Essays on HIV, Marriage and Education in Sub Saharan Africa

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ABSTRACT

ESSAYS ON HIV, MARRIAGE AND EDUCATION IN SUB SAHARAN AFRICA

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This paper examines the impact of spatial variation in HIV rates on female marriage rates in Zambia. I formulate a search model that predicts lower marriage rates of educated females relative to uneducated females in regions with higher HIV rates. I use exogenous geographic variation in HIV rates to identify the causal effect of HIV on female marriage. The risk of HIV infection causes marriage rates to fall for educated females but rise for uneducated females. One explanation is that in high HIV regions: (1) educated females take the time to find a partner who will use condoms and get HIV tested, which delays marriage, and (2) uneducated females marry sooner because youth and virginity are prized by males, and employment opportunities are scarce. These findings imply that returns to education for young females are likely underestimated since they miss conceivably substantial health-related benefits.

Is widow remarriage beneficial to child school enrollment? Women are widowed at relatively young ages in high-HIV areas of Sub Saharan Africa and are likely to have school-aged children. A main finding in the parental death literature is that the death of a mother hurts child education more so than does the death of a father. This masks important differences in child school enrollment across households who have experienced a father's death. This paper estimates the effect of widow remarriage on child school enrollment by exploiting regional variation in HIV, religion, and the sex ratio. The cross-country empirical results indicate that remarriage is detrimental to child enrollment

for widows with less than six years of schooling, yet beneficial to child enrollment for widows with six or more years of schooling. This is consistent with (1) marital sorting by education (correlation=.7), (2) intra-household bargaining, and (3) differences in tastes for remarriage and schooling. A policy implication is that investing in female education in high-HIV areas – among those likely to become widows – can have multiplier effects, as there is complementarity between the returns to education on marriage market outcomes and children's education.

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Chapter 1

The Effect of HIV on Marriage in Zambia

1.1 Introduction

Can considerable variation in HIV rates across Zambia explain observed marriage rate differences between educated and uneducated females? I provide evidence of a previously undocumented marriage gap between uneducated and educated 20-24 year-old females that is increasing in the risk of HIV infection (Figure 1).[1] This disparity is common across countries in East and Southern Africa where over 10% of the population is infected with HIV.[2] Precisely because there have been nearly one million AIDS deaths in Zambia since the HIV epidemic hit in 1984, it is important that assessments of behavioral response to HIV (1) identify groups that are changing their behavior and (2) account for the principal routes of HIV infection. Uncovering reasons why this marriage gap exists where HIV rates are high can provide insight into the consequences of the

[1]Importantly, this increasing marriage gap holds when excluding females enrolled in school. The marriage gap is positive but flatter for 25-29 year-old females (Figure 2).

[2](Figures 3-4). I study Zambia for its high HIV rates and rich spatial variation in HIV.

risk of exposure to HIV on social structure and the incentives to marry. It also sheds light on the timing of marriage as being responsive to HIV risk where changes in sexual behavior have failed to be and leads to a policy recommendation that is practical and intuitively appealing.

Specifically, a large literature has focused on the responsiveness of sexual behavior to the risk of HIV infection. Most studies find that individuals, on average, do not react to the risk of HIV infection [3], [6], [18], [19], [21], [32], [34], [35]. They do not use condoms more frequently, nor do they reduce their number of concurrent sexual partners. Groups that are responsive to a higher risk of HIV infection are those with a longer life expectancy, more wealth, or more education [11], [12], [23].

The literature also aims to account for the principal routes of HIV infection, with four main hypotheses attempting to explain high rates of HIV in the face of low rates of HIV transmission: marriage (unfaithful husbands infect their wives) [25], spousal search [20], heterogeneity in risk preferences [24], [29], and dense sexual networks [28]. Magruder (2008) shows that a death profile that is *decreasing* in age between ages 30 and 50 is common in countries with high HIV rates and consistent with a declining HIV risk after age 30.[3] He contends that a declining HIV risk after age 30 is generated when most people are infected with HIV through spousal search, given that the average lifecycle leads from spousal search into marriage. His literature review suggests that an HIV risk that is increasing in age beyond age 30 is generated when most people are infected with HIV during marriage.[4]

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[3]Magruder infers the age-profile of HIV infection risk from the age-profile of deaths in South Africa, 1996-2002 (Figure 5). The risk of HIV infection is independent of age in models where heterogeneity in risk preferences or dense sexual networks are used to explain high HIV with low transmission rates.

[4]Magruder uses a search and matching model of serial monogamy in which there is heterogeneity in HIV transmission probability. Individuals randomly match with a partner who is uninfected (no risk),

This paper adds to the literature in three ways: (1) I document that (a) educated females are less likely to marry (i) in high-HIV than low-HIV regions and (ii) than uneducated females in high-HIV regions, and (b) uneducated females are more likely to marry in high-HIV than low-HIV regions; (2) I am the first to analyze the effect of the risk of HIV infection on female marriage rates, by education status; and (3) I formulate a model of spousal search that takes HIV risk into account and has a testable implication.

I find a causal relationship between HIV and marriage. I present estimates taking into account the potential endogeneity of HIV with respect to marriage by using an instrumental variables strategy. A 10 percentage point increase in HIV rates causes a 10 percentage point drop in marriage rates of educated females and a 12 percentage point rise in marriage rates of uneducated females. These results are statistically significant at the 5% level, controlling for employment rates for males and females, male education rates, an urban binary, and female access to information.

The findings are consistent with a model in which HIV causes a divergence in marriage rates between educated and uneducated females due to differences in their financial abiliy to stay single and in their bargaining power to stay protected from HIV when single. Both types of females want to marry someone of the same HIV status as themselves (uninfected match with uninfected; infected match with infected), so that they do not get infected by their partner (uninfected match with infected), or infect their partner

just-infected (highly infectious), or infected and in their latent state (low infectiousness). Magruder's spousal search model is able to simulate an HIV epidemic with low HIV transmission rates, given entry of a mere 1-3% of infected people into spousal search. When individuals have clusters of very short relationships that they easily reject in between a few longer ones, HIV is highly transmissible, given that unprotected sex occurs. Upon entering a new relationship, individuals are likely to have just left a very short relationship in which they are infected, remain highly infectious for up to three months and likely infect their new partner.

(infected match with uninfected). However, since partner HIV status is unobservable, there is a time cost to uncovering it. Educated females can afford to stay single and, in high-HIV areas where there is emphasis on condom use, take the time to find a partner who will use condoms and get HIV-tested with her, only marrying if they match on HIV status, which delays marriage. Uneducated females marry sooner in high-HIV areas because of higher demand for their youth and virginity – the absence of HIV risk – and, because they cannot get their partners to use condoms when single, they choose their second best option of minimizing their number of sexual partners, and marry.[5]

Perhaps the paper's main contribution is highlighting that the optimal timing of marriage – in terms of minimizing lifetime HIV risk – may differ by education. I establish that spousal search is an optimal response to the risk of HIV infection until the mid-20s for females who can enforce condom use when single and that marriage is an optimal response at around age 20 for females who cannot enforce condom use when single; this is shown by stratifying the female age-profile of HIV risk by *education* and *age at first marriage*. My results, *by education*, reconcile two findings from the literature: (1) early marriage is an HIV risk factor for sexually active teenagers [7] and (2) late marriage is an HIV risk factor for sexually active females[4]. That is, early marriage is a risk factor for educated females who benefit from delaying marriage by using their leverage when single to ensure positive assortative matching on HIV status, and late marriage is a risk factor for uneducated females who do not have this same leverage over condom use and are more likely to become HIV-infected by staying single.

[5]Sexually active females have no way to protect themselves from HIV aside from their partner wearing a condom. This highlights the importance of controlled trials finding that a vaginal microbicidal gel reduces female HIV risk by 50%, as it can be used by females without male consent. Hence, only uninfected single females who can persuade their partner to use condoms can be selective during spousal search.

Further implications of my findings include non-pecuniary benefits to education. The results imply that females might benefit a lot from education, over and above earnings differences. The conventional wisdom is that HIV lessens the incentives to get an education because life expectancy shrinks. But the implications here are the opposite, since being better educated can have significant health benefits. An educated female who can safeguard herself from HIV while single has better control over her lifetime HIV risk, and a potentially higher life expectancy. Thus, pecuniary returns to the education of females likely underestimate the actual rates of return since they miss conceivably substantial health-related benefits.

In the remainder of this paper, I present the theoretical framework, describe the data and descriptive statistics, and discuss the estimation and instrumenting strategy before presenting the estimated impact of HIV on marriage, interpreting and concluding.

1.2 Theoretical Framework

I present a theoretical framework that is consistent with a stylized fact: a gap in marriage rates exists between uneducated and educated females in Zambia in 2007 that is considerably larger where HIV rates are high and almost nonexistent where HIV rates are low (Figure 1).[6]

The model is based on McCall's (1970) model of intertemporal job search [26] [27]. Consider a single individual who is searching for a spouse. Each period, the individual draws one marriage offer x from a distribution of partner quality, $F(X)=Prob(x \leq X)$.

[6] I plot the difference in marriage rates between 20-24 year-old uneducated and educated females against male HIV rates, along with the 95% confidence interval. Each observation is an average at the region-rural level in Zambia 2007. Marriage rates are nearly always higher for uneducated than educated females.

An individual has the option of rejecting the offer, in which case she receives utility $V_t = V_0$ this period by staying single and waits until next period to draw another offer from F. Alternately, she can accept the marriage offer and receive utility $V_t = x$, in which case she receives a utility of x per period forever after. Divorce and recall are not permitted. The single individual maximizes E $\sum \beta^t V_t$, where $0 < \beta < 1$ is a discount factor.

Let Π be the probability an individual is matched with an HIV-infected partner and P the probability of HIV infection per match with an infected partner.[7] This implies that each marriage offer drawn carries a risk of HIV infection, ΠP, including offers that are rejected. A single individual who has just drawn a marriage offer is simultaneously exposed to an HIV risk and observes both partner quality and her partner's HIV status *before deciding to accept or reject the offer.* There are uninfected and infected individuals in spousal search each period. Given an individual's own HIV status, HIV_i, and partner HIV status, HIV_j, an individual will accept a match if x $\geq \overline{x}^{HIV_i}_{(HIV_j)}$, where $\overline{x}^{HIV_i}_{(HIV_j)}$ is the reservation value of partner quality.

I make the following assumptions. Because educated females are in relationships that are more likely to use condoms than are uneducated females, I assume that the probability of HIV infection per match with an infected partner, P, differs by education. That is, the probability of HIV infection is greater for uneducated than educated females ($\frac{\partial P}{\partial Educ} < 0$). Also, the value of staying single, V_0, is increasing in education ($\frac{\partial V_0}{\partial Educ} > 0$). An HIV-infected individual receives disutility, $\overline{V}$, from transmitting HIV to an uninfected individual and an uninfected individual receives disutility, D, from being infected by their partner. λ is the match offer rate.

Let $v(x_j, HIV_j|HIV_i)$ be the expected value of $\sum \beta^t V_t$ for a single individual with

[7] Π is the HIV rate and P is the HIV transmission rate.

HIV status HIV_i who has offer x_j in hand from a partner with HIV status HIV_j, and is deciding whether to accept or reject the offer, while behaving optimally.

1.2.1 Value Functions

The value function for an *uninfected* single individual i who draws a marriage offer with an *uninfected* partner j, $v(x_j, HIV_j^-|HIV_i^-)$, with $x_{(j)}^{HIV_i}$, satisfies the Bellman equation:

$$v(x_j, HIV_j^-|HIV_i^-) = max\{\frac{x_{(-)}^{HIV^-}}{1-\beta}, V_0 + \beta[(1-\Pi)\int v(x_{(-)}^{HIV^-}|HIV_i^-)dF(x')+ \quad (1.1)$$

$$\Pi(1-P)\int v(x_{(+)}^{HIV^-}|HIV_i^-)dF(x') + \Pi P\int (v(x_{(+)}^{HIV^+}|HIV_i^+) - D)dF(x')]\}$$

where maximization is over two actions: (1) accept the marriage offer and stay married forever at utility $x_{(-)}^{HIV^-}$ or (2) reject the offer, receive V_0 this period, and draw a new marriage offer x' from distribution F next period. With her current draw, she faces no risk of HIV infection. If she rejects the offer, her draw next period comes with the probability ΠP of matching with an infected partner, being infected by him and receiving disutility D, or the probability $\Pi(1-P)$ of not being infected by him. The chance that next period she draws an uninfected partner is $(1-\Pi)(1-P) = (1-\Pi)$, as there is no transmission risk when an uninfected individual is matched with an uninfected partner, $(1-\Pi)P$ =0.

Similarly, I describe the three other match type possibilities (*infected* draws *uninfected* partner, *infected* draws *infected* partner, *uninfected* draws *infected* partner); see appendix for solutions. Consider the value function for an *infected* single individual who draws a marriage offer with an *uninfected* partner, $v(x_j, HIV_j^-|HIV_i^+)$. This infected individual in a discordant current match faces a risk P of infecting her partner and receiving disutility $\overline{V}$. If she rejects, she either meets another uninfected partner next period with probability $(1-\Pi)$ and faces the same risk of infecting him, or meets an HIV-positive partner with probability Π, and marries with no utility loss.

Consider an *infected* individual who draws a match with a concordant *infected* partner. If she rejects the offer, with probability Π she is again matched with an infected partner, but with probability $(1-\Pi)P$ draws an uninfected partner, infects him, and receives disutility $\overline{V}$, and with probability $(1-\Pi)(1-P)$ draws an uninfected partner and does not infect him.

Lastly, consider an *uninfected* individual who is currently matched with an *infected* partner. Recall that an individual can be infected by a match *even if she rejects the match.* With probability P she is infected at the time of the draw and receives disutility D. If she then rejects, next period she faces the chance $P(1-\Pi)(1-P)$ of drawing an uninfected partner but not infecting him, the chance $P(1-\Pi)P$ of infecting him and receiving disutility $\overline{V}$, or of drawing an infected partner with probability $P\Pi$. With probability (1-P) in her current draw, she is not infected. If she rejects, she meets a similarly uninfected partner next period with probability $(1-P)(1-\Pi)$, an infected partner who she does not infect with probability $(1-P)\Pi(1-P)$, or who she does infect with probability $(1-P)\Pi P$ and receives disutility D.

For each case, the average waiting time until receiving a successful marriage offer is $\overline{N} = \frac{1}{P(x \geq \overline{x})} = \frac{1}{e^{\overline{x}}}$, as the solution to the dynamic programming problem is a constant reservation value and hence a constant hazard rate.[8] As $\overline{N}$ is an increasing function of $\overline{x}$, an increase in the reservation value of partner quality is equivalent to an increase in the time until marriage.

From this, one can perform comparative statics of interest for each of the possible

[8]A constant hazard rate means that the probability of marriage next period does not depend on the length of time spent unmarried.

matches: (1) the effect of a change in HIV rates on the waiting time until marriage, and (2) the mediating effect of education on the relationship between HIV and marriage through (a) protection against HIV (using condoms), P, and (b) the outside option, V_0.

1.2.2 Comparative Statics

For an *uninfected* individual matched with an *uninfected* partner, the equation that characterizes the determination of the reservation value of partner quality (see appendix) is:[9]:

$$\overline{x}_{(-)}^{HIV^-} - V_0 = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} - \Pi PD)e^{-\lambda \overline{x}_{(-)}^{HIV^-}}]$$

I define the right side of the above equation as $h(\overline{x}_{(-)}^{HIV^-}) = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} - \Pi PD)e^{-\lambda \overline{x}_{(-)}^{HIV^-}}]$.

For an *uninfected* individual matched with an *uninfected* partner, (1) an increase in HIV rates is predicted to increase marriage rates, on average. That is, an increase in HIV rates reduces the value of continued search, the reservation value of partner quality ($\frac{\partial h(\overline{x}_{(-)}^{HIV^-})}{\partial \Pi} < 0$), and the waiting time to marriage. Put simply, as HIV increases, an uninfected individual is luckier to be matched with an uninfected partner and so marries more quickly (Figure A.1).

For the uninfected, as HIV rates increase, (2a) marriage rates are predicted to increase for the uneducated relative to the educated. As the probability of meeting an infected partner increases, uninfected individuals with a higher infection risk (by assumption, the uneducated) are more likely to accept their current draw ($\frac{\partial(\frac{\partial h(\overline{x}_{(-)}^{HIV^-})}{\partial \Pi})}{\partial P} < 0$). If they reject, it is likely they will be infected by and receive disutility from an infected

[9]The left side is the cost of searching one more period when an offer $\overline{x}_{(-)}^{HIV^-}$ is in hand. The right side is the expected benefit of searching one more period in terms of the expected present value associated with drawing $x' > \overline{x}_{(-)}^{HIV^-}$. This equation instructs the uninfected agent to set $\overline{x}_{(-)}^{HIV^-}$ so that the cost of searching one more time equals the benefit.

draw next period. Thus, those who face a higher HIV infection risk, as HIV rises, lower their reservation value of partner quality and marry sooner.

For the uninfected, as the option value V_0 of staying single increases, (2b) marriage rates are predicted to fall, independent of HIV rates. That is, as the outside option increases, the cost of searching decreases, and the partner quality one needs to be matched with to accept an offer increases ($\frac{\partial \overline{x}^{HIV^-}_{(-)} - V_0}{\partial V_0}$ <0). A higher option value, then, increases the waiting time to marriage. The comparative statics for the remaining match possibilities are shown in the appendix.

Figure A.2 presents numerical solutions of the average waiting time to marriage for uninfected educated and uneducated females matched with uninfected partners. By assumption, only the outside option, V_0, and ability to reduce the risk of infection, P, differ by education as channels through which HIV affects marriage. I parameterize values $P = .25, V_0 = 4$ for educated females and $P = .5, V_0 = 2$ for uneducated females and plot $\overline{N}$–the average waiting time to marriage–against male HIV rates, Π. I also set $\beta = .95, D = 2, \overline{V} = 2$, and $\lambda = 1$. Figure A.2 depicts the ability of the theoretical model to mimic a female marriage gap, by education, that is increasing in HIV rates. See Figure A.3-A.5 for numerical solutions to other match combinations.

This framework formalizes the intuition set forth in the introduction: educated females in high HIV regions are expected to delay marriage due to a high outside option and a better ability to protect themselves from HIV when single. The expectation is that uneducated females in high HIV regions marry sooner because of their low outside option and lack of bargaining power to enforce condom use when single.

1.3 Data & Descriptive Statistics

1.3.1 Data

I use the Zambia 2007 cross-section of Demographic & Health Surveys (DHS) data. The data are repeated cross-sections of nationally representative samples of households in a number of countries in Africa, collected at roughly five-year intervals. All women aged 15-49 and men aged 15-59 are eligible for the survey. The most recent cross-section(s) includes HIV test results, for which all households were eligible. Blood samples were taken by finger prick for all respondents who consented to HIV testing.

