

**Mortality and engagement in HIV/AIDS risk behaviors in developing countries**

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**Abstract**

Life history theory predicts that increased extrinsic mortality will lead to greater engagement in HIV/AIDS risk behaviors. This model puts a novel perspective on HIV/AIDS risk behaviors, suggesting that mortality is both a cause the patterning of sexual behaviors as well as an outcome of such behaviors. To test this prediction, I examine the relationship between two measures of mortality (death rate and life expectancy at birth) and several proxies for HIV/AIDS risk behaviors (ages at first sex and marriage, total fertility rate, and ideal number of children), measured for both men and women. Data on sexual behaviors come from the Demographic and Health Surveys (DHS). Two separate samples are analyzed: a cross-sectional sample of 62 countries, and a panel sample which includes multiple cross-sectional panels from 48 countries. Multivariate regression analysis is used to control for potential confounding variables, including survey year, per capita income, and location sub-Saharan Africa. The results generally support the predictions, with men and women experiencing earlier sex and marriage, and having and desiring more children, when mortality is high.

**Key words:** HIV/AIDS risk behaviors; mortality; life expectancy; life history theory;

Demographic and Health Surveys

## **Introduction**

HIV/AIDS prevalence has reached record high levels throughout the world, particularly in developing countries (UNAIDS 2009). HIV/AIDS is the fourth leading cause of death worldwide, and the leading cause in sub-Saharan Africa; the epidemic has lowered life expectancy at birth by decades in many countries (Ashford 2006; Lamptey et al. 2006). Although the growth rate of the epidemic is showing signs of declining (UNAIDS 2009), it remains a major public health challenge, and prevention and education efforts in the fight against HIV/AIDS have received great attention. Health behavior models suggest that increased knowledge of the pathways of infection and of the disease itself will lead to more realistic perceived HIV/AIDS risk, which will in turn reduce engagement in high risk behaviors (Catania et al. 1990; Neff and Crawford 1998; Rosenstock et al. 1994). Thus education is seen as a key component in the prevention of HIV infection.

While public health campaigns have met with some success in using knowledge about HIV/AIDS to reduce high risk behaviors (e.g., Cohen 2004; Stoneburner and Low-Beer 2004), the lack of success preventing HIV/AIDS risk behaviors in developing countries is notable (Caldwell 1999; Lamptey et al. 2006). Despite knowledge of HIV/AIDS, individuals, especially youth, often underestimate their personal risk of HIV/AIDS (see review in Anderson et al. 2007). Furthermore, HIV/AIDS knowledge and perceived risk of HIV infection often show little or no correlation with engagement in high risk sexual behavior (e.g., Anderson et al. 2007), suggesting that knowing which behaviors are associated with risk of HIV infection does not necessarily lead to avoidance of those behaviors.

These results present a puzzling question that public health officials have a difficult time answering, namely, why do people who know that engagement in certain behaviors may lead to

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infection with HIV and a potentially fatal illness nonetheless continue to engage in those behaviors?<sup>1</sup> In this paper I will present and test a possible answer to this question, based on a model derived from life history theory, using data on sexual behavior in 62 countries.

### *Life history theory*

HIV/AIDS is transmitted in the developing world primarily through heterosexual intercourse. Thus, HIV/AIDS risk behaviors are closely related to life history traits, which are the key maturational and reproductive characteristics (such as age at sexual maturity, age-specific mortality and fertility schedules, timing of first reproduction, lifespan) that define the life course. Life history theory has shown that life history traits tend to follow predictable patterns (e.g., Hill and Hurtado 1996; Stearns 1992). For example, species that are short-lived typically begin reproduction relatively early and have offspring more frequently, while long-lived species delay reproduction and reproduce fairly slowly (Harvey and Zammuto 1985; Stearns 1992). Culture and ecology contribute to significant variation in life history traits across human populations, even in the absence of modern birth control (e.g., Wood 1994). Human life histories nonetheless follow a typical primate pattern: for our body size, humans exhibit a markedly long pre-reproductive juvenile period, followed by a long adulthood characterized by widely spaced births (e.g., Hill and Kaplan 1999; Kaplan et al. 2000). Within this general pattern, we observe tremendous variation in life history traits both within and across cultures (for example, in age at first sex, total fertility, etc.).

Many factors favor earlier reproduction over delayed reproduction. All else being equal, individuals who reproduce earlier leave more descendents, while those who delay reproduction leave fewer descendents. Delayed reproduction is thus associated with lower long-term fitness

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and a greater probability of lineage extinction (Low et al. 2002, 2003). One key variable that may influence the patterning of life history traits is *extrinsic mortality*, that is, mortality caused by sources of mortality generally not under the organism's control (Stearns 1992). Under conditions of high mortality and low life expectancy, earlier reproduction is favored because the individual may not survive to older ages. When mortality rates are low, individuals can delay reproduction and invest resources in themselves, furthering the development of a long lifespan. This model has been used to explain variation in life history traits across species (Promislow and Harvey 1991), but can also explain different demographic patterns across human populations (e.g., Chisholm 1993; Low et al. 2008; Quinlan 2007; Wilson and Daly 1997). Geronimus (1996b) and Wilson and Daly (1997), using urban American samples, found that fertility is higher and earlier when actual or perceived life expectancy is lower. Although earlier reproduction is associated with poorer health outcomes in the long run (Geronimus 1996a; Mirowsky 2005), these future costs are discounted by the reduced probability of surviving long enough to incur them.

