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# The Socio-Economic Determinants of HIV/AIDS Infection Rates in Lesotho, Malawi, Swaziland and Zimbabwe

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*Using data from the Demographic and Health Survey, this article analyses the relationship between HIV status and the socio-economic and demographic characteristics of adults in Lesotho, Malawi, Swaziland and Zimbabwe. It constructs the risk profile of the average adult, computes the values of age, education and wealth where the estimated probability of infection assumes its highest value, and determines the percentage of adults for whom these three factors are positively correlated with that probability. It finds that in all 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 than for rural residents; and (iii) there is an inverted-U relationship between age and HIV status. Also that, unlike gender, rural/urban residence and age, the relationship between the probability of infection and wealth, education and marital status varies by country. The results provide support for country-specific and more targeted HIV policies and programmes.*

**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 million) of the people infected with the

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1. Statement by Robert Zoellick, President of the World Bank, at the 17th International AIDS Conference, Mexico City, August 2008.


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disease live in SSA (UNAIDS, 2010). Furthermore, about 90% of the countries that fall under the United Nations classification of 'generalised epidemic' are located in SSA.[2] In contrast, none of the countries in Asia and Europe have generalised 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 (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 in the other sub-regions. Indeed, the 9 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%).

The data clearly demonstrate the need for HIV/AIDS intervention programmes in SSA. However, one of the hurdles in implementing intervention programmes 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 programmes 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 programmes 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 generalise results across countries' (ibid.: 17).

Another issue is that country-specific policies or programmes should be based on a rigorous analysis 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 programmes 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

2. The United Nations uses three categories to describe the state of the epidemic: low-level, concentrated, and generalised. 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 generalised epidemic implies that HIV prevalence is consistently over 1% in pregnant women (UNAIDS, 2000).
3. Foreign aid to developing countries for HIV/AIDS was about $8 billion in 2005 and $10 bn in 2007. Meanwhile, the resources needed to effectively fight the epidemic have increased from about $11 bn in 2005 to about $18 bn in 2007. This implies that the financing gap increased by over 250%---from $3 bn in 2005 to $8 bn in 2007 (UNAIDS, 2007). We note that the price of antiretroviral (ARV) drugs has declined substantially in the past fifteen years. From 1996 to 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 in poor countries with high prevalence rates, such as Lesotho and Zimbabwe.

partners must know their epidemic in order to develop national plans that will achieve maximum impact' (UNAIDS, 2008: 27).

Clearly, research on the determinants of HIV infection rates is crucial for countries with high prevalence rates. This article analyses 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, its aim is to assist policy-makers in these four countries to 'know their epidemic' and also aid them in designing evidence-based HIV programmes. We estimate a probit model where an individual's HIV status depends on their 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 to emerge from our analysis 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 regard 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 utilise 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 the general population. In addition, inferences based on a study where the sample size is small may be unreliable because the analysis is susceptible to the 'small-sample bias' problem. Clearly, such problems curtail the policy relevance of most of the existing studies.

This article uses 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 have large sample sizes (usually between 5,000 and 30,000 households) and the survey has information on a wide range of demographic and socio-economic indicators. So far, the survey covers 82 countries. Although the DHS has been around since 1988, it started collecting data on HIV only in 2001. Currently, the data on HIV are available for 24 countries.

A few recent studies have used the DHS data to examine the socio-economic 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. Mishra et al. (2007) also study these five countries but add three others – Lesotho, Malawi and Uganda.

This article makes three contributions to the literature. First, it adds to the limited number of studies that use nationally representative data to analyse the determinants of HIV infection rates. Second, to the best of our knowledge, this is the first study that uses 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

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

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] Third, we take a different approach in analysing 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 adults for whom age, education and wealth are positively correlated with the probability of infection. Such an analysis has not been conducted before in the literature.

The article 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 centred 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, Marseille 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 vs prevention strategies has changed in the light of the findings from two new studies released on 13 July 2011, which find that antiretroviral therapy is effective in treating and 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: 1) emphasises 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.' As noted earlier, HIV/AIDS is a generalised 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 article contributes to this important debate by providing a framework for identifying the MARPs in various countries.

