subjective probability of being currently infected with HIV
Difference in survival probability ΔP_i	0.963**		
	[0.484]		
Had multiple partners in the last 12 months in 2006	0.702	-0.503*	0.119**
	[0.596]	[0.263]	[0.056]
Less than 29 years old in 2008			
30-39	0.242	-0.128*	0.032**
	[0.231]	[0.077]	[0.015]
40-49	0.328	-0.061	0.015
	[0.258]	[0.081]	[0.016]
50+	0.36	-0.072	0.014
	[0.341]	[0.096]	[0.021]
No school in 2008			
Primary school	0.245	-0.122*	0.026*
	[0.266]	[0.072]	[0.015]
Secondary school or more	0.507	-0.066	0.009
	[0.394]	[0.132]	[0.026]
Married in 2008	-0.864**	0.12	-0.027
	[0.329]	[0.106]	[0.023]
Catholic			
Muslim	0.282	0.148	-0.03
	[0.386]	[0.111]	[0.024]
Indigenous Christian /African Independent Churches	0.425	-0.087	0.02
	[0.296]	[0.097]	[0.021]
Other Christian	0.023	0.042	-0.007
	[0.268]	[0.082]	[0.017]
Other or no religions	0.28	0.041	-0.006
	[0.374]	[0.118]	[0.025]
Much more/more attractive than average	0.080		
	[0.198]		
2006 pre-test probability of being currently infected with HIV		4.591***	
		[0.143]	
Know people on ARV		0.006	
		[0.009]	
Financial incentive in 2004			0.000

			[0.000]
Did not participate in 2004 testing experiment			-0.010
			[0.014]
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if married to someone who is infected with HIV/AIDS			0.000
			[0.004]
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if has several sexual partners in addition to spouse			-0.000
			[0.003]
Constant	-1.515**	-0.647***	0.156***
	[0.489]	[0.159]	[0.029]
r_33		0.217	
		[0.006]	
r_12		0.003	
		[0.083]	
r_13		-0.009	
		[0.082]	
r_23		-0.998***	
		[0.005]	
N		1,507	

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.
All regressions include regions dummies and a missing indicator for age and education.

Table 5: The impact of subjective beliefs on sexual behavior for males (system of equations 2)

	Had multiple partners in the last 12 months in 2008 conditional on being sexually active	Learned HIV status in 2006	2006 pre-test subjective probability of being currently infected with HIV
Difference in survival probability ΔP_i	0.639**		
	[0.316]		
Had multiple partners in the last 12 months in 2006	1.092***	0.460***	0.076***
	[0.140]	[0.104]	[0.017]
Less than 29 years old in 2008			
30-39	0.174	0.063	0.007
	[0.167]	[0.102]	[0.015]
40-49	-0.016	0.034	0.001
	[0.170]	[0.109]	[0.016]
50+	-0.061	-0.136	-0.026**
	[0.164]	[0.092]	[0.013]
No school in 2008			
Primary school	-0.025	-0.033	-0.005
	[0.172]	[0.089]	[0.014]
Secondary school or more	0.107	0.091	0.018
	[0.238]	[0.131]	[0.021]
Married in 2008	-0.811***	-0.033	0
	[0.205]	[0.120]	[0.016]
Catholic			
Muslim	0.137	0.036	0.01
	[0.223]	[0.110]	[0.017]
Indigenous Christian /African Independent Churches	0.064	0.231*	0.037*
	[0.221]	[0.139]	[0.022]
Other Christian	-0.414**	0.107	0.02
	[0.174]	[0.096]	[0.016]
Other or no religions	-0.325	-0.082	-0.01
	[0.233]	[0.118]	[0.019]
Much more/more attractive than average	0.246**		
	[0.120]		
2006 pre-test probability of being currently infected with HIV		-6.192***	
		[0.310]	
Know people on ARV		-0.009	
		[0.015]	
Financial incentive in 2004			0.000
			[0.000]

Did not participate in 2004 testing experiment			0.009
			[0.013]
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if married to someone who is infected with HIV/AIDS			0.002
			[0.004]
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if has several sexual partners in addition to spouse			0.001
			[0.004]
Constant	-0.152	0.583**	0.070**
	[0.319]	[0.193]	[0.026]
r_33		0.160	
		[0.007]	
r_12		0.016	
		[0.062]	
r_13		0.018	
		[0.061]	
r_23		0.997**	
		[0.009]	
N		1,149	

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.
All regressions include regions dummies and a missing indicator for age and education.