The appeal of the DHS data is that the HIV test results can be merged with the demographic data. This data is a significant improvement over HIV data used previously. In the past, researchers have used national HIV estimates that are representative of the population, as respondents were pregnant women, intravenous drug users, and commercial sex workers. Most empirical HIV research has been cross-country analysis, making it difficult to argue that all else is constant across countries. I use demographic and HIV data for one country and one year, exploiting geographic variation in HIV and marriage rates, which requires weaker assumptions.

Due to the inability of an econometrician to pinpoint the marriage market within which each female and male searches, one must make geographic assumptions. I assume that the geographic boundaries of each sub-marriage market in Zambia are the rural and urban part of each administrative region, for a total of eighteen region-rural sub-marriage markets. Surely, smaller marriage markets exist within each region-rural sub-marriage market, given that Zambia is home to seventy tribes.[10] One or two large tribes

[10]The smallest DHS-defined geographic region is a cluster, defined as urban or rural, where rural denotes a village and urban can be either a city or town. There are 320 DHS clusters in Zambia.

and several smaller tribes reside in each sub-marriage market, across which inter-tribal marriage occurs. What is important for identification of the effect of HIV on marriage is that the spatial variation of male HIV rates *across* region-rural areas, not within a region-rural area, induces differences in marriage rates *across* marriage markets.

The geographic definition of a marriage market is more palatable if there is limited in- and out-migration. Data on spousal origins suggest that females are more likely to have migrated if they are married, and males are less likely to have migrated if they are married, consistent with patrilocal migration of females to the male's home upon their marriage.[11] Females who recently migrated are more likely to have recently married. This is consistent with married females migrating only to move to their husband's home, and of single males migrating for work. As long as the expected distribution of male HIV rates from which females sample during spousal search is updated by females as males migrate, then female marriage behavior will be responsive to contemporaneous male HIV rates.

Table 1 presents summary statistics. Overall response rates for the Zambia 2007 sample are 98% for the demographic survey and 75% for the HIV testing. [20] There are 13,646 15-59 year-old males and females in the Zambia 2007 sample, of which 7,146 are 15-49 year-old females. Zambia is the most highly urbanized country in Africa, with 44% of 15-59 year-olds living in urban areas. For males only, 79.3% consented to HIV testing. Table 2 presents observable characteristics of males who did and did not consent to HIV testing. Males who consented to HIV testing were older and more likely to live in a rural area.

[11] The majority of tribes in Zambia are patrilineal and practice patrilocal migration, with the exception of the Bemba, who are matrilineal and practice the reverse migration of males to the female's home; they are concentrated in Copperbelt, the most highly urbanized region.

The main variables used in the analysis are an indicator for educated, female marriage rates and male HIV rates. I consider an individual educated if they have completed seven or more years of education (completed primary school) or are still enrolled in school. I chose 7 years of education as the cut-off as it is the mode, mean, and median for the sample of 20-24 year-old females. Of the 1,405 20-24 year-old females that I focus on in this analysis, 9% have no education, 48% have completed primary school, 38% have completed secondary school, and 5% have completed some higher schooling.

I calculate marriage, education, and employment rates as averages at the region-rural level, weighted with individual sampling weights to obtain nationally-representative samples. I consider a female married if she self-reports as (1) married or (2) currently living with a partner (commonly accepted as married in the literature). Male HIV rates are the percent of males who are HIV-positive in a region-rural area, weighted by HIV sampling weights.[12] Employment rate is the percent currently working, and male education rate the percent who completed at least a primary school education, both in a region-rural area.

[12]DHS surveys collect data from nationally-representative probability samples, often over-sampling certain categories of respondents. Because the samples are not self-weighting and because response rates vary across sampling domains, weights are used to obtain nationally-representative estimates. Beyond the standard weighting, to deal with variations in non-response rates for HIV testing the DHS generates a separate weight for the sample of respondents who participate in HIV testing. These weights are constructed separately for men and women and are adjusted for non-response by sampling strata to develop nationally-representative HIV prevalence estimates that attempt to account for non-response on HIV testing.[30]

1.3.2 Descriptive Statistics

Tables 3 and 4 present evidence that educated females are better able to protect themselves from HIV while single. These tables display descriptive statistics on the sexual behavior of 20-24 year-old females in regions with a high and low risk of HIV infection, by education and marital status. I consider a geographic cluster to be in a high-HIV region if its average male HIV rates are above the median region-rural HIV rate, 12%.[13]

Table 3a displays the percent of 20-24 year-old females who used condoms during their last sexual intercourse, and Table 3b the sensitivity of condom use at last sex to age-group specification. In both high- and low-HIV regions, single educated females are roughly 20 percentage points more likely than single uneducated females to use condoms with their last sexual partner (55% vs. 35% in high-HIV regions; 30% vs. 15% in low-HIV regions). Both educated and uneducated females are more likely to use condoms at last sex in high HIV regions than low HIV regions, again by roughly 20 percentage points. Interestingly, when married there is no difference in condom use by education or HIV region, since condoms are rarely used in marriage.

Table 4 presents sexual behavior statistics for 20-24 year-old females: the percent who have never had sex, the number of lifetime sexual partners, and the percent ever tested for HIV, by education, marital status, and HIV region. The table shows that (1) when at high risk of HIV infection, single educated females are more likely be virgins than single uneducated females (32% vs. 14%) and (2) by the time they marry, educated females are more likely to have been tested for HIV than uneducated females – when married and HIV rates are high (79% vs. 49%) or low (46% and 28%). Lastly, (3) single

[13] 53% of the sample lives in high-HIV regions, with region x rural HIV rates between 12 and 21.5%; 47% live in low-HIV regions, with HIV rates between 3 and 11.8%

educated females have had fewer sexual partners than single uneducated females. This is consistent with a search model in which educated females are more selective.[14],[15]

Consider the population of married couples by whether each spouse has ever been HIV tested and by own and partner HIV status. Presumably, couples who recently married are more likely to have chosen their spouse based on his/her HIV status than to have affected their partner's HIV status within that time. Just-married couples' HIV statuses should therefore be more indicative of partner choice (ex ante HIV status) and 10-20 year marriages more indicative of an outcome (ex post concordant HIV status).

Of marriages formed in the last year, educated-female marriages are more likely to exhibit positive assortative matching on HIV status than are uneducated-female marriages, conditional on both members of the couple having been HIV tested. As the time since marriage increases, a couple is increasingly likely to become concordant (same HIV status).[16]

Figure 6 presents descriptive evidence that is consistent with educated females delaying marriage when at a high relative to low risk of HIV infection. I plot the percent

[14]That single educated females are not more likely to get HIV tested than single uneducated females could be due to higher rates of out-of-wedlock pregnancy among the uneducated than educated. A pregnant woman who visits a prenatal clinic in Zambia is strongly encouraged to get tested for HIV. If a pregnant infected woman is put on HIV drugs (ARVs), mother-to-child HIV transmission can be prevented in all but 5% of cases. (cite) Also, because HIV is primarily transmitted through heterosexual sex, HIV testing may seem less necessary for the 32% of single educated females who are sexually inactive and feel certain of their HIV status.

[15]As motivation for theoretical simulations, of educated single females in high-HIV regions, 70% can be considered protected from HIV: 32% are sexually inactive and 55% of sexually active use condoms; $.32 + .68 * .55 \approx 70\%$. Of uneducated single females in high-HIV regions, 50% can be considered protected from HIV: 14% are sexually inactive and 44% of sexually active use condoms; $.14 + .86 * .44 \approx 50\%$.

[16]While no information is available on the timing of HIV infection, the time since marriage can be calculated from current age and age at first marriage.

of educated females who are married on the y-axis against female age on the x-axis, for regions with male HIV rates higher than the median (bottom dotted line) and lower than the median (solid line above). I document that (1) marriage rates of 20-24 year-old educated females are lower in high HIV than low HIV regions and that (2) there is no difference in marriage rates of educated females before age 18 or by age 26.

A female marriage gap, then, exists for those in the 20-24 year-old age range and is at least partially driven by educated females in *high HIV* regions having lower marriage rates than educated females in *low HIV* regions. That is, educated females enter the marriage market once they finish school at roughly 18 in both high and low HIV regions, after which marriage rates by HIV region diverge through age 24, then converge by age 26. Crucially, under the assumption that females within education groups behave similarly to those just older than themselves, the figure suggests that the educated at high risk of infection delay marriage rather than decide to never marry.

1.4 Estimation

1.4.1 Basic Specification

I estimate the impact of male HIV rates on female marriage rates, controlling for factors that affect the attractiveness of males and the propensity of females to marry:

$$M_{ir}^{f} = \alpha_0 + \alpha_1 HIV_r^m + X'\alpha + \epsilon_1$$

where M_{ir}^{f} is the female marriage rate of age group i in region-rural area r, HIV_r^m is the male HIV rate in region-rural r, and X is a set of control variables for the region-rural average desirability of males as husbands (male education rate, male employment rate), an urban binary, and female opportunities (female employment rate, female information sources (tv, newspaper, radio)).

1.4.2 Sources of Bias

Male HIV is potentially endogenous in the OLS marriage rate regressions, due to (1) reverse causality, (2) omitted variable bias, and/or biased due to (3) measurement error in HIV.

Reverse Causation

In addition to HIV affecting marriage, the decision to marry or not may affect the female risk of infection. The literature review pointed out that spousal search and marriage are two of the principal routes of HIV infection. An issue in region-level regressions is that HIV might be high precisely because marriage rates are low to begin with (e.g. skewed sex ratios). Reverse causation can cause inconsistent estimates, but can be corrected for by instrumental variables.

Omitted Variable Bias

If relevant determinants of the propensity to marry are omitted that are correlated with HIV rates, then the HIV point estimate will be biased. Potential omitted relevant variables include (1) economic development/poverty, (2) tribal customs/traditions, and (3) female migration status.

The lack of economic development in a region-rural area incentivizes marriage for women (insurance mechanism, joint resources) and could isolate an area from the spread of HIV if highways are absent; trucking routes have high HIV rates due to the demand for commercial sex by truck drivers.

Tribal custom may dictate both that marriage is universal and that multiple sexual partners are acceptable, which perpetuates the epidemic. Or, if females marry young in certain tribes, this may protect against HIV risk.

If females migrate to gain access to better marriage or employment prospects, then even if this changes the composition of the urban population, controlling for characteristics of educated female types who migrate will reduce the bias on urban. I control for female access to information as a proxy for the types of (educated) females that migrate to urban areas.

Measurement Error in HIV

Measurement error in HIV data does not seem to be an issue, as HIV testing was conducted and recorded by DHS, not self-reported, and HIV weights are used to make HIV test results nationally-representative. However, if measurement error exists, instrumenting for HIV corrects for it.

1.4.3 Instruments for HIV

Variation in HIV rates across region-rural areas in Zambia are correlated with distance to the origin of the HIV epidemic [22] and male circumcision rates. Male circumcision is protective against HIV, cutting the male HIV risk in half.[17] I exploit variation in the tribal custom of circumcision to explain variation in male HIV rates *across* local marriage markets. Christianity is practiced by 99% of Zambians, so it is not religion,

[17] Randomized controlled trials of male circumcision were completed in 2007 in Uganda and Kenya. [3] The study found that male circumcision reduces the risk of HIV infection in males by removing high-risk cells in the foreskin, which makes the cells under the foreskin less sensitive and less prone to bleeding. With the finding that male circumcision is medically protective against HIV risk, the Population Council began designing a roll-out of medical circumcision of males after 2007. As of 2010, there have been no men medically circumcised in Zambia, according to the Population Council, which reduces concerns of any medical circumcision information campaigns occurring by the time of the interview in 2007, as well as females knowing that males who are circumcised are at lower HIV risk; they should be no more likely to search for a circumcised male in the marriage market.

but tribal custom, that dictates whether males are circumcised. Circumcision rates are quite high in the western part of Zambia – in Western and Northwestern provinces (36% and 70%, respectively) – and quite low elsewhere (less than 15%). Male HIV rates are relatively low in these regions (15% and 7%, respectively).

Distance from the origin of the HIV epidemic is correlated with male HIV rates. The origin of the epidemic is in the Democratic Republic of Congo (DRC), at the geographic center of the country, (-6.31, 23.59), rather than at a political or urban center; the first human HIV cases were located on both sides of the country. The closer a region is to the origin of the epidemic in the DRC, the higher is the expected HIV rate, as HIV travels through sexual networks. The DRC borders Zambia to the north. Southern Africa was hit first and is still the hardest by HIV, next closest and hardest hit is East Africa, and furthest away and hit least is West Africa.

GPS coordinates for DHS data are available for each of 320 clusters in the sample. For each DHS cluster, a single GPS coordinate is available, defined as the geographic center of the cluster. I calculate the distance, in kilometers, from each DHS cluster in Zambia to the origin of the HIV epidemic in the DRC, and take the average of all cluster-origin distances within each region-rural area; log distance best fits the relationship with male HIV rates.[18]

I control for latitude to ensure the relationship between distance from the origin of the epidemic and HIV is not driven by geographical location. I do not control for longitude, as it is not significantly related to male HIV rates, and only reduces my degrees of freedom.

[18]There are 320 clusters and 18 region-rural areas; each cluster is in only one region-rural areas.

1.4.4 First-Stage Results

Due to the potential endogeneity of male HIV rates, I instrument for HIV with male circumcision rates, distance from the origin of the HIV epidemic, and latitude, all averaged at the region-rural level. In the first-stage regression results in Appendix Table A.1, male circumcision is protective against HIV. The further a region is from the origin of the epidemic, the longer it takes HIV to spread through sexual networks, and the lower the male HIV rates. Latitude has a small negative, but significant effect on male HIV. The first-stage regressors explain over 90% of the variation in HIV rates.

1.5 Results

1.5.1 OLS and IV Results

Table 5 presents OLS and instrumental variables estimates, which are entirely consistent with one another. I show both to ensure that the results are not driven by my choice of instruments. Each column is a separate regression for educated or uneducated females, with the OLS estimates in Panel A and the IV estimates in Panel B. Overall, a 10 percentage point increase in male HIV rates causes a 12 percentage point rise in uneducated female marriage rates, ceteris paribus, as well as a 10 percentage point drop in educated female marriage rates. The unconditional OLS estimates are downward-biased compared to column (2) with urban included, due to a strong positive correlation between HIV and urban residence and a negative association between marriage and urban residence.

Column (3) adds the male employment rate, which is positively associated with marriage for both types of females; employed males are more desirable to women, and a wife and wedding more affordable to men who have jobs. Column (3) also adds the male education rate. The coefficients on male education are indicative of positive assortative matching on education. The higher the percent of educated males, the harder time uneducated females have finding a spouse and the easier time educated females have finding a spouse.

Column (4) holds female employment opportunities constant. The HIV point estimate in the IV regression reflects a negative and significant causal impact of the risk of HIV infection on the propensity of educated females to marry. Educated females have employment opportunities that may allow them to delay marriage in search of a better matched spouse.

Column (5) includes frequency of access to three sources of information: TV, the radio, and the news. The bias on column (5) OLS urban and HIV estimates is reduced by controlling for female types that may be more likely to migrate to urban areas with lower HIV rates. A majority of the variation in marriage is explained by the independent variables.

Columns (3) and (4) pass all identification tests, which leads me to my preferred specification of the IV estimates in column (4), which control for female employment. For the underidentification and weak identification tests, I reject the null (preferred; null hypothesis: underidentification; excluded instruments are uncorrelated with the endogenous regressors, respectively) in columns (3)-(5) where male education and employment are controlled for. For the overidentification test, I fail to reject the null (preferred; null hypothesis: instruments are valid, i.e. uncorrelated with the error term) in regressions (1)-(4) without female access to information.

In pooled OLS regressions (not shown), I combine educated and uneducated females, and test for equality of the educated and uneducated female parameters. As expected, I find a significant difference in the effect of the risk of HIV infection on female marriage between educated and uneducated females. I perform a Chow test for equality of the intercept and slopes, by education, and reject the null hypothesis that the educated and uneducated female marriage equations should be identically specified.

I perform sensitivity tests (not shown) on OLS regressions, by varying the age group and definition of the educated binary. Sequentially adding a year at a time, the results are robust with significance for 20-25 year-old females, and robust, just with the loss of significance, for 18-26 year-olds. Results do not hold for ages 17 and below or ages 27 and above; above age 27, widowhood becomes a factor. The results are also robust to varying the criteria for educated from 'currently enrolled in school or 7 years of education' to 'currently enrolled in school and varying years of education to between 6 and 12.'[19]

1.5.2 Hazard Estimates, by Female HIV Status and Education

In Table 6, I test the theoretical predictions over search behavior, by HIV infection status of educated and uneducated females. The model predicts that (1) educated females delay marriage relative to uneducated females, and that the marriage gap is (2) increasing in HIV rates among the uninfected and (3) decreasing in HIV rates among the infected.[20] That is, the uneducated-educated marriage gap is closing for infected

[19]The HIV point estimates get stronger for educated females by increasing the number of years of education, sequentially, from 7 to 12 (stricter cut-off) and weaker for uneducated females. Vice versa, the HIV point estimate gets stronger for uneducated females by lowering the cut-off number of years of education from 7 to 6. Finally, the results are robust to varying the criteria for the educated binary from 'currently enrolled in school or 7 years of education' to simply '7 years of education'.

[20]Model prediction (1) is driven by assuming a higher outside option for educated females, and (2) and (3) are driven by the lower HIV transmission probability for educated than uneducated females. Crucially, I assume an altruistic disutility is received by an infected individual who infects an uninfected partner. Where HIV rates are high, an infected individual who is matched with an infected partner

females as HIV rates rise, as it is easier for both to assortatively match on HIV status.[21] Also, the marriage gap is increasing for uninfected females as HIV rates rise, as it is harder to match on unobservable partner HIV status.

Table 6 displays Weibull hazard rate regressions of female time to marriage, with the effect of HIV rates on the hazard varying by female education and female HIV status.[22] The results appear to confirm the selective search process of 20-24 year-old educated uninfected females. The higher are HIV rates, the less likely they are to marry in the next year, conditional on having been unmarried up until that point. *All other types* of females – all uneducated and the infected educated – who have been single up until that point, have a *higher probability of marrying* in the next year, the higher are HIV rates.

The hazard estimates highlight that high HIV rates are conducive to matching for

knows there are potentially higher quality infected partners that she may draw next period if she rejects the current partner. Because of the disutility from infecting an uninfected draw, an educated female is more likely to reject in search of a better quality infected match than is an uneducated female, as the educated are more likely to use condoms and less likely to infect an uninfected draw. An infected female, then, is likely to wait longer to marry – the higher are HIV rates – if she is educated than uneducated.

[21]The focus group of HIV-infected college-age men and women I conducted in Kisumu, Kenya in August 2010 made clear the notion that infected individuals, with 30 years of lifespan remaining, wish to marry just as uninfected individuals do. The only difference is that they would like to match with an infected partner.

