“A cross-national analysis of factors associated with HIV infection in sub-Saharan Africa: evidence from the DHS”

Monica A. Magadi & Muluye Desta
Department of Sociology,
City University,
London.

Paper presented at the IUSSP Conference,
27 September – 03 October 2009, Marrakech, Morocco.

This paper is part of a secondary analysis research project on HIV/AIDS and the well-being of children in sub-Saharan Africa, sponsored by the UK medical Research Council.

Introduction

Background of HIV/AIDS epidemic in sub-Saharan Africa and recent epidemiological trends

There exists significant national variations in both scale and scope of the HIV/AIDS epidemic in Sub-Saharan Africa. According to recent UNAIDS estimates, adult national HIV prevalence is below two per cent in several countries of West and Central Africa, as well as in the horn of Africa, but in 2007 it exceeded 15% in seven southern African countries (Botswana, Lesotho, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe), and was above five per cent in seven other countries, mostly in Central and East Africa (Cameroon, the Central African Republic, Gabon, Malawi, Mozambique, Uganda, and the United Republic of Tanzania) (UNAIDS, 2008). Women in sub-Saharan Africa are disproportionately affected in comparison with men, the difference being particularly stark among young people. Although there are signs that most epidemics in sub-Saharan Africa (including Southern Africa) are stabilizing and that adult HIV prevalence appears to be falling in a growing number of countries, especially in eastern Africa, the actual number of people infected continues to grow due to new infections and use of antiretroviral drugs (UNAIDS, 2008). This calls for continued efforts to improve understanding of factors associated with HIV infection in the region.

Heterosexual sex remains the main mode of HIV transmission in sub-Saharan Africa. However, recent epidemiological evidence has revealed the region's epidemic to be more diverse than previously thought (UNAIDS, 2008). For instance, sex work has been noted to be an important factor in many of West Africa's HIV epidemics, while injecting drug use is a factor to some extent in several of the HIV epidemics in East and southern Africa, including Mauritius, where the use of contaminated injecting equipment is the main cause of HIV infection. Furthermore, several recent studies suggest that unprotected anal sex between men is probably a more important factor in the epidemics in sub-Saharan Africa than is commonly thought (UNAIDS, 2008).

The relatively high serodiscordance rates (i.e only one partner is infected) has important implications for the future of HIV epidemic in sub-Saharan Africa, with heterosexual sex being the main mode of HIV transmission, and the low condom use. According to Demographic and Health Surveys in five African countries (Burkina Faso, Cameroon, Ghana, Kenya, and the United Republic of Tanzania), two thirds of HIV infected couples were serodiscordant. A separate, community-based study in Uganda has shown that, among serodiscordant heterosexual couples, the uninfected partner has an estimated eight per cent annual chance of contracting HIV. Strikingly, in about 30% – 40% of the serodiscordant couples surveyed, the infected partner was female (UNAIDS, 2008).

Most societies have traditions that links AIDS with sexual promiscuity, and often causes HIV positive people to be rejected by their communities and even their families (UNAIDS, 2008). This is due to the fact that HIV is often associated in such societies with behaviours that may be considered socially unacceptable. As a result, HIV infection is widely stigmatised and many people do not want to know their HIV status, and those who know their status, will often keep it a secret, some even from their sexual partners. Auer (1996) and Malcolm et al (1998) concluded that people with HIV/AIDS usually experience "discrimination, stigmatization and ostracization". The wide spread stigma associated with HIV and AIDS in many sub-Saharan African (SSA) countries had been and still is a huge barrier for many people from being tested for HIV or declaring their HIV status if they are already positive. In many SSA countries the estimate of people in the country who know their HIV status is as low as less than 10 percent (PRB, 2008).

A review of correlates of HIV infection

In the absence of a vaccine or effective therapy for preventing or treating HIV/AIDS, research to inform ways to curb risk taking behaviour through proxy factors, remains a priority for researchers. An improved understanding of the risk factors of HIV infection will go a long way towards informing efforts to curb the spread of the epidemic.

Various factors such as gender, cultural practices, socio-economic status and reproductive behaviour are all important in the risk of HIV infection, but age shows perhaps the strongest association with HIV infection due to its connection to biological and psycho-social factors (Rosenthal et al, 1999; UNAIDS, 2003). The populations of most sub-Saharan African countries are predominantly young with up to 43 per cent of the population being under the age of 15 (PRB, 2008). More and more young people are sexually experienced by age 20 and sexually transmitted infections (STI), including HIV are increasingly becoming common among young people. Much of existing literature indicates that focus has been given to adolescent sexuality and its consequences (Rosenthal et al., 1999). However, there is also research evidence that HIV particularly affects the 20-50 years actively working age bracket (UNAIDS, 1998; Bernett and Whiteside, 2002).

The issue of poverty or wealth and its association with HIV/AIDS is as controversial as the epidemic itself. Some policy executives have argued that the pandemic is economically opportunistic, affecting the poor more than those who are relatively richer (Whitehead et al., 2001). However, there is little empirical evidence supporting this argument. On the contrary, it has also been argued that being wealthier may lead to reckless lifestyle and risky sexual relationship as wealthier people (particularly men) can attract multiple partners (Hargreaves et al, 2002; Kimuna and Djamba, 2005). Mishra et al (2007) carried out a study of the association between household wealth and HIV infection using eight DHS surveys in sub-Saharan Africa and found out that adults in the wealthiest quintiles have a higher prevalence of HIV than those in the poorer. The current study will examine whether the above finding holds across most SSA countries.

Existing literature indicates that there is a reversal of patterns observed in the association of HIV infection and education status. In the years up to mid-1990s, those with the highest levels of education were found to be more likely to be infected with HIV than those at the lower end of the education spectrum for the reasons that the more educated were wealthier, more mobile and had broader networks of sexual partners (Hargreaves and Glynn, 2002). However, a recent study by the same group of researchers revealed that the trend is reversed with lower risk of HIV infection among respondents with higher educational attainment (Hargreaves et al, 2008).

Religion and circumcision are among the socio-cultural factors that have attracted research attention. It is argued that because religious leaders are esteemed and frequently exchange with the public, religion can be used as both positive (protective factor) or negative (against protective mechanisms such as condom use). For instance, in a study of the relationship between religion and HIV infection, Trinitapoli and Regnerus (2006) observed that "men belonging to Pentecostal churches consistently report lower levels of both HIV risk behaviour and perceived risk". Other studies have also revealed lower rate of HIV infection in some African communities where circumcision is carried out at birth or early childhood, or in communities where taking alcohol is prohibited as a requirement of their religious affiliation (Gray et al, 2000).

It has been noted in previous studies that sexual migration, which refers either to: 'sex tourism' where men travel in order to have commercial sex; or migrating women who come to work as 'commercial sex workers'; or long distance truck drivers have contributed to the increase in HIV infection (Ntozi & Lubega,1992, Orubuloye et al, 1993). In addition, due to their lengthy separations from their spouses, migrant workers tend to form sexual liaisons in the places to which they migrate. On the other hand, HIV infection may lead to migration as HIV positive individuals are more likely to migrate perhaps in fear of stigmatization and ostracization.

Overall, existing studies suggest rather complex relationships between the risk of HIV infection and various background demographic, socio-economic and cultural factors such as age/sex, educational attainment, socio-economic status, and circumcision. The background factors are likely to be linked to the risk of HIV infection through proximate factors relating to HIV awareness/risk perception, sexual behaviour and biological factors. Boerma and Weir (2005:s64) noted that "statistical analyses of the determinants of HIV infection that indiscriminately include underlying and proximate determinants in the same model and that do not take advantage of the multilevel data structure will produce estimates difficult to interpret". They recommended careful examination and statistical evaluation of pathways to improve estimates of the association between determinants and transmission of HIV infection. This study has particular emphasis on the role of proximate factors such as HIV/AIDS awareness and sexual behaviour factors on the association between various background characteristics and the risk of HIV infection.

Study objectives

We use recent Demographic and Health Survey (DHS) data collected in the mid 2000s (2003-2007) to explore factors associated with HIV infection in SSA. The comparative nature of DHS data, along with the availability of HIV/AIDS test data that can be linked to individual level survey data from recent surveys, provides a unique opportunity for a population-based study of factors associated with the HIV/AIDS epidemic in different contexts.

This paper is part of a larger study on HIV/AIDS and well being of children in SSA, whose main objectives are to: determine socio-economic and behavioural factors associated with HIV infection; examine the association between HIV/AIDS prevalence and rates of orphanhood within communities in sub-Saharan Africa; and examine the effect of orphanhood and HIV/AIDS status of parents on the health and well-being of children. This paper focuses on the first objective investigating individual, household and contextual community factors associated with HIV infection. The specific objectives are to:

(i) determine socio-economic and demographic risk factors of HIV/AIDS infection among males and females in SSA;
(ii) explore the role of the proximate factors relating to HIV/AIDS awareness, stigma/prejudice, and sexual behaviour; and
(iii) examine national and sub-national variations in HIV infection .

The paper aims at providing an overall picture of general patterns and risk factors of HIV infection, as well as identify key areas for more in-depth investigation. Throughout the analysis, emphasis is placed on differences between males and females, as well as cross-national variations.

Data and Methods

The Data

The paper is based on secondary analysis of existing data from the international Demographic and Health Surveys (DHS) programme from different countries in sub-Saharan Africa. The DHS has been implemented in a total of 39 (40 including Ondo State - Nigeria) countries in sub-Saharan Africa up to

2008. The study will use the recent DHS data for each country, conducted in the mid-2000s. Since 2001, MEASURE DHS has conducted nationally representative population-based HIV testing in a number of developing countries. Our analysis is based on data collected by the DHS programme between 2003 and 2007 from a total of 19 countries in Sub-Saharan Africa. A summary of the DHS surveys analysed in this paper is given in Table 1. Some of the surveys for 2006 and 2007 are still being processed, but the data are expected to be available for inclusion in the final version of the paper. The linkage of DHS HIV test results to the full DHS survey record (without personal identifiers) allows for an in-depth analysis of the socio-demographic and behavioural factors associated with HIV infection.

Table 1 Summary of DHS SSA surveys analysed in the study

Country	Women		Men	
	cases	% HIV+	Cases	% HIV+
Burkina Faso 2003	4189	1.8	3341	2.0
Cameroon 2004	5154	6.6	5041	3.9
Cote d'Ivoire 2005	4535	6.4	3893	2.9
DR Congo 2007	4632	1.6	4304	0.9
Ethiopia 2005	5942	1.9	5107	0.9
Ghana 2003	5289	2.7	4265	1.6
Guinea 2005	3842	1.9	2925	1.1
Kenya 2003	3271	8.7	2917	4.6
Liberia 2007	6482	1.9	5190	1.2
Lesotho 2004-05	3020	26.4	2232	18.9
Malawi 2004	2864	13.3	2404	10.2
Mali 2006	4743	1.5	3886	1.1
Niger 2006	4441	0.7	3232	0.7
Rwanda 2005	5663	3.6	4728	2.2
Senegal 2005	4466	0.9	3250	0.4
Swaziland 2006	4584	31.1	3602	19.7
Tanzania 2003-04	5969	7.7	4774	6.3
Zambia 2007	5713	16.1	5161	12.3
Zimbabwe 2005-06	7494	21.1	5555	14.7
All (Sub-Saharan Africa)	92293		75807	

Other DHS data yet to be accessed include: Benin 2006; Central African Republic 2006; Nigeria 2007; and Uganda 2004-05 (restricted)

In each country, the sample tested for HIV (see Table 1) is large enough to permit individual country level analysis.

The DHS HIV testing protocol provides for informed, anonymous, and voluntary testing of women and men in the reproductive ages. The testing protocol undergoes a host country ethical review. The testing is simple: blood spots are collected on filter paper from a finger prick and transported to a laboratory for testing. The laboratory protocol includes an initial ELISA test, and then retesting of all positive tests and 10 percent of the negative tests with a second ELISA. For those tests with discordant results on the two ELISA tests, a Western blot test is performed. Since the testing is anonymous, survey respondents cannot be provided with their results. However, all respondents are offered referrals for free voluntary counselling and testing (VCT) and AIDS educational materials. In some countries, mobile VCT teams follow-up after interviewers to counsel and test willing DHS respondents.

Methods of Analysis

The key outcome variable of interest is HIV/AIDS infection while explanatory variables include:

- individual characteristics including demographic characteristics (gender, age), socio-cultural factors (e.g. circumcision,), sexual behaviour (age at first sex, age at first union, type of union, number of sex partners, condom use), and HIV/AIDS factors (awareness, stigma/prejudice);
- household factors, including socio-economic status; and
- contextual factors at national and sub-national (within country) level.

Most contextual factors have been derived from the individual level information based on mean indices or the proportion of the population in the community/region or country with characteristics of interest. The analysis is based on multilevel modelling, and places particular emphasis on country and community variations in factors associated with HIV/AIDS, and the extent of clustering of HIV infection within countries and communities (region within country). The general form of the multilevel logistic regression model applied may be expressed as:

$$\pi_{ijk} = X'_{ijk}\beta + Y'_{ijk}u_{jk} + Z'_{ijk}v_k \qquad (1)$$

where: π_{ijk} is the probability of HIV infection for a specific individual i, in the j^{th} region in the k^{th} country; X'_{ijk} is the vector of covariates which may be defined at the individual/household, region or country level; β is the associated vector of usual regression parameter estimates; Y'_{ijk} is a vector of covariates (usually a subset of X'_{ijk}) which vary randomly at region level; Z'_{ijk} is a vector of covariates (usually a subset of X'_{ijk}) which vary randomly at country level; and the quantities v_k, and

u_{jk} are the residuals at the country and region level, respectively. These are assumed to have normal distribution with mean zero and variances σ^2_v and σ^2_u (Goldstein, 2003).

The estimates of country and regional level variances are used to calculate intra-unit correlation coefficients to examine the extent to which the risk of HIV infection is clustered within countries (or regions within countries) in sub-Saharan Africa, after taking into account the effect of significant covariates. Since regions are within countries, the intra-country correlation includes region variances. Thus, the intra-region (ρ_u) and intra-country (ρ_v) correlation coefficients are given by:

$$\rho_u = \frac{\sigma_u^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2} \tag{2}$$

and

$$\rho_v = \frac{\sigma_v^2 + \sigma_u^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2} \tag{3}$$

where: σ_v^2 - is the total variance at country level;
σ_u^2 - is the total variance at region level; and
σ_e^2 - is the total variance at individual level.

For the multilevel logistic regression model, the level-1 residuals, e_{ijk}, are assumed to have a standard logistic distribution with mean zero and variance $\pi^2/3$ (π is the constant 3.1416).

To explore country level variations in HIV infection, we have constructed 95% simultaneous confidence intervals (Goldstein and Healy, 1995) for multiple comparisons of country effects based on country level residuals, after controlling for specific sets of covariates. Countries whose confidence intervals do not overlap are associated with different risks of HIV infection (significant at 5% level).

The analysis was undertaken using MLwiN multilevel software and estimations based on second order PQL procedure (Rasbash et al, 2005).

Coverage of HIV testing in the DHS

By collecting blood for HIV testing from representative samples of the population of men and women in a country, the DHS can provide nationally representative estimates of HIV rates. However, it is important to recognize that population-based testing is dependent on the population's willingness to be voluntarily tested for HIV. Where the characteristics of those who agreed to be tested are different from those who refused testing, bias may result. The preliminary analysis, therefore, starts by examining the response rates of HIV test data in different countries. The coverage of HIV testing by gender is presented in Table 2 while HIV testing response rates by selected key characteristics (age group, education level, urban/rural residence) are presented in Appendices i(a) – i(c).

Of particular interest are those who refused testing. It has been argued that those who are positive and know about their status may be more likely to refuse HIV testing than those who do not know their status or know that they are negative. Overall, the proportion of men and women who refused to be tested ranges from less than two per cent in Rwanda to about 20-22% in Malawi and Zambia. In countries where a significant proportion of the respondents refused to be tested, it is possible that patterns of HIV infection observed may be biased if those who are infected are more likely to refuse testing. Also, it is possible that the risk of HIV infection may be higher among the more mobile sub-groups of the population who are more likely to be away from home at the time of the survey.

Table 2: Coverage for HIV testing by country and gender

	HIV testing status							
	Women				Men			
	Tested	Refused	Other /missing	Cases	Tested	Refused	Other /missing	Cases
Burkina Faso 2003	91.7	3.5	4.8	4575	83.9	4.5	11.6	5984
Cameroon 2004	90.4	3.7	5.9	5703	88.9	3.7	7.4	5676
Cote d'Ivoire 2005	79.1	10.6	10.3	5772	76.3	11.1	12.6	5148
DR Congo 2007	90.3	4.4	5.3	5127	86.3	5.7	8.0	4 985
Ethiopia 2005	83.2	11.2	5.6	7142	75.4	12.6	12.0	6778
Ghana 2003	89.0	4.8	6.2	5949	79.8	9.7	10.5	5345
Guinea 2005	91.8	5.7	2.5	4189	87.2	5.0	7.8	5560
Kenya 2003	76.1	12.9	11.0	4303	69.7	10.5	19.8	4183
Lesotho 2004-05	80.4	10.7	8.9	3758	67.6	13.3	19.1	3305
Liberia 2007	87.0	7.3	5.7	7448	80.4	11.3	8.3	6476
Malawi 2004	70.4	22.5	7.1	4071	63.3	21.9	14.8	3797
Mali 2006	92.0	3.2	4.8	5157	83.7	4.8	11.5	4643
Niger 2006	87.8	4.0	8.2	8738	84.2	4.7	11.1	3839
Rwanda 2005	97.0	0.9	2.1	5837	95.3	1.6	3.1	4959
Senegal 2005	84.5	9.9	5.6	5350	75.5	16.0	8.5	4375
Swaziland 2006	87.2	9.5	3.3	5301	77.6	16.6	5.8	4675
Tanzania 2003/4	83.5	12.3	4.2	7154	77.0	13.9	9.1	6196
Zambia 2007	77.1	19.9	3.0	7408	72.2	20.1	7.7	7146
Zimbabwe 2005/06	75.9	13.2	10.9	9870	63.4	17.4	19.2	8761

Source: Compiled from each country's DHS reports.

The HIV testing response rates by selected key characteristics presented in Appendices i(a) – i(c) show no clear systematic pattern by age group, but there is a general tendency for those with higher educational attainment or residing in urban areas to have lower response rates across countries and gender, with a few exceptions.

Results

Descriptive analysis

Descriptive analysis examined the association between HIV infection and other HIV factors relating to awareness and stigma/prejudice or risk perception. We believe that background socio-economic and demographic risk factors are linked to the risk of HIV infection through HIV awareness, stigma/prejudice or risk perception which in turn may influence sexual behaviour that is directly linked to the risk of infection. For instance, it is possible that those with greater awareness of how HIV is transmitted and how it can be prevented will adopt appropriate sexual behaviour to reduce their risk of infection.

Association between HIV infection and HIV/AIDS awareness

A set of eight DHS questions (see Table A2 in the appendix) were used to construct an awareness index, through Principal Components Analysis, and the resulting awareness score classified into quartiles or tertiles. The first quartile (Q1) represents the 25% of the respondents with the lowest awareness, while the highest quartile (Q4) represents the top 25% with the highest awareness. Similarly, the tertiles divide the population in three equal sub-groups, where the first tertile represents the 33% of respondents with lowest awareness. Table 3 gives the percent of HIV positive men and women in each awareness tertile by country. A higher percent of HIV positive in the 'low' awareness tertile than in the 'high' tertile suggest a lower risk of infection among those with higher awareness, while the reverse suggest the converse.

In all countries where there is a significant association between HIV infection and HIV/AIDS awareness, the general pattern suggests a higher HIV prevalence among those with higher HIV/AIDS awareness, especially among females. It is possible that the observed associations are due to confounding factors, associated with both HIV/AIDS awareness and the risk of infection. A multivariate analysis that simultaneously takes into account the effect of other important factors will more accurately establish the association between HIV/AIDS awareness and HIV infection.

Table 3 Percent of females and males HIV positive by HIV/AIDS awareness by country

Country	AIDS Awareness - females				AIDS awareness - males			
	Low	mid	high	Sig.	low	mid	high	Sig.
Burkina Faso 2003	1.3	2.4	1.9	ns	1.6	2.7	1.4	ns
Cameroon 2004	5.2	7.5	7.8	**	4.0	3.6	4.2	ns
Cote d'Ivoire 2005	5.9	6.2	7.1	ns	3.4	2.9	2.6	ns
DR Congo 2007	1.7	1.7	1.3	ns	1.0	0.8	0.9	ns
Ethiopia 2005	1.1	1.4	3.6	***	0.4	0.7	1.4	**
Ghana 2003	2.1	3.4	2.5	ns	1.2	1.8	1.7	ns
Guinea 2005	1.3	2.3	2.4	*	1.1	1.0	1.2	ns
Kenya 2003	6.1	8.8	11.2	***	4.4	4.5	4.9	ns
Liberia 2007	1.2	2.3	2.3	**	1.4	1.2	1.2	ns
Lesotho 2004-05	20.1	28.4	28.9	***	16.5	20.7	20.0	ns
Malawi 2004	12.1	13.4	14.4	ns	8.2	10.7	11.6	*
Mali 2006	1.1	1.5	2.1	*	1.2	1.4	0.7	ns
Niger 2006	0.4	1.1	0.9	ns	0.6	0.7	0.8	ns
Rwanda 2005	2.8	3.5	4.6	**	1.3	2.5	2.6	*
Senegal 2005	0.7	1.1	0.9	ns	0.3	0.3	0.7	ns
Swaziland 2006	29.6	32.2	31.6	ns	18.3	22.1	18.8	ns
Tanzania 2003-04	6.4	7.3	9.1	**	5.3	5.9	7.4	*
Zambia 2007	13.6	17.9	16.6	**	10.7	13.3	13.1	*
Zimbabwe 2005-06	18.7	19.8	23.4	***	13.2	14.6	15.8	*
All (Sub-Saharan Africa)	6.7	7.6	10.3	***	5.1	5.1	5.7	ns

ns – not significant; * - p<0.05; ** - p<0.01; *** - p<0.001

Association between HIV infection and HIV/AIDS stigma/prejudice

We have used three questions in the DHS to assess HIV/AIDS stigma/prejudice: whether the respondent would care for an AIDS patient; whether someone with HIV/AIDS should be allowed to teach; and whether they would buy vegetables from someone with AIDS. Answering no to these questions would be indicative of AIDS stigma or prejudice. A simple additive approach was used to derive a summary stigma/prejudice index, with values ranging from 0 (for someone who answered yes to all the three statements) to a value of 3 (for someone who answered no to all the three questions). Those wish score of 0 or 1 were further classified as having ‘low’ stigma/prejudice, while those with scores of 2 or 3 were classified as having ‘high’ stigma/prejudice. Table 4 gives the percent of HIV positive by HIV/AIDS stigma/prejudice by gender and country.

Table 4 Percent HIV positive by HIV/AIDS stigma and gender

Country	HIV/AIDS stigma - females			HIV/AIDS stigma - males		
	Low	high	Sig.	low	high	Sig.
Burkina Faso 2003	-	1.8	-	2.7	1.3	**
Cameroon 2004	8.0	5.2	***	4.2	3.4	ns
Cote d'Ivoire 2005	6.7	6.1	ns	2.9	2.8	ns
DR Congo 2007	1.8	1.5	ns	1.1	0.6	ns
Ethiopia 2005	4.5	0.6	***	1.7	0.2	***
Ghana 2003	2.3	3.0	ns	1.6	1.6	ns
Guinea 2005	2.8	1.7	ns	0.9	1.2	ns
Kenya 2003	9.9	6.3	**	5.0	3.5	ns
Liberia 2007	2.3	1.7	ns	1.9	0.5	***
Lesotho 2004-05	25.6	27.0	ns	22.0	17.0	**
Malawi 2004	14.5	9.1	**	10.6	6.7	*
Mali 2006	1.7	1.5	ns	1.1	1.1	ns
Niger 2006	1.0	0.6	ns	1.1	0.4	*
Rwanda 2005	4.1	1.5	***	2.3	1.1	*
Senegal 2005	0.7	1.0	ns	0.6	0.3	ns
Swaziland 2006	31.6	25.5	*	20.0	17.2	ns
Tanzania 2003-04	9.0	3.9	***	6.7	4.6	*
Zambia 2007	17.1	10.8	***	13.1	6.2	***
Zimbabwe 2005-06	21.6	19.5	ns	14.9	14.3	ns
All (Sub-Saharan Africa)	14.4	4.3	***	6.7	3.2	***

ns – not significant; * - p<0.05; ** - p<0.01; *** - p<0.001

The results in Table 4 suggest that the relationship between HIV infection and AIDS stigma/prejudice is significant in about half the countries, for both females and males. In general, those who are HIV positive tend to have lower AIDS stigma/prejudice. As in the case of AIDS awareness, it is possible that the observed bivariate associations could be possibly due to the effect of confounding factors which are taken into account in the multivariate analysis presented in the subsequent sections.

Background socio-economic/demographic, HIV/AIDS awareness/stigma and sexual behaviour risk factors of HIV infection

We start by examining the country risk factors of HIV infection, controlling for background socio-economic and demographic factors, HIV/AIDS awareness and stigma, and sexual behaviour factors in successive stages based on logistic regression models that treat the country effect as fixed. The odds ratio of HIV infection for individual countries, relative to the overall country effect, is presented in Table 5 for females and males.

Table 5 Odds ratio of HIV infection by gender for individual countries (versus mean)

Country	Females				Males			
	M0	M1	M2	M3	M0	M1	M2	M3
Burkina Faso 2003	0.40	0.52	0.57	0.59	0.57	0.60	0.62	0.69
Cameroon 2004	1.43	1.32	1.36	1.21	1.32	1.22	1.23	1.02$
Cote d'Ivoire 2005	1.17	1.26	1.27	1.09$	0.79	0.81	0.81	0.75
DR Congo 2007	0.35	0.31	0.32	0.29	0.32	0.27	0.27	0.25
Ethiopia 2005	0.48	0.52	0.54	0.60	0.44	0.44	0.45	0.50
Ghana 2003	0.53	0.47	0.49	0.51	0.51	0.49	0.50	0.51
Guinea 2005	0.36	0.41	0.46	0.47	0.38	0.36	0.38	0.37
Kenya 2003	1.81	1.60	1.54	1.45	1.51	1.49	1.46	1.39
Liberia 2007	0.46	0.39	0.41	0.34	0.38	0.34	0.35	0.30
Lesotho 2004-05	6.95	7.17	7.70	7.84	7.20	8.69	9.05	8.88
Malawi 2004	3.39	3.58	3.30	3.23	3.55	3.61	3.46	3.36
Mali 2006	0.29	0.35	0.36	0.38	0.31	0.29	0.29	0.32
Niger 2006	0.18	0.18	0.19	0.22	0.33	0.30	0.30	0.37
Rwanda 2005	0.80	0.77	0.68	0.81	0.79	0.79	0.75	0.87$
Senegal 2005	0.21	0.22	0.22	0.28	0.16	0.16	0.16	0.17
Swaziland 2006	9.00	8.63	7.65	6.97	7.66	9.87	9.46	9.98
Tanzania 2003-04	1.51	1.43	1.33	1.25	1.89	1.93	1.88	1.74
Zambia 2007	3.91	3.53	3.21	3.02	4.54	4.20	4.07	3.80
Zimbabwe 2005-06	5.15	4.97	4.74	5.10	5.17	5.96	5.89	6.06

$ - not significantly different from the overall mean at 5% level (i.e p>0.05)
Model 0 – no covariates controlled for;
Model 1 – controlling for background socio-economic and demographic factors;
Model 2 – controlling for background factors plus HIV/AIDS awareness/stigma; and
Model 3 – controlling for background factors, HIV/AIDS awareness, and sexual behaviour.

The results presented in Table 5 show considerable variation in the risk of HIV across countries in sub-Saharan Africa. The odd ratios of HIV infection relative to the overall country effect varies from a low of below 0.2 in some Western Africa countries (i.e. Senegal and Niger (females)) to a high of greater than 5.0 in some southern Africa countries (i.e. Swaziland, Lesotho and Zimbabwe). Controlling for various individual level characteristics have differential effect in the risk of HIV infection for specific countries. For a number of countries, including Cameroon, Kenya, Liberia, Tanzania and Zambia, controlling for individual characteristics (especially sexual behaviour) tends to be associated with reduced risk of HIV infection. This implies that the risk of HIV infection in these countries is partly attributable to individual level risk factors relating to background socio-economic/ demographic characteristics, HIV awareness/ stigma or sexual behaviour. These countries seem to have a disproportionately higher proportion of individuals with high risk factors. However, the converse seems to be the case for some of the other countries, such as Burkina Faso, Ethiopia and Lesotho. For these countries, controlling for individual level characteristics tends to increase the country relative risk factors.

Multilevel analysis

Next, we analyse factors associated with HIV infection across countries in sub-Saharan Africa, using multilevel logistic regression models applied to pooled data across countries. We have used three level models with country as the third level and region within country as the second level. In addition to individual level characteristics, we have included contextual country level and regional level factors relating to wealth index, media exposure, HIV/AIDS awareness /stigma, and sexual behaviour factors. All contextual factors are derived from relevant individual level data with the exception of country level GDP per capita[1].

As in the previous section, we have introduced specific sets of risk factors in successive stages to examine the role of proximate factors relating to HIV/AIDS awareness/stigma and sexual behaviour on the risk of HIV infection. The results are presented in Table 6a for females and in Table 6b for males. The results in Table 6a suggest that the low risk of HIV infection among younger females, especially teenagers is to a large extent explained by sexual behaviour factors. For instance, young women aged 15-19 years have 71% lower odds of HIV infection as older women aged 45+ years of similar background socio-economic and demographic characteristics. After controlling for sexual behaviour factors, the odds are 44% lower.

Also, the higher risk of HIV infection among women in female headed households is to a large extent explained by sexual behaviour factors. Women in female headed households have 73% higher odds of HIV infection than their male counterparts of similar background socio-economic and demographic characteristics. However, the odds are less than 20% higher when sexual behaviour factors are controlled for.

[1] Source: World Development Indicators database and CIA World Factbook – estimates for 2006. http://www.nationmaster.com/graph/eco_gdp_percap-economy-gdp-per-capita accessed 12-08-2009.

Table 6a Multilevel logistic regression parameter estimates of HIV infection in SSA - Females

Parameter	Model 0	Model 1	Model 2	Model 3
Fixed Effects				
Constant	-3.36(0.297)	-3.34(0.267)	-3.58(0.272)	-4.14(0.276)
Age group (45 +)				
- 15-19	-1.18(0.071)*	-1.25(0.072)*	-1.20(0.072)*	-0.58(0.081)*
- 20-24	0.07(0.061)	0.07(0.062)	0.06(0.063)	0.29(0.066)*
- 25-29	0.60(0.060)*	0.62(0.062)*	0.60(0.062)*	0.78(0.064)*
- 30-34	0.73(0.062)*	0.76(0.063)*	0.74(0.063)*	0.88(0.064)*
- 35-39	0.70(0.064)*	0.72(0.065)*	0.70(0.065)*	0.81(0.066)*
- 40-44	0.41(0.068)*	0.41(0.040)*	0.40(0.069)*	0.48(0.070)*
Residence (urban)				
- rural		-0.50(0.040)*	-0.48(0.040)*	-0.42(0.041)*
Education level (none)				
- primary		0.32(0.046)*	0.26(0.047)*	0.24(0.047)*
- secondary +		0.17(0.054)*	0.08(0.055)	0.09(0.056)
Sex of household head (male)				
- female		0.55(0.029)*	0.54(0.029)*	0.17(0.033)*
Circumcised (no)				
- yes		-0.44(0.087)*	-0.41(0.087)*	-0.40(0.088)*
- not stated		0.06(0.122)	0.10(0.120)	0.10(0.121)
Wealth quintile (lowest)				
- second		0.16(0.050)*	0.15(0.050)*	0.17(0.051)*
- third		0.26(0.051)*	0.24(0.051)*	0.27(0.051)*
- fourth		0.42(0.054)*	0.39(0.054)*	0.43(0.055)*
- highest		0.35(0.064)*	0.31(0.064)*	0.35(0.065)*
Media exposure (lowest)				
- second quarter		0.03(0.038)	0.01(0.039)	0.07(0.040)
- third quarter		-0.01(0.042)	-0.04(0.043)	0.03(0.043)
- highest		-0.21(0.051)*	-0.25(0.052)*	-0.16(0.052)*
HIV/AIDS awareness (lowest)				
- second quarter			0.03(0.042)	0.01(0.043)
- third quarter			0.08(0.043)	0.04(0.043)
- highest			0.10(0.041)*	0.06(0.042)
HIV/AIDS stigma score (0)				
- 1			-0.19(0.035)*	-0.19(0.036)*
- 2			-0.21(0.043)*	-0.21(0.043)*
- 3			-0.32(0.062)*	-0.31(0.063)*
Tested for HIV/AIDS			0.22(0.033)*	0.16(0.033)*
Knows someone with AIDS			-0.01(0.035)	-0.03(0.036)
Marital status (married)				
- never married				0.49(0.063)*
- previously married				1.10(0.040)*
Age at first marriage (20+)				
- < 16 yrs				-0.02(0.067)
- 16-17				-0.16(0.054)*
- 18-19				-0.15(0.048)*
Age at first sex (20+)				
- Never had sex				-1.22(0.092)*
- < 16 yrs				0.27(0.062)*
- 16-17				0.29(0.054)*
- 18-19				0.22(0.050)*
Premarital sex				0.27(0.042)*
Risky sexual behaviour$				0.09(0.046)
Multiple sex partners				0.35(0.071)*

Table 6a (continued)

Parameter	Model 0	Model 1	Model 2	Model 3
Contextual factors - Region				
Wealth index		-0.36(0.166)*	-0.22(0.090)*	-0.21(0.088)*
Media exposure		0.76(0.235)*	0.40(0.237)	0.29(0.233)
HIV/AIDS stigma			-0.51(0.194)*	-0.52(0.186)*
Prop. Tested for HIV			2.41(0.891)*	2.31(0.873)*
Contextual - Country				
Media exposure		-8.20(3.882)*	-6.42(3.039)*	-6.10(3.092)
Random effects				
Region - constant	0.21(031)*	0.13(0.021)*	0.11(0.019)*	0.11(0.019)*
Country - constant	1.58(0.526)*	1.06(0.354)*	0.64(0.216)*	0.65(0.219)*

*Statistical significance at 5% level - p<0.05; ns – not significant at 5% level.
$ - no condom use at last sex, with non-spousal partner
Model0 – no covariates controlled for besides age.
Model 1 – controlling for background socio-economic and demographic factors;
Model 2 – controlling for background factors plus HIV/AIDS awareness; and
Model 3 – controlling for background factors, HIV/AIDS awareness, and sexual behaviour.

The other background individual-level factors (besides age and gender of household head) that are significantly associated with the risk of HIV infection are urban/rural residence, educational attainment, household socio-economic status, media exposure, and circumcision. In general, the risk of infection is higher among urban residents, those with primary education, in wealthier households, not circumcised, and with low media exposure. There is little evidence that the proximate factors relating to HIV/AIDS awareness/stigma or sexual behaviour factors play a significant role in these risk factors. Contextual factors relating to wealth (region level) and media exposure (region and country level) are also significant but exhibit contrasting patterns. For instance, although wealthier women generally have a higher risk of HIV infection, wealthier regions are associated with a lower risk.

HIV/AIDS awareness shows little association with HIV infection when other factors are controlled for, but higher AIDS stigma is generally associated with a lower risk of HIV infection. The results relating to sexual behaviour factors suggest that never married women have a higher risk of HIV infection than their married counterparts of similar characteristics. There is no evidence that early marriage is associated with increased risk of HIV infection, but earlier initiation of sexual activity is associated with significantly higher odds of HIV infection.

Table 6b Multilevel logistic regression parameter estimates of HIV infection in SSA - Males

Parameter	Model 0	Model 1	Model 2	Model 3
Fixed Effects				
Constant	-3.39(0.300)	-2.38(0.452)	-2.30(0.395)	-2.72(0.389)
Age group (45 +)				
- 15-19	-2.17(0.091)*	-2.22(0.095)*	-2.18(0.094)*	-1.62(0.117)*
- 20-24	-1.10(0.073)*	-1.16(0.077)*	-1.15(0.076)*	-0.90(0.086)*
- 25-29	-0.15(0.063)*	-0.19(0.065)*	-0.20(0.065)*	-0.12(0.067)
- 30-34	0.40(0.061)*	0.38(0.062)*	0.37(0.062)*	0.38(0.063)*
- 35-39	0.55(0.063)*	0.54(0.064)*	0.53(0.064)*	0.53(0.064)*
- 40-44	0.56(0.067)*	0.55(0.068)*	0.55(0.068)*	0.54(0.068)*
Residence (urban)				
- rural		-0.45(0.053)*	-0.44(0.053)*	-0.43(0.053)*
Education level (none)				
- primary		0.11(0.065)	0.08(0.065)	0.07(0.065)
- secondary +		0.07(0.072)	0.08(0.055)	0.03(0.073)
Sex of household head (male)				
- female		0.08(0.056)	0.08(0.056)	0.09(0.058)
Circumcised (no)				
- yes		-0.40(0.097)*	-0.42(0.096)*	-0.46(0.096)*
- not stated		0.07(0.163)	0.04(0.162)	0.02(0.161)
Wealth quintile (lowest)				
- second		0.11(0.066)	0.11(0.066)	0.12(0.067)
- third		0.21(0.067)*	0.19(0.067)*	0.22(0.067)*
- fourth		0.30(0.071)*	0.28(0.071)*	0.31(0.071)*
- highest		0.12(0.084)	0.09(0.084)	0.15(0.084)
Media exposure (lowest)				
- second quarter		-0.15(0.061)*	-0.15(0.061)*	-0.13(0.062*)
- third quarter		-0.05(0.061)	-0.06(0.061)	-0.05(0.062)
- highest		-0.03(0.068)	-0.06(0.069)	-0.06(0.069)
HIV/AIDS awareness (lowest)				
- second quarter			0.05(0.055)	0.03(0.055)
- third quarter			0.05(0.057)	0.030.057)
- highest			0.07(0.054)	0.02(0.054)
HIV/AIDS stigma score (0)				
- 1			-0.03(0.046)	-0.03(0.046)
- 2			-0.12(0.059)*	-0.13(0.059)*
- 3			-0.08(0.088)	-0.08(0.088)
Tested for HIV/AIDS			0.26(0.045)*	0.25(0.045)*
Knows someone with AIDS			-0.11(0.043)*	-0.14(0.044)*
Marital status (married)				
- never married				-0.11(0.083)
- previously married				0.78(0.062)*
Age at first marriage (20+)				
- < 16 yrs				0.31(0.145)*
- 16-17				0.05(0.107)
- 18-19				0.18(0.069)*
Age at first sex (20+)				
- Never had sex				-0.27(0.110)*
- < 16 yrs				0.11(0.063)
- 16-17				0.23(0.058)*
- 18-19				0.140.053)*
Premarital sex				0.24(0.059)*
Risky sexual behaviour$				ns
Multiple sex partners				0.30(0.047)*

Table 6b (continued)

Parameter	Model 0	Model 1	Model 2	Model 3
Contextual factors - Region				
Prop. circumcised		-0.76(0.350)*	-0.64(0.331)	-0.61(0.328)
Wealth index		0.05(0.199)	-0.02(0.188)	-0.21(0.088)*
Media exposure index		0.25 (0.096)*	-0.18(0.273)	-0.23(0.123)
HIV/AIDS stigma			-1.11(0.216)*	-1.08(0.213)*
Contextual - Country				
Media exposure index		-9.50(4.36)*	-8.73(3.556)*	-8.36(3.452)*
Random effects				
Region - constant	0.22(0.037)*	0.15(0.029)*	0.12(0.025)*	0.12(0.024)*
Country - constant	1.62(0.542)*	1.15(0.394)*	0.75(0.259)*	0.71(0.245)*

*Statistical significance at 5% level - p<0.05; ns – not significant at 5% level.
$ - no condom use at last sex, with non-spousal partner
Model0 – no covariates controlled for besides age.
Model 1 – controlling for background socio-economic and demographic factors;
Model 2 – controlling for background factors plus HIV/AIDS awareness; and
Model 3 – controlling for background factors, HIV/AIDS awareness, and sexual behaviour.

The overall patterns of the risk of HIV infection by background factors are generally similar for males (Table 6b) as for females, but one notable difference relates to living in a female headed household which is not significant for males despite being highly significant for females. The patterns suggest that women in female headed households rend to have risky sexual behaviour that increases their risk of HIV infection, but the same does not apply for their male counterparts. The other notable difference relates to the patterns of HIV infection by age where even though sexual behaviour does partly explain the lower risk of HIV infection among younger men compared to their older counterparts, this is not to the same extent as observed for women.

Some difference is also observed with respect to HIV/AIDS awareness and exposure/risk perception factors. As in the case of women, there is no evidence of a significant association between HIV awareness and the risk of infection. However, those who have personal acquaintance with an AIDS victim have a lower risk of HIV infection.

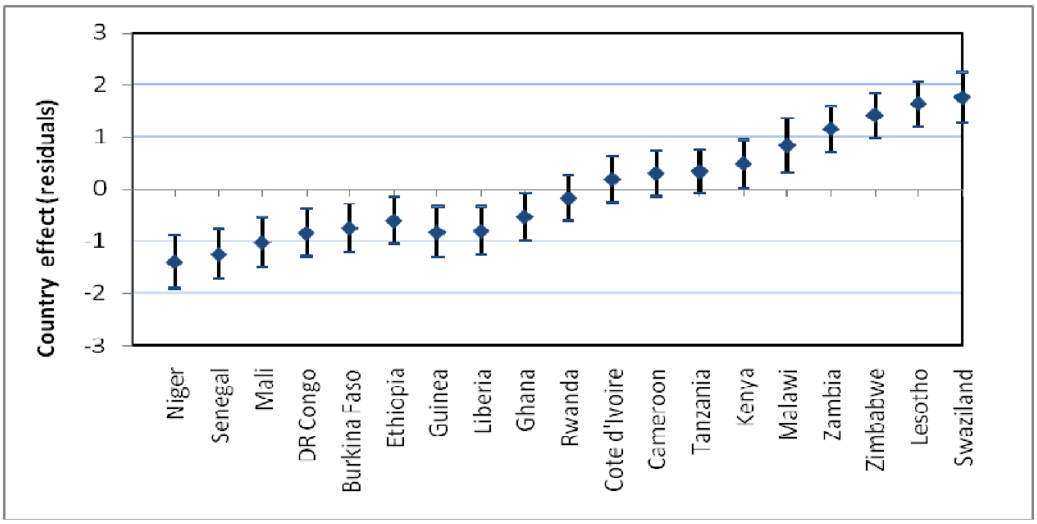
The patterns of HIV risk with respect to sexual behaviour factors is generally as might be expected. Previous marriage (widowed or divorced/separated), early marriage, early initiation of sexual activity, premarital sex and multiple sex partners are all associated with a higher risk of infection. However, it is interesting to note that there is no evidence of a significantly higher risk of infection among those engaged in ‘risky sexual behaviour’ (non-condom use with non-spousal sexual partners) for men, as for women.

National variations in the risk of HIV infection

There are significant variations in HIV infection among both men and women across countries, partly explained by background socio-economic and demographic characteristics as well as HIV/AIDS awareness/stigma factors. Estimates of intra-unit correlations suggest that while less than 5% of the total variation in HIV infection among both males and females are explained by regional level factors, about 35% of the total variation is attributable to country-level differences. After taking into account important background characteristics relating to educational attainment, urban rural residence, socio-economic status, media exposure, and circumcision, more than 25% (27% for females and 28% for males) of the total unexplained variation is attributable to country level factors. This proportion reduces to about 20% when HIV/AIDS awareness and stigma factors are controlled for, and remains unchanged when sexual behaviour factors are included in the model.

We have used simultaneous confidence intervals (Goldstein and Healy, 1995) of country level residuals for multiple comparison of the risk of HIV infection across countries, after controlling for different sets of factors. The countries whose 95% confidence intervals do not overlap have different risks of HIV infection, significant at 5% level. As in the previous section, the first model (Model 0) has no covariates (only the random region and country effects included); Model 1 includes only background socio-economic and demographic factors; Model 2 adds HIV/AIDS awareness and stigma factors to the background factors; while Model 3 adds the sexual behaviour factors. The results for females are presented in Figures 1a-d, while corresponding figures for males are presented in Appendices iii(a) to iii(b). The countries are ordered from left to right by increasing HIV prevalence.