Table 6: The impact of subjective beliefs on sexual behavior: robustness checks

Dependent variable	Had multiple partners in the last 12 months in 2008 conditional on being sexually active					
	Potential endogeneity of the HIV transmission expectations†		Accounting for HIV testing between 2006 and 2008†		Historical frequencies instead of subjective beliefs†	
	Females	Males	Females	Males	Females	Males
Difference in survival probability *ΔPi*	1.102**	0.684**	1.096**	0.687**		
	[0.498]	[0.333]	[0.501]	[0.332]		
Beliefs *ΔPi* based on historical frequencies					-9.198	-0.833
					[10.310]	[20.427]
Had multiple partners in the last 12 months in 2006	0.649	1.097***	0.671	1.097***	0.746	1.114***
	[0.592]	[0.140]	[0.592]	[0.140]	[0.608]	[0.143]
Less than 29 years old in 2008						
30-39	0.243	0.174	0.253	0.175	0.182	0.211
	[0.225]	[0.166]	[0.225]	[0.166]	[0.231]	[0.175]
40-49	0.346	-0.021	0.346	-0.021	0.281	0.021
	[0.252]	[0.171]	[0.253]	[0.171]	[0.264]	[0.179]
50+	0.352	-0.068	0.339	-0.067	0.435	-0.046
	[0.344]	[0.166]	[0.348]	[0.166]	[0.339]	[0.173]
No school in 2008						
Primary school	0.238	-0.030	0.221	-0.030	0.191	-0.065
	[0.263]	[0.173]	[0.262]	[0.173]	[0.263]	[0.177]
Secondary school or more	0.521	0.099	0.503	0.101	0.604	0.028
	[0.390]	[0.240]	[0.385]	[0.240]	[0.390]	[0.248]
Married in 2008	-0.872**	-0.813***	-0.873**	-0.815***	-0.883**	-0.837***
	[0.331]	[0.205]	[0.331]	[0.205]	[0.337]	[0.209]
Catholic						
Muslim	0.288	0.130	0.280	0.129	0.251	0.122
	[0.387]	[0.223]	[0.384]	[0.223]	[0.391]	[0.223]
Indigenous Christian /African Independent Churches	0.426	0.058	0.413	0.059	0.358	0.076
	[0.292]	[0.220]	[0.292]	[0.220]	[0.312]	[0.227]
Other Christian	0.043	-0.414**	0.046	-0.414**	-0.088	-0.428**
	[0.262]	[0.173]	[0.264]	[0.173]	[0.280]	[0.180]
Other or no religions	0.287	-0.332	0.278	-0.333	0.320	-0.415*
	[0.370]	[0.234]	[0.367]	[0.234]	[0.362]	[0.249]
Much more/more attractive than average	0.05	0.243**	0.052	0.242**	0.120	0.280**
	[0.191]	[0.120]	[0.189]	[0.120]	[0.199]	[0.123]
Constant	-1.470**	-0.131	-1.460**	-0.129	-1.569***	-0.240
	[0.489]	[0.320]	[0.489]	[0.320]	[0.470]	[0.318]

† Estimates from system of equation (3) (other equations not shown). Robust standard errors in brackets. All regressions include regions dummies and a missing indicator for age and education.