[22]Let duration be the length of time, in years, until an individual is married; i.e. their age at first marriage. Although the duration is rounded to the nearest year, I treat duration as a continuous variable with an Weibull distribution. The data are flow data on a random sample surveyed between April and October 2007. The data are retrospective in that individuals reported their age at first marriage and their current marital status. Because of the different dates of birth but same survey year, the entry into observation differs while the censoring time is the same. The duration of time until marriage varies from 20-24 years. Due to the right-censoring of the flow data (not all females are married in the sample), I make the assumption that the actual (unobserved) duration of time to marriage is the minimum of the observed duration and the censoring time.

infected females, even educated infected females. High HIV rates increase the hazard for uninfected uneducated females. That is, uninfected uneducated females marry sooner in high-HIV than low-HIV areas. This is consistent with the statistic that uneducated-female couples are more likely to have the same HIV status *without HIV testing* than are educated-female couples; i.e. older, uninfected males have targeted these no-risk females before their sexual debut in high-HIV areas. Uninfected educated females delay marriage in high-HIV relative to low-HIV areas to selectively search for a partner who will use condoms and get HIV tested, so that they may positively assortatively match as well. The estimate of p of roughly 6.5 indicates positive duration dependence: for a particular unmarried person, the rate of marriage increases with age.

1.5.3 Grouped Logit Results

Table 7 presents grouped logit marginal effects. The grouped data and clustered standard errors are at the region-rural level, with the log odds of female marriage as the dependent variable. There are 824 educated 20-24 year-old females and 581 uneducated 20-24 year-old females. I find that the results hold even more strongly when applied to the micro data: a 10 percentage point increase in male HIV rates is associated with an 18 *percent* decline in the odds of marriage for an educated female and a 12 *percent* increase in the odds of marriage for an uneducated female. However, less than 10% of the variation in individual marriage behavior is explained.

1.6 Discussion

Taken together, the results by female education and female HIV status isolate selective search processes and help tie the previous literature together. Magruder suggests that an age-death profile that is decreasing after age 30 is driven by declining HIV risk after age 30, which is consistent with a model of spousal search. His review of the literature points to a model of marriage explaining increasing HIV risk past age 30. Given this, I find that educated females in high-HIV areas face most of their HIV risk in marriage and that educated females in low-HIV areas AND all uneducated females face most of their HIV risk in spousal search.

Figures 8-9 display female HIV rate-'age at marriage' profiles, by female education and high/low HIV region. A significantly higher HIV risk is posed through spousal search than marriage for the uneducated in high- and low-HIV regions and for the educated in low-HIV regions – those who are less likely to use condoms when single. This is consistent with late marriage as an HIV risk factor for the sexually active [4], [20], [13], [36]. My results confirm that late marriage is an HIV risk factor *for those who have unprotected pre-marital sex*: the uneducated in high- and low-HIV regions and the educated in low-HIV regions. The HIV rate-age at marriage profiles of these three groups show that high rates of HIV infection occur by staying single – through spousal search rather than marriage. This is because educated females in regions where there is a low probability of being matched with an infected partner use condoms as infrequently as the uneducated do in high-risk regions. Average HIV rates are increasing until age 30 and declining after that for those who face some pre-marital HIV risk. This is consistent with most females who face a pre-marital risk of HIV infection being infected through spousal search and having declining HIV-infection profiles and death profiles after age 30.

Figures 8-9 also depict a relatively higher HIV risk posed until the mid-20s through marriage rather than through spousal search for the educated in high-HIV regions – those who can enforce condom use when single. This is consistent with early marriage as a risk factor for sexually-active females [7], [11]. My results confirm that early marriage is an HIV risk factor *for those who face little to no pre-marital HIV risk*: the educated in high-HIV regions. A higher risk is posed through marriage relative to spousal search for those who face little to no pre-marital HIV risk–those who are sexually inactive until marriage and those who use condoms when single. For those not exposed to pre-marital HIV risk, the HIV risk in marriage – given unprotected sex with one's husband and the chance that he has an infected extra-marital partner – is higher than when single. The HIV rate-age at marriage profile of this one group shows that the HIV risk from within marriage is increasing as one ages. The expectation is that the increasing HIV rate-age at marriage profile will be more pronounced as the time frame rolls out, as females older than 35 in 2007 were not exposed to HIV during spousal search, given the timing of the epidemic. This is consistent with most females who face little to no pre-marital HIV risk being infected through marriage and having increasing HIV-infection profiles and death profiles through age 30.

1.7 Conclusion

In both developed and developing countries, the average female waits until she has finished school to get married. Because of this, marriage rates are expected to be higher for less-educated than more-educated female teenagers. Some remaining gap in marriage rates would be expected even once nearly all females are done with schooling in their early 20s. Yet there would be no reason to suspect, at first glance, that the marriage gap would be any different in high- or low-HIV regions. In this paper, I document that a gap in marriage rates exists between uneducated and educated females that is considerably larger in high- than low-HIV regions.

Consistent with a search model, educated females do eventually want to marry, they simply face a friction in the marriage market in unobservable partner HIV status; this friction causes educated females to carry out a selective spousal search in high-HIV regions, which delays marriage. This paper's main contribution is demonstrating that marriage is optimal by age 20 – but no younger than 18 – for females who cannot safeguard against HIV risk when single, and that spousal search is optimal through the mid-20s for females at high risk of HIV infection who *can* enforce condom use.

Further implications of my findings include non-pecuniary benefits to education. The results imply that females might benefit a lot from education, over and above mere earnings differences. The conventional wisdom is that HIV lessens the incentives to get an education because life expectancy shrinks. But the implications here are the opposite, since being better educated can have significant health benefits. Thus, pecuniary returns to female education are likely to underestimate the actual rates of return since they miss conceivably substantial health-related benefits.

Figure 1.

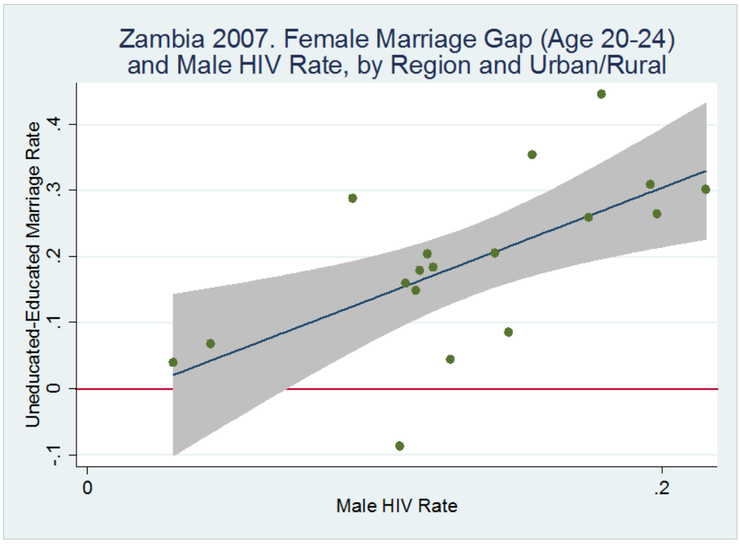


Figure 2.

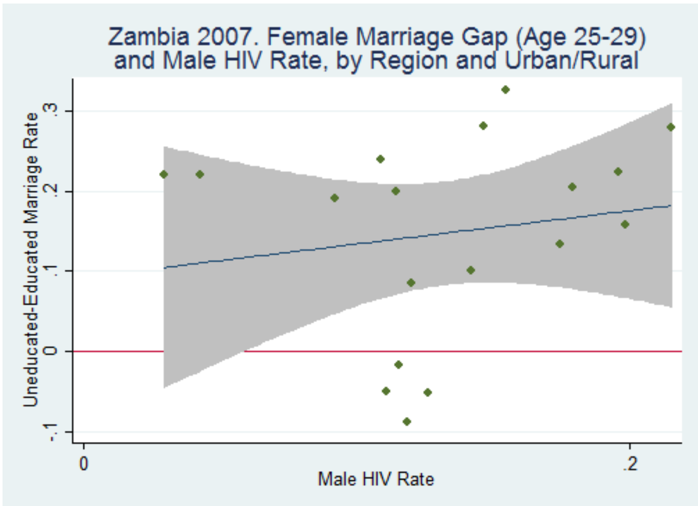


Figure 3.

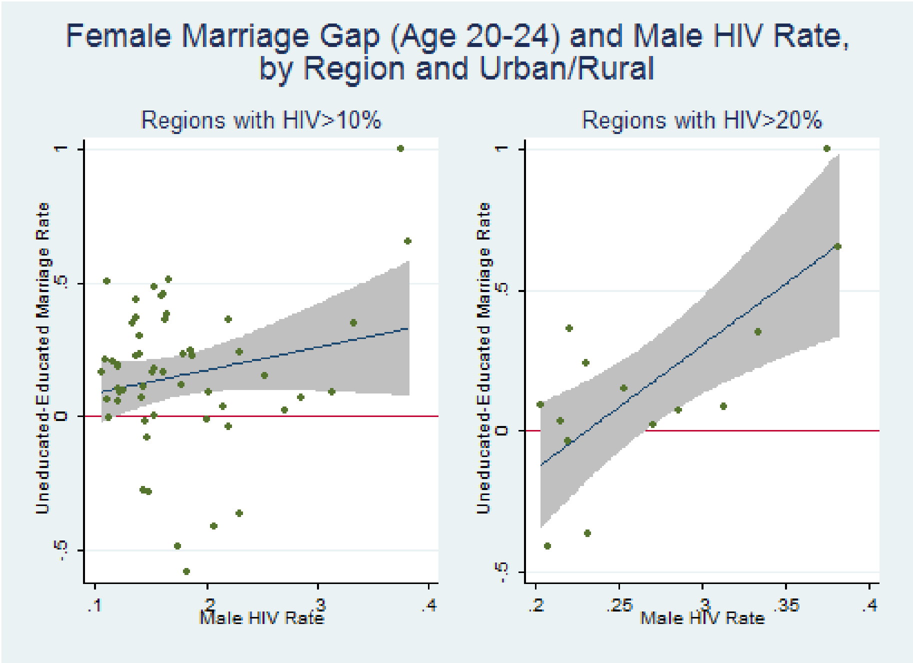


Figure 4.

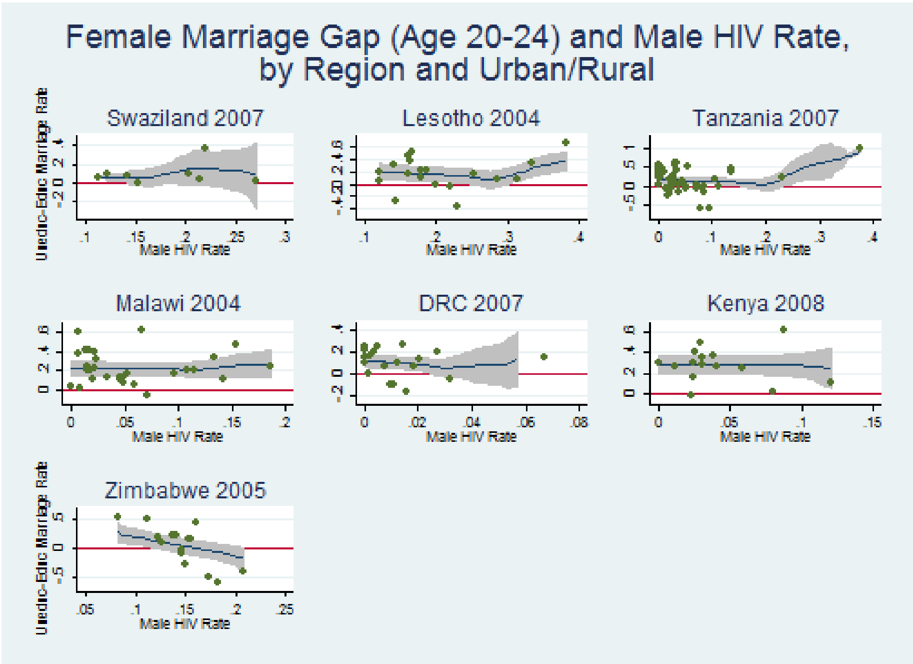
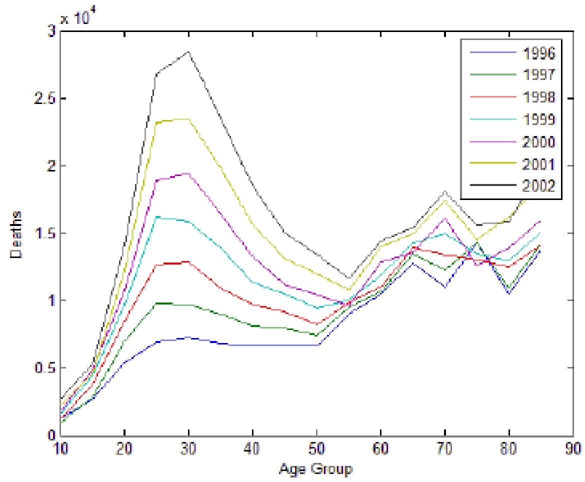


Figure 5. From Magruder (2008). South Africa



Women's Deaths by Age, 1996-2002

Table 1.

Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
20-24 Year-Old Females					
Married Binary	1405	0.65	0.48	0	1
Educated Binary: At Least 7 Years Education	1405	0.57	0.50	0	1
Currently In School Binary	1405	0.06	0.25	0	1
Years of Schooling	1405	6.77	3.81	0	18
Urban Binary	1405	0.43	0.50	0	1
Female Watches TV at Least Once/Week Binary	1405	0.30	0.46	0	1
Female Listens to Radio at Least Once/Week Binary	1404	0.58	0.49	0	1
Female Reads News at Least Once/Week Binary	1403	0.21	0.40	0	1
Females					
Female Employed Binary	7131	0.47	0.50	0	1
Males					
Married Binary	6277	0.55	0.50	0	1
Educated Binary: At Least 7 Years Education	6277	0.73	0.44	0	1
Currently In School Binary	6277	0.22	0.41	0	1
Years of Schooling	6277	7.71	3.53	0	20
Urban Binary	6277	0.43	0.50	0	1
Male Employed Binary	6257	0.77	0.42	0	1
Male Circumcised Binary	6272	0.13	0.33	0	1
Male HIV-infected	4980	0.12	0.33	0	1
All					
Distance to Origin of Epidemic (km)	13423	1031.55	169.01	557.06	1337.31
Log Distance to Origin of Epidemic	13423	6.92	0.17	6.32	7.20
Latitude	13423	-13.53	2.18	-17.87	-8.46
Longitude	13423	28.77	2.47	22.10	33.56
Instruments for Male HIV at Region x Rural Level					
Male Circumcision Rate	18	0.17	0.21	0.02	0.74
Log Distance to Origin of Epidemic	18	6.90	0.19	6.58	7.15
Latitude	18	-13.54	2.21	-17.11	-10.00

All variables are weighted.

Table 2.

Observable Characteristics of Males who Did/Did Not Consent to HIV Testing

	Male Consented to HIV Testing		
	Yes	No	Difference
Male Age	29.41	28.70	0.71**
Male Currently Enrolled in School Binary	0.21	0.22	-0.01
Male Highest Year of Schooling	7.69	7.75	-0.06
Urban Binary	0.41	0.51	-0.10***
Male Circumcised Binary	0.12	0.14	-0.02
Male Employed Binary	0.77	0.77	0.00
Latitude	-13.54	-13.57	0.04
Longitude	28.83	28.67	0.16
Distance from Origin of Epidemic	1036.51	1018.15	18.36
N	4980	1297	
Percent	0.79	0.21	

Tables 3a & 3b.

Zambia 2007. % Condom Use Last Sex, 20-24 Year-Old Females

	Never Married			Currently Married		
	Educated	Uneducated	Difference	Educated	Uneducated	Difference
High HIV Region	0.55	0.44	0.11	0.10	0.08	0.02
N	113	25		238	172	
Low HIV Region	0.33	0.04	0.29**	0.08	0.08	0.00
N	33	16		192	276	
Difference	0.21***	0.39***		0.02	0.00	

Note: High HIV Region considered > 12% HIV-positive

Zambia 2007. % Condom Use Last Sex, Never-Married Females

	Age 19-24			Age 19-25			Age 19-26			Age 18-26			Age 18-27		
	Educ	Uneduc	Diff	Educ	Uneduc	Diff	Educ	Uneduc	Diff	Educ	Uneduc	Diff	Educ	Uneduc	Diff
High HIV Region	0.58	0.34	0.24***	0.58	0.31	0.26***	0.55	0.36	0.20***	0.53	0.38	0.15**	0.54	0.37	0.17**
N	148	32		162	34		173	36		194	62		210	64	
Low HIV Region	0.32	0.14	0.18*	0.33	0.14	0.20*	0.32	0.13	0.19	0.31	0.16	0.15	0.32	0.18	0.13
N	59	22		68	23		71	24		82	39		84	40	
Difference	0.26***	0.19*		0.24***	0.18*		0.23***	0.22**		0.22***	0.22**		0.22***	0.19*	

Note: High HIV Region considered > 12% HIV-positive

Table 4.

Zambia 2007. Female Sexual Behavior, 20-24 Year-Olds, By Education, Marital Status, HIV Region

	Never Married					Currently Married				
	Educated		Uneducated		Difference	Educated		Uneducated		Difference
	N	Statistic	N	Statistic		N	Statistic	N	Statistic	
High HIV Region										
% Virgin	240	0.32	174	0.14	0.17**	257	0	39	0	0
# Lifetime Sexual Partners	238	2.05	174	2.52	-0.47	187	1.98	35	1.80	0.18
% Ever Tested	238	0.42	174	0.49	-0.07	257	0.79	38	0.49	0.30***
Low HIV Region										
% Virgin	194	0.24	281	0.12	0.12	75	0	25	0	0
# Lifetime Sexual Partners	193	1.67	281	2.00	-0.33	55	1.69	22	1.58	0.11
% Ever Tested	194	0.39	280	0.28	0.11	75	0.46	25	0.28	0.18***
Difference										
% Virgin		0.07		0.02			0		0	
# Lifetime Sexual Partners		0.37		0.51			0.29		0.23*	
% Ever Tested		0.03		0.21			0.33***		0.21***	

Note: High HIV Region considered > 12% HIV-positive

Figure 6.

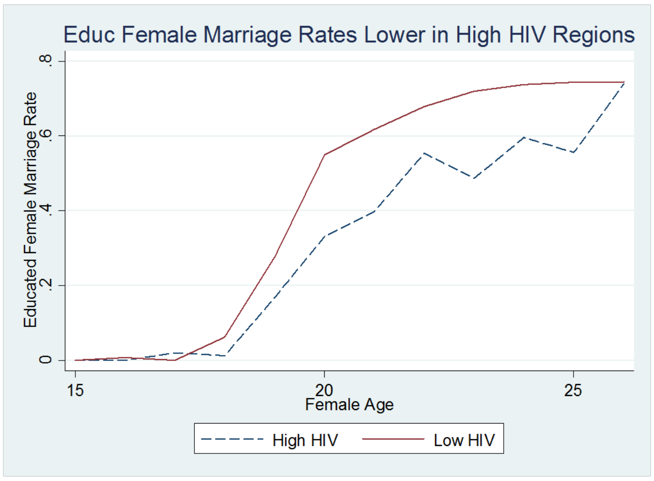


Figure 7.