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 their HIV status. Also, we did not include Zambia in our sample because the HIV data for the country cannot be linked to the socio-economic 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.
7. The two studies are the TDF2 study sponsored by the Centers for Disease Control and Prevention, and the 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 % 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, 17-20 July 2011.

The remainder of the article is structured 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 conclusions.

## 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, the term 'adults' refers to men aged 15-59 (Lesotho), 15-49 (Swaziland and Malawi), and 15-54 (Zimbabwe), and women aged 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.

Table 1 shows the number of adults who agreed to be tested and those who 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]

### 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 |

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

In carrying out our analysis, we recognise 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 (for example, knowledge of HIV/AIDS), as well as factors that require the disclosure of sensitive information (for example, sexual preferences, number of partners and condom usage). Clearly, the second group of

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.

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 used in a probit model. The authors recommend using likelihood techniques; however, they caution that the 'numerics can be delicate'.

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 programmes or they 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 minimise measurement errors and also carry out an analysis that will facilitate the design of HIV intervention programmes, our empirical analyses use variables that are observable and easily quantifiable. We group these variables into three categories: demographic (gender, age); geographic (rural/urban); and socio-economic (marital status, education and wealth).

## *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.

**Table 2: HIV prevalence rates (%)**

| | | **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 aged 15-49 (all countries), and men aged 15-59 (Lesotho), 15-49 (Malawi and Swaziland), and 15-54 (Zimbabwe). Unmarried includes never-married, divorced, separated and widowed.

*Gender.* Table 2 shows that HIV prevalence is higher for females than for males in all four countries. Note that these frequency data cannot be used to determine the 'true' association between gender and HIV status. One reason is that the data do 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 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 ranges 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 latter question. Suppose an (average) adult male and female are similar with regard 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 being 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 being 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 analyse 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 analyse the relationship between HIV status and education in SSA suggest that the relationship between the two variables varies 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.

11. See Asiedu et al. (2010) for a detailed analysis of the relationship between HIV status and marital status.
12. See WFP (2006) for a review of the literature.

*Wealth*. Similar to education, the relationship between HIV status and wealth seems to be country-specific. For example, after controlling for several factors (such as 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 (for example, television and bicycles), availability of amenities (for example, electricity, source of drinking water, and type of toilet facility), and ownership of agricultural land.[13] For similar reasons to 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 in cohabitant relationships, compared with 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 average, respondents from Zimbabwe and Swaziland have 8 years of education, while those in Lesotho and Malawi have 6 and 5 years, 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 countries in the signs and level of significance of the correlation coefficients for the measures of gender, age and marital status. In all four countries, *female*, *age* and *married* are positively and significantly correlated with HIV status at the 1% level. Second, the sign and level of significance of the coefficients of education 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 not significant for Zimbabwe. The third point is that there is a wide variation across countries in the 'degree' of association between HIV status and gender, 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

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 www.measuredhs.com/pubs/pdf/CR6/CR6.pdf.

to 22% for Zimbabwe. In Section 3 we examine whether these relationships hold after controlling for other important determinants of HIV infection rates.

### 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 |
| No. of respondents | 5241 | | 5262 | | 8167 | | 13042 | |

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

### Table 4: Correlations between HIV status and the explanatory variables

| Variable | Lesotho | Malawi | Swaziland | Zimbabwe |
|---|---|---|---|---|
| | 0.087*** | 0.069*** | 0.133*** | 0.086*** |
| *Female* | (0.000) | (0.000) | (0.000) | (0.000) |
| | 0.077*** | 0.078*** | 0.078*** | 0.0156* |
| *Urban* | (0.000) | (0.000) | (0.000) | (0.076) |
| | 0.096*** | 0.0578 *** | 0.1294*** | 0.07*** |
| *Married* | (0.000) | (0.000) | (0.000) | (0.000) |
| | 0.158*** | 0.125 *** | 0.212*** | 0.215*** |
| *Age* | (0.000) | (0.000) | (0.000) | (0.000) |
| | 0.0335** | 0.011 | -0.060*** | -0.033*** |
| *Educ* | (0.015) | (0.407) | (0.000) | (0.000) |
| | 0.0408*** | 0.0472*** | -0.0183* | 0.003 |
| *Wealth* | (0.000) | (0.000) | (0.098) | (0.733) |
| No. 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%).

## 3 Empirical analysis

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

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

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 (for example, Stata's mfx and dprobit commands) estimate the wrong marginal effect if the variable has higher order terms.[14] Hence, we wrote a Stata programme 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 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 – namely, to construct the HIV risk profile of the average adult. Furthermore, it keeps the article focused.

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 $E[y|x_1,X]= \varphi(\alpha_1 x_1+\alpha_2 x1^2+X\beta)=(u)$, then $((\partial\varphi (u))/(\partial x_1))=(\alpha_1+2 \alpha_2 x_1)\varphi '(u)$.
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 et al. (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.

## *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 four countries. In contrast, the signs and the level of significance of the estimated coefficient of the socio-economic variables (i.e., *married*, *wealth* and *educ*) vary by country.[19] We next discuss the estimated relationship between the explanatory variables and HIV status.

*Gender*. The estimated coefficient of *female* is significant and positive at the 1% level in all the regressions, suggesting that, in all 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 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.

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

## Table 5: Probit estimations

| Variables | Estimated coefficients | | | | Marginal effects evaluated at the multivariate means | | | |
|---|---|---|---|---|---|---|---|---|
| | (1) Lesotho | (2) Malawi | (3) Swaziland | (4) Zimbabwe | (5) Lesotho | (6) Malawi | (7) Swaziland | (8) Zimbabwe |
| *Female* | 0.198*** | 0.305*** | 0.376*** | 0.236*** | 0.054*** | 0.053*** | 0.110*** | 0.054*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Urban* | 0.230*** | 0.276*** | 0.266*** | 0.241*** | 0.067*** | 0.055*** | 0.082*** | 0.059*** |
| | (0.000) | (0.001) | (0.000) | (0.002) | (0.000) | (0.001) | (0.000) | (0.002) |
| *Married* | -0.096* | -0.105 | -0.141*** | -0.306*** | -0.027* | -0.019 | -0.041*** | -0.072*** |
| | (0.050) | (0.104) | (0.001) | (0.000) | (0.050) | (0.104) | (0.001) | (0.000) |
| *Age* | 0.250*** | 0.206*** | 0.343*** | 0.262*** | 0.020*** | 0.013*** | 0.028*** | 0.024*** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| *Education* | -0.012 | 0.049** | 0.005 | 0.064*** | -0.005* | 0.005** | -0.015*** | -0.005** |
| | (0.531) | (0.013) | (0.719) | (0.000) | (0.071) | (0.027) | (0.000) | (0.026) |
| *Wealth* | 0.135*** | 0.146*** | 0.108*** | 0.242*** | 0.002 | 0.006*** | -0.002** | -0.001 |
| | (0.000) | (0.000) | (0.008) | (0.000) | (0.107) | (0.000) | (0.037) | (0.381) |
| *Age²* | -0.003*** | -0.003*** | -0.005*** | -0.003*** | | | | |
| | (0.000) | (0.000) | (0.000) | (0.000) | | | | |
| *Educ²* | -0.000 | -0.003* | -0.003*** | -0.005*** | | | | |
| | (0.942) | (0.076) | (0.002) | (0.000) | | | | |
| *Wealth²* | -0.001*** | -0.001*** | -0.001*** | -0.001*** | | | | |
| | (0.000) | (0.000) | (0.004) | (0.000) | | | | |

| | | | | |
|---|---|---|---|---|
| $Chi^2$ test for joint significance of *Age* and *Age²* (p-values) | 0.000 | 0.000 | 0.000 | 0.000 |
| $Chi^2$ test for joint significance of *Educ* and *Educ²* (p-values) | 0.192 | 0.000 | 0.000 | 0.000 |
| $Chi^2$ test for joint significance of *Wealth* and *Wealth²* (p-values) | 0.000 | 0.000 | 0.000 | 0.000 |
| Log-likelihood | -2508.674 | -1786.392 | -4057.332 | -5449.978 |
| Wald $Chi^2$ | 548.560 | 361.730 | 1186.840 | 1115.900 |
| Pseudo $R^2$ | 0.111 | 0.104 | 0.136 | 0.111 |
| No. of respondents | 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 cluster at the household level are in parenthesis. Asterisks denote significance levels (***=1%, **=5%, *=10%).

*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.

*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 to 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 Risk profile of the average adult

To facilitate the discussion, we summarise 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 $\leq 0.05$; 'negative' implies that the estimated marginal effect evaluated at the mean is negative and the p-value $\leq 0.05$; 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.

In Lesotho, an average adult 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. In Malawi, an average adult 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. An average adult in Swaziland is more likely to be HIV-positive if the person has any of the following attributes: is female, lives in an urban area, or is unmarried. Furthermore, the probability of infection is negatively correlated with wealth and education, and positively correlated with age. An average adult in Zimbabwe is more likely to be HIV-positive if the person has any of the same attributes. In addition, the probability of infection is negatively correlated with education and positively correlated with age.

**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, 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 ≤0.05; 'negative' implies that the estimated marginal effect evaluated at the mean is negative and the p-value ≤0.05; and 'none' means the p-value >0.05.

### *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 of 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 are equal to zero, when the other variables are evaluated at their means. Thus, HIV status is positively correlated with age when $age<age^*$, and negatively correlated when $age>age^*$, and the estimated probability of being HIV-positive assumes its highest

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.

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 whom age is positively correlated with the 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 into the critical values, we report the range and the mean, as well as the median of age. Panel B and Panel C show similar results for education and wealth, respectively.

## 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**.

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 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% 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 regard to wealth, there is a significant difference across countries 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 our conclusions. 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 being 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%-80% of the labour 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 et al., 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 being equal, the risk of infection is significantly higher (6-8 percentage points higher) for urban residents than rural residents, in all four countries. This suggests that there may be underlying factors that are specific to urban residence, 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 urbanisation, often associated with the growth of informal settlements, provides a favourable 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 urbanising region. SSA has been experiencing a massive rural-urban migration in the past decades 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 shown 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% 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 forms a large share of the labour force. Thus, the result has important implications for the labour market, such as a decline in labour productivity, high labour turnover, increased absenteeism, and a decline in labour supply. For example, about 53% of firms operating in SSA reported that HIV/AIDS has led to a 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 they fall 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 socio-economic variables. Our findings that the relationship between HIV and socio-economic factors varies 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 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 programmes? 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

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21. See Lisk (2002) for a discussion of the effect of HIV/AIDS on the labour 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, 2010). Also, about 18% of college students graduating in 1987 had died of AIDS by 2001 – i.e., about 21 years after graduation (Asiedu et al., 2011).

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 programmes 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 programmes 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 increase labour supply, raise productivity and reduce 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 programmes in Swaziland and Zimbabwe may focus on less educated adults, while programmes in Malawi may target the more educated. Similarly, intervention programmes in Swaziland may target the poor, while Malawi may direct its efforts towards wealthier households.

We end with a recommendation to help promote country-level, evidence-based HIV/AIDS intervention programmes in Africa. Specifically, we call for more rigorous empirical country studies on the socio-economic 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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23. The 19 countries in SSA are Burkina Faso (2003), Cameroon (2005), Côte d'Ivoire (2005), Congo Dem. Rep. (2007), Ethiopia (2005), Ghana (2003), Guinea (2005), Kenya (2003), Lesotho (2004), Liberia (2007), Malawi (2004), Mali (2006), Niger (2006), Rwanda (2005), Senegal (2005), Swaziland (2006), Tanzania (2003), Zambia (2001), Zimbabwe (2006). The 4 countries outside SSA are Cambodia (2005), Dominican Republic (2007), Haiti (2005) and India (2005). The years the data were collected are in parenthesis.

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