Table 7: Impact of policies on the distribution of predicted probabilities of having multiple partners

Panel A — Predicted probabilities

All sample

stats	Baseline (from Columns 1 and 2, Table 6)	Fully updated beliefs: Information campaign on mortality risk	Fully updated beliefs: Information campaign on infection risk	Partially updated beliefs: Information campaign on mortality risk	Partially updated beliefs: Information campaign on infection risk
Males					
p25	0.0829	0.0790	0.1217	0.0828	0.1045
p50	0.1348	0.1243	0.1678	0.1295	0.1529
p75	0.2373	0.2253	0.2888	0.2278	0.2574
mean	0.2018	0.1930	0.2460	0.1979	0.2226
Females					
p25	0.0072	0.0063	0.0179	0.0070	0.0116
p50	0.0135	0.0106	0.0228	0.0119	0.0182
p75	0.0249	0.0197	0.0421	0.0223	0.0324
mean	0.0248	0.0214	0.0396	0.0229	0.0306

Panel B

Excluding respondents who know they are HIV+

stats	Baseline (from Columns 1 and 2, Table 6)	Extension of ARV to all people sick with AIDS
Males		
p25	0.0829	0.0909
p50	0.1347	0.1488
p75	0.2435	0.2576
mean	0.2034	0.2150
Females		
p25	0.0071	0.0090
p50	0.0132	0.0165
p75	0.0236	0.0284
mean	0.0233	0.0269

Appendix A

Table A1: Probability of attrition between 2006 and 2008 among respondents who were sexually active in 2006 (probit specification)

	Attrition between 2006 and 2008	
	Females	Males
Had multiple partners in the last 12 months in 2006	-0.008	0.110
	[0.310]	[0.111]
Difference in survival probability ΔP_i	0.241	-0.038
	[0.207]	[0.221]
Less than 29 years old in 2006		
30-39	-0.168*	-0.319**
	[0.095]	[0.118]
40-49	-0.228**	-0.356**
	[0.112]	[0.133]
50+	-0.076	-0.339**
	[0.138]	[0.125]
No school in 2008		
Primary school	0.123	-0.006
	[0.106]	[0.131]
Secondary school or more	0.234	0.066
	[0.174]	[0.174]
Married in 2006	-0.553***	0.106
	[0.137]	[0.132]
Catholic		
Muslim	0.095	-0.173
	[0.161]	[0.165]
Indigenous Christian /African Independent Churches	0.157	0.069
	[0.130]	[0.163]
Other Christian	-0.011	0.132
	[0.112]	[0.127]
Other or no religions	0.032	0.294
	[0.175]	[0.193]
Constant	-0.255	-0.615**
	[0.190]	[0.221]
N	1,482	1,110

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.
All regressions include regions dummies and a missing indicator for age and education.

Table A2: Ten-year survival probability by age group in 2006 among respondents who were sexually active in 2006 and 2008

	Subjective probability that hypothetical individual will be alive in 10 years			Ten-year survival rates	
	Someone your age healthy	Someone your age sick with AIDS	Someone your age sick with AIDS and treated with ART	Malawi life tables (no AIDS scenario)	Since year of sero-conversion observed in East Africa cohort population
<29	0.435	0.008	0.107	0.972	0.594
30-39	0.396	0.005	0.106	0.958	0.425
40-49	0.394	0.004	0.094	0.896	0.276
50+	0.348	0.011	0.113	0.678	0.175

† Source: United Nations (2008)
†† Source: Todd et al. (2007) based on 4 East African Population cohorts

Table A3: The impact of subjective beliefs on sexual behavior for females (system of equation 3)