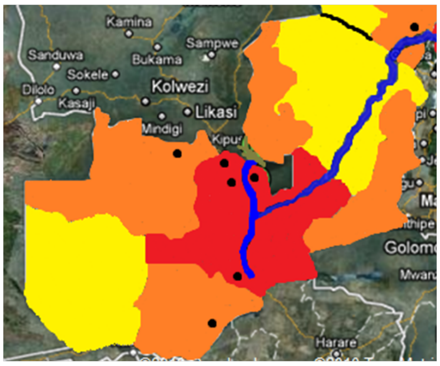


Table 5.

Dependent Variable: Educated or Uneducated Female Marriage Rate of 20-24 Year-Olds, by Region-Rural in Zambia 2007

	(1)		(2)		(3)		(4)		(5)	
Panel A. OLS Estimates	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Male HIV Rate	-1.92***	-0.26	-0.86	1.15*	-0.74	1.42**	-0.99*	1.17*	-1.09*	1.21*
	(.55)	(.65)	(.59)	(.65)	(.42)	(.57)	(.47)	(.66)	(.51)	(.66)
Urban Binary			-0.16**	-0.22***	-0.19**	-0.05	-0.23**	-0.09	-0.24**	-0.08
			(.06)	(.06)	(.08)	(.11)	(.09)	(.12)	(.10)	(.14)
Male Education Rate					0.47	-0.47	0.64*	-0.31	0.42	-0.36
					(.32)	(.43)	(.35)	(.49)	(.41)	(.64)
Male Employment Rate					0.78***	0.82**	0.71**	0.75**	0.76**	0.69
					(.24)	(.32)	(.24)	(.33)	(.28)	(.40)
Female Employment Rate							-0.16	-0.16	-0.06	-0.09
							(.14)	(.20)	(.17)	(.22)
Female Access to Informatio	No	No	No	No	No	No	No	No	Yes	Yes
N	18	18	18	18	18	18	18	18	18	18
Adjusted R-squared	0.40	0.01+	0.59	0.37	0.79	0.52	0.80	0.51	0.78	0.52

+ R-squared

	(1)		(2)		(3)		(4)		(5)	
Panel B. IV Estimates	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Male HIV Rate	-0.25	1.55	-0.16	1.70**	-0.70*	1.62***	-0.90**	1.39**	-1.19***	1.18**
	(1.04)	(1.19)	(.72)	(.78)	(.40)	(.55)	(.44)	(.61)	(.40)	(.48)
Urban Binary			-0.21***	-0.25***	-0.19***	-0.06	-0.23***	-0.09	-0.24***	-0.08
			(.06)	(.07)	(.07)	(.10)	(.07)	(.10)	(.07)	(.10)
Male Education Rate					0.46*	-0.50	0.62**	-0.36	0.43	-0.35
					(.27)	(.37)	(.29)	(.40)	(.29)	(.45)
Male Employment Rate					0.78***	0.84***	0.72***	0.78***	0.75***	0.68**
					(.20)	(.27)	(.20)	(.28)	(.20)	(.28)
Female Employment Rate							-0.15	-0.13	-0.08	-0.10
							(.12)	(.17)	(.12)	(.16)
Female Access to Informatio	No	No	No	No	No	No	No	No	Yes	Yes
N	18	18	18	18	18	18	18	18	18	18

	(1)		(2)		(3)		(4)		(5)	
	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Underidentification Test	7.1 (.07)	7.1 (.07)	10.9 (.01)	10.9 (.01)	14.5 (.00)	14.5 (.00)	13.8 (.00)	13.8 (.00)	14.5 (.00)	17.4 (.00)
Weak Identification Test: A-P F test of excluded instruments										
	3.0 (.07)	3.0 (.07)	6.6 (.01)	6.6 (.01)	15.2 (.00)	15.2 (.00)	11.1 (.00)	11.1 (.00)	9.8 (.01)	66.6 (.00)
Overidentification Test	1.8 (0.40)	0.9 (.65)	4.5 (0.11)	2.2 (.33)	0.6 (.75)	3.6 (.16)	2.2 (.33)	3.3 (.19)	6.1 (.05)	4.9 (.09)

Table 6.

Estimated Weibull Hazard of Female Time Until Marriage: Coefficients

	Weibull Hazard Coefficient				
	(1)	(2)	(3)	(4)	(5)
Male HIV Rate x Female Uninfected x	-1.66	1.93	7.03*	3.86**	3.88**
Female Uneducated	(1.65)	(1.47)	(1.94)	(1.95)	(1.96)
Male HIV Rate x Female Uninfected x	-0.84	-3.50*	-1.73***	-2.08**	-1.69
Female Educated	(1.41)	(0.79)	(0.90)	(1.06)	(1.14)
Male HIV Rate x Female Infected x Female	-4.2	3.86	21.04*	21.25*	24.49*
Uneducated	(3.12)	(3.82)	(4.40)	(5.25)	(6.31)
Male HIV Rate x Female Infected x Female	3.61	5.76***	9.66*	8.00**	6.63**
Educated	(2.27)	(3.11)	(3.54)	(3.16)	(2.82)
Controls for Years of Schooling	Yes	Yes	Yes	Yes	Yes
Controls for Urban	No	Yes	Yes	Yes	Yes
Controls for Male Education, Employment	No	No	Yes	Yes	Yes
Controls for Female Employment	No	No	No	Yes	Yes
Controls for Female Information	No	No	No	No	Yes
p	6.51***	6.65***	6.84***	6.92***	6.97***
	(0.30)	(0.30)	(0.31)	(0.32)	(0.32)
N	1104	1104	1104	1104	1102

Clustered standard errors in parentheses

Table 7.

Grouped (Blocked) Logit Marginal Effects of Female Marriage, Zambia 2007
Dependent Variable: Log Odds of Female Marriage of 20-24 Year-Olds, at the Region-Rural Level

	(1)		(2)		(3)		(4)		(5)	
	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Male HIV Rate	-3.77*	-0.51	-1.70**	0.86	-1.43	1.68**	-1.74***	0.72	-1.78***	1.18
	(0.67)	(0.48)	(0.87)	(0.63)	(0.87)	(0.67)	(0.95)	(0.78)	(0.96)	(0.83)
Urban Binary			-0.30*	-0.26*	-0.31***	0.08	-0.37***	-0.12	-0.38***	-0.13
			(0.08)	(0.08)	(0.18)	(0.14)	(0.19)	(0.17)	(0.20)	(0.20)
Male Education Rate					0.75	-1.04**	1.01	-0.27	0.69	-0.4
					(0.66)	(0.52)	(0.73)	(0.63)	(0.79)	(0.91)
Male Employment Rate					1.47*	1.65*	1.39*	1.13**	1.49**	1.24**
					(0.51)	(0.41)	(0.52)	(0.45)	(0.58)	(0.56)
Female Employment Rate							-0.31	-0.44**	-0.14	-0.08
							(0.36)	(0.20)	(0.41)	(0.27)
Female Watches TV at Least Once/Week Binary									0.15	-0.3
									(0.32)	(0.36)
Female Reads News at Least Once/Week Binary									-0.14	0.33
									(0.28)	(0.84)
Female Listens to Radio at Least Once/Week Binary									0.43	0.61**
									(0.49)	(0.25)
Pseudo R-squared	0.03	0.002	0.04	0.02	0.05	0.05	0.05	0.06	0.05	0.07
N	824	581	824	581	824	581	824	581	824	581

*Standard errors clustered at the region-rural level

Figure 8.

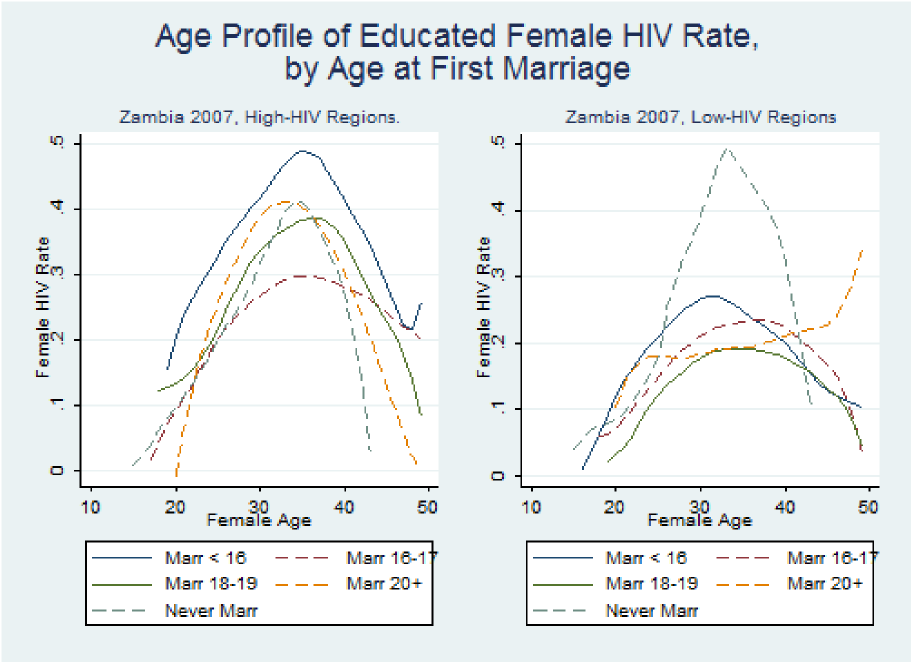
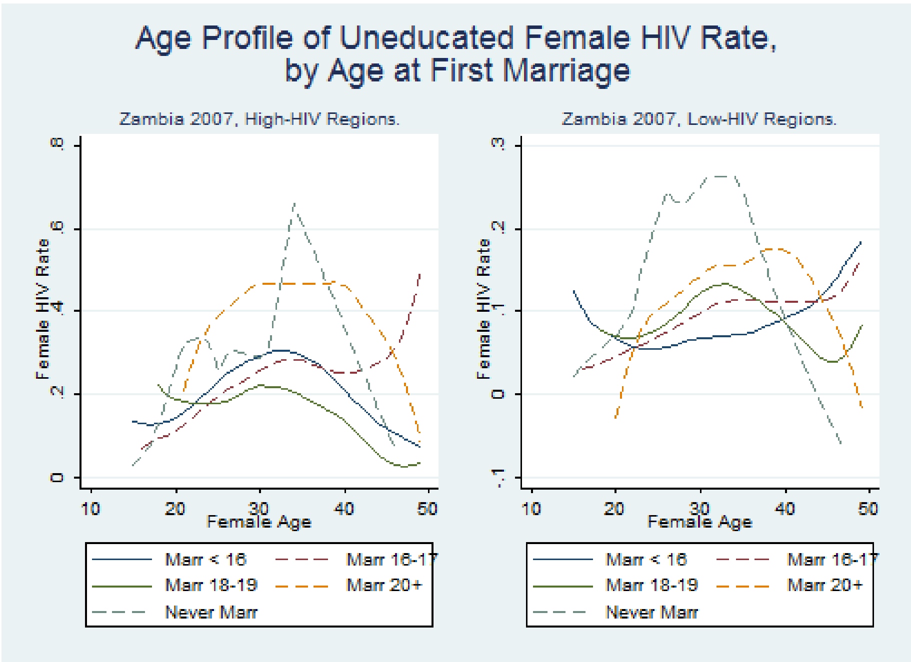


Figure 9.



1.8 Appendix

1.8.1 Solving for Reservation Partner Quality

Uninfected Individual Matches with Uninfected Partner

The value function for an *uninfected* single individual i who draws a marriage offer with an *uninfected* partner j, $v(x_j, HIV_j^-|HIV_i^-)$, with $x_{(j)}^{HIV_i}$, satisfies the Bellman equation:

$$v(x_j, HIV_j^-|HIV_i^-) = max\{\frac{x_{(-)}^{HIV^-}}{1-\beta}, V_0 + \beta[(1-\Pi)\int v(x_{(-)}^{HIV^-}|HIV_i^-)dF(x')+ \quad (1.2)$$

$$\Pi(1-P)\int v(x_{(+)}^{HIV^-}|HIV_i^-)dF(x') + \Pi P\int (v(x_{(+)}^{HIV^+}|HIV_i^+) - D)dF(x')]$$

Its solution will be of the form:

$$v(x_j, HIV_j^-|HIV_i^-) = \{\frac{\overline{x}_{(-)}^{HIV^-}}{1-\beta} = V_0 + \beta[(1-\Pi)\int_0^B v(x_{(-)}^{HIV^-}|HIV_i^-)dF(x')+ \quad (1.3)$$

$$\Pi(1-P)\int_0^B v(x_{(+)}^{HIV^-}|HIV_i^-)dF(x')+\Pi P\int_0^B (v(x_{(+)}^{HIV^+}|HIV_i^+)-D)dF(x')], if \quad x \leq \overline{x}$$

$$= \{\frac{x_{(-)}^{HIV^-}}{1-\beta}, if \quad x \geq \overline{x}$$

Using equation (2), we can convert the functional equation (1) into an ordinary equation in the reservation value, $\overline{x}_{(-)}^{HIV^-}$. Evaluating $v(\overline{x}_j, HIV_j^-|HIV_i^-)$ and using equation (2), we have:

$$\frac{\overline{x}_{(-)}^{HIV^-}}{1-\beta}[\int_0^{\overline{x}_{(-)}^{HIV^-}} dF(x') + \int_{\overline{x}_{(-)}^{HIV^-}}^B dF(x')] = V_0 + \beta[\int_0^{\overline{x}_{(-)}^{HIV^-}} \frac{\overline{x}_{(-)}^{HIV^-}}{1-\beta}dF(x')+$$

$$(1-\Pi)\int_{\overline{x}_{(-)}^{HIV^-}}^B \frac{x'^{HIV^-}_{(-)}}{1-\beta}dF(x') + \Pi(1-P)\int_{\overline{x}_{(-)}^{HIV^-}}^B \frac{x'^{HIV^-}_{(+)}}{1-\beta}dF(x') +$$

$$\Pi P\int_{\overline{x}_{(-)}^{HIV^-}}^B \frac{x'^{HIV^+}_{(+)}-D}{1-\beta}dF(x')]$$

or

$$\overline{x}_{(-)}^{HIV^-}\int_0^{\overline{x}^{HIV^+}} dF(x') - V_0 = -\frac{\overline{x}_{(-)}^{HIV^-}}{1-\beta}\int_{\overline{x}^{HIV^+}}^B dF(x')$$

$$\beta[(1-\Pi)\int_{\overline{x}^{HIV-}_{(-)}}^{B}\frac{x'^{HIV^-}_{(-)}}{1-\beta}dF(x')+\Pi(1-P)\int_{\overline{x}^{HIV-}_{(-)}}^{B}\frac{x'^{HIV^-}_{(+)}}{1-\beta}dF(x')+$$
$$\Pi P\int_{\overline{x}^{HIV-}_{(-)}}^{B}\frac{x'^{HIV^+}_{(+)}-D}{1-\beta}dF(x')]$$

Adding $\overline{x}^{HIV-}_{(-)}\int_{\overline{x}^{HIV-}_{(-)}}^{B}dF(x')$ to both sides gives:

$$\overline{x}^{HIV-}_{(-)}-V_0=\frac{\beta}{1-\beta}[(1-\Pi)\int_{\overline{x}^{HIV-}_{(-)}}^{B}(x'^{HIV-}_{(-)}-\overline{x}^{HIV-}_{(-)})dF(x')+$$

$$\Pi(1-P)\int_{\overline{x}^{HIV-}_{(-)}}^{B}(x'^{HIV-}_{(+)}-\overline{x}^{HIV-}_{(-)})dF(x')+\Pi P\int_{\overline{x}^{HIV-}_{(-)}}^{B}(x'^{HIV+}_{(+)}-D-\overline{x}^{HIV-}_{(-)})dF(x')]$$

In order to evaluate $\int_{\overline{x}}^{B}(x'-\overline{x})dF(x')$, I assume an exponential functional form for the CDF of F(x), F(x)=1 $-$ e^{-x}. Notice that F(0)=0, F(B)=1-e^{-B}=1 and therefore e^{-B}=0, and that F(x) is differentiable, with derivative $F'(x)=e^{-x}$. Using integration by parts: $\int_{\overline{x}}^{B}(x-\overline{x})dF(x)=\frac{1}{\lambda}e^{-\lambda x}$.

$$\overline{x}^{HIV-}_{(-)}-V_0=\frac{\beta}{1-\beta}[(1-\Pi)\frac{1}{\lambda}e^{-\lambda\overline{x}^{HIV-}_{(-)}}+\Pi(1-P)\frac{1}{\lambda}e^{-\lambda\overline{x}^{HIV-}_{(-)}}+\Pi P(\frac{1}{\lambda}-D)e^{-\lambda\overline{x}^{HIV-}_{(-)}}]$$

or

$$\overline{x}^{HIV-}_{(-)}-V_0=\frac{\beta}{1-\beta}[(\frac{1}{\lambda}-\Pi PD)e^{-\lambda\overline{x}^{HIV-}_{(-)}}]$$

This equation characterizes the determination of the reservation value of partner quality $\overline{x}^{HIV-}_{(-)}$ for an infected individual draws a marriage offer. The left side is the cost of searching one more time when an offer $\overline{x}^{HIV-}_{(-)}$ is in hand. The right side is the expected benefit of searching one more time in terms of the expected present value associated with drawing $x'>\overline{x}^{HIV-}_{(-)}$. This equation instructs the uninfected agent to set $\overline{x}^{HIV-}_{(-)}$ so that the cost of searching one more time equals the benefit.