Mortality might be expected to influence fertility patterns in humans even more strongly than in other mammals, because human offspring have very long periods of dependency on their parents (Kaplan et al. 2000; Lancaster 1991). As a result, adult mortality will decrease an individual's fitness not only by depriving that individual of future reproductive opportunities, but also by jeopardizing the survival of existing young children. Thus, human life histories may have been selected to respond to local mortality pressures, adjusting sexual behavior and fertility in adaptive patterns to maximize future reproductive success (Chisholm 1993; Wilson and Daly 1997). These responses are not necessarily conscious; nor does their existence deny the important role of culture in shaping human fertility patterns. Indeed, local cultural patterns and

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fertility preferences may help reinforce fertility patterns that are optimal in view of local mortality rates. For example, pronatalist beliefs, urging early marriage and high fertility, may reflect cultural knowledge about high mortality rates, especially infant mortality.

### *Life history theory and HIV/AIDS risk behavior*

The timing of sexual maturation and first intercourse, the frequency of sex and of reproduction, and the number of sexual partners are life history traits that influence exposure to sexually transmitted infections (STIs) such as HIV. The fact that many aspects of sexual behavior are life history traits allows us to bring life history theory to bear on high risk sexual behaviors. Risk behaviors, like all aspects of human behavior, are embedded in a complex social and cultural matrix. They are not simply the result of individual decision making processes; cultural preferences, past behaviors, family and social obligations and economic necessity are a few of the many factors that influence an individual's decision to engage in risk behaviors (e.g., Helleringer and Kohler 2005). Life history theory predicts that higher levels of extrinsic mortality will be associated with earlier reproduction. This may translate into greater engagement in HIV/AIDS risk behaviors such as earlier and more frequent intercourse, greater number of sexual partners, and higher rates of unprotected intercourse. Life history theory thus provides a novel perspective on HIV/AIDS risk behaviors: while other theories of sexual behavior view mortality as a potential outcome of engaging in high risk sexual behavior, life history suggests that mortality may be a *cause* of life history traits such as patterning of sexual behavior, as well as an outcome of such behavior.

Relatively little work has directly examined the relationship between mortality and HIV/AIDS risk behaviors. Wilson and Daly (1997), using aggregate data from 77 Chicago

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neighborhoods, found that women in neighborhoods with lower life expectancy and higher mortality had higher fertility at earlier ages. Other studies have reported similar results with aggregate cross-cultural data. Heath and Gant (2004), using data from 157 countries, found that age-specific fertility of women 15-19 years old was negatively correlated with life expectancy and positively correlated with infant mortality. Low et al. (2008) report similar findings for a sample of 98 countries: nations with higher life expectancies have later age at first birth and lower age-specific fertility.

HIV/AIDS prevalence is highest in sub-Saharan Africa, and several studies have examined the relationship between mortality and reproductive behavior (though not from an explicitly evolutionary or life history framework) in sub-Saharan Africa, using individual-level data. DeRose and colleagues (DeRose and Klein 2005; DeRose 2006) used data from Kenya and Zambia to find that although HIV infection suppresses individual fecundity, community-level HIV prevalence was associated with higher fertility within marriage, suggesting that local HIV rates may influence marital fertility rates. Ueyama and Yamauchi (2009) reported that local mortality is associated with earlier age at first sex and age at first marriage among women in Malawi.

These previous studies have all focused solely on women, and used only one or two variables to measure engagement in HIV/AIDS risk behaviors. The current study will include data on both men and women and use multiple measures of sexual behaviors. The following specific predictions are derived from the hypothesis that extrinsic mortality has an influence on sexual behaviors, leading to earlier and more rapid reproduction.

*Prediction 1:* High risk HIV/AIDS sexual behaviors will be positively correlated with death rate.

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Prediction 2: High risk HIV/AIDS sexual behaviors will be negatively correlated with life expectancy at birth.

I will test these predictions using demographic variables that are proxies for HIV/AIDS risk behaviors. The variables will include early sexual activity (measured by age at first sex and age at first marriage), actual fertility (total fertility rate), and desired fertility (ideal number of children). Because HIV/AIDS is transmitted in the developing world primarily through heterosexual intercourse, early sexual activity is an important HIV/AIDS risk behavior. In an uncertain environment, individuals who reproduce earlier are more likely to leave descendents than individuals who postpone reproduction. While fertility is not necessarily closely linked to HIV/AIDS risk behaviors (for example, in cultures where strictly monogamous unions are enforced, high fertility need not increase risk of HIV infection), individuals in countries with higher fertility rates are more likely to engage in earlier and more frequent unprotected sexual intercourse, increasing the risk of HIV infection. Fertility preferences are not themselves a form of HIV/AIDS risk behavior, but may track people's willingness and desire to engage in unprotected sex (as well as reflect cultural preferences for high or low fertility).