	Had multiple partners in the last 12 months in 2008 conditional on being sexually active	Learned HIV status in 2006	2006 pre-test probability of being currently infected with HIV	Probability that someone healthy female become infected with HIV in the next 12 months if HIV+ spouse	Probability that healthy female becomes infected with HIV in the next 12 months if several sexual partners in addition to spouse
Difference in survival probability ΔP_i	1.102**				
	[0.498]				
Had multiple partners in the last 12 months in 2006	0.649	-0.550**	0.124**		
	[0.592]	[0.256]	[0.055]		
Less than 29 years old in 2008					
30-39	0.243	-0.144**	0.034**	-0.002	0.015
	[0.225]	[0.069]	[0.015]	[0.008]	[0.012]
40-49	0.346	-0.073	0.018	-0.012	-0.005
	[0.252]	[0.075]	[0.016]	[0.010]	[0.014]
50+	0.352	-0.073	0.015	-0.006	-0.014
	[0.344]	[0.096]	[0.021]	[0.013]	[0.018]
No school in 2008					
Primary school	0.238	-0.118*	0.025	0.01	0.014
	[0.263]	[0.071]	[0.015]	[0.010]	[0.014]
Secondary school or more	0.521	-0.047	0.007	0.025*	0.024
	[0.390]	[0.122]	[0.026]	[0.013]	[0.023]
Married in 2008	-0.872**	0.123	-0.029	0.013	-0.003
	[0.331]	[0.104]	[0.022]	[0.013]	[0.018]
Catholic					
Muslim	0.288	0.142	-0.03	-0.015	-0.039**
	[0.387]	[0.111]	[0.024]	[0.016]	[0.019]
Indigenous Christian /African Independent Churches	0.426	-0.088	0.017	0.018**	-0.031*
	[0.292]	[0.097]	[0.021]	[0.009]	[0.018]
Other Christian	0.043	0.035	-0.008	0.004	-0.025*
	[0.262]	[0.079]	[0.017]	[0.009]	[0.014]
Other or no religions	0.287	0.031	-0.003	-0.034*	-0.032
	[0.370]	[0.115]	[0.025]	[0.018]	[0.023]
Much more/more attractive than average	0.050				
	[0.191]				

2006 pre-test probability of being currently infected with HIV		4.602***			
		[0.139]			
Know people on ARV		0.003			
		[0.004]			
Financial incentive in 2004			0		
			[0.000]		
Did not participate in 2004 testing experiment			-0.005		
			[0.005]		
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if married to someone who is infected with HIV/AIDS			0.096***		
			[0.013]		
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if has several sexual partners in addition to spouse			-0.043**		
			[0.015]		
Number of known people suspected to be sick with AIDS				0	0.003
				[0.002]	[0.003]
Reports that a pregnant woman can transmit the AIDS virus to her unborn child				0.009	0.013
				[0.009]	[0.016]
Reports that a woman can transmit the AIDS virus to her child through her breast milk				-0.028	-0.04
				[0.020]	[0.033]
Constant	-1.470**	-0.675***	0.099**	0.942***	-1.526***
	[0.489]	[0.137]	[0.038]	[0.024]	[0.030]
r_33			0.218***		
			[0.007]		
r_44			0.128***		
			[0.004]		
r_55			0.187***		
			[0.004]		
r_12			0.013		
			[0.083]		
r_13			-0.012		
			[0.082]		
r_14			0.002		
			[0.090]		

r_15	0.102
	[0.086]
r_23	-0.998***
	[0.001]
r_24	-0.032
	[0.021]
r_25	-0.037
	[0.030]
r_34	-0.019
	[0.022]
r_35	0.065**
	[0.030]
r_45	0.153***
	[0.028]
N	1,511

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.
All regressions include regions dummies and a missing indicator for age and education.
All probabilities in dependent variables are subjective.

Table A4: The impact of subjective beliefs on sexual behavior for males (system of equation 3)

	Had multiple partners in the last 12 months in 2008 conditional on being sexually active	Learned HIV status in 2006	2006 pre-test probability of being currently infected with HIV	Probability that someone healthy female become infected with HIV in the next 12 months if HIV+ spouse	Probability that healthy female becomes infected with HIV in the next 12 months if several sexual partners in addition to spouse
Difference in survival probability ΔP_i	0.684**				
	[0.333]				
Had multiple partners in the last 12 months in 2006	1.097***	0.461***	0.077***		
	[0.140]	[0.105]	[0.017]		
Less than 29 years old in 2008					
30-39	0.174	0.069	0.007	-0.008	-0.003
	[0.166]	[0.102]	[0.015]	[0.011]	[0.018]
40-49	-0.021	0.043	0.002	-0.001	-0.010
	[0.171]	[0.109]	[0.016]	[0.013]	[0.019]
50+	-0.068	-0.127	-0.025**	0.007	-0.006
	[0.166]	[0.091]	[0.013]	[0.012]	[0.017]
No school in 2008					
Primary school	-0.030	-0.033	-0.005	-0.006	0.020
	[0.173]	[0.090]	[0.014]	[0.015]	[0.017]
Secondary school or more	0.099	0.089	0.017	-0.003	0.017
	[0.240]	[0.132]	[0.020]	[0.016]	[0.024]
Married in 2008	-0.813***	-0.042	-0.001	0.008	0.033*
	[0.205]	[0.120]	[0.017]	[0.013]	[0.019]
Catholic					
Muslim	0.130	0.030		0.000	-0.020
	[0.223]	[0.110]		[0.019]	[0.023]
Indigenous Christian /African Independent Churches	0.058	0.231*		0.007	0.011
	[0.220]	[0.139]		[0.013]	[0.024]
Other Christian	-0.414**	0.104		0.010	0.008
	[0.173]	[0.097]		[0.011]	[0.018]
Other or no religions	-0.332	-0.087		0.003	0.014
	[0.234]	[0.117]		[0.014]	[0.025]
Much more/more attractive than average	0.243**				
	[0.120]				
2006 pre-test probability of being currently infected with HIV		-6.174***			