Infected Individual Matches with Uninfected Partner

The value function for *infected* single individuals who draw a marriage offer with an *uninfected* partner, $v(x_j, HIV_j^-|HIV_i^+)$, satisfies the Bellman equation:

$$v(x_j, HIV_j^-|HIV_i^+) = max\{\frac{x_{(-)}^{HIV^+} - \overline{V}P}{1-\beta}, V_0 +$$

$$\beta[(1-\Pi)\int(v(x_{(-)}^{HIV^+}|HIV^+) - \overline{V}P)dF(x') + \Pi\int v(x_{(+)}^{HIV^+}|HIV^+)dF(x')]$$

Its solution will be of the form:

$$v(x_j, HIV_-|HIV^+) = \{\frac{(\overline{x}_{(-)}^{HIV^+} - \overline{V}P)}{1-\beta} = V_0 +$$

$$\beta[(1-\Pi)\int_0^B(v(x_{(-)}^{HIV^+}|HIV^+) - \overline{V}P)dF(x') + \Pi\int_0^B v(x_{(+)}^{HIV^+}|HIV^+)dF(x')], if \quad x \leq \overline{x}$$

$$= \{\frac{x_{(-)}^{HIV^+}}{1-\beta}, if \quad x \geq \overline{x}$$

Evaluating $v(\overline{x}_j, HIV_j^-|HIV_i^+)$, we have:

$$\frac{\overline{x}_{(-)}^{HIV^+}}{1-\beta}[\int_0^{\overline{x}_{(-)}^{HIV^+}} dF(x') + \int_{\overline{x}_{(-)}^{HIV^+}}^B dF(x')] = V_0 + \beta[\int_0^{\overline{x}_{(-)}^{HIV^+}} \frac{\overline{x}_{(-)}^{HIV^+} - \overline{V}P}{1-\beta}dF(x') +$$

$$(1-\Pi)\int_{\overline{x}_{(-)}^{HIV^+}}^B \frac{x'^{HIV^+}_{(-)} - \overline{V}P}{1-\beta}dF(x') + \Pi\int_{\overline{x}_{(+)}^{HIV^+}}^B \frac{x'^{HIV^+}_{(+)}}{1-\beta}dF(x')]$$

Adding $(\overline{x}_{(-)}^{HIV^+} - \overline{V}P)\int_{\overline{x}_{(-)}^{HIV^+}}^B dF(x')$ to both sides gives:

$$\overline{x}_{(-)}^{HIV^+} - \overline{V}P - V_0 = \frac{\beta}{1-\beta}[(1-\Pi)\int_{\overline{x}_{(-)}^{HIV^+}}^B (x'^{HIV^+}_{(-)} - \overline{V}P - (\overline{x}_{(-)}^{HIV^+} - \overline{V}P))dF(x') +$$

$$\Pi\int_{\overline{x}_{(-)}^{HIV^+}}^B (x'^{HIV^+}_{(+)} - (\overline{x}_{(-)}^{HIV^+} - \overline{V}P))dF(x')]$$

or

$$\overline{x}_{(-)}^{HIV^+} - \overline{V}P - V_0 = \frac{\beta}{1-\beta}[(1-\Pi)\frac{1}{\lambda}e^{-\lambda\overline{x}_{(-)}^{HIV^+}} + \Pi(\frac{1}{\lambda} + \overline{V}P)e^{-\lambda\overline{x}_{(-)}^{HIV^+}}]$$

or

$$\overline{x}_{(-)}^{HIV^+} - \overline{V}P - V_0 = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} + \Pi P\overline{V})e^{-\lambda\overline{x}_{(-)}^{HIV^+}}]$$

Infected Individual Matches with Infected Partner

The value function for *infected* single individuals who draw a marriage offer with an *infected* partner, $v(x_j, HIV_j^+|HIV_i^+)$, satisfies:

$$v(x_j, HIV_j^+|HIV_i^+) = max\{\frac{x_{(+)}^{HIV^+}}{1-\beta}, V_0 + \beta[(1-\Pi)(1-P)\int v(x_{(-)}^{HIV^+}|HIV^+)dF(x')+$$

$$(1-\Pi)P\int(v(x_{(+)}^{HIV^+}|HIV^+) - \overline{V})dF(x') + \Pi\int v(x_{(+)}^{HIV^+}|HIV^+)dF(x')]$$

Its solution will be of the form:

$$v(x_j, HIV_+|HIV^+) = \{\frac{\overline{x}_{(+)}^{HIV^+}}{1-\beta} = V_0 + \beta[(1-\Pi)(1-P)\int_0^B v(x_{(-)}^{HIV^+}|HIV_i^+)dF(x')+$$

$$(1-\Pi)P\int_0^B(v(x_{(+)}^{HIV^+}|HIV_i^+) - \overline{V})dF(x') + \Pi\int_0^B v(x_{(+)}^{HIV^+}|HIV_i^+)dF(x')], if \quad x \leq \overline{x}$$

$$= \{\frac{x_{(+)}^{HIV^+}}{1-\beta}, if \quad x \geq \overline{x}$$

Evaluating $v(\overline{x}_j, HIV_j^+|HIV_i^+)$ and using equation (2), we have:

$$\frac{\overline{x}_{(+)}^{HIV^+}}{1-\beta}[\int_0^{\overline{x}_{(+)}^{HIV^+}} dF(x') + \int_{\overline{x}_{(+)}^{HIV^+}}^B dF(x')] = V_0 + \beta[\int_0^{\overline{x}_{(+)}^{HIV^+}} \frac{\overline{x}_{(+)}^{HIV^+}}{1-\beta}dF(x')$$

$$+(1-\Pi)(1-P)\int_{\overline{x}_{(+)}^{HIV^+}}^B \frac{x'^{HIV_{(-)}^+}}{1-\beta}dF(x')+$$

$$(1-\Pi)P\int_{\overline{x}_{(+)}^{HIV^+}}^B \frac{x'^{HIV_{(+)}^+} - \overline{V}}{1-\beta}dF(x') + \Pi\int_{\overline{x}_{(+)}^{HIV^+}}^B \frac{x'^{HIV_{(+)}^+}}{1-\beta}dF(x')]$$

or

$$\overline{x}_{(+)}^{HIV^+}\int_0^{\overline{HIV^+}_{(+)}} dF(x') - V_0 = -\frac{\overline{x}_{(+)}^{HIV^+}}{1-\beta}\int_{\overline{x}_{(+)}^{HIV^+}}^B dF(x') + \beta[(1-\Pi)(1-P)\int_{\overline{x}_{(+)}^{HIV^+}}^B \frac{x'^{HIV_{(-)}^+}}{1-\beta}dF(x')+$$

$$(1-\Pi)P\int_{\overline{x}_{(+)}^{HIV^+}}^B \frac{x'^{HIV_{(+)}^+} - \overline{V}}{1-\beta}dF(x') + \Pi\int_{\overline{x}_{(+)}^{HIV^+}}^B \frac{x'^{HIV_{(+)}^+}}{1-\beta}dF(x')]$$

Adding $\overline{x}_{(+)}^{HIV^+}\int_{\overline{x}_{(+)}^{HIV^+}}^B dF(x')$ to both sides gives:

$$\overline{x}_{(+)}^{HIV^+} - V_0 = \frac{\beta}{1-\beta}[(1-\Pi)(1-P)\int_{\overline{x}_{(+)}^{HIV^+}}^B (x_{(-)}'^{HIV^-} - \overline{x}_{(+)}^{HIV^+})dF(x')+$$

$$(1-\Pi)P\int_{\overline{x}_{(+)}^{HIV^+}}^{B}(x'^{HIV^+}_{(+)}-\overline{V}-\overline{x}_{(+)}^{HIV^+})dF(x')+\Pi\int_{\overline{x}_{(+)}^{HIV^+}}^{B}(x'^{HIV^+}_{(+)}-\overline{x}_{(+)}^{HIV^+})dF(x')]$$

or

$$\overline{x}_{(+)}^{HIV^+}-V_0=\frac{\beta}{1-\beta}[(1-\Pi)(1-P)\frac{1}{\lambda}e^{-\lambda\overline{x}_{(+)}^{HIV^+}}+(1-\Pi)P(\frac{1}{\lambda}-\overline{V})e^{-\lambda\overline{x}_{(+)}^{HIV^+}}+\Pi\frac{1}{\lambda}e^{-\lambda\overline{x}_{(+)}^{HIV^+}}]$$

or

$$\overline{x}_{(+)}^{HIV^+}-V_0=\frac{\beta}{1-\beta}[(\frac{1}{\lambda}-(1-\Pi)P\overline{V})e^{-\lambda\overline{x}_{(+)}^{HIV^+}}]$$

Uninfected Individual Matches with Infected Partner

The value function for *uninfected* single individuals who draw a marriage offer with an *infected* partner, $v(x_j, HIV_j^+|HIV_i^-)$, satisfies:

$$v(x_j,HIV_j^+|HIV_i^-)=max\{\frac{P(x_{(+)}^{HIV^+}-D)+(1-P)x_{(+)}^{HIV^-}}{1-\beta},V_0+$$

$$\beta[P(1-\Pi)(1-P)\int v(x_{(-)}^{HIV^+}|HIV^+)dF(x')+P(1-\Pi)P\int(v(x_{(+)}^{HIV^+}|HIV^+)-\overline{V})dF(x')+$$

$$P\Pi\int v(x_{(+)}^{HIV^+}|HIV^+)dF(x')+(1-P)(1-\Pi)\int v(x_{(-)}^{HIV^-}|HIV^-)dF(x')+$$

$$(1-P)\Pi(1-P)\int v(x_{(+)}^{HIV^-}|HIV^-)dF(x')+(1-P)\Pi P\int(v(x_{(+)}^{HIV^+}|HIV^-)-D)dF(x')]$$

Its solution will be of the form:

$$v(x_j,HIV_+|HIV^-)=\{\frac{P(\overline{x}_{(+)}^{HIV^+}-D)+(1-P)\overline{x}_{(+)}^{HIV^-}}{1-\beta},V_0+$$

$$\beta[P(1-\Pi)(1-P)\int_0^B v(x_{(-)}^{HIV^+}|HIV^+)dF(x')+P(1-\Pi)P\int_0^B(v(x_{(+)}^{HIV^+}|HIV^+)-\overline{V})dF(x')+$$

$$P\Pi\int_0^B v(x_{(+)}^{HIV^+}|HIV^+)dF(x')+(1-P)(1-\Pi)\int_0^B v(x_{(-)}^{HIV^-}|HIV^-)dF(x')+$$

$$(1-P)\Pi(1-P)\int_0^B v(x_{(+)}^{HIV^-}|HIV^-)dF(x')+(1-P)\Pi P\int_0^B(v(x_{(+)}^{HIV^+}|HIV^-)-D)dF(x')],if\quad x\leq\overline{x}$$

$$=\{\frac{P(x_{(+)}^{HIV^+}-D)+(1-P)x_{(+)}^{HIV^-}}{1-\beta},if\quad x\geq\overline{x}$$

Evaluating $v(\overline{x}_j, HIV_+|HIV^-)$ and using equation (2), we have:

$$\frac{P(\overline{x}_{(+)}^{HIV^+}-D)}{1-\beta}[\int_0^{\overline{x}_{(+)}^{HIV^+}} dF(x')+\int_{\overline{x}_{(+)}^{HIV^+}}^{B} dF(x')]\frac{(1-P)\overline{x}_{(+)}^{HIV^-}}{1-\beta}[\int_0^{\overline{x}_{(+)}^{HIV^-}} dF(x')+\int_{\overline{x}_{(+)}^{HIV^-}}^{B} dF(x')]$$

$$= V_0+\frac{\beta}{1-\beta}[P\int_0^{\overline{x}_{(+)}^{HIV^+}} \frac{(\overline{x}_{(+)}^{HIV^+}-D)}{1-\beta}+(1-P)\int_0^{\overline{x}_{(+)}^{HIV^-}} \frac{\overline{x}_{(+)}^{HIV^-}}{1-\beta}$$

$$P(1-\Pi)(1-P)\int_0^{\overline{HIV^+}_{(+)}} x'^{HIV^+}_{(-)}dF(x')+P(1-\Pi)P\int_0^{\overline{HIV^+}_{(+)}} (x'^{HIV^+}_{(+)}-\overline{V})dF(x')+$$

$$P\Pi\int_0^{\overline{HIV^+}_{(+)}} x'^{HIV^+}_{(+)}dF(x')+(1-P)(1-\Pi)\int_0^{\overline{HIV^+}_{(-)}} x'^{HIV^-}_{(-)}dF(x')+$$

$$(1-P)\Pi(1-P)\int_0^{\overline{HIV^+}_{(-)}} x'^{HIV^-}_{(+)}dF(x')+(1-P)\Pi P\int_0^{\overline{HIV^+}_{(-)}} (x'^{HIV^+}_{(+)}-D)F(x')]$$

Adding $P(\overline{x}_{(+)}^{HIV^+}-D)\int_{\overline{x}_{(+)}^{HIV^+}}^{B} dF(x')+(1-P)\overline{x}_{(+)}^{HIV^-}\int_{\overline{x}_{(+)}^{HIV^-}}^{B} dF(x')$ to both sides gives:

$$P(\overline{x}_{(+)}^{HIV^+}-D)+(1-P)\overline{x}_{(+)}^{HIV^-}-V_0=\frac{\beta}{1-\beta}[P(1-\Pi)(1-P)\int_{\overline{x}_{(+)}^{HIV^+}}^{B} x'^{HIV^+}_{(-)}-(\overline{x}_{(+)}^{HIV^+}-D)dF(x')+$$

$$P(1-\Pi)P\int_{\overline{x}_{(+)}^{HIV^+}}^{B} x'^{HIV^+}_{(+)}-\overline{V}-(\overline{x}_{(+)}^{HIV^+}-D)dF(x')+P\Pi\int_{\overline{x}_{(+)}^{HIV^+}}^{B} x'^{HIV^+}_{(+)}-(\overline{x}_{(+)}^{HIV^+}-D)dF(x')+$$

$$(1-P)(1-\Pi)\int_{\overline{x}_{(+)}^{HIV^-}}^{B} x'^{HIV^-}_{(-)}-\overline{x}_{(+)}^{HIV^-}dF(x')+(1-P)\Pi(1-P)\int_{\overline{x}_{(+)}^{HIV^-}}^{B} x'^{HIV^-}_{(+)}-\overline{x}_{(+)}^{HIV^-}dF(x')+$$

$$(1-P)\Pi P\int_{\overline{x}_{(+)}^{HIV^-}}^{B} (x'^{HIV^+}_{(+)}-D)-\overline{x}_{(+)}^{HIV^-}F(x')]$$

or

$$P(\overline{x}_{(+)}^{HIV^+}-D)+(1-P)\overline{x}_{(+)}^{HIV^-}-V_0=\frac{\beta}{1-\beta}[$$

$$P(1-\Pi)(1-P)(\frac{1}{\lambda}+D)e^{-\lambda\overline{x}_{(+)}^{HIV^+}}+P(1-\Pi)P(\frac{1}{\lambda}-\overline{V}+D)e^{-\lambda\overline{x}_{(+)}^{HIV^+}}+P\Pi(\frac{1}{\lambda}+D)e^{-\lambda\overline{x}_{(+)}^{HIV^+}}+$$

$$(1-P)(1-\Pi)\frac{1}{\lambda}e^{-\lambda\overline{x}_{(+)}^{HIV^-}}+(1-P)\Pi(1-P)\frac{1}{\lambda}e^{-\lambda\overline{x}_{(+)}^{HIV^-}}+(1-P)\Pi P(\frac{1}{\lambda}+D)e^{-\lambda\overline{x}_{(+)}^{HIV^-}}]$$

or

$$P(\overline{x}_{(+)}^{HIV^+}-D)+(1-P)\overline{x}_{(+)}^{HIV^-}-V_0=\frac{\beta}{1-\beta}[$$

$$P(\frac{1}{\lambda}-(1-\Pi)P\overline{V}+D)e^{-\lambda\overline{x}_{(+)}^{HIV^+}}+(1-P)(\frac{1}{\lambda}-P\Pi D)e^{-\lambda\overline{x}_{(+)}^{HIV^-}}]$$

1.8.2 Comparative Statics

Uninfected Individual Matches with Uninfected Partner

The comparative statics for an uninfected individual matched with an uninfected partner are first and second derivatives of $h(\overline{x}^{HIV^-}_{(-)}) = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} - \Pi PD)e^{-\lambda\overline{x}^{HIV^-}_{(-)}}]$:

1. $\frac{\partial h(\overline{x}^{HIV^-}_{(-)})}{\partial \Pi} = -\frac{\beta}{1-\beta}PDe^{-\lambda\overline{x}^{HIV^-}_{(-)}} < 0$
2. $\frac{\partial(\frac{\partial h(\overline{x}^{HIV^-}_{(-)})}{\partial \Pi})}{\partial P} = -\frac{\beta}{1-\beta}De^{-\lambda\overline{x}^{HIV^-}_{(-)}} < 0$
3. $\frac{\partial \overline{x}^{HIV^-}_{(-)} - V_0}{\partial V_0}$ <0

Uninfected Individual Matches with Infected Partner

The equation that characterizes the determination of the reservation value of partner quality for an uninfected individual matched with an *infected* partner is:

$$P(\overline{x}^{HIV^+}_{(+)} - D) + (1-P)\overline{x}^{HIV^-}_{(+)} - V_0 = \frac{\beta}{1-\beta}[$$

$$P(\frac{1}{\lambda} - (1-\Pi)P\overline{V} + D)e^{-\lambda\overline{x}^{HIV^+}_{(+)}} + (1-P)(\frac{1}{\lambda} - P\Pi D)e^{-\lambda\overline{x}^{HIV^-}_{(+)}}]$$

with $h(\overline{x}^{HIV^+}_{(-)}) = \frac{\beta}{1-\beta}[P(\frac{1}{\lambda} - (1-\Pi)P\overline{V} + D)e^{-\lambda\overline{x}^{HIV^+}_{(+)}} + (1-P)(\frac{1}{\lambda} - P\Pi D)e^{-\lambda\overline{x}^{HIV^-}_{(+)}}]$. (See Figure A.2).

1. $\frac{\partial h(\overline{x}^{HIV^+}_{(-)})}{\partial \Pi} = \frac{\beta}{1-\beta}[(P^2\overline{V} + D + (\frac{1}{\lambda} - (1-\Pi)P\overline{V} + D))e^{-\lambda\overline{x}^{HIV^+}_{(+)}} + -((\frac{1}{\lambda} - P\Pi D) + (P(1-P)D))e^{-\lambda\overline{x}^{HIV^-}_{(+)}}] < 0$: With HIV rates low, an uninfected individual who rejects a draw with an infected partner has a good chance of finding a high quality uninfected individual next period. As HIV rates increase, finding an uninfected partner becomes less possible, and the standards for partner quality are lowered. That is, as Π increases, the function $h(\overline{x}^{HIV^+}_{(-)})$ falls, which decreases reservation quality $\overline{x}^{HIV^+}_{(-)}$ and waiting time $\overline{N}^{HIV^+}_{(-)}$.

2. $\frac{\frac{\partial h(\overline{x}^{HIV^+}_{(-)})}{\partial \Pi}}{\partial P} = \frac{\beta}{1-\beta}[(\Pi + 2P)\overline{V}e^{-\lambda \overline{x}^{HIV^+}_{(+)}} + (\Pi + 2P - 1)De^{-\lambda \overline{x}^{HIV^-}_{(+)}}] > 0$: As the risk of HIV infection increases, the effect of HIV on the reservation value of partner quality becomes stronger for an infected individual matched with an uninfected partner. The disutility from infecting a partner can cause them to reject the current match and the existence of more infected individuals allows them to increase their reservation value of partner quality, for reasonable parameter values of P, i.e. $P < .5$.

3. $\frac{\partial P(\overline{x}^{HIV^+}_{(+)} - D) + (1-P)\overline{x}^{HIV^-}_{(+)} - V_0}{\partial V_0} < 0$: An increase in the option value decreases the cost of further spousal search, making a delay in marriage possible.

4. Note that the cost of search is also decreasing in the infection rate, P. An increase in P lowers the intercept on search, increasing reservation partner quality further and allowing for a delay in marriage.

Infected Individual Matches with Infected Partner

The equation that characterizes the determination of the reservation value of partner quality for an infected individual matched with an infected partner is:

$$\overline{x}^{HIV^+}_{(+)} - V_0 = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} - (1-\Pi)P\overline{V})e^{-\lambda \overline{x}^{HIV^+}_{(+)}}]$$

and define the right side as $h(\overline{x}^{HIV^+}_{(+)}) = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} - (1-\Pi)P\overline{V})e^{-\lambda \overline{x}^{HIV^+}_{(+)}}]$. (See Figure A.3).