### *Proximate vs. ultimate causation*

Evolutionary biologists distinguish between proximate causation, the mechanism that allows an organism to exhibit a behavior or trait, and ultimate causation, the reason the behavior or trait evolved. This is in essence a distinction between how traits function versus why they occur. Life history theory explains traits at the ultimate, not proximate, level, while other theories may focus on the proximate mechanisms by which the relationship could occur (i.e., explaining how it occurs but not why). For example, people engage in sex because it feels good; the

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behavior releases certain neurological and hormonal signals that are perceived as pleasurable. This is a proximate explanation. The complex physiology and behaviors involved in sexual intercourse evolved in order to produce offspring, e.g., genetic descendants. This is an ultimate explanation. The two are not contradictory; they merely explain the phenomenon at different levels.

This is not to deny that there are other potentially valid alternative explanations at the ultimate level for HIV/AIDS risk behaviors. Correlations between mortality and sexual behavior do not prove a causal relationship; an omitted or unobserved variable may be driving the observed relationship between these variables. For example, it is possible that poverty causes both greater incidence of high risk sexual behavior and higher levels mortality, for such reasons as lack of quality birth control and medical care.<sup>2</sup> If this is the case, an observed association between measures of sexual behavior and mortality/life expectancy will not be causal. To partially control for this, I will perform multivariate regression analysis, controlling for income and other potential confounding variables to see whether the predicted relationship between mortality and sexual behavior remains once these background factors are controlled for.

## **Methods**

The data used in this analysis come from the Demographic and Health Surveys (DHS), which have been collected in developing countries since the 1980s. Each DHS is a complete nationally representative cross-sectional household survey focusing on population and health indicators. DHS questionnaires are designed to be consistent across countries to facilitate cross-cultural comparisons. The DHS targets women (ages 15-49 in most countries), but many DHS surveys also include a male module, asking questions of male household members ages 15-59.

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On average, each national survey interviews over 12,000 women, with male modules interviewing over 3,000 men.

Data were compiled from STATcompiler ([www.statcompiler.com](http://www.statcompiler.com)), an on-line database providing aggregate summary data (at the national level) for many variables collected by the DHS. Aggregate data are used for the dependent variables (sexual behaviors) because measures of mortality and life expectancy, key independent variables, are often available only at the national level. More geographically fine-grained mortality measures would be desirable (for example, at the level of the province or county or local equivalent), but are not widely available for most developing countries.

Two overlapping but distinct datasets are used for the present analysis: a cross-sectional sample and a panel sample. The *cross-sectional sample* contains the most recent survey for every country available from STATcompiler (as of June 2009) where at least one survey was collected between 1996 through 2007. This sample includes data on women from 62 countries. In addition, a subset of 40 of these countries have a male module as well. The *panel sample* takes advantage of the fact that many countries have been surveyed by the DHS at least twice, each representing a separate cross-sectional sample (i.e., the same individuals are not reinterviewed across multiple surveys). This creates a sample of repeated cross-sections, with between two to six panels per country. At the time of this writing, STATcompiler provided multiple panels from 48 countries, for a total of 148 panels (approximately three per country). The Appendix lists the specific countries and years of each survey included in both samples.

STATcompiler provides several proxies for HIV/AIDS risk behaviors that will be used as dependent variables, aggregated at the national level. *Age at first sex* measures the median age at first sexual intercourse for women ages 25-49 and men ages 25-54. *Age at first marriage* is the

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median age at first marriage for women ages 25-49 and men ages 25-54. *Total fertility rate* (TFR) measures the expected fertility rate women 15-44 would expect to experience based on current age-specific fertility rates. TFR is not available for men. *Ideal number of children* is the ideal number of children for women ages 15-49 and men ages 15-59.

In addition to the DHS variables, additional variables, aggregated at the level of the country, were collected from other sources. Every effort was made to match the data as close to the DHS survey year as possible. All variables are used for both the cross-sectional and panel samples, unless otherwise indicated. *Death rate* (or gross death rate) is the number of deaths per 1,000 population, and is used as a proxy of mortality. It was obtained from the *Demographic Yearbook* (e.g., United Nations 2007; data also came from the 1987, 1990, 1995, 1998, 2001 and 2005 editions) and the *World Factbook* (Central Intelligence Agency 2007; data also came from the 1986 through 2006 editions).

The second mortality proxy, *life expectancy at birth*, is handled differently for the cross-sectional and panel samples. The cross-sectional sample uses life expectancy excluding deaths from HIV/AIDS, defined as “the average number of years a person would have been expected to live in the absence of AIDS-related mortality” (United Nations 2005:1), calculated for the years 2000-2005. Life expectancy excluding HIV/AIDS is preferred over overall life expectancy because in countries with high HIV/AIDS prevalence, life expectancy has dropped dramatically, sometimes by decades (Lamptey et al. 2006). There is thus circularity in using life expectancy that includes death from HIV/AIDS to examine sexual behavior if life expectancy is driven in part by HIV infection. Using a cause-deleted measure of life expectancy provides a stronger argument for a causal role of life expectancy on high risk sexual behaviors (see Wilson and Daly 1997). Unfortunately, this variable is not available separately for males and females, nor is it

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available for years before 2000. Thus it cannot be used for the panel dataset, which requires year-specific measures of mortality dating back to 1986 for some countries. For the panel sample only, sex-specific life expectancy at birth (including deaths from HIV/AIDS) is used, matched to the year of the survey.