		[0.311]			
Know people on ARV		-0.011			
		[0.016]			
Financial incentive in 2004			0.000		
			[0.000]		
Did not participate in 2004 testing experiment			0.011		
			[0.013]		
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if married to someone who is infected with HIV/AIDS			-0.003		
			[0.036]		
Probability that someone healthy of respondent's gender become infected with HIV in the next 12 months if has several sexual partners in addition to spouse			0.037		
			[0.072]		
Number of known people suspected to be sick with AIDS				0.003**	0.001
				[0.001]	[0.002]
Reports that a pregnant woman can transmit the AIDS virus to her unborn child				-0.006	-0.003
				[0.016]	[0.021]
Reports that a woman can transmit the AIDS virus to her child through her breast milk				0.021	0.019
				[0.021]	[0.029]
Constant	-0.131	0.603**	0.047	0.928***	0.749***
	[0.320]	[0.191]	[0.050]	[0.028]	[0.045]
r_33			0.160***		
			[0.007]		
r_44			1.307***		
			[0.071]		
r_55			1.954***		
			[0.043]		
r_12			0.012		
			[0.063]		
r_13			0.014		
			[0.063]		
r_14			0.024		
			[0.052]		
r_15			0.019		
			[0.057]		

r_23	0.994**
	[0.013]
r_24	-0.041
	[0.027]
r_25	0.047
	[0.030]
r_34	-0.041
	[0.035]
r_35	0.003
	[0.088]
r_45	0.111***
	[0.032]
N	1,150

Robust standard errors in brackets. * significant at 10%; ** significant at 5%; *** significant at 1%.
All regressions include regions dummies and a missing indicator for age and education.
All probabilities in dependent variables are subjective.

Table A5: The impact of subjective beliefs on sexual behavior for different misreporting probabilities for females

alpha1	coefficient of ΔPi	SE
0.1	0.962	0.610
0.2	0.988	0.623
0.3	1.022	0.640
0.4	1.065	0.662
0.5	1.122	0.691
0.6	1.205	0.732

Appendix B: Mortality and Infection Expectations Questions (Woman questionnaire)

I will ask you several questions about the chance or likelihood that certain events are going to happen. There are 10 beans in the cup. I would like you to choose some beans out of these 10 beans and put them in the plate to express what you think the likelihood or chance is of a specific event happening. One bean represents one chance out of 10. If you do not put any beans in the plate, it means you are sure that the event will NOT happen. As you add beans, it means that you think the likelihood that the event happens increases. For example, if you put one or two beans, it means you think the event is not likely to happen but it is still possible. If you pick 5 beans, it means that it is just as likely it happens as it does not happen (fifty-fifty). If you pick 6 beans, it means the event is slightly more likely to happen than not to happen. If you put 10 beans in the plate, it means you are sure the event will happen. There is not right or wrong answer, I just want to know what you think.

Let me give you an example. Imagine that we are playing Bawo. Say, when asked about the chance that you will win, you put 7 beans in the plate. This means that you believe you would win 7 out of 10 games on average if we play for a long time.