1. $\frac{\partial h(\overline{x}^{HIV^+}_{(+)})}{\partial \Pi} = \frac{\beta}{1-\beta}P\overline{V}e^{-\lambda \overline{x}^{HIV^+}_{(+)}} > 0$: As HIV rates increase, an infected indiviudals who draws a match with an infected partner will see a benefit in continuing to search. Being matched with a same-HIV status partner when HIV rates are low is valuable, as there are few infected partners available and a big disutility from

infecting an uninfected draw next period. As HIV rates rise, there are more options available over infected partners and one can be more selective, only accepting a match with a high partner quality.

2. $\frac{\partial \frac{\partial h(\overline{x}^{HIV^+}_{(+)})}{\partial \Pi}}{\partial P} = \frac{\beta}{1-\beta}\overline{V}e^{-\lambda \overline{x}^{HIV^+}_{(+)}}$ >0: For those with higher infection probabilities (uneducated females) where HIV rates are high, the possibility of rejecting a current match and finding a better quality partner outweighs the now smaller disutility of infecting an uninfected match next period, as the uninfected are a proportionally smaller population in high-HIV regions.

3. $\frac{\partial \overline{x}^{HIV^+}_{(+)}}{\partial V_0}$ <0: A higher outside option increases reservation quality.

Infected Individual Matches with Uninfected Partner

The equation that characterizes the determination of the reservation value of partner quality for an infected individual matched with an uninfected partner is:

$$\overline{x}^{HIV^+}_{(-)} - \overline{V}P - V_0 = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} + \Pi P\overline{V})e^{-\lambda \overline{x}^{HIV^+}_{(-)}}]$$

and define the right side as $h(\overline{x}^{HIV^+}_{(-)}) = \frac{\beta}{1-\beta}[(\frac{1}{\lambda} + \Pi P\overline{V})e^{-\lambda \overline{x}^{HIV^+}_{(-)}}]$. (See Figure A.4).

Although h(x) differs for infected individuals depending on the type of partner they match with, their first and second order conditions are identical.

1. $\frac{\partial h(\overline{x}^{HIV^+}_{(-)})}{\partial \Pi} = \frac{\beta}{1-\beta}P\overline{V}e^{-\lambda \overline{x}^{HIV^+}_{(-)}}$ >0:

2. $\frac{\partial \frac{\partial h(\overline{x}^{HIV^+}_{(-)})}{\partial \Pi}}{\partial P} = \frac{\beta}{1-\beta}\overline{V}e^{-\lambda \overline{x}^{HIV^+}_{(-)}}$ >0:

3. $\frac{\partial \overline{x}^{HIV^+}_{(-)}}{\partial V_0}$ <0: A higher outside

4. Note that the cost of search is again decreasing in the infection rate, allowing for a marriage delay.

Figure A.1. Uninfected Individual Matched with Uninfected Partner

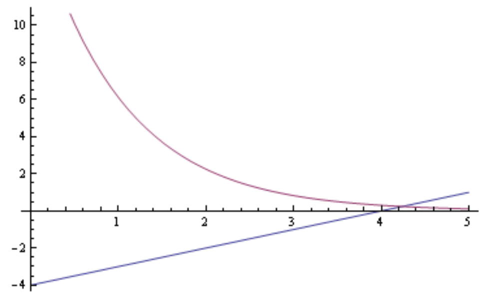


Figure A.2.

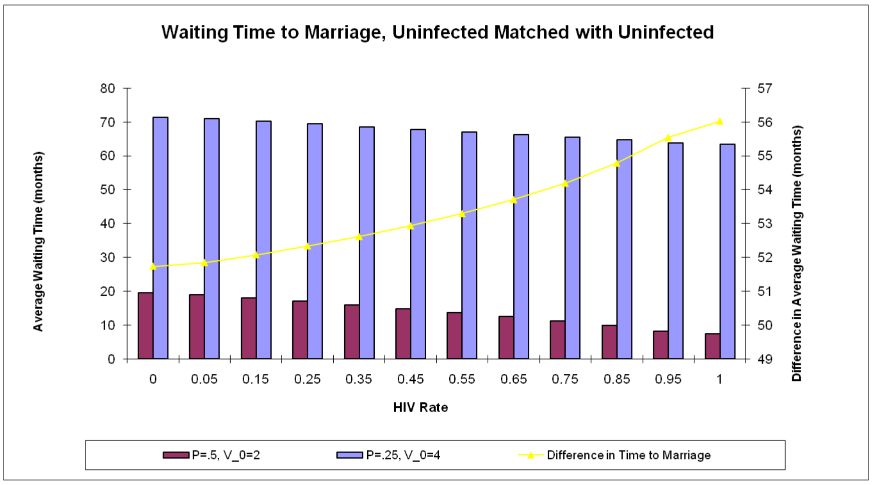


Figure A.3.

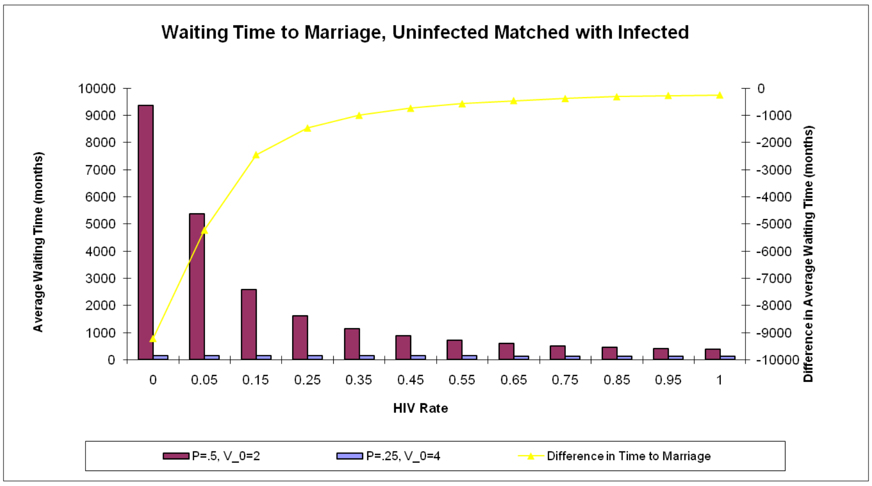


Figure A.4.

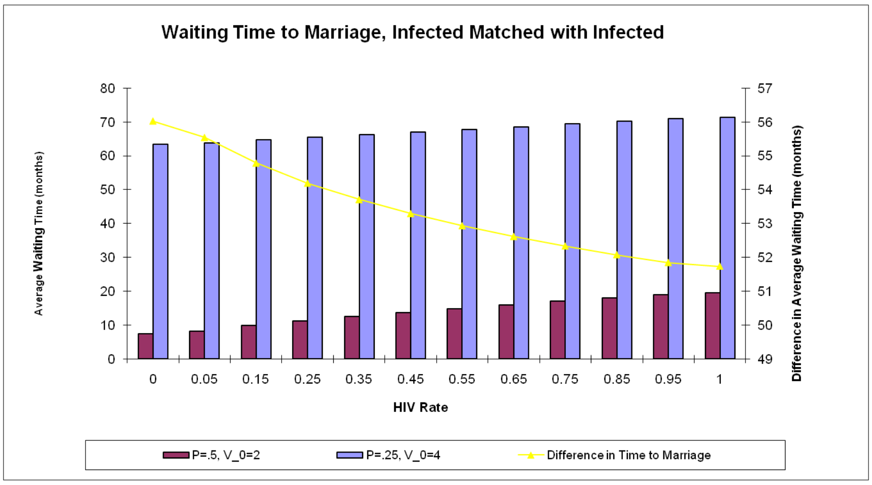


Figure A.5.

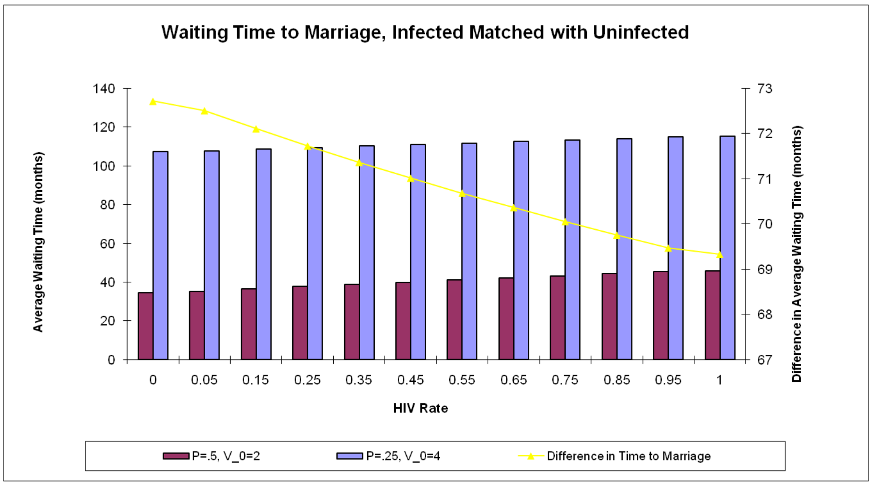


Table A.1.

First-Stage Regression Results. Dependent Variable: Male HIV Rate

	(1)		(2)		(3)		(4)		(5)	
	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Male Circumcision Rate	-0.19**	-0.19**	-0.18***	-0.18***	-0.28***	-0.28***	-0.26***	-0.26***	-0.21**	-0.26***
	(.08)	(.08)	(.05)	(.05)	(.05)	(.05)	(.06)	(.06)	(.07)	(.03)
Log Distance from Origin	-0.21*	-0.21*	-0.19**	-0.19**	-0.37***	-0.37***	-0.36***	-0.36***	-0.29**	-0.35***
	(.11)	(.11)	(.07)	(.07)	(.07)	(.07)	(.06)	(.08)	(.09)	(.04)
Latitude	-0.02**	-0.02**	-0.02***	-0.02***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***
	(.008)	(.008)	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)	(.005)	(.002)
Urban Binary			0.06***	0.06***	0.12***	0.12***	0.11***	0.11***	0.14**	0.10***
			(.01)	(.01)	(.03)	(.03)	(.04)	(.04)	(.04)	(.02)
Male Education Rate					-0.40**	-0.38**	-0.34**	-0.34**	-0.37*	-0.18*
					(.13)	(.13)	(.15)	(.15)	(.16)	(.08)
Male Employment Rate					-0.14	-0.14	-0.14	-0.14	-0.14	-0.14**
					(.09)	(.09)	(.09)	(.09)	(.09)	(.04)
Female Employment Rate	No	No	No	No	No	No	Yes	Yes	Yes	Yes
Female Information	No	No	No	No	No	No	No	No	Yes	Yes
N	18	18	18	18	18	18	18	18	18	18
R-squared	0.39	0.39	0.76	0.76	0.89	0.89	0.89	0.89	0.92	0.99

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Chapter 2

The Effect of Widow Remarriage on Child School Enrollment

2.1 Introduction

This paper examines whether widow remarriage is beneficial to child school enrollment in Sub Saharan Africa. I exploit exogenous regional variation in HIV, religion, and the sex ratio to identify the effect of remarriage by widowed mothers on child school enrollment within a country. The prevalence of widowhood in Sub Saharan Africa has increased substantially since the HIV epidemic began spreading in the early 1980s. The population of interest, widowed women with school-aged children, has also grown disproportionately and is uniquely vulnerable relative to male widowers with school-aged children.[1] Given the sheer size of this vulnerable population and the disparity in cur-

[1]In high-HIV areas, this may be due to women marrying older men who have longer pre-marital sexual histories and are more likely to have extramarital partners than themselves, and thus have a greater likelihood of becoming HIV-infected and dying from AIDS before their wives. Men are also more likely to partake in and die from armed combat than are women. As most African tribes are patrilineal, widowed women are vulnerable relative to male widowers as the widow's late husband's

rent and future outcomes between orphans and non-orphans, it is important to locate behavioral responses that a widow can take to improve the probability of enrolling her child in school.[2]

The effect of widow remarriage on child school enrollment has not been studied. This paper builds on the parental death and child education literature, namely on the finding that the death of a mother hurts child education more so than does the death of a father. Specifically, three panel-data studies find that a mother's death significantly lowers child school enrollment, years of schooling and education expenditures relative to non-orphans, whereas a father's death has less of an effect than does a mother's death and sometimes has no effect at all [16], [23], [30]. That paternal orphans, on average, are as likely to be enrolled in school as non-orphans masks important enrollment differences across households who have experienced a father's death. Also in the parental death literature, Case et al. find that the likelihood of child school enrollment after a parent's death is highly contingent upon the degree of closeness to the household head [15]. In the parental death and child mortality literature, the death of a mother and even a maternal grandmother are associated with a greater likelihood of malnourishment and child mortality relative to non-orphanhood, whereas a father's death has no effect on child mortality [26], [34], [35]. Outside of the parental death literature, there is strong evi-

family has the customary right to take back any of the deceased's property after his death.

[2]In my sample of ten African countries, 15% of children 6-14 years old are orphans. Long-term impacts of orphanhood include fewer years of schooling, reduced height, and adult poverty (a lifelong deficit in consumer expenditures of 8.5%) [4]. Policy interest in making sure that orphans's schooling does not fall behind in part prompted the United Nation's shift toward promoting universal primary school education, gender equality, and curbing HIV rates in 2000. There is a direct cost to schooling-tuition fees, school uniforms, books, supplies-and an opportunity cost of the child's time spent traveling to and from school, attending school, when he/she could have been helping their widowed mother in the field, with household chores, or watching younger siblings.

dence of a link between maternal schooling and child education that is more consistently positive than between father's schooling and child education [7], [8], [13], [11].

I add to the literature by pulling back the curtain on the average enrollment outcome experienced after a father's death and analyzing the impact of a widow's decision to remarry on her child's school enrollment. Specifically, on a cross-country sample of school-aged paternal orphans living with their mothers, I estimate the effect of a mother's remarriage on her child's school enrollment status, separately for mothers with less than six years and at least six years of schooling.[3] Past data deficiencies may have precluded such a causal analysis. In particular, it is hard to study the remarriage decision in Africa without looking at a root cause of widowhood: HIV/AIDS. Due to recently-released cross-sections from the Demographic & Health Surveys (DHS), the opportunity arose to study exactly this. In addition to most DHS cross-sections that include religion and orphanhood status, the *most-recent* DHS cross-sections – which include HIV status and male circumcision – allow me to exploit exogenous variation in HIV rates, religion and local sex ratios across regions in order to explain remarriage decisions of widows within a country.[4] Male HIV rates proxy for the female risk of HIV infection and, given that DHS data do not contain the husband's cause of death, the likelihood that a widow's husband died of AIDS. I present three-stage maximum likelihood estimates of child school enrollment, widow remarriage, and male HIV rates, accounting for all

[3]I perform specification tests varying the cutoff of mother's education; results qualitatively hold for between three and seven years of education.

[4]Educated (uneducated) females are less (more) likely to marry where the risk of HIV infection is high [38]. Widowhood is quite high where male HIV rates are high, as many husbands likely died from AIDS in these areas. In 2002, AIDS was the leading cause in five of the ten countries in the sample (Malawi, Swaziland, Tanzania, Zambia and Zimbabwe) and the second leading cause of death in two of the ten countries (Democratic Republic of Congo and Ethiopia), the 5th in Guinea, 8th in Senegal, and not even top ten in Niger [44].

potential endogeneity, where enrollment and remarriage are binary dependent variables, and the HIV rate is a continuous dependent variable.

My empirical results indicate that remarriage is detrimental to child school enrollment for widows with less than six years of schooling (uneducated), but beneficial to child school enrollment for widows with at least six years of schooling (educated). Among uneducated widows, remarriage lowers the likelihood of enrolling one's child in school by 27%. Among educated widows, remarriage increases the likelihood of child school enrollment by 15%. The positive effect of educated widow remarriage on child schooling only appears once I account for endogeneity. These results are significant at the 5% and 1% level, respectively, and significantly different from one another, even controlling for household wealth quintile, a rural fixed effect, and regional education and employment rates.

The findings are consistent with marital sorting of couples by education, intra-household bargaining, and/or differences in tastes for schooling and remarriage. Each partner brings to the marriage their assets and labor income; the husband may have children as well if he is polygymous. With a correlation of 0.7 between a widow's and her husband's schooling, an educated widow is more likely to marry an educated man if she remarries and that well-educated couple is less likely to be resource-constrained than she would alone. This allows the well-educated couple to invest in the education of her, and perhaps all, children in the household should they have higher marginal rates of return to schooling than marginal cost, especially if both parents have an unobserved taste for schooling.

Uneducated widowed mothers may be more attractive to males working in subsistence agriculture and also less likely to enroll their children in school should they marry such a male. Among males working in agriculture, there may be greater demand for a widow who is willing to marry and has kids, but little leverage. The male may expect to use the children as unpaid manual labor, i.e. as a small workforce, rather than enroll her children in school. An uneducated widow is more likely to need to marry to make ends meet and assortatively match with an uneducated male. She may expect her children to be more likely to be enrolled once she remarries, yet if spousal preferences conflict and his bargaining power is greater than hers, the poorly-educated couple will be less likely to enroll her child(ren) in school than if she had not remarried.[5] Otherwise, the couple may have equally low tastes for schooling or low expectations about the relative returns to her child(ren)'s education.

A policy implication is that there is a multiplier effect on investment in female education in high-HIV areas – where the prevalence of orphans and widows are highest *and* where females are most likely to become widows. Reducing school fees, providing school uniforms or even deworming in high-HIV areas where access to education is lowest could ease the fiscal burden on the marginal widow deciding whether she can afford child schooling. Targeted investments may increase intergenerational mobility, allowing her daughter to be the first in the family to complete primary school, marry an educated husband, and boost her *own* children's schooling one day.

In the remainder of the paper, I present the empirical specification, describe the data and sample selection, present empirical results, and conclude.

2.2 Empirical Specification

The system of equations to be estimated is:

$$y_1^* = \beta_0 + \beta_1 y_2^* + Z_1' \beta_2 + (u_{1jrc} + \epsilon_{1kijrc})$$

[5]When resource-constrained, household decision-maker(s) will invest in children with the highest marginal rates of return to schooling.

$$y_2^* = \alpha_0 + \alpha_1 y_3 + Z_2'\alpha_2 + (u_{2jrc} + \epsilon_{2kijrc})$$

$$y_3 = \gamma_0 + Z_3'\gamma_1 + (u_{3jrc} + \epsilon_{3kijrc})$$

which is a fully recursive system of equations, where y_1^* is the school enrollment status of child k, born to mother i, in household j, region-rural r, country c; y_2^* is the remarriage decision of mother i, in household j, region-rural r, country c; y_3 is the male HIV rate in region-rural r, country c; and Z is a set of exogenous variables. Household-level unobservable, u_{gjrc}, is constant among siblings within a household but varies across households; ϵ_{gkijrc} is an idiosyncratic child-level unobservable, with g=1, 2, 3.

If the errors are uncorrelated, there is no econometric problem. The system of equations is identified and can be consistently estimated by full-information maximum likelihood.

