The Socioeconomic Determinants of HIV/AIDS Infection Rates in Lesotho, Malawi, Swaziland and Zimbabwe[*]

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Abstract: This paper uses data from the Demographic and Health Survey to analyze the relationship between HIV status and the socioeconomic and demographic characteristics of adults in Lesotho, Malawi, Swaziland and Zimbabwe. We construct the HIV/AIDS risk profile of the average adult, compute the values of age, education and wealth where the estimated probability of infection assumes its highest value, and we determine the percentage of adults for which age, education and wealth are positively correlated with the probability of infection. We find that in all the four countries: (i) the probability of being HIV positive is higher for women than for men; (ii) the likelihood of infection is higher for urban residents than for rural residents; and (iii) there is an inverted-U relationship between age and HIV status. We also find that unlike gender, rural/urban residence and age, the relationship between the probability of HIV infection and wealth, education and marital status varies by country. Our results provide support for country specific and more targeted HIV policies and programs.

JEL Classification: I10, O10

Key Words: AIDS, HIV, Sub-Saharan Africa

We cannot talk about more inclusive and sustainable development in Africa without also committing to the long-term battle against AIDS, the largest single cause of premature death on the continent. Robert Zoellick, President of the World Bank.[1]

1. Introduction

Without a doubt, HIV/AIDS is a global epidemic, and as noted in (UNDP, 2005), the disease "has inflicted the single greatest reversal in human development in modern history". Although the disease is "global", it is more pervasive in Sub-Saharan Africa (SSA) than in other regions. About 68% (22.5 billion) of the people infected with the disease live in SSA (UNAIDS, 2010). Furthermore, about 90% of the countries that fall under the United Nations classification of "generalized epidemic" are located in SSA.[2] In contrast, none of the countries in Asia and Europe have generalized epidemics, and only 3% of the countries in Latin America and the Caribbean, and 5% of the countries in the Middle East and North Africa have generalized epidemics (UNAIDS, 2011). We also note that the region has the highest new infection rates: about 69% of newly infected people in 2009 lived in SSA. These statistics are troubling because the region accounts for only 14% of the world's population. However, it is important to note that within SSA there is a wide variation in infection rates across sub-regions and countries. Specifically, the prevalence rates are higher in southern Africa than the other sub-regions. Indeed, the top nine countries in the world with the highest infection rates are all located in southern Africa: Swaziland (25.3%), Botswana (24.8%), Lesotho (23.6%), South Africa (17.8%), Zimbabwe (14.3%), Zambia (13.5%), Namibia (13.1%), Mozambique (11.5%) and Malawi (11%).

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[1] Statement made at the 17th International AIDS Conference, in Mexico City in August 2008.

[2] The United Nations employs three categories to describe the state of the epidemic: low level, concentrated, or generalized. The categories are based on a numerical proxy: A low-level epidemic implies that HIV prevalence has not consistently exceeded 5% in any defined sub-population; concentrated epidemic means that HIV prevalence is consistently over 5% in at least one defined sub-population and is below 1% in pregnant women in urban areas; and generalized epidemic implies that HIV prevalence is consistently over 1% in pregnant women (UNAIDS, 2000).

The data clearly demonstrate the need for HIV/AIDS intervention programs in SSA. However, one of the hurdles in implementing intervention programs is lack of resources. Specifically, the gap between the funds available and the funds needed for prevention and treatment of the disease has widened, and the financing gap has increased over time. [3] However, in order for the programs to be cost-effective and successful, the intervention strategies have to target the right populations, in particular, most-at-risk populations (MARPS). Furthermore, as noted by Beegle and de Walque (2009), the profiles of MARPS differ significantly by country, suggesting that intervention programs need to be country-specific. Specifically the authors conduct an extensive review of the literature on the determinants of HIV infection rates and note that "... even with improved data sources, it will still be difficult to generalize results across countries." p. 17

Another issue is that country-specific policies or programs should be based on a rigorous analyses rather than anecdotal evidence. Indeed, the importance of designing policies based on evidence-based country-level studies is well articulated in the 2008 report on the Global AIDS epidemic which notes that HIV/AIDS programs and policies "need to be informed by evidence and carefully tailored to national needs and circumstances if they are to be optimally effective. National decision-makers and partners must know their epidemic in order to develop national plans that will achieve maximum impact." (UNAIDS, 2008: 27; emphasis added).

Clearly, research on the determinants of HIV infection rates is crucial for high prevalence rate countries. This paper analyzes the determinants of HIV infection rates in all the high prevalence rate countries in SSA for which data on HIV are readily available---Lesotho, Malawi, Swaziland and Zimbabwe (we expound on this below). Thus, the goal of this paper is to assist policy makers in these four countries to "know their epidemic" and also aid them to design evidence-based HIV programs.

[3] Foreign aid for HIV/AIDS to developing countries was about $8 billion in 2005 and $10 billion in 2007. Meanwhile, the resources needed to effectively fight the epidemic have increased from about $11 billion in 2005 to about $18 billion in 2007. This implies that the financing gap increased by over 250%---from $3 billion in 2005 to $8 billion in 2007 (UNAIDS, 2007). We note that the price of antiretroviral (ARV) drugs has declined substantially in the past fifteen years. From 1996-2010, the cost of the most widely used ARV drug dropped by about 99%--- from $10,000-$15,000 per person per year to about $64 per person per year (AVERT, 2011). However, the financial constraint is binding for most of the countries in SSA, in particular, poor countries with high prevalence rates, such as Lesotho and Zimbabwe.

We estimate a probit model where an individual's HIV status depends on the person's gender, area of residence, marital status, age, education and household wealth, and we construct the risk profile of the average adult in these countries. An important message that emerges from our analyses is that the risk profiles differ significantly by country, and therefore there is a need for more country studies on the determinants of HIV infection rates.