X2	Pick the number of beans that reflects how likely you think it is that…
a)	you are infected with HIV/AIDS now
<u>FOR MARRIED RESPONDENTS</u> (INTERVIEWER: If respondent is not married → X2f)	
b)	your spouse is infected with HIV/AIDS now
<u>FOR UNMARRIED RESPONDENTS</u>	
c)	your romantic partner is infected with HIV/AIDS now (INTERVIEWER: If no romantic partner, write 99 and → X2h)
<u>FOR BOTH MARRIED AND UNMARRIED RESPONDENTS</u>	
X3	Consider a healthy woman in your village who currently does not have HIV. Pick the number of beans that reflects how likely you think it is that she will become infected with HIV …
a)	during a single intercourse without a condom with someone who has HIV/AIDS
b)	within the next 12 months (with normal sexual behavior)
c)	within the next 12 months if she is married to someone who is infected with HIV/AIDS
d)	within the next 12 months if she has several sexual partners in addition to her spouse
e)	What about if this woman we just spoke about [in X3d] uses a condom with all extra-marital partners? How many beans would you leave on the plate?

Next, I would like you to consider the likelihood that somebody dies as time goes by. This is an imaginary person, and I am going to describe her to you. The beans in the plate represent the chances out of 10 that the person dies within a certain time period. The person is alive today so we start with an empty plate. As time goes by, more unfortunate things can happen and the person has more chances of dying, so more beans will be added to the plate"

INTERVIEWER:

1. Ask questions X4 to X5b for the INDIVIDUAL described in Column A. After X4 and X5a, LEAVE beans in plate. After X5b, put beans back in the cup. RECORD the number of beans in the plate after each question.
2. COLUMN by COLUMN, REPEAT questions X4 to X5b for the INDIVIDUALS described in Columns B, C and D. For each individual, LEAVE the beans in the plate after X4 and X5a, and put beans back in the cup after X5b. RECORD the number of beans in the plate after each question.
3. If respondent says "I Don't Know", probe with examples: "someone might die because of old age, disease, car accident. How likely do you think it is any of those things happen within [*for X4*: 1 year; *for X5a:* 5 years; *for X5b:* 10 years]?

		DESCRIPTION OF INDIVIDUAL	
	RECORD the number of beans in the plate for each question.	A A woman your age who is healthy and does not have HIV	B A woman your age who is sick with AIDS
X4	Pick the number of beans that reflects how likely you think it is that [INDIVIDUAL] will die within a one-year period beginning today. (LEAVE BEANS ON PLATE)	[_____] Beans in plate If 10, → X4 for individual B	[_____] Beans in plate If 10, →X4 for individual C
X5	Add additional beans so that the number of beans in the plate reflects how likely you think it is that [INDIVIDUAL] a) will die within a five-year period beginning today (LEAVE BEANS ON PLATE; IT IS POSSIBLE TO ADD ZERO ADDITIONAL BEANS)	[_____] Beans in plate If 10, → X4 for individual B	[_____] Beans in plate If 10, →X4 for individual C
	b) will die within a ten-year period beginning today. (IT IS POSSIBLE TO ADD ZERO ADDITIONAL BEANS. PUT BEANS BACK IN CUP AFTER RECORDING THE ANSWER)	[_____] Beans in plate → X4 for individual B	[_____] Beans in plate → X4 for individual C
		C A woman your age who is sick with AIDS and is treated with ARV If R does not know about ARV, skip and go to X6	
X4	Pick the number of beans that reflects how likely you think it is that [INDIVIDUAL] will die within a one-year period beginning today. (LEAVE BEANS ON PLATE)	[_____] Beans in plate If 10, → X4 for individual D	
X5	Add additional beans so that the number of beans in the plate reflects how likely you think it is that [INDIVIDUAL] a) will die within a five-year period beginning today. (LEAVE BEANS ON PLATE; IT IS POSSIBLE TO ADD ZERO ADDITIONAL BEANS)	[_____] Beans in plate If 10, → X4 for individual D	
	b) will die within a ten-year period beginning today. (IT IS POSSIBLE TO ADD ZERO ADDITIONAL BEANS. PUT BEANS BACK IN CUP AFTER RECORDING THE ANSWER)	[_____] Beans in plate → X4 for individual D	