If any of the pair-wise errors are correlated, however, exclusion restrictions are needed for identification. Idiosyncratic unobservables for children's enrollment, ϵ_{1kijrc}, and mother's remarriage, ϵ_{2kijrc}, are likely correlated; that is, mother's remarriage is potentially endogenous in the child enrollment equation. Educated mothers may not need to remarry and yet may be able to easily keep their child(ren) in school ($\rho_{12} = corr(\epsilon_{1kijrc}, \epsilon_{2kijrc}) < 0$ for educated mothers). Uneducated mothers may find their children's education to be low-priority and may also be undesirable wives ($\rho_{12} > 0$ for uneducated mothers).

Unobservable determinants of mother's remarriage, ϵ_{2kijrc}, and male HIV rates, ϵ_{3kijrc}, are likely correlated as well. Omitted variables, such as tribal customs, that are correlated with both male HIV rates and the marital status of widows will cause endogeneity of male HIV rates in the remarriage equation. Tribal customs may dictate that marriage is universal but having extramarital partners is culturally acceptable, which raises HIV rates ($\rho_{23} > 0$).

With correlated errors, the system of equations is identified as long as at least one exclusion restriction is imposed for each endogenous variable. First, the y_2^* equation must contain at least one exogenous variable that is not in the y_1^* equation; i.e. an instrument that is highly correlated with y_2^* but uncorrelated with unobservable determinants of child enrollment, ϵ_{1kijrc}. Second, the y_3 equation must also contain at least one exogenous variable that is not in the y_2^* equation.

In the y_2^* equation, I instrument for widow remarriage with the percent of adults who are Muslim and the sex ratio in a region-rural area. I exploit variation in the percent Muslim and the sex ratio in a region-rural area to explain variation in the remarriage decision of widows across marriage markets within a country. The percent Muslim in a region-rural area is positively correlated with marriage; there is less of a constraint on the supply of males in high-Muslim areas, where males can have up to four wives by Sharia law and are more likely to be polygymous. Percent Muslim is a valid instrument if it exogenously shifts marriage and only affects school enrollment through remarriage. Even if school enrollment rates differ in high-Muslim and low-Muslim areas unconditionally (i.e. if Christian schools differ from Muslim madrasas), as long as they do not differ after conditioning on exogenous variables including adult education rates, then percent Muslim is a valid instrument. This would be the case if there have not been substantial changes in the schooling composition between the parent's and child's generation, as the adult education rate will pick up any differences in schooling patterns by religion, within a region. The conditional validity of the percent Muslim in a region as an instrument for widow remarriage can be tested, as the model is overidentified.

For validity as an instrument, the sex ratio in a region-rural area should affect the supply of partners and thus the remarriage possibilities, conditional on HIV rates, but not the enrollment status of children. The higher the sex ratio, the greater the excess supply of females and relative scarcity of males, and the lower is the expectation of female marriage rates. Holding the death risk from HIV constant, the local sex ratio exogenously changes the partner supply for widows and, thereby, remarriage decisions. Even if school enrollment rates differ in high- and low-sex ratio areas unconditionally (i.e. if bargaining power is greater in low-sex ratio regions), as long as they do not differ after conditioning on exogenous variables including adult education rates, the percent Muslim, and fitted HIV rates, then the local sex ratio is a valid instrument. Again, this should hold as long as the schooling composition is not significantly different between a parent's and child's generation, as the death risk from HIV, religion, and adult education rates will pick up any differences in the gradient of schooling patterns by the sex ratio, within a region. Its conditional validity as an instrument can be tested as well, as the model is overidentified.

Second, in the y_3 equation, I instrument for male HIV rates with male circumcision rates, both at the region-rural level. Male circumcision cuts the risk of male HIV infection by 60%. To be a valid instrument, male circumcision should only affect widow remarriage through male HIV rates. Any concern that uninfected widows targeted circumcised males in the marriage market is minimized given that the roll-out of medical circumcision campaigns began after 2007, after all surveys were completed (2004-2007) in the sample I use [2], [3], [38]. [6] A negative correlation is expected between circumci-

[6]Randomized controlled trials of male circumcision that were completed in Uganda and Kenya in 2007 found that male circumcision is medically protective against HIV risk. After 2007, the Population Council began designing a roll-out of medical circumcision of males. As of 2010, no men had been medically circumcised in Zambia, according to the Population Council. This reduces concerns of any medical circumcision information campaigns occurring by the time of the interview between 2004 and 2007, as well as females knowing that males who are circumcised are at lower HIV risk.

sion and male HIV rates. As circumcision rates are higher among Muslims, a positive correlation between circumcision and male HIV rates would suggest that, holding religion constant, there is a high density of tribes who practice circumcision and also have higher HIV rates.

Once I instrument for y_3 and y_2^*, the system of equations is properly identified and can be consistently estimated. Another econometric issue is the household-level unobservable, which is identical for all siblings in a household but varies across households, for which I cluster the standard errors at the household level.

I estimate the system of equations with a full-information maximum likelihood estimator, called a conditional (recursive) mixed process estimator [41]. I assume that the Z satisfy E($Z'\epsilon_{gkijrc}$)=0, with g=1,2,3, that the idiosyncratic unobservables are drawn from a joint normal distribution and are mean-zero, and that the variance of ϵ_{gkijrc} is normalized to one. The covariance of the idiosyncratic errors across equations are allowed to be non-zero, with $\rho_{12} = corr(\epsilon_{1kijrc}, \epsilon_{2kijrc})$, and likewise for ρ_{23} and ρ_{13}. I specify probit specifications for the y_1^* and y_2^* equations and a linear specification for the y_3 equation.

2.3 Data & Sample Selection

I analyze individual-level DHS data from nationally-representative samples of households in ten Sub Saharan African countries: the Democratic Republic of Congo, 2007; Guinea, 2005; Ethiopia, 2004; Malawi, 2005; Niger, 2006; Senegal, 2005; Swaziland, 2007; Tanzania, 2007; Zambia, 2007; Zimbabwe, 2005 [20]. I selected this ten-country sample from the twenty-eight Sub Saharan countries in DHS with repeated cross-sections as this subset contained orphanhood status (most recent cross-section(s) for all twenty-eight countries), HIV status of adults consenting to HIV testing (most recent cross-section for twenty-two countries and the past two cross-sections for four countries), and information on the amount of property inherited by a widow after her husband's death (most recent cross-section for thirteen countries).

Children aged seventeen and younger were asked whether their mother and father are currently alive and, if so, their household observation number. I define a paternal orphan as a child whose father has passed away but whose mother is still alive. I restrict the sample to paternal orphans of primary school-age (6-14 years old) who are living with their mother. I consider each mother of a paternal orphan to be a widow. I include the mother's demographic and health information in each of her child(ren)'s observations; each retained observation is a unique child-mother pair. The main variables of interest are child school enrollment status - a binary for currently enrolled in school - and whether the child's mother is currently married - a binary for currently married or cohabiting (considered married in the marriage literature on Sub Saharan Africa).

I use region-rural-level, household-level, mother-level, and child-level variables in the analysis. Region-rural-level variables include the male HIV rate, male circumcision rate, average years of education for males, the male employment rate, the percent of adults who are Muslim, the female-male sex ratio within a ten-year age group and a rural binary. A 29-year old female is within the 25-34 year old age group, whereas a 35-year old female is within the 35-44 year old age group. To construct region-rural averages, a binary for "male is HIV-positive" is weighted with HIV weights, while binaries for "male is circumcised," "male is currently employed," "religion is Muslim," and continuous "male years of schooling" and "sex ratio" are weighted with individual weights. Because religion is missing as a variable in the Tanzania 2007 cross-section, I use religion in the Tanzania 2004 cross-section to construct weighted percent Muslim in a region-rural area. Adult males aged 15-59 and adult females aged 15-49 were asked if they would consent to a finger-prick blood test, from which an HIV test result would be taken and confidentially used in the survey data. Roughly 51% of females and 42% of males in the unrestricted sample consented to HIV testing.

Household-level variables include the number of primary school-aged paternal orphans in the household, the total number of other children aged 0-17 in the household (including paternal orphans younger than 6 or older than 14) and the durable goods wealth quintile of the household. I weight all regressions with the household weight. Mother-level variables used are binary variables for currently married and for six or more years of education. A widow's marital status (not having remarried since her husband's death) may be a direct function of male HIV rates, given that AIDS is the leading or second leading cause of death in seven of the ten countries in the sample. An uninfected widow or a widow who does not know her HIV status may also be less likely to remarry where the risk of HIV infection is high. Thirty-six percent of widowed mothers in the sample have six or more years of schooling, 46% have no formal education, and the average years of schooling is 4. Child-level variables used are a binary for current school enrollment, gender, age, and birth order among biological siblings in the household.

Table 1 presents descriptive statistics on all variables used in the analysis, by whether it is at the region-rural-, household-, mother-, or child-level. Of 130,000 school-aged children in my ten-country sample, 20,000 are orphans, 12,000 are paternal orphans, 7,218 are paternal orphans living with their mother, and for the final sample of 5,651 school-aged paternal orphans living with their mother, I have information on child school enrollment, mother's marital status, and mother's years of schooling. There are 3,282 widowed mothers to these 5,651 school-aged paternal orphans. There are 1,923 paternal orphans to mothers with at least six years of schooling and 3,669 paternal orphans to mothers with less than six years of schooling. The average number of paternal orphans aged 6-14 per household is 2.2. Fifty-nine percent of children's mothers consented to HIV testing, that is, 3,330 child-mother pairs; 33% of children's mothers who consented to testing are HIV-positive. Twenty-seven percent of children's mothers are remarried. Average adult male HIV rates at the region-rural level are 6.9% and range from 0% to 37.5%.

2.3.1 Validity of Instruments

Table 2 displays identification tests for the first-stage regression of widow remarriage on percent Muslims and the sex ratio, as well as fitted HIV rates and exogenous variables in Z_2. I perform limited information maximum likelihood estimation (LIML). In the LIML regression of child enrollment on widow remarriage, I instrument for remarriage with percent Muslims, the sex ratio, and fitted HIV rates. I can reject the null hypotheses that widow remarriage is underidentified. For weak identification, with a null hypothesis that the instruments should be included in the enrollment equation, I can also reject the null. For the overidentification test, the null hypothesis specifies that, conditional on instrument one being valid, instrument two is valid, and vice versa; I fail to reject the null, which is preferred. Therefore, percent Muslim and the sex ratio are both conditionally valid instruments.

The sex ratio is negatively correlated with remarriage for uneducated (less desirable) widows: the scarcer are males, the fewer are remarriage possibilities. Areas that consistently have high sex ratios may have adapted by using social arrangements to accommodate the excess supply of females, such as polygymy, the acceptability of remarriage, and even wife inheritance. In these high-sex ratio areas, educated (more desirable) widows will be in greater relative demand. This is consistent with the positive association between the sex ratio and remarriage for educated widows. The percent Muslim in a region is positively correlated with remarriage for both educated and uneducated widows. This is consistent with Sharia law, in that Muslim males do not have an upper bound of one wife, but four.

I also perform a LIML regression of widow remarriage on male HIV rates, instrumenting for male HIV rates with male circumcision rates. The equation is exactly identified, therefore I cannot test for its conditional validity. Circumcision is negatively correlated with male HIV rates, as expected, in areas where there is a high density of educated widows. Circumcision is positively correlated with male HIV rates, however, in areas where there is a high density of uneducated widows. As Muslims are more likely to be circumcised, once I condition on religion, areas with a high density of uneducated widows are populated with tribes who practice circumcision and have higher HIV rates.

2.4 Results

Table 3 presents results from three-stage maximum likelihood estimation. Each column is a separate regression for widows with six or more years of schooling (educated) and for widows with less than six years of schooling (uneducated). The empirical results indicate that among school-aged paternal orphans living with their mother, a mother's remarriage decreases the likelihood of school enrollment by 27% if the mother has less than six years of schooling, while it increases the probability of school enrollment by 15% if the mother has six or more years of schooling.

In Table 3, columns (1) through (5) iteratively add exogenous variables to the system of equations. In column (1), for the third-stage probit marginal effects, the unconditional effect of an uneducated mother's remarriage is a 53% reduction in the likelihood of her child's school enrollment, and is significant at the 1% level. The effect of an uneducated mother's remarriage remains robust with significance at the 1% level after each iteration, attenuating by about half to a reduction in the likelihood of schooling of 27% after all controls are added.

Also in Table 3, column (1), the unconditional effect of an educated mother's remarriage on her child's school enrollment is negative and insignificant. This effect becomes a significant 11% increased likelihood once country fixed effects are added (column (2)), loses significance after controlling for child age fixed effects, child gender, and regional education and employment rates (column (3)), increases in magnitude and significance to 17% once a rural binary, household durable assets fixed effects, and mother's age are added (column (4)) and, lastly, the effect is a significant 15% at the 5% level after controlling for birth order fixed effects, the number of school-aged paternal orphans and other children in the household (column (5)).[7]

[7] In Table 3 (not shown), adult education rates have no effect on the enrollment of children of educated mothers, but do increase enrollment for children of uneducated mothers. All else constant, school enrollment rates are higher for paternal orphans of uneducated mothers living in rural areas, but no different for paternal orphans of educated mothers. The number of school-aged paternal orphans in the household has no effect on the probability of school enrollment, but, controlling for mother's marital status, more children in the household other than school-aged paternal orphans hurts the chances of schooling for paternal orphans, regardless of their mother's education. Being in a higher wealth quintile (having more durable assets in the household) increases the likelihood of school enrollment for paternal orphans (not shown). Systematic trends in enrollment appear based on the birth order of biological paternal orphans. Middle children (4th born) of uneducated mothers fare worse than first-born children, per the resource dilution hypothesis (birth order 5, 6, and 7 are insignificant and not shown). The oldest child of educated widowed mothers is squeezed out of schooling likely to help provide for younger siblings (3rd born is most likely to be enrolled), as with the conditional altruism and credit constraints hypothesis.

In Table 3, I also present the second-stage probit marginal effects, for the effect of male HIV rates on mother's remarriage. There is a negative association between male HIV rates and remarriage for educated widows and a positive association between male HIV and remarriage for uneducated widows. A widow's decision not to remarry may be based on high HIV rates - and thus a high risk of HIV infection - in her region if she is uninfected, does not know her HIV status, or if she knows she is infected and does not want to further transmit HIV. The results are consistent with descriptive statistics: educated widows are more likely to know their HIV status and are more likely to be HIV-positive; they are making a more-informed decision not to remarry. Uneducated widows are less likely to know their HIV status but also less likely to be HIV-positive. This is consistent with being less informed but less worried about the risks (feeling safer from HIV risk by being married than single, or believing one's husband did not die from AIDS and there is no need to get HIV-tested) as well as remarriage out of necessity – HIV rates may be picking up some measure of poverty and destitution that household wealth fixed effects are not.[8]

This may be especially likely if the oldest child was taken out of school around the time of the father's death. Daughters of widows are no less likely to be enrolled than are sons (not shown). Compared to six year-olds, paternal orphans aged 7-14 are all more likely to be enrolled in school (not shown). There is no relationship between a mother's age and the likelihood of her enrolling her child(ren) in school, ceteris paribus.

[8]Of interest in the second-stage regression in Table 3 is the lower probability of remarriage for older widows and widows with the option of living in higher-wealth quintile households (if have a wealthy extended family, there is less of a need to marry); there is a higher likelihood of remarriage for educated widows the higher are male education rates (positive assortative matching on education, before controlling for rural residence) and for all widows the higher are male employment rates (employed males are better able to take on a first wife or co-wife and are more attractive to widows). Uneducated widows are less likely to remarry the more school-aged paternal orphans they have. Educated widows are more willing to remarry the more other children are in the household, which includes any of her children who

The Table 3 first-stage estimates of male HIV rates display the same correlations between circumcision and male HIV rates found in Table 2: negative where educated widows are densely populated and positive where uneducated widows are densely populated.

Table 4 varies the cutoff for separating the regressions by mother's education. The results qualitatively hold for an education cutoff of between three and seven years of schooling. Using the same controls in this three-stage maximum likelihood estimation (MLE) as in Table 3, a mother's remarriage increases the likelihood of her child's school enrollment by 19% if the mother has at least three years of schooling, by 17% if she has at least five years of schooling, and by 15% with at least six years of schooling, but has an insignificant effect otherwise. A mother's remarriage decreases the probability of her child being in school by 21% if she has less than three years of schooling, by 20% with less than four years, by 27% with less than six, and by 23% with less than seven.

Table 5 demonstrates the importance of model specification and accounting for endogeneity. I present (1) probit marginal effects of widow remarriage on child school enrollment, ignoring the potential endogeneity of (a) widow remarriage with respect to child school enrollment and (b) male HIV rates with respect to widow remarriage; (2) bivariate probit estimates of the effect of widow remarriage on child school enrollment and of male HIV rates on widow remarriage, ignoring the potential endogeneity of male HIV rates with respect to widow remarriage; and (3) three-stage maximum likelihood estimates of child school enrollment, widow remarriage, and male HIV rates, where male HIV rates is a linear regression, and account for all potential endogeneity. I use the same

are younger than six or greater than fourteen and any children a potential husband or anyone he lives with may have. This is consistent with "the more the merrier" hypothesis that larger family sizes in Sub Saharan Africa are conducive to child education, with extended families lending help [12].

controls in each stage as in Tables 3 and 4. The third-stage MLE estimates are the exact same as in column (5) of Table 3 and Table 4 with a cutoff of six years of schooling.

In Table 5, for uneducated widows, the detrimental effect of remarriage on child school enrollment is present even without correcting for endogeneity. In the probit and bivariate probit estimation, respectively, the effect is a negative and significant 15% which strengthens to a negative and significant 26% once I allow the errors to be correlated between remarriage and enrollment (ρ_{12} =.31**).[9]

In Table 5, for educated widows, in probit estimates of child school enrollment that do not correct for endogeneity, remarriage appears harmful to child school enrollment. Once I jointly estimate the enrollment and remarriage equations, the bivariate probit marginal effect of remarriage on enrollment is negative but insignificant. Accounting for the correlation in unobservables matters, but not without also exploiting exogenous variation in male HIV rates do I capture the positive effect of remarriage on child schooling for educated widows.

Lastly, Table 6 explores the child schooling decision among married couples. I present probit marginal effects on a sample of 1,634 children of remarried mothers, including controls for the widow and her husband in addition to those used in Table 5. In column (1), each additional year of a mother's schooling and separately *her husband's* schooling increases the likelihood of her child's school enrollment by 6%. There are decreasing returns to scale, however, as each additional combined year of schooling decreases enrollment by nearly 1%. In column (2), a remarried mother who is educated (has six or more years of schooling) is 77% more likely to enroll her child in school, a remarried

[9]That the bivariate probit marginal effects are nearly equal to the three-stage MLE estimates for uneducated widows suggests that the error covariance in the first and third as well as second and third equations is not strong; this is confirmed by the estimated covariance matrix.

mother whose husband is educated is 33% more likely to enroll her child in school, yet if both are educated school enrollment is 90% less likely.