With regards to the literature, we note that until recently, nationally representative survey data on HIV were not readily available. As a consequence, most of the studies on the determinants of HIV infection rates relied on data collected by individual researchers. Data collection is time consuming and expensive, especially when it entails obtaining sensitive information from respondents. Thus, the studies typically utilize data from non-representative groups and the sample size of the data employed for the analysis tends to be small. Note that an analysis that is not based on a representative sample cannot be (statistically) extrapolated to general populations. In addition, inferences based on a study where the sample size is small may be unreliable because the analyses are susceptible to the "small-sample bias" problem. Clearly, such problems curtail the policy relevance of most of the existing studies.

This paper employs data from the Demographic and Health Survey (DHS) --- the only survey that currently collects national, population-based HIV data in several countries.[4] The DHS data has large sample sizes (usually between 5,000 and 30,000 households) and the survey has information on a wide range of demographic and socioeconomic indicators. So far, the survey covers 82 countries. Although the DHS has been around since 1988, the survey started collecting data on HIV in 2001. Currently, the data on HIV are available for 24 countries.

A few recent studies have used the DHS data to examine the socioeconomic determinants of HIV infection rates. Our work is most closely related to De Walque (2006), Mishra et al. (2007) and Fortson (2008). The analyses of de Walque (2006) and Fortson (2008) cover the same set of five countries: Burkina Faso, Cameroon, Ghana, Kenya and Tanzania; and Mishra et al., (2007) also study these five countries but add other three countries---Lesotho, Malawi and Uganda.

[4] For more information on the DHS, see http://www.measuredhs.com/aboutsurveys/dhs/start.cfm.

The paper makes three contributions to the literature. First, it adds to the limited number of studies that employ a nationally representative data to analyze the determinants of HIV infection rates. Second, to the best of our knowledge, this is the first study that employs the DHS data to examine the determinants of HIV infection rates for Swaziland and Zimbabwe --- two of the countries with the highest infection rates in the world. Moreover, the four countries that we study cover all the high prevalence rate countries in SSA for which the DHS data are available.[5] Previous studies have focused on countries with low or medium HIV prevalence rates, probably because the data for high-risk countries were not available until recently.[6] The third contribution is that we take a different approach in analyzing the determinants of HIV/AIDS. Specifically we construct the risk profile of the average adult, estimate the values of age, wealth and education where the probability of infection assumes its highest value, and determine the percentage of the adults for which age, education, wealth are positively correlated with the probability of infection. Such an analysis has not been conducted in the literature.

The paper is also timely and contributes to the recent debate about using antiretroviral (ARV) drugs to combat the HIV/AIDS epidemic. Until recently, discussions about HIV intervention strategies have centered on the cost-effectiveness of treatment versus prevention strategies (See Creese et al., 2002; and Galárraga et al., 2009 for a review of the literature). The consensus in the literature is that, overall, prevention is more cost effective than treatment. For example, Canning (2006) asserts that for poor countries, prevention is more cost-effective than treatment. Also, Maeseille et al. (2002) find that for SSA, prevention is at least 28 times more cost-effective than antiretroviral therapy. We note however, that the discussion about the merits of treatment versus prevention strategies has changed in light of the findings from two new studies released on July 13, 2011, which find that antiretroviral therapy is effective in treating and

[5] We did not study the following high prevalence rate countries: South Africa, Botswana, Namibia and Mozambique because the DHS did not collect information on HIV status. Also, we did not include Zambia in our sample because the HIV data for the country cannot be linked to the socioeconomic characteristics of specific individuals.

[6] For example the HIV data for Zimbabwe and Swaziland were collected in 2006 and made available in 2008. The data for countries, which have been studied in the past, such as Ghana, Tanzania and Burkina Faso, were collected in 2003 and have been available since 2004.

preventing HIV.[7] Specifically, the focus of the debate has changed to who should be offered the drug.[8] Clearly, this new finding raises several research questions. For example, Knox (2011) emphasizes the importance of country-specific research on HIV/AIDS and asserts that "there will need to be studies to sort out the most effective way to deploy the approaches in different countries and different populations with different HIV rates. Turning all this into a coherent HIV prevention strategy in country after country, at a time of declining resources, is going to need more work" p. 1. As noted earlier, HIV/AIDS is a generalized epidemic in SSA, and therefore the countries in the region may benefit from targeting the whole population. However, due to a lack of resources, this option is not viable for SSA countries. We assert that it may be more cost-effective to target sub-populations, in particular, the MARPS. Thus, this paper contributes to this important debate by providing a framework for identifying the MARPS in various countries.

The remainder of the paper is as follows. Section 2 describes the data and the variables, Section 3 presents the empirical results and Section 4 discusses the policy implications and presents the conclusion.

2. The Data and the Variables

We use the 2006 household survey for Swaziland and Zimbabwe, and the 2004 survey for Lesotho and Malawi.[9] All the adults who participated in the survey were eligible for HIV testing. Here, adults refer to men ages 15-59 (Lesotho), ages 15-49 (Swaziland and Malawi), and ages 15-54 (Zimbabwe), and women ages 15-49 (all countries). Participation in HIV testing was voluntary. To ensure confidentiality, case numbers (and not names) were used in linking the HIV test results to individual and household characteristics.

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[7] The two studies are the TDF2 study sponsored by the Centers for Disease Control and Prevention, and PrEP study, conducted by the International Clinical Research Center at the University of Washington. The TDF2 study found that taking antiviral drugs reduces the risk of contracting HIV by about 63-73 percent a year. The study covered 6,000 young people in Kenya, Uganda and Botswana. See Knox (2011) for more information about the two studies.

[8] This issue was the focus of discussion at the 6th International AIDS conference held in Rome, July17-July 20.

[9] The sampling design and survey implementation procedures for each country are described in the individual country survey reports. See http://www.measuredhs.com/pubs/start.cfm.

Table 1 shows the number of adults that agreed to be tested and those that refused. The response rates are quite high, ranging from 75% to 87%. Since the HIV test is done voluntarily, respondents self-select into the sample, and this may introduce a bias. Specifically, there could be a potential bias if the characteristics of those who agreed to be tested are systematically different from those who refused testing. However, analysis by DHS statisticians shows no evidence of such bias in the data for the four countries Nevertheless, addressing a non-response bias in a probit model can be complicated (Freedman and Sekhon, 2010). [10]

In carrying out our analysis, we recognize that several factors can predispose an individual to HIV. We broadly classify these factors into two categories. The first category consists of factors that are observable/verifiable and can be easily quantified. Gender, marital status and area of residence fall into this category. The second category includes factors that are not easily quantifiable (e.g., knowledge of HIV/AIDS), as well as factors that require the disclosure of sensitive information (e.g. sexual preferences, number of partners and condom usage). Clearly, the second group of factors is likely to exhibit large measurement errors, and therefore including these factors as explanatory variables in regressions can produce biased estimates and unreliable results (Curtis and Sutherland, 2004). Obtaining accurate results is critical because the results have a potential impact on policy formulation. For example, the results may serve as an input in designing HIV intervention programs or it may influence the allocation of health care funds.

Another issue is that it is easier to reach high-risk populations if the individuals are identified by characteristics that are easily observable. Thus, in order to minimize measurement errors and also carry out an analysis that will facilitate the design of HIV intervention programs, our empirical analyses employ variables that are observable and easily quantifiable. We group these variables into three categories: demographic (gender, age); geographic (rural/urban); and socioeconomic (marital status, education and wealth).

[10] Freedman and Sekhon (2010) argue that the Heckman two-step technique, which is often used to address this selection problem, may worsen the bias if employed in a probit model. The authors recommend using likelihood techniques, however, they caution that the "numerics can be delicate."

2.1 Description of the Variables

To facilitate the discussion, we report the HIV prevalence rate by gender, area of residence and marital status in Table 2. The dependent variable is *hiv,* and it takes on value 1 if the respondent is HIV positive, and is equal to zero otherwise. We now describe the explanatory variables.

Gender: Table 2 shows that HIV prevalence is higher for females than for males in all the four countries. Note that this frequency data cannot be used to determine the "true" association between gender and HIV status. One reason is that the data does not take into consideration other factors that affect a person's HIV status. For example, if less educated individuals are more likely to be HIV positive, and on the average, women and men have different levels of education, then a difference in prevalence rate between the two groups may be largely explained by differences in educational attainment, rather than gender. Another point is that the difference in prevalence rates range from 3% (Malawi) to 11% (Swaziland). This raises two questions: (i) How important or "significant" is this gender gap? (ii) Will the gap exist or will the size of the gap change if other determinants of HIV are taken into account?

We examine the relationship between gender and HIV status by answering this question: suppose an (average) adult male and female are similar with regards to the following attributes: area of residence, marital status, age, educational attainment and wealth. Is the probability of being HIV positive significantly different for these two individuals? To answer this question, we include a dummy variable, *female,* which takes on value 1 if the respondent is female and zero otherwise. If the estimated coefficient of *female* is positive and significant, then it implies that all else equal, there is a significant difference in the risk of infection for men and women.

Geographical Location: Globally, the HIV prevalence rate is higher in urban areas (about 1.7 times higher) than in rural areas (UNAIDS, 2008). As shown in Table 2, this observation is consistent with the DHS data for our sample countries. Similar to gender, we test whether all else equal, the risk of HIV infection is significantly different for urban and rural residents, by including in our regressions a dummy variable, *urban,* which takes on value 1 if the respondent lives in an urban area, and zero otherwise. We also control for regional fixed effects by including in the regressions a set of dummy variables representing the various geographical regions.

Marital Status: Table 2 reveals that the HIV prevalence rates are higher for married adults than unmarried adults. Similar to gender, we examine whether the probability of infection is significantly different for married and non-married adults, by including the variable, *married,* which takes on value 1 if the individual is married and zero otherwise.[11]

Age: Fortson (2008) finds an inverted-U relationship between age and HIV status. To analyze whether this relationship holds for our sample countries, we include age in years, *age,* and age^2 as explanatory variables in our regressions.

Education: The results from studies that analyze the relationship between HIV status and education in SSA suggest that the relationship between the two variables vary by country.[12] For example, Fortson (2008) finds a positive and significant association between education and HIV status for Cameroon, Kenya and Tanzania, but concludes that education is not significantly correlated with HIV in Ghana and Burkina Faso. In contrast, the following studies find a negative and significant correlation: Vandemoortele and Delamonica (2000) in Zambia, de Walque (2007) in Uganda, and Bradley et al. (2007) in Ethiopia. Furthermore, the analysis of Fortson (2008) indicates that the relationship between education and HIV status is quadratic. We therefore include years of schooling, *educ*, and $educ^2$ in our regressions.

Wealth: Similar to education, the relationship between HIV status and wealth seems to be country specific. For example, after controlling for several factors (e.g., age, education, urban residence), Mishra et al. (2007) find a positive association between household wealth and HIV status for men in Cameroon and Malawi, but a negative association for men in Ghana and Burkina Faso. Our measure of wealth is derived from the DHS household index, which is computed based on several factors, including household ownership of consumer durable goods (e.g., television and bicycles), availability of amenities (e.g., electricity, source of drinking water, and type of toilet

[11] See Asiedu, Asiedu and Owusu (2010) for a detailed analysis about the relationship between HIV status and marital status.
[12] See WFP (2006) for a review of the literature.

facility), and ownership of agricultural land. [13] For similar reasons as age and education, we include both *wealth* and *wealth²* in the regressions.

2.2 Summary Statistics and Correlations

Table 3 presents the summary statistics of the variables. The sample sizes are large (Lesotho=5,241; Malawi=5,262; Swaziland=8,167; and Zimbabwe=13,042) and the HIV prevalence rates are also high (Lesotho=23%, Malawi=13%, Swaziland=26% and Zimbabwe=18%). In addition, most of the variables display a wide variation across countries. For example, about 70% of the Malawian respondents are married or are in cohabitant relationships, compared to only 36% in Swaziland, 49% in Lesotho and 53% in Zimbabwe. The urban populations in Zimbabwe and Swaziland are large relative to Lesotho and Malawi (Lesotho=23%, Malawi=14%, Swaziland=30% and Zimbabwe= 32%). On the average, respondents from Zimbabwe and Swaziland have 8 years of education, while those in Lesotho and Malawi have 6 and 5 years of education, respectively.

Table 4 shows the sample correlation coefficients between the explanatory variables and HIV status. There are three notable points. First, there is consistency across country in the signs and level of significance of the correlation coefficients for the measures of gender, age and marital status. In all the four countries, *female*, *age* and *married* are positively and significantly correlated with HIV status at the 1% level. Second, the sign and the level of significance of the coefficients of *educ* and *wealth* vary by country. The coefficient of education is positive and significant at the 5% level for Lesotho, negative and significant at the 1% level for Swaziland and Zimbabwe, and insignificant for Malawi. The coefficient of wealth is positive and significant at the 1% level for Lesotho and Malawi, negative and marginally significant (10% level) for Swaziland, and is not significant for Zimbabwe. The third point is that there is a wide variation across country in the "degree" of association between HIV status and gender,

[13] The DHS data had negative values; hence to facilitate the interpretation of the results, we transformed the data. Specifically, for each country, we added the absolute value of the minimum of wealth index to each observation and multiplied by 100. The transformation had no effect on the sign and significance of the estimated coefficients. Fortson (2008) computed a wealth index based on selected assets from the DHS data. For more information about the DHS wealth index, see http://www.measuredhs.com/pubs/pdf/CR6/CR6.pdf.

marital status and age. The correlation coefficient of *female* ranges from 7% for Malawi to 13% (about double) for Swaziland; the coefficient for *married* ranges from 6% for Malawi to 13% for Swaziland, and the coefficient for *age* ranges from 13% for Malawi to 22% for Zimbabwe. In Section 3 we examine whether these relationships hold after controlling for other important determinants of HIV infection rates.

3. Empirical Analysis

We estimate a probit model for each of the four countries:

$$P(hiv_i = 1)=F(\alpha+\beta_1 female_i + \beta_2 urban_i + \beta_3 marriage_i + \beta_4 age_i + \beta_5 age_i^2 + \beta_6 educ_i + \beta_7 educ_i^2 + \beta_8 wealth_i + \beta_9 wealth_i^2 + \Sigma^{J}_{j=1}{}^{J}\, \gamma_j Z_j) \qquad (1)$$

Here, *i* refers to respondents, *hiv* takes on value 1 if the respondent is HIV positive and is equal to zero otherwise; and Z is a vector of dummy variables representing the geographical regions in the country.

It is reasonable to expect the error terms to be correlated within households, and as a consequence, we cluster our observations at the household level. Our main findings hold even when we do not allow for clustering and simply run a standard probit regression under the assumption of independent error terms. Note that the explanatory variables include linear and quadratic terms. As asserted by Ai and Norton (2003), the standard commands used by most statistical packages in computing the marginal effect of a variable for probit models (e.g., Stata's mfx and dprobit commands) estimate the wrong marginal effect if the variable has higher order terms.[14] Hence, we wrote a Stata program to calculate the correct marginal effects and standard errors (available upon request from authors).[15] We also note that it is difficult to determine the direction of causality between HIV status and some of the explanatory variables. One reason is that causality may run in both directions. We use marital status as an example to illustrate our point. On the one hand, widowhood may be caused by the death of an infected partner. On the other hand, widowhood implies being single, and may expose a person to multiple partners and

[14] For example in Stata 10, the mfx and dprobit commands treat higher order terms as "different" variables, so they cannot take the full derivative with respect to that variable. This is true for other regression models that have categorical dependent variables.

[15] We used the predictnl command in Stata. The idea is that if $E[y|x_1,X]=\varphi(\alpha_1 x_1+\alpha_2 x_1^2 +X\beta)= (u)$, then $((\partial\varphi(u))/(\partial x_1))=(\alpha_1+2\alpha_2 x_1)\varphi'(u)$.

thereby increase their risk of infection (Porter et al., 2004; Boileau, et al., 2009).[16] Another reason why it is difficult to establish the direction of causality is that we cannot ascertain when infection occurred. For example, a woman who is currently married may have contracted the disease when she was single (Glynn et al., 2003).[17] Bearing this in mind, we interpret the relationship between HIV status and the explanatory variables as correlations/associations instead of causal relationships. This simple strategy allows us to achieve one of our main objectives --- i.e., to construct the HIV risk profile of the average adult. Furthermore, it keeps the paper focused.

3.1 Estimation Results

Table 5 shows the estimation results. Columns (1)-(4) depict the estimated coefficients of the explanatory variables. Note that the marginal effect will vary through the sample space of independent variables. We report the marginal effects calculated at the multivariate point of means (see columns (5)-(8)), which can be interpreted as the marginal effects for an average individual.[18] An advantage of this approach is that it permits us to construct the HIV risk profile of an average adult. Since we are interested in the risk profiles of an average individual, our discussion will focus on the estimated marginal effects. As revealed in Table 5, the signs and the level of significance of the estimated coefficients of the demographic and geographical variables (i.e., *female*, *age* and *urban*) are the same for all the four countries. In contrast, the signs and the level of significance of the estimated coefficient of the socioeconomic variables (i.e., *married*, *wealth* and *educ*) vary by country.[19]We next discuss the estimated relationship between the explanatory variables and HIV status.

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[16] Porter et al. (2004) find that being HIV positive significantly increased the likelihood of separation, divorce and widowhood among women in Rakai, Uganda. Boileau (2009) arrive at a similar conclusion based on data for women in rural Malawi.

[17] Glynn et al. (2003) find that about 26% of women in Kisumu, Kenya, and 21% of women in Ndola, Zambia, were HIV positive at the time of marriage.

[18] Note that the marginal values can be calculated at other points. Indeed, some argue that it would be preferable to compute the average marginal effect, which is the average of each individual's marginal effect. For more on this issue see Baum (2006).

[19] The discussion focuses on the qualitative similarities and differences in the determinants of HIV infection rates for the four countries. A quantitative comparison of HIV rates determinants across countries will require a formal statistical test, and this will entail including interaction terms for each of the nine explanatory variables. Here, the number of independent variables will increase to 36, and the discussion of the estimation results can be cumbersome. Another point is that computing the marginal effect for Probit

Gender: The estimated coefficient of *female* is significant and positive at the 1% level in all the regressions, suggesting that in all the four countries, the probability of HIV infection is higher for women than for men. Specifically, columns (5)-(8) show that the probability of infection is about 11 percentage points higher for females than for males in Swaziland, and about 5 percentage points higher for females in Lesotho, Malawi and Zimbabwe. Thus, the "gender" inequality in HIV risk persists even after controlling for other determinants of HIV.

Geographical Location: The estimated coefficient of *urban* is positive and significant at the 1% level in all of the regressions, suggesting that conditional on all other covariates, respondents who live in urban areas have a higher likelihood of infection than those who reside in rural areas. The probability of infection is about 8 percentage points higher for urban residents in Swaziland, 7 percentage points higher for urban residents in Lesotho, and about 6 percentage points higher for urban residents in Malawi and Zimbabwe.

Marital Status: In contrast to gender and geographical location, the relationship between marital status and HIV status varies by country. The estimated coefficient of *married* is not significant for Malawi, it is negative and significant at the 1% level for Swaziland and Zimbabwe, and is negative and significant only at the 10% level for Lesotho. The probability of infection is about 4 percentage points lower for married adults in Swaziland and 7 percentage points lower for married adults in Zimbabwe. Thus, the result suggests that in Swaziland and Zimbabwe marriage is associated with a lower risk of infection.

Age: The marginal effects imply that in Swaziland, a one-year increase in age from the average of 27 years is associated with a 2.8 percentage point increase in the probability of infection. For Lesotho, Malawi and Zimbabwe, a one year increase in age from the average (Lesotho=29 years, Malawi=29 years and Zimbabwe=28 years) is associated with a 2, 1.3 and 2.4 percentage point increase in the probability of being HIV positive, respectively.

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models that include interaction terms can be complicated (Ai and Norton, 2003). Thus, in order to keep the paper focused, we concentrate on qualitative comparison across country.

Education: Unlike age, the relationship between education and HIV status varies by country. Specifically, the estimated marginal effect of education for an average adult is negative and significant at the 5% level for Zimbabwe, negative and significant at the 1% level for Swaziland, and negative but marginally significant (10% level) for Lesotho. In contrast, the estimated marginal effect of education is positive and significant at the 5% level for Malawi. An extra year of schooling from the average (average for Malawi=5 years, Swaziland=8 years and Zimbabwe=8 years) is associated with a 0.5 percentage point decrease in the probability of infection for Zimbabwe, 1.5 percentage point decrease for Swaziland, and a 0.5 percentage point increase in the probability of infection for Malawi. There is no significant association between education and the HIV status for the average adult in Lesotho.

Wealth: Similar to education, the association between wealth and HIV status differs by country. There is no significant association between wealth and the HIV status for the average adult in Lesotho and Zimbabwe; but wealth is positively correlated with HIV status in Malawi, and negatively correlated in Swaziland. For Malawi, a one unit increase in wealth from the mean is associated with a 0.6 percentage point increase in the probability of being HIV positive whereas for Swaziland, a unit increase is associated with a 0.2 percentage point decrease in infection rate.

3.2 HIV Risk Profile of the Average Adult

To facilitate the discussion, we summarize the results of the probit regressions in Table 6. The table reflects the association between the probability of infection and the explanatory variables, when the variables are evaluated at their means. Here, "Positive" implies that the estimated marginal effect evaluated at the mean is positive and the p-value $\leqslant$0.05; "Negative" implies that the estimated marginal effect evaluated at the mean is negative and the p-value $\leqslant$0.05; and "None" means the p-value >0.05. Based on Table 6, we construct the HIV risk profile for the average adult in each country.

Lesotho: An average adult in Lesotho is more likely to be HIV positive if the person is female or lives in an urban area. In addition, the probability of infection is positively correlated with age.

Malawi: An average adult in Malawi is more likely to be HIV positive if the person is female or lives in an urban area. Moreover, the probability of infection is positively associated with wealth, education and age.

Swaziland: An average adult in Swaziland is more likely to be HIV positive if the person has any of these attributes: is female, lives in an urban area, is unmarried. Furthermore, the probability of infection is negatively correlated with wealth and education, and positively correlated with age.

Zimbabwe: An average adult in Zimbabwe is more likely to be HIV positive if the person has any of these attributes: is female, lives in an urban area, and is unmarried. In addition, the probability of infection is negatively correlated with education and positively correlated with age.

3.3 Critical Values of Age, Education and Wealth

The discussion so far has focused on the relationship between HIV status and the explanatory variables, when the variables are evaluated at their means. Although this permits us to construct the HIV risk profile of the average adult, it presents a narrow picture about the relationship between age, education, wealth and HIV status. The reason is that unlike the qualitative variables (*female, urban* and *marriage*), which take on only two possible values, *age*, *wealth* and *educ* assume a wide range of values. In addition, the results in Table 5 point to an inverted-U relationship between HIV status and the three variables.[20] Using *age* as an example, an inverted-U relationship implies that the predicted probability of HIV infection increases with *age* until *age* peaks at some critical value, age^*. Note that, age^* is the value of age at which the estimated marginal effects is equal to zero, when the other variables are evaluated at their means. Thus, HIV status is positively correlated with age when $age<age^*$, it is negatively correlated with age when $age>age^*$, and the estimated probability of being HIV positive assumes its highest value when $age=age^*$. Furthermore, the percentage of adults that have values of *age* such that $age<age^*$ is the estimated share of adults for which age is positively correlated with the

[20] The estimated coefficients of *age*, *educ* and *wealth* are positive and the estimated coefficients of age^2, $educ^2$ and $wealth^2$ are negative, suggesting that there is an inverted-U relationship between HIV status and age, education and wealth. This result holds for all the countries except Lesotho, where the estimated coefficients of educ and $educ^2$ are not significant.

probability of infection, and therefore this percentage reflects the share of the population that are at risk of contracting the disease. Two important questions arise: (i) What is the value of age^* and (ii) What percentage of adults have $age<age^*$? In Panel A of Table 7, we report the value of age^* and the percentage of the respondents for which $age<age^*$. Also, in order to provide the reader with a better insight about the critical values, we report the range, the mean, as well as the median of age. Panel B and Panel C show similar results for education and wealth, respectively.

Panel A of Table 7 shows that age^* is roughly equal for the four countries: about 38 for Zimbabwe and Malawi, 36 for Lesotho and 34 for Swaziland. This suggests that in all the four countries, adults in the 15-34 age group are part of the high-risk-population. Panel A also shows that in all the countries, the percentage of adults that are at risk of infection is quite high. Specifically, HIV is positively correlated with age for about 81% of the respondents in Zimbabwe, 79% in Lesotho, 76% in Swaziland, and about 75% of the respondents in Malawi.

Panel B shows the critical values of the years of schooling, $educ^*$. We do not report $educ^*$ for Lesotho because the estimated coefficients of $educ$ and $educ^2$ are not significantly different from zero. Furthermore, we rejected the hypothesis that $educ$ and $educ^2$ are jointly significant for the Lesotho sample (see Table 5). Clearly, $educ^*$ varies widely across countries: about 1 for Swaziland, 6 for Zimbabwe and 8 for Malawi. Also, for about 86% of the respondents in Malawi, HIV is positively correlated with education. This compares with only 8% and 17%, for the respondents in Swaziland and Zimbabwe, respectively.

Panel C shows that with regards to wealth, there is a significant difference across country in the estimated share of the respondents that are at risk of contracting the virus. Wealth is positively correlated with HIV status for about 94% of the respondents in Malawi, 72% of the respondents in Lesotho, 58% of the respondents in Zimbabwe, but only 36% of the respondents in Swaziland.

4. Discussion and Conclusion

In this section, we discuss the implications of our findings and present the conclusion. We start with the demographic and geographic variables: gender, area of residence and age. We find that the relationship between these three variables and HIV status is qualitatively similar for all the countries. The probability of HIV infection is significantly higher for females than for males (5-11 percentage points higher), even after controlling for important determinants of HIV, such as marital status, area of residence, age, education and wealth. This result suggests that there may be "gender" related factors that increase the vulnerability of women to HIV infection. Furthermore, since women form more than 50% of the adult populations in most African countries (WDI, 2010), the result also implies that all else equal, a higher share of infected adults will be women. Indeed, this observation is consistent with HIV data for the region. According to UNAIDS (2007), about 61% of infected adults in SSA are women.

The higher prevalence rate for women has important social and economic implications for SSA. First, in most countries in SSA, women, in particular, mothers, are considered the "pivots" of the household. For example, women contribute to about 60% to 80% of the labor in food production for household consumption. Furthermore, women are the principal health care providers for the household, and their role as caregivers assumes much greater significance when a family member is infected with HIV. Thus, declining health and a reduction in life expectancy among women will affect the cohesiveness of the household (Gittinger, 1990, Sontheimer 1991). Second, children's education and health are significantly related to the well-being of the mother, and therefore a higher infection rate among women implies a reduction in human capital development among children, which translates into a decline in future economic growth (Currie and Stabile, 2003). Third, a high number of infected women can lead to an increase in the number of cases where the virus is transmitted from mother to child.

We also find that all else equal, the risk of infection is significantly higher (6-8 percentage points higher) for urban residents than rural residents, in all the four countries. This suggests that there may be underlying factors that are specific to urban residency, which raise the risk of infection for urban residents. Cities, by their very nature of concentrating large numbers of people in small areas, facilitate the speed of transmission of HIV. Africa's rapid urbanization, often associated with the growth of informal settlements, provides a favorable environment for the spread of diseases, including HIV/AIDS (SCAN, 2004). This finding is particularly disturbing for SSA because the region is the world's most rapidly urbanizing region. SSA has been experiencing a massive rural-urban migration in the past decade and according to the United Nations, more than half of the people in SSA will live in urban areas by 2030 (UNFPA, 2007). Thus, as more people migrate from rural to urban areas, the number of infected people can be expected to increase.

As we show in Table 7, age is positively correlated with the probability of infection for individuals in the 15-34 age group; and this group accounts for at least 75 percent of the population in the four countries. Also note that the average life expectancy in these countries is less than 45 years (WDI, 2010). This implies that the 15-34 age group form a large share of the labor force. Thus, the result has important implications for the labor market, such as, a decline in labor productivity, high labor turn over, increased absenteeism, and a decline in labor supply. For example, about 53% of firms operating in SSA reported that HIV/AIDS has led to significant reduction in productivity and an increase in absenteeism (Asiedu et al., 2011).[21] The findings also suggest that HIV/AIDS can have an adverse impact on savings and investment in education. For instance, a high prevalence rate among young and middle-aged adults implies a shorter life span, which in turn may induce individuals to be myopic when making decisions about saving for the future and investing in their education.[22] Also, the years 15-34 are important because it falls within the childbearing years. As pointed out earlier, this may facilitate the spread of the disease by increasing the number of transmissions from mother to child.

We now turn our attention to the socioeconomic variables. Our findings that the relationship between HIV and socioeconomic factors vary across the four countries highlight some of the unique dimensions of the HIV/AIDS epidemic, even in countries within the same sub-region, i.e., southern Africa. For instance, we find that education is

[21] See Lisk (2002) for a discussion about the effect of HIV/AIDS on the labor market.
[22] HIV/AIDS has reversed the gains made in life expectancy in these countries. For example, for Zimbabwe, life expectancy at birth increased from 55 years in 1970 to 61 years in 1990 (i.e., prior to the HIV/AIDS epidemic), and declined to 45 years in 2009 WDI, 2011). Also, about 18% of college students that graduated in 1987 had died of AIDS by 2001---i.e., about 21 years after graduation (Asiedu et al., 2011).

negatively correlated with the probability of infection in Swaziland and Zimbabwe. However, the reverse is true for Malawi, where HIV status is positively correlated with education. In addition, poorer households in Swaziland have a higher probability of infection; in contrast, wealthier households are more likely to be infected in Malawi. Similarly, unmarried adults are at a higher risk of infection in Zimbabwe and Swaziland; but marital status does not seem to have any significant effect on HIV infection in Lesotho and Malawi.

In sum, our analyses show that although the countries share some common factors in terms of their relationship to HIV/AIDS, overall the HIV risk profiles differ significantly across countries. What is the implication of this finding in designing HIV intervention programs? Our results suggest that countries can work together and share their strategies for targeting high-risk populations, specifically, females, young adults, and urban residents. Nevertheless, policies have to be country-specific, since overall, the HIV risk profiles differ significantly across countries. Thus, our results make a strong case against a one-size-fits-all approach in addressing the HIV/AIDS epidemic. For instance, the countries studied here can benefit from HIV programs that aggressively address social, cultural and structural factors that increase the vulnerability of women, urban residents and young and middle-aged adults to HIV infection. Examples include programs aimed at changing the cultural expectations of men and women (Lindgren et al., 2005; Niens and Lowrey, 2009), and implementing policies that reduce informal settlement and slums in major cities (Dyson, 2003; Hattori and Doodo, 2007). Antiretroviral (ARV) drugs increases labor supply, raises productivity and reduces absenteeism at the workplace (Rosen et al., 2008; Thirumurthy et al., 2008). Thus, encouraging young adults to test for HIV and making ARV drugs available to infected young adults may benefit all the countries. Intervention programs in Swaziland and Zimbabwe may focus on less educated adults, but programs in Malawi may target the more educated. Similarly, intervention programs in Swaziland may target the poor, but Malawi may direct its efforts towards wealthier households.

We end with a recommendation to help promote country-level, evidence-based HIV/AIDS intervention programs in Africa. Specifically, we call for more rigorous empirical country studies on the socioeconomic determinants of HIV. To facilitate this, the DHS should collect HIV data for more countries, in particular, high-risk countries. Currently, the data on HIV are available for 24 countries, 19 of which are in SSA. [23]

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Table 1

HIV Testing Response Rates

	Lesotho	Malawi	Swaziland	Zimbabwe
Agreed to be tested	5,276	5,272	8,250	13,042
Refused to be tested	996	1,747	1,277	2,832
Total Testing Sample	6,272	7,018	9,527	15,874
Response Rate (%)	84	75	87	82

Notes: "Testing Sample" refers to the adults who were asked to be tested. The sample includes women ages 15-49 (all countries), and men ages 15-59 (Lesotho), ages 15-49 (Malawi and Swaziland), and ages 15-54 (Zimbabwe).

Table 2

HIV Prevalence Rates (Percent)

		Lesotho	Malawi	Swaziland	Zimbabwe
Gender	Female	26	13	31	21
	Male	19	10	20	15
Geographical Location	Urban	29	17	29	19
	Rural	22	11	20	18
Marital Status	Married	29	13	30	21
	Unmarried	20	9	28	17

Notes: The sample includes women ages 15-49 (all countries), and men ages 15-59 (Lesotho), ages 15-49 (Malawi and Swaziland), and ages 15-54 (Zimbabwe). Unmarried includes never-married, divorced, separated and widowed.

Table 3

Summary Statistics

Variable	Lesotho		Malawi		Swaziland		Zimbabwe	
	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
HIV	0.23	0.42	0.13	0.33	0.26	0.44	0.18	0.38
Female	0.58	0.49	0.54	0.50	0.56	0.50	0.57	0.49
Urban	0.23	0.42	0.14	0.34	0.30	0.46	0.32	0.47
Married	0.49	0.50	0.70	0.46	0.36	0.48	0.53	0.50
Wealth	100.34	9.85	101.02	10.96	99.32	9.54	99.99	9.99
Education	6.20	3.31	5.03	3.54	7.92	3.95	8.03	2.73
Age	28.68	11.10	28.77	9.69	27.05	9.71	27.68	9.93
Number of Respondents	5241		5262		8167		13042	

Notes: The sample includes women ages 15-49 (all countries), and men ages 15-59 (Lesotho), ages 15-49 (Malawi and Swaziland), and ages 15-54 (Zimbabwe).

Table 4

Correlations between HIV Status and the Explanatory Variables

Variable	Lesotho	Malawi	Swaziland	Zimbabwe
Female	0.087*** (0.000)	0.069*** (0.000)	0.133*** (0.000)	0.086*** (0.000)
Urban	0.077*** (0.000)	0.078*** (0.000)	0.078*** (0.000)	0.0156* (0.076)
Married	0.096*** (0.000)	0.0578 *** (0.000)	0.1294*** (0.000)	0.07*** (0.000)
Age	0.158*** (0.000)	0.125 *** (0.000)	0.212*** (0.000)	0.215*** (0.000)
Educ	0.0335** (0.015)	0.011 (0.407)	-0.060*** (0.000)	-0.033*** (0.000)
Wealth	0.0408*** (0.000)	0.0472*** (0.000)	-0.0183* (0.098)	0.003 (0.733)
Number of Respondents	5,241	5,262	8,167	13,042
HIV Positive (%)	23	13	26	18

Notes: P-values are in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

Table 5

Probit Estimations

VARIABLES	Estimated Coefficients				Marginal Effects Evaluated at the Multivariate Means			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Lesotho	Malawi	Swaziland	Zimbabwe	Lesotho	Malawi	Swaziland	Zimbabwe
Female	0.198*** (0.000)	0.305*** (0.000)	0.376*** (0.000)	0.236*** (0.000)	0.054*** (0.000)	0.053*** (0.000)	0.110*** (0.000)	0.054*** (0.000)
Urban	0.230*** (0.000)	0.276*** (0.001)	0.266*** (0.000)	0.241*** (0.002)	0.067*** (0.000)	0.055*** (0.001)	0.082*** (0.000)	0.059*** (0.002)
Married	-0.096* (0.050)	-0.105 (0.104)	-0.141*** (0.001)	-0.306*** (0.000)	-0.027* (0.050)	-0.019 (0.104)	-0.041*** (0.001)	-0.072*** (0.000)
Age	0.250*** (0.000)	0.206*** (0.000)	0.343*** (0.000)	0.262*** (0.000)	0.020*** (0.000)	0.013*** (0.000)	0.028*** (0.000)	0.024*** (0.000)
Education	-0.012 (0.531)	0.049** (0.013)	0.005 (0.719)	0.064*** (0.000)	-0.005* (0.071)	0.005** (0.027)	-0.015*** (0.000)	-0.005** (0.026)
Wealth	0.135*** (0.000)	0.146*** (0.000)	0.108*** (0.008)	0.242*** (0.000)	0.002 (0.107)	0.006*** (0.000)	-0.002** (0.037)	-0.001 (0.381)
Age^2	-0.003*** (0.000)	-0.003*** (0.000)	-0.005*** (0.000)	-0.003*** (0.000)				
$Educ^2$	-0.000 (0.942)	-0.003* (0.076)	-0.003*** (0.002)	-0.005*** (0.000)				
$Wealth^2$	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.004)	-0.001*** (0.000)				
Chi-squared test for joint significance of *Age* and *Age^2* (p-values)	0.000	0.000	0.000	0.000				
Chi-squared test for joint significance of *Educ* and *$Educ^2$* (p-values)	0.192	0.000	0.000	0.000				
Chi-squared test for joint significance of *Wealth* and *$Wealth^2$* (p-values)	0.000	0.000	0.000	0.000				
Log-likelihood	-2508.674	-1786.392	-4057.332	-5449.978				
Wald Chi-squared	548.560	361.730	1186.840	1115.900				
Pseudo R-squared	0.111	0.104	0.136	0.111				
Number of Respondent	5241	5262	8167	13042				
% of HIV Positive Respondents	26	13	26	18				
Region Fixed Effects	Yes	Yes	Yes	Yes				

Notes: The dependent variable takes on value 1 if the individual is HIV positive, and zero otherwise. All the regressions include region dummies. Robust p-values clustered at the household level are in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

Table 6

Summary of the Marginal Effects Evaluated at the Mean

Variable	**Lesotho**	**Malawi**	**Swaziland**	**Zimbabwe**
Female	Positive	Positive	Positive	Positive
Urban	Positive	Positive	Positive	Positive
Age	Positive	Positive	Positive	Positive
Married	None	None	Negative	Negative
Wealth	None	Positive	Negative	None
Education	None	Positive	Negative	Negative

Notes: The table reflects the association between the probability of infection and the explanatory variables, variables are evaluated at their means. Here, "Positive" implies that the estimated marginal effect evaluated mean is positive and the p-value ≤0.05; "Negative" implies that the estimated marginal effect evaluated at th is negative and the p-value ≤0.05; and "None" means the p-value >0.05.

Table 7

Critical Values for Age, Education and Wealth

Description	Lesotho	Malawi	Swaziland	Zimbabwe
Panel A: Age and HIV status				
Range	(15-59)	(15-54)	(15-59)	(15-54)
Median	26	27	25	25
Mean	29	29	27	28
Critical value of *age, age**	36	38	34	38
% of respondents with *age<age**	79	75	76	81
Panel B: Education and HIV status				
Range	(0-15)	(0-19)	(0-20)	(0-19)
Median	7	5	8	8
Mean	6	5	8	8
Critical value of *educ, educ**	n.a	8	1	6
% of respondents with *educ<educ**	n.a	86	8	17
Panel C: Wealth and HIV status				
Range	(88-141)	(94-170)	(78-124)	(86-119)
Median	98	97	97	98
Mean	100	101	99	100
Critical Value of *wealth, wealth**	105	120	94	99
% of respondents with *wealth<wealth**	72	94	36	58

Notes: *age** is the value of age where the estimated probability of infection assumes its highest value when the covariates are evaluated at their means. The percentage of respondents with *age<age** are the share of the respondents for which age is positively correlated with the estimated probability. Similar definitions apply to *educ** and *wealth**.