*Per capita income* is measured by per capita gross national income (in U.S. dollars) for each country. This variable was obtained from the *World Population Datasheet* (Population Reference Bureau 2000, 2001, 2004, 2007) or, for earlier years, the *World Factbook*. Income data were converted to real (2000) U.S. dollars and then logged. A dummy variable indicated whether the country was located in sub-Saharan Africa, an important control variable since HIV/AIDS prevalence as well as non-AIDS mortality are much higher in that region of the world (Gant et al. 2009). The year the DHS data were collected was added as a control variable. Lastly, all statistics are weighted by population size, obtained from the United Nations (2005). Failure to weight the data would result in countries with very small populations (such as Swaziland or the Comoros) having the same statistical influence on our understanding of global HIV/AIDS risk behavior patterns as large countries (such as India or Brazil).

All analyses were done with Stata/SE v. 10.1 for Windows. For the cross-sectional sample, univariate correlations are used to explore whether there are relationships between mortality and sexual behavior. This is followed by multivariate OLS regressions, in which each dependent variable (age at first sex, age at first marriage, TFR and ideal number of children) is predicted by mortality (either death rate or life expectancy at birth excluding deaths from HIV/AIDS, included separately), survey year, an indicator for whether the country was in sub-Saharan Africa, and logged per capita income. Each model is presented separately by gender. For the panel sample, Generalized Estimating Equations (GEE) are used to assess whether

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relationships between mortality and sexual behavior exist. GEE models adjust for the lack of independence among observations (resulting from each country in the sample contributing multiple panels). The *xtgee* command in Stata fits population-averaged panel data models using GEE, with standard errors derived from the conventional variance estimator for generalized least squares regression. In the analysis, univariate GEE models are presented first, to explore whether simple relationships between mortality and sexual behavior exist. These are followed by multivariate GEE regressions, using the same dependent and independent variables described for the OLS regressions, with the exception that life expectancy without HIV/AIDS is replaced for sex-specific life expectancy from all causes (including HIV/AIDS), since the cause-deleted measure of life expectancy is available only for the year 2005. Models are again run separately by gender.

## Results

Unweighted descriptive statistics are presented in Table 1. For the cross-sectional sample, the average death rate is 12.15 deaths per 1,000 population, while life expectancy at birth, excluding deaths from HIV/AIDS, is 61.4 years. The average survey took place in 2003, while 52% of countries in the sample are in sub-Saharan Africa. Logged per capita income in the sample is 7.00, equivalent to US\$1764/year. Age at first sex is 18.1 for women and 19.2 for men. For women, average age at first marriage is roughly a year after age at first sex, while for men first marriage occurs on average about five years after first sex. The average total fertility rate (TFR) is 4.1. Ideal fertility is nearly identical to actual fertility for women, while men, in contrast, desire about one child more than women do.

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Because the panel sample includes a longer time frame, average values differ slightly from the cross-sectional sample. Death rate is slightly lower, but life expectancy includes deaths from HIV/AIDS, and is thus much lower (about 58 for women and 54 for men). The sample still consists of roughly half sub-Saharan African countries, and the average survey dates from 1997. Average ages at first sex and marriage occur about a half year earlier than in the cross-sectional sample, while average TFR and ideal fertility are both higher (with the gap between men and women having increased, so that men in the panel sample desire 1.77 more children than women).

[Table 1 about here]

Correlations between dependent variables and mortality measures are presented for the cross-sectional sample in Table 2. For women, all correlations are large (all but one greater than 0.5), statistically significant, and in the predicted direction. Women have sex early, marry early and both have and desire more children when death rates are high, and delay sex and marriage and have and desire fewer children when life expectancy (excluding HIV/AIDS) is high. For males, death rate and life expectancy are both significantly correlated with age at first sex, but in the opposite of the predicted direction: men delay sex when mortality is high, and have earlier sex when life expectancy is long. Neither mortality nor life expectancy has a significant association with age at first marriage. Only the ideal number of children is significantly correlated with mortality proxies in the predicted direction, consistent with the result found for women.

[Table 2 about here]

Table 3 presents multivariate OLS regression analysis of the cross-sectional sample, controlling for background variables including income and survey year. There are two models

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for each dependent variable, one with death rate as a mortality proxy, the other using life expectancy. For women, age at first sex is predicted by life expectancy but not death rate, while age at first marriage is predicted by both death rate (marginally, with  $p=0.052$ ) and life expectancy. TFR is predicted by both death rate and life expectancy; however, death rate is in the opposite of the predicted direction, with higher death rate associated with lower TFR. Ideal number of children is predicted by life expectancy but not death rate. For men, neither mortality measure predicts age at first sex or marriage, while ideal number of children is significantly predicted only by life expectancy. With the exception of the association between death rate and TFR for women, all significant relationships between mortality and sexual behavior are in the predicted directions.

[Table 3 about here]

Univariate GEE regression models using the panel sample are presented in Table 4. For women, both death rate and life expectancy are significantly associated with all measures of sexual behavior, and in the predicted directions, except for ideal number of children which is not significantly associated with death rate. For men, age at first sex is correlated with both death rate and life expectancy, but in the opposite of the predicted direction. The predicted relationship is found between death rate and age at first marriage (while life expectancy is only a marginally significant predictor, with  $p=0.086$ ), and between both death rate and life expectancy and ideal number of children.

[Table 4 about here]

Multivariate GEE models for the panel sample, controlling for background variables, are presented in Table 5. For women, death rate and life expectancy at birth are both statistically significant predictors of age at first sex, age at first marriage, and total fertility rate, and in the

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predicted directions. For ideal fertility, death rate is a significant predictor, but in the opposite direction of what was expected (high death rate associated with fewer desired children), while life expectancy at birth is not significantly associated with ideal fertility. For men, death rate and life expectancy are both significant predictors of age at first sex and first marriage, and in the predicted direction, while ideal number of children is predicted only by death rate, not by life expectancy.

[Table 5 about here]

## **Discussion**

This paper tested two predictions regarding the relationships among death rate, life expectancy, and HIV/AIDS risk behaviors, using data from 62 developing countries. Each prediction received support from the data. The results suggest that in general, when death rate is high, HIV/AIDS risk behaviors (early sex and marriage, higher actual and desired fertility) are also high. The opposite is generally true for life expectancy: engagement in HIV/AIDS risk behaviors is more common when life expectancy is low.

Two separate but overlapping samples were used, suggesting the results are robust. While not every mortality measure was significant for every form of sexual behavior across both samples of men and women, every predicted relationship was found in multivariate models for both sexes at least once in either the cross-sectional or panel samples. The one exception to this was the relationship between death rate and women's ideal fertility, which was non-significant in the cross-sectional sample and significant but negative (the opposite of the predicted direction) in the panel sample.

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Simple correlations (cross-sectional sample) and univariate GEE models (panel sample) suggested that mortality and male age at first sex were significantly related to each other, but in the opposite direction, with men having later first sex when mortality was high and earlier first sex and life expectancy was long. However, multivariate models found no association between death rate or life expectancy and male age at first sex with the cross-sectional sample, and significant associations in the predicted direction were found for men in the panel sample. Thus, once income, survey year and sub-Saharan Africa status are controlled for, this unexpected relationship disappears.

The analysis models sexual behaviors for both women and men, which is somewhat notable as male reproductive behaviors are typically understudied or ignored. Understanding male involvement in HIV/AIDS risk behaviors is particularly important in that male sexual promiscuity may lead to infection of monogamously married women, especially in sub-Saharan Africa (Clark 2004). Ueyama and Yamauchi (2009:44) hypothesize that increased adult mortality leads women to ‘have a shorter period of premarital sexual activity before marriage, [and to] marry at a younger age,’ a prediction which is supported by their analysis of data from Malawi. The descriptive statistics presented here for both DHS samples suggest important gender differences in some key variables. Men have a much longer lag between first sex and marriage than women – roughly five years as opposed to one year – allowing greater time for exposure to HIV. Men in the countries sampled also desire more children than women. The multivariate results suggest that while mortality influences engagement in reproductive behaviors for both women and men, the life history model may have stronger predictive power for females than males. Specifically, in the cross-sectional sample, in eight models run for men, only one mortality measure is a significant predictor of male sexual behavior (life expectancy, which is

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associated with lower ideal fertility). In contrast, life expectancy is associated with every measure of female sexual behavior in the cross-sectional sample, and death rate with half of the measures. Results for females and males are much more similar in the panel sample. The somewhat weaker effects observed for men could perhaps be due to the smaller sample size for men, with only about two thirds of countries in the DHS sample having a male module.

However, males and females frequently pursue very different reproductive strategies and face different constraints, in which case the discovery of differential sex-specific sensitivity to local mortality pressures should be not be surprising.

### *Limitations*

Several limitations of this study should be addressed. The data come from many sources, which may lead to noise or measurement error. The use of different measures of life expectancy in the cross-sectional and panel datasets make the results from those samples not directly comparable. The use of data aggregated at the national level may also confound relationships between variables, as millions of people are represented in a single data point. Factors that influence individual-level behaviors (such as age, parity, marital status, educational level, rural status, etc.) are poorly captured in aggregate data. Future work should take advantage of micro-level datasets to compare relationships between variables across individuals rather than across nations. However, it may be difficult (especially in developing countries) to match existing survey datasets to localized vital statistics on mortality or income within those countries.

On a similar note, although the DHS provides age-specific measures of several risk behavior variables, the age-specific proxies of mortality were not available and thus these variables were not used. Sex-specific measures of death rate and of life expectancy without

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HIV/AIDS were also unavailable, limiting the ability to make sex-specific interpretations of the data. This is an unfortunate drawback, because mortality risks change throughout the life course, and are usually considerably higher among young males than any other adult group (e.g., Wilson and Daly 1997).

Lastly, the predictions from life history theory are expected to hold true when factors such as mortality and fertility are at equilibrium. Yet mortality rates are changing rapidly, particularly in response to the HIV/AIDS epidemic (Neumayer 2004). This disequilibrium may undermine the relationships being studied, leading to weaker results. Given this, it is perhaps surprising that the findings of this study are as strong as they are. Historical datasets using data from the pre-HIV/AIDS era may find even stronger relationships between mortality and sexual behaviors than those shown here.

### *Implications for HIV/AIDS Prevention*

Life history theory makes an important contribution to the study of HIV/AIDS risk behaviors by focusing on relationships not apparent from other theoretical perspectives. For example, while other theories of sexual behavior view mortality as a potential outcome of engaging in high risk sexual behavior, life history proposes a bi-directional relationship, with mortality both a cause and an outcome of high risk behaviors. The results in this paper are consistent with this hypothesis: when mortality is high and life expectancy low, people tend to engage in higher rates of HIV/AIDS risk behaviors, potentially leading to further increased HIV infection and subsequent increased mortality.

This approach grounded in life history theory may help explain why HIV/AIDS public health information campaigns have not met with universal success. Many health behavior models

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assume that once people learn the facts about HIV infection risk, they will modify their behavior accordingly. However, although many studies have demonstrated that people in developing countries have learned the facts of HIV/AIDS, these people nonetheless often do not modify their behaviors to reduce their personal risk. A life history theory perspective suggests there are trade-offs between behaviors that will increase personal survival versus increasing fertility and reproductive success. If individuals are using proximate cues of high mortality and low survival to guide long-term decision making, and if HIV/AIDS prevalence and mortality are high, then they may severely discount the future payoffs to changing their behavior. In other words, the perceived benefits to behavior change may not exceed the current costs of changing behavior, if the perceived probability of surviving to experience the long-term benefits is low. These cost/benefit calculations and decisions to modify behavior need be made neither consciously nor in the absence of cultural preferences and guidelines, and many questions remain regarding the proximate mechanisms by which people assess mortality risks and fertility outcomes.

Several potential policy implications may emerge from this theoretical perspective. The life history model calls attention to the often unquestioned assumption that as local HIV prevalence (and subsequent mortality) increases, engagement in high risk behaviors will decrease of its own accord as people see firsthand the consequences of high risk sexual behavior. While some studies have found that knowing somebody who died of HIV/AIDS is associated with reduced engagement in HIV/AIDS risk behaviors (Anderson et al. 2007), other studies have found no or inconsistent support for this (Camlin and Chimbwete 2003; Macintyre et al. 2001). In contrast, the life history approach suggests that increased AIDS-related mortality may lead somewhat counterintuitively to *increased* levels of high risk sexual behavior, rather than decreased engagement in risky behavior. It is therefore important not to be complacent and

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assume that a potential benefit of rising mortality will be an increase in safe sex. If rising mortality does result in greater engagement in high risk behaviors, public education and intervention programs may be better positioned to respond accordingly if this can be predicted in advance.

Life history theory may also offer insights on how to change behaviors even in the face of increased HIV/AIDS prevalence. For example, if HIV/AIDS prevalence increases but mortality declines (through widespread use of antiretroviral drugs, for example), one unintended (but beneficial) result may be a decrease in high risk behaviors as life expectancy increases. This unforeseen consequence is not predicted by other health models, to the best of my knowledge. Proximate cultural factors influencing the acceptability or cost of high risk behaviors may also influence the relationship between HIV/AIDS risk behaviors and mortality (for example, by altering the cost, availability or acceptability of condoms). Thus we would expect the magnitude of the effect of mortality on high risk HIV/AIDS behaviors to differ across developed and less developed nations. Mortality rates are predicted to have less of an effect on risk behaviors in more developed countries because the mortality costs of engaging in such behavior are less, due to such factors as greater availability of antiretroviral drugs or lower prevalence of other untreated sexually transmitted infections that influence HIV transmission (see Oster 2005). This prediction has not yet been empirically tested.

In conclusion, life history theory presents a novel perspective on cross-cultural patterns of HIV/AIDS risk behaviors by linking them to concrete measures of mortality, suggesting mortality is both a cause and an outcome of high risk behaviors. The model has important policy implications, and may provide a valuable addition to our understanding of why people engage in risky sexual behaviors in the era of HIV/AIDS.

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## **Notes**

1. This puzzle is of course not restricted to HIV/AIDS risk behaviors. Many public health issues arise from people willfully engaging in behaviors which they know carry health risks, such as smoking, alcohol or drug use, or excessive eating. For life history perspectives on other forms of engagement in health risk behaviors, see, for example, Hill et al. 1997, Hill and Chow 2002, Kruger and Nesse 2006, Neill 2007.
2. Evidence for a link between poverty or socioeconomic status and risk of HIV infection is inconclusive, though it is commonly assumed that poverty leads to greater engagement in HIV risk behaviors (Wojcicki 2004).

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**Table 1. Descriptive statistics****A. Cross-sectional sample**

	<i>Mean</i>	<i>Std. dev</i>	<i>N (countries)</i>
Death rate	12.15	5.99	62
Life expectancy without HIV/AIDS	61.40	7.37	62
Survey year	2002.95	3.29	62
Sub-Saharan Africa	0.52	—	62
Per capita income (logged)	7.00	1.04	62
Age at first sex (female)	18.10	1.69	53
Age at first sex (male)	19.17	1.77	38
Age at first marriage (female)	19.05	1.93	60
Age at first marriage (male)	24.30	1.41	35
Total fertility rate (female)	4.11	1.47	62
Ideal number of children (female)	4.08	1.56	61
Ideal number of children (male)	5.18	2.35	37

**B. Panel sample**

	<i>Mean</i>	<i>Std. dev</i>	<i>N (countries)</i>	<i>N (panels)</i>
Death rate	11.96	5.24	48	148
Life expectancy (female)	58.01	10.40	48	148
Life expectancy (male)	54.87	9.30	48	148
Per capita income (logged)	6.67	0.99	48	148
Sub-Saharan Africa	0.51	—	48	148
Survey year	1997.19	5.85	48	148
Age at first sex (female)	17.66	1.74	39	118
Age at first sex (male)	18.79	1.55	34	66
Age at first marriage (female)	18.63	1.93	48	145
Age at first marriage (male)	23.63	1.25	32	53
Total fertility rate (female)	4.70	1.46	48	147
Ideal number of children (female)	4.23	1.53	48	147
Ideal number of children (male)	6.00	2.55	34	70

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**Table 2. Correlations between sexual behaviors and mortality measures, cross-sectional sample**

	Females		Males	
	<i>Death rate</i>	<i>Life expectancy without HIV/AIDS</i>	<i>Death rate</i>	<i>Life expectancy without HIV/AIDS</i>
Age at first sex	-0.697 ***	0.815 ***	0.344 *	-0.456 **
Age at first marriage	-0.362 **	0.528 ***	0.014	-0.227
Total fertility rate	0.613 ***	-0.837 ***	—	—
Ideal number of children	0.627 ***	-0.868 ***	0.644 ***	-0.915 ***

+ p<0.01; \* p<0.05; \*\* p<0.01; \*\*\* p<0.001

**Table 3. Multivariate regressions, cross-sectional sample**

A. Females	Age at first sex		Age at first marriage		TFR		Ideal number of children	
	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>
Intercept	54.115	-9.312	206.188 +	8.366	-207.455 ***	-111.833 *	-186.694 **	-38.063
Survey year	-0.018	0.011	-0.098	-0.007	0.107 ***	0.060 *	0.096 **	0.025
Sub-Saharan Africa	-1.987 ***	-1.412 **	2.115 **	3.384 ***	2.435 ***	1.192 ***	2.640 ***	0.992 **
Per capita income (logged)	0.316 +	0.140	1.391 ***	0.849 ***	-0.390 ***	-0.050	-0.222 *	0.273 **
Death rate	-0.033	—	-0.173 +	—	-0.086 *	—	-0.058	—
Life expectancy without HIV/AIDS	—	0.085 *	—	0.271 ***	—	-0.090 **	—	-0.158 ***
N	53	53	60	60	62	62	61	61
F	26.90	31.09	17.78	29.16	47.45	54.10	42.36	85.09
p	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
R-sq	0.692	0.722	0.564	0.680	0.769	0.792	0.752	0.859

**Table 3. (continued)**

<b>B. Males</b>	<b>Age at first sex</b>		<b>Age at first marriage</b>		<b>Ideal number of children</b>	
	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>
Intercept	-310.790 +	-225.988	161.743	195.617 +	-59.368	220.214 +
Survey year	0.166 +	0.126	-0.071	-0.089 +	0.031	-0.101 +
Sub-Saharan Africa	0.013	-1.157	2.716 ***	2.458 **	4.224 ***	1.159
Per capita income (logged)	-0.240	-0.100	0.576 *	0.688 **	-0.020	0.413 +
Death rate	-0.002	—	-0.084	—	-0.045	—
Life expectancy without HIV/AIDS	—	-0.098	—	0.005	—	-0.260 ***
N	38	38	35	35	37	37
F	2.63	3.30	6.74	5.60	23.21	54.32
p	0.052	0.022	0.001	0.002	0.000	0.000
R-sq	0.242	0.286	0.473	0.427	0.744	0.872

+ p<0.01; \* p<0.05; \*\* p<0.01; \*\*\* p<0.001

**Table 4. Univariate GEE regressions, panel data**

A. Females	Age at first sex		Age at first marriage				TFR		Ideal number of children						
	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>			
Death rate	-0.235	***	—	—	-0.089	***	—	—	0.165	***	—	—	0.079	—	
Life expectancy	—	—	0.166	***	—	—	0.047	***	—	—	-0.074	***	—	-0.036	***
N (countries)	39		39		48		48		48		48		48		48
N (panels)	118		118		145		145		147		147		147		147
Chi-sq	577.3		1351.0		117.7		126.4		4037.79		3462.2		915.4		863.9
p	8		0		3		5		0.000		8		5		5
	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000

B. Males	Age at first sex		Age at first marriage				Ideal number of children					
	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>
Death rate	0.048	***	—	—	-0.034	**	—	—	0.141	***	—	—
Life expectancy	—	—	-0.018	*	—	—	0.011	+	—	—	-0.068	***
N (countries)	34		34		32		32		34		34	
N (panels)	66		66		53		53		70		70	
Chi-sq	35.69		5.97		4.91		2.96		58.73		37.12	
p	0.000		0.015		0.027		0.086		0.000		0.000	

+ p<0.01; \* p<0.05; \*\* p<0.01; \*\*\* p<0.001

**Table 5. Multivariate GEE regressions, panel data**

<i>A. Females</i>	<i>Age at first sex</i>		<i>Age at first marriage</i>				<i>TFR</i>		<i>Ideal number of children</i>							
	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>		
Intercept	-61.15	***	-94.95	***	-76.93	***	-78.11	***	105.75	***	107.63	***	47.64	***	46.90	***
Survey year	0.038	***	0.050	***	0.048	***	0.048	***	-0.051	***	-0.052	***	-0.022	***	-0.022	***
Sub-Saharan Africa	0.235		1.260	***	-1.155	***	-1.131	***	2.341	***	2.372	***	2.778	***	2.731	***
Per capita income (logged)	0.581	***	0.387	***	0.094	**	0.096	**	-0.010		-0.010		-0.012		-0.005	
Death rate	-0.156	***	—		-0.035	***	—		0.033	***	—		-0.008	**	—	
Female life expectancy	—		0.154	***	—		0.019	***	—		-0.015	***	—		0.001	
N (countries)	39		39		48		48		48		48		48		48	
N (panels)	118		118		145		145		147		147		147		147	
Chi-sq	1433.01		2014.66		524.91		523.25		13004.99		13042.41		11404.47		11485.48	
p	0.000		0.000		0.000		0.000		0.000		0.000		0.000		0.000	

**Table 5. (continued)**

<i>B. Males</i>	<i>Age at first sex</i>		<i>Age at first marriage</i>				<i>Ideal number of children</i>					
	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>	<i>Coeff</i>	<i>sig</i>		
Intercept	-148.36	***	-110.26	***	4.93		10.59		178.60	***	177.46	***
Survey year	0.084	***	0.064	***	0.009		0.004		-0.088	***	-0.088	***
Sub-Saharan Africa	1.498	***	1.367	***	1.655	***	1.725	***	3.570	***	3.711	***
Per capita income (logged)	-0.051	**	-0.088	+	0.162	*	0.257	***	0.117	***	0.101	***
Death rate	-0.050	***	—		-0.125	***	—		0.026	***	—	
Female life expectancy	—		0.028	**	—		0.061	***	—		-0.003	
N (countries)	34		34		32		32		34		34	
N (panels)	66		66		53		53		70		70	
Chi-sq	1682.49		126.11		119.68		105.86		2330.97		5551.42	
p	0.000		0.000		0.000		0.000		0.000		0.000	

+ p<0.01; \* p<0.05; \*\* p<0.01; \*\*\* p<0.001

## Appendix. Countries included in the cross-sectional and panel samples

<i>Country</i>	<b>Cross-sectional sample</b> <i>Year</i>	<b>Panel Sample</b>					
		<i>Wave 1</i>	<i>Wave 2</i>	<i>Wave 3</i>	<i>Wave 4</i>	<i>Wave 5</i>	<i>Wave 6</i>
Armenia	2005*	2000*	2005*				
Azerbaijan	2006*						
Bangladesh	2004	1993	1996*	1999	2004		
Benin	2006*	1996*	2001*	2006*			
Bolivia	2003*	1989	1994	1998	2003*		
Brazil	1996*	1986	1991	1996*			
Burkina Faso	2003*	1992*	1998*	2003*			
Cambodia	2005	2000	2005				
Cameroon	2004*	1991*	1998*	2004*			
Chad	2004*	1996*	2004*				
Colombia	2005	1986	1990	1995	2000	2005	
Comoros	1996*						
Congo Democratic Republic	2007*						
Cote d'Ivoire	1998*	1994*	1998*				
Dominican Republic	2007*	1986	1991	1996*	1999*	2002	2007*
Egypt	2005	1988	1992	1995	2000	2005	
Eritrea	2002	1995*	2002				
Ethiopia	2005*	2000*	2005*				
Gabon	2000*						
Ghana	2003*	1988	1993*	1998*	2003*		
Guatemala	1998	1987	1995	1998			
Guinea	2005*	1999*	2005*				
Haiti	2005*	1994*	2000*	2005*			
Honduras	2005						
India	1998	1992	1998				
Indonesia	2002*	1987	1991	1994	1997	2002*	
Jordan	2007	1990	1997	2002	2007		
Kazakhstan	1999*	1995	1999*				
Kenya	2003*	1989	1993*	1998*	2003*		
Kyrgyz Republic	1997						
Lesotho	2004*						
Liberia	2007*	1986	2007*				
Madagascar	2003*	1992	1997	2003*			
Malawi	2004*	1992*	2000*	2004*			
Mali	2006*	1987	1995*	2001*	2006*		

## Appendix. (continued)

<i>Country</i>	<b>Cross-sectional sample</b> <i>Year</i>	<b>Panel Sample</b>					
		<i>Wave 1</i>	<i>Wave 2</i>	<i>Wave 3</i>	<i>Wave 4</i>	<i>Wave 5</i>	<i>Wave 6</i>
Mauritania	2000*						
Moldova	2005*						
Morocco	2003	1987*	1992	2003			
Mozambique	2003	1997*	2003				
Namibia	2006*	1992	2000*	2006*			
Nepal	2006*	1996	2001*	2006*			
Nicaragua	2001	1997*	2001				
Niger	2006*	1992*	1998*	2006*			
Nigeria	2003*	1990	1999	2003*			
Pakistan	2006	1990*	2006				
Peru	2000	1986	1992	1996*	2000		
Philippines	2003*	1993	1998	2003*			
Rwanda	2005*	1992*	2000*	2005*			
Senegal	2005*	1986	1992*	1997*	2005*		
South Africa	1998						
Swaziland	2006*						
Tanzania	2004*	1992*	1996*	1999*	2004*		
Togo	1998*	1988	1998*				
Turkey	1998*	1993	1998*				
Turkmenistan	2000						
Uganda	2006	1988	1995*	2000*	2006		
Ukraine	2007*						
Uzbekistan	1996						
Vietnam	2002	1997	2002				
Yemen	1997	1991	1997				
Zambia	2007*	1992	1996*	2001*	2007*		
Zimbabwe	2005	1988	1994*	1999*	2005		

Note: an asterisk indicates that a male survey was conducted that year