In column (3), I add interactions of the educated mother binary and the column (1) controls. Each additional year of a mother's and her husband's schooling increases the child enrollment likelihood by an insignificant 8% and a significant 10%, respectively, with a decreasing returns to scale effect of negative 2%. Among educated mothers, each additional year of her and her husband's schooling has no effect and a negative 15% effect, respectively, with an *increasing returns to scale* effect of positive 2.5%; i.e. there is complementarity in the returns to "educated parental schooling" on child school enrollment.

In column (4), if an uneducated mother's husband works in agriculture and she does not, the child is a significant 24% less likely to be enrolled. This is in line with lower expected child school enrollment (and higher child manual labor) among uneducated widows who marry men in subsistence agriculture. Additionally, among educated widows, if either the child's mother or the mother's husband works in agriculture, the child enrollment likelihood doubles, yet the effect is completely wiped out if both work in agriculture.

In column (5), an educated widow who inherited any of her late husband's property after his death is 1.5 times more likely to enroll her child in school; there is no effect for uneducated widows. Intuitively, inheritance denotes property ownership at the time of marriage, a huge boost to one's outside option and bargaining power. This estimate displays the largest positive effect on enrollment thus far, on a sample of children whose remarried mothers reported the amount of property inherited from their late husband (N=923).

The column (6) estimates are on a sample of children whose remarried mothers and their husbands consented to HIV testing (N=632). An HIV-positive mother is 58% more likely to enroll her child in school.[10] Column (7) adds interactions of the educated mother binary and the column (6) controls. If an educated mother's husband is HIV-positive and she is not, her child's enrollment likelihood is tripled, and if both are HIV-positive, enrollment likelihood is a fifth of what it otherwise would have been.[11]

The married-couple results indicate that a mother's schooling is beneficial to her child's education not only directly but additionally through her desirability as a wife to partners who have a similar education and taste for schooling; the further (indirect) payoff is that her husband's schooling additionally increases the likelihood of her child's school enrollment. Yet for uneducated widows who marry men working in subsistence agriculture, remarriage is harmful to schooling prospects.

2.5 Conclusion

In Sub Saharan Africa, the sheer quantity and percentage of children who have lost one or both parents is enormous. For example, 15% of school-aged children are orphans in the sample of ten African countries I analyze. What is striking is not just the size of this vulnerable population, but the disparity in current and future outcomes between orphans and non-orphans. Orphans are less likely to be enrolled in school as children and

[10]If the mother's husband is HIV-positive, the child is an insignificant 68% more likely to be enrolled, and if both are HIV-positive, the likelihood of enrollment is reduced by an insignificant 47%.

[11]If the mother, her husband, or both are HIV-positive, the likelihood of her child's school enrollment is increased by an insignificant 43%, 66%, and 51%, respectively. If an HIV-positive mother is educated, enrollment likelihood is increased by an insignificant 33%. Other notable married-couple results (not shown) that are beneficial to child school enrollment if the mother has six or more years of schooling but have no effect if the mother has less than six years of schooling include polygamy, mother as the household head and grandparents living in the house.

by the time they are adults, they have fewer years of schooling, are shorter (suggestive of malnourishment since the parent's death), and are more likely to live in poverty [4].

From my ten-country sample of orphans, 58% are paternal orphans, 22% are maternal orphans and 20% are double orphans. That there are nearly three times as many paternal orphans as there are maternal or double orphans can be attributed to higher male than female death rates in areas that have experienced armed combat and high HIV rates. In seven of the ten countries in my sample, AIDS is the leading or second leading cause of death; these AIDS deaths were primarily concentrated among males.[12] This is because most men marry younger women in Sub Saharan Africa and are more likely to be HIV-infected and die before their wives.[13] It is not unusual, then, for women to be widowed relatively young in Sub Saharan Africa and have school-aged children. What is crucial is knowing whether widows can take some action to increase the likelihood of enrolling their children in school.

I build on the finding in the parental death literature that, relative to non-orphans, children are no less likely (or marginally less likely) to be enrolled in school if their father died but are significantly less likely to be enrolled if their mother died [16], [23], [30]. This masks important enrollment differences across households who experienced the loss of a father.

In this paper, I estimate the effect of a widowed mother's remarriage on her child's school enrollment by using exogenous variation in HIV, religion, and sex ratios across

[12] HIV rates skyrocketed from the 1980s-90s and, since there was roughly a ten-year gap from the time of HIV infection to AIDS death before HIV medication, with a lag of about ten years, AIDS deaths soared from the 1990s-2000s.

[13] At the time of marriage, men have longer pre-marital sexual histories than their wives and, during marriage, are more likely to have extramarital partners; relative to their wives, they are more likely to be HIV-infected and die first.

regions within a country, among a sample of school-aged children whose fathers died but are living with their mother. My empirical results indicate that widow remarriage decreases the likelihood of child school enrollment by 27% for less-educated widows but increases the likelihood of child school enrollment by 15% for more-educated widows.

This is consistent with marital sorting by education, intra-household bargaining, and/or differences in tastes for schooling and remarriage. The positive effect of remarriage among educated widows only appears once I correct for endogeneity.[14] Educated widows are a better "catch" in the marriage market, have higher outside options and therefore a lower cost of continuing to search; unless they find an equally well-educated man, they need not marry.[15] It is easier for well-educated, less resource-constrained couples to enroll her children in school than it is for educated widows who do not remarry. It could be that spousal preferences coincide on child education as a high-priority, or that spousal preferences differ on the relative marginal returns to the education of each child, but the household is not resource-constrained and each of her children's expected marginal return to schooling is higher than the marginal cost.

On the other hand, uneducated widows have fewer outside options, a lower option value, and so a higher cost of continuing to search; they may lower their reservation value of partner quality and end up accepting an uneducated male. While uneducated widows may enter remarriage voluntarily at the interest of household welfare, it may be at the cost of enrolling her children in school. That remarriage is detrimental to child school enrollment for uneducated widows informs that either (1) spousal preferences

[14]This is due to an unobserved correlation between remarriage and enrollment – between a woman's characteristics as a mother and a wife. Among educated widows, the negative correlation proxies for greater outside options and independence, while for uneducated widows, the positive correlation proxies for hardships/undesirableness as a wife and education as a low-priority.

[15]The educated that choose to marry can be thought of as finding a "good match."

differ and, likely, his bargaining power trumps hers, or (2) spousal preferences coincide and child education is equally a low-priority.

A policy implication is that there is a multiplier effect on investment in female education in high-HIV areas – where females are more likely to become widows and the prevalence of orphans and widows is highest. Targeting investments in female education by reducing school fees, providing school uniforms or even deworming in high-HIV areas can aid a widowed mother in increasing intergenerational mobility in her family. Given the complementarity in the returns to education on marriage market outcomes and children's education, the widow's daughter could be the first in her family to complete primary school, marry an educated male and provide her own children with a higher education one day.

Table 1. Summary Statistics of Variables Used in Estimation

Variable	Obs	Mean	Std. Dev.	Min	Max
Child-Level					
Child is Currently Enrolled in School	5651	0.70	0.46	0	1
Child's Age	5651	10.15	2.54	6	14
Birth Order Among Biological Siblings	5651	1.81	0.95	1	7
Child is Female Binary	5651	0.50	0.50	0	1
Mother-Level					
Mother is Married	5651	0.27	0.44	0	1
Mother's Age	5651	37.91	6.40	18	49
Mother's Years of Schooling	5651	3.67	4.03	0	19
Mother has 6+ Years of Schooling	5651	0.36	0.48	0	1
Mother is HIV-Positive	3330	0.33	0.47	0	1
Household-Level					
# School-Aged Paternal Orphans in Household	5651	2.25	1.06	1	8
# Other Children in Household	5651	1.92	2.19	0	29
Household Durable Assets Quintile	5651	2.84	1.42	1	5
Region-Rural Level					
Male HIV Rate	5651	0.07	0.07	0	0.38
Male Circumcision Rate	5651	0.54	0.41	0.02	1
Male Years of Schooling	5651	5.70	2.70	0.64	10.70
Male Employment Rate	5651	0.68	0.16	0.25	0.95
Percent Muslim	5597	0.28	0.37	0	1
Sex Ratio in 10-Year Age Group	5651	1.21	0.36	0.40	4.33
Rural Binary	5651	0.73	0.44	0	1

Note: Weighted with household weights

Table 2. Identification Tests. First-Stage Regression Results, using Limited Information Maximum Likelihood Estimation

Dependent Variable: Mother Remarried Binary

	Educated	Uneducated
Fitted Male HIV Rate	-6.24**	3.21**
	(2.55)	(1.55)
Percent Muslim	0.19*	0.11
	(0.12)	(0.08)
Sex Ratio	0.02	-0.01
	(0.03)	(0.02)
Male Average Years of Schooling	-0.08***	0.01
	(0.03)	(0.02)
Male Employment Rate	0.45***	-0.13
	(0.17)	(0.17)
Rural Binary	-0.44**	0.18**
	(0.18)	(0.08)
Mother's Age	-0.01***	-0.01***
	(0.002)	(0.002)
# School-Aged Paternal Orphans in HH	-0.02	-0.02*
	(0.02)	(0.01)
# Other Children in Household	0.02***	0.01
	(0.01)	(0.01)
N	1923	3669
R-squared	0.09	0.15
Underidentification Test: K-P LM statistic	7.9 (.05)	8.1 (.04)
Weak Identification Test: A-P F test	3.0 (.03)	2.7 (.05)
Overidentification Test: Hansen J statistic	0.4 (.84)	2.0 (.36)

Dependent Variable: Male HIV Rate

	Educated	Uneducated
Male Circumcision Rate	-0.03**	0.06***
	(0.01)	(0.01)
Percent Muslim	0.01	0.003
	(0.02)	(0.003)
Sex Ratio	-0.003	0.004***
	(0.003)	(0.001)
Male Average Years of Schooling	-0.01***	0.0003
	(0.002)	(0.001)
Male Employment Rate	0.004	0.06***
	(0.02)	(0.01)
Rural Binary	-0.06***	-0.02***
	(0.01)	(0.004)
Mother's Age	-0.0004*	-0.0001
	(0.0002)	(0.0001)
# School-Aged Paternal Orphans in HH	-0.001	-0.00001
	(0.001)	(0.001)
# Other Children in Household	0.001	0.0001
	(0.002)	(0.0002)
N	1923	3669
R-squared	0.73	0.83
Underidentification Test: K-P LM statistic	4.2 (.04)	25.9 (.00)
Weak Identification Test: A-P F test	5.2 (.02)	18.6 (.00)
Overidentification Test: Hansen J statistic	0.0	0.0

Note: Controls include country, household wealth quintile, and child age fixed effects, and child gender binary. Birth order effects are partialled out
Standard errors are in parentheses under estimates and clustered at the household level; p-values are next to test statistics.

Table 3. Maximum Likelihood Estimates of Child School Enrollment, by Mother's Schooling

Third-Stage Probit Marginal Effects: Child School Enrollment Binary

	(1)		(2)		(3)		(4)	
	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Mother Remarried Binary	-0.14	-0.53***	0.12*	-0.45***	0.16***	-0.36***	0.15**	-0.27***
	(0.89)	(0.02)	(0.06)	(0.06)	(0.04)	(0.09)	(0.07)	(0.10)

Second-Stage Probit Marginal Effects: Mother Remarried Binary

	(1)		(2)		(3)		(4)	
	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Male HIV Rate	-0.91	-0.88***	-9.89***	2.65*	-4.81	1.71	-2.21	1.36
	(1.23)	(0.32)	(0.89)	(1.57)	(4.42)	(1.95)	(6.26)	(1.94)
Percent Muslim	0.06	0.18***	0.57**	0.15*	0.27*	0.13	0.20*	0.15
	(0.20)	(0.04)	(0.25)	(0.08)	(0.15)	(0.09)	(0.12)	(0.09)
Sex Ratio	0.001	0.03***	-0.06*	0.01	0.02	0.01	0.03	0.0005
	(0.03)	(0.01)	(0.03)	(0.01)	(0.03)	(0.02)	(0.04)	(0.02)

First-Stage OLS Estimates: Male HIV Rate, in Region-Rural Area

	(1)		(2)		(3)		(4)	
	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc	Educ	Uneduc
Male Circumcision Rate	-0.12***	-0.12***	-0.01	0.07***	-0.04***	0.06***	-0.03**	0.06***
	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Country Fixed Effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Region-Rural Level Controls	No	No	No	No	Yes	Yes	Yes	Yes
HH and Child-Level Controls	No	No	No	No	No	No	Yes	Yes
N	1954	3697	1954	3697	1954	3697	1954	3697
corr(u1,u2)	0.09	1.37***	-0.16	0.73***	-0.86*	0.54***	-1.23*	0.35*
corr(u1,u3)	0.05	0.14***	-0.04	0.08***	-0.10**	0.04	-0.10	0.01
corr(u2,u3)	0.21	0.17***	2.41*	-0.13	0.72	-0.04	0.38	-0.03

Note: Standard errors are in parentheses and clustered at the HH level. Controls are added to all stages. HH-level controls include HH wealth quintile fixed effects, # school-aged paternal orphans and # other children in HH, and mother's age. Child-level controls include child age and birth order fixed effects and child gender. Region-rural level controls in the 1st and 3rd stages are adult employment and employment rates; 1st and 2nd stages are male employment and education rates, % Muslim and sex ratio.

Table 4. Maximum Likelihood Estimates of Child School Enrollment, Varying Mother's Education Cutoff
Third-Stage Regression, Probit Marginal Effects
Dependent Variable: Child School Enrollment Binary

	Mother's Years of Schooling					
	Educ: 5+	Uneduc: <5	Educ: 6+	Uneduc: <6	Educ: 7+	Uneduc: <7
Mother Remarried Binary	0.17**	-0.18	0.15**	-0.27***	0.12	-0.23**
	(0.09)	(0.12)	(0.07)	(0.10)	(0.09)	(0.10)
Adult Years of Schooling, Average in Region-Rural Area	0.02	0.08***	0.02	0.08***	0.02**	0.07***
	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)
Adult Employment Rate, in Region-Rural Area	-0.15	0.19	-0.07	0.13	-0.05	0.11
	(0.24)	(0.16)	(0.09)	(0.15)	(0.09)	(0.15)
Rural Binary	0.05	0.14**	0.05	0.15**	0.07*	0.14**
	(0.08)	(0.07)	(0.04)	(0.06)	(0.04)	(0.06)
# School-Aged Paternal Orphans in Household	0.01	-0.0004	0.01	-0.005	0.01	-0.01
	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
# Other Children in Household	-0.01**	-0.01*	-0.02**	-0.01*	-0.01	-0.01**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
N	2274	3377	1954	3697	1697	3954

Note: Standard errors are in parentheses and clustered at the household level. Controls include country, household wealth quintile, child age and birth order fixed effects, a child gender binary and mother's age.

Table 5. Estimates of Child School Enrollment, Before and After Accounting for Endogeneity

	Educated Widows			Uneducated Widows		
	Probit Marg Effects	Bivariate Probit ME	Three-Stage MLE	Probit Marg Effects	Bivariate Probit ME	Three-Stage MLE
Third-Stage: Child School Enrollment Binary						
Mother Remarried Binary	-0.34***	-0.17	0.15**	-0.15**	-0.26**	-0.27***
	(0.13)	(0.46)	(0.07)	(0.08)	(0.11)	(0.10)
Second-Stage: Mother Remarried Binary						
Male HIV Rate		0.68	-2.21		1.01**	1.36
		(0.50)	(6.26)		(0.49)	(1.94)
Percent Muslim		0.14	0.20*		0.15*	0.15
		(0.14)	(0.12)		(0.09)	(0.09)
Sex Ratio		0.05*	0.03		0.002	0.0005
		(0.03)	(0.04)		(0.02)	(0.02)
First-Stage: Male HIV Rate, in Region-Rural Area						
Male Circumcision Rate			-0.03**			0.06***
			(0.02)			(0.01)
N	1952	1954	1954	3693	3697	3697
corr(u1,u2)		0.29	-1.23*		0.31*	0.35*
corr(u1,u3)			-0.10			0.01
corr(u2,u3)			0.38			-0.03

Note: Standard errors are in parentheses and clustered at the HH level. All stages include controls for country, HH wealth quintile, child age & birth order fixed effects, child gender, rural, mother's age, # school-aged paternal orphans & other children in HH. 1st & 3rd stages include controls for adult employment & education rates; 1st & 2nd stages for male employment and education rates, % Muslim & sex ratio.

Table 6. Married Couples. Probit Marginal Effects of Child School Enrollment
Dependent Variable: Child School Enrollment Binary

	(1)	(2)	(3)	(4)
Mother's Years of Schooling	0.06*		0.08	
	(0.03)		(0.06)	
Mother's Husband's Years of Schooling	0.06***		0.10***	
	(0.02)		(0.02)	
Mother's Years of Schooling*Husband's Years of Schooling	-0.01*		-0.02**	
	(0.00)		(0.01)	
Educated Mother Binary		0.77***		
		(0.27)		
Educated Mother's Husband Binary		0.33*		
		(0.17)		
Educated Mother Binary*Educated Mother's Husband Binary		-0.90***		
		(0.32)		
Mother's Years of Schooling*Educated Mother Binary			0.004	
			(0.07)	
Mother's Husband's Years of Schooling*Educated Mother Binary			-0.15***	
			(0.05)	
Mother's Years of Schooling*Mother's Husband's Years of Schooling*Educated Mother Binary			0.02**	
			(0.01)	
Mother Works in Agriculture				-0.31
				(0.23)
Mother's Husband Works in Agriculture				-0.24*
				(0.14)
Mother Works in Agriculture*Mother's Husband Works in Agriculture				0.35
				(0.26)
Mother Works in Agriculture*Educated Mother Binary				0.99***
				(0.38)
Mother's Husband Works in Agriculture*Educated Mother Binary				1.10***
				(0.41)
Mother Works in Agriculture*Mother's Husband Works in Agriculture*Educated Mother Binary				-2.42***
				(0.62)
N	1481	1481	1481	1362

Table 6. Married Couples. Probit Marginal Effects of Child School Enrollment
Dependent Variable: Child School Enrollment Binary

	(5)	(6)	(7)
Mother Inherited Any Property from Late Husband	-0.09		
	(0.18)		
Mother Inherited Any Property from Late Husband*Educated Mother Binary	1.50***		
	(0.49)		
Mother is HIV-Positive		0.58**	0.43
		(0.25)	(0.30)
Mother's Husband is HIV-Positive		0.68	0.66
		(0.49)	(0.51)
Both Mother and her Husband are HIV-Positive		-0.47	0.51
		(0.63)	(0.69)
Mother is HIV-Positive*Educated Mother Binary			0.33
			(0.36)
Mother's Husband is HIV-Positive*Educated Mother Binary			2.95***
			(0.59)
Both Mother and her Husband are HIV-Positive*Educated Mother Binary			-4.69***
			(0.91)
N	923	632	632

Note: Standard errors are in parentheses and clustered at the household level. Controls for all Table 6 regressions include country, household wealth quintile, child age and birth order fixed effects, binary variables for child gender and rural, mother's age, adult employment rate and average years schooling, and number of school-aged paternal orphans and other children in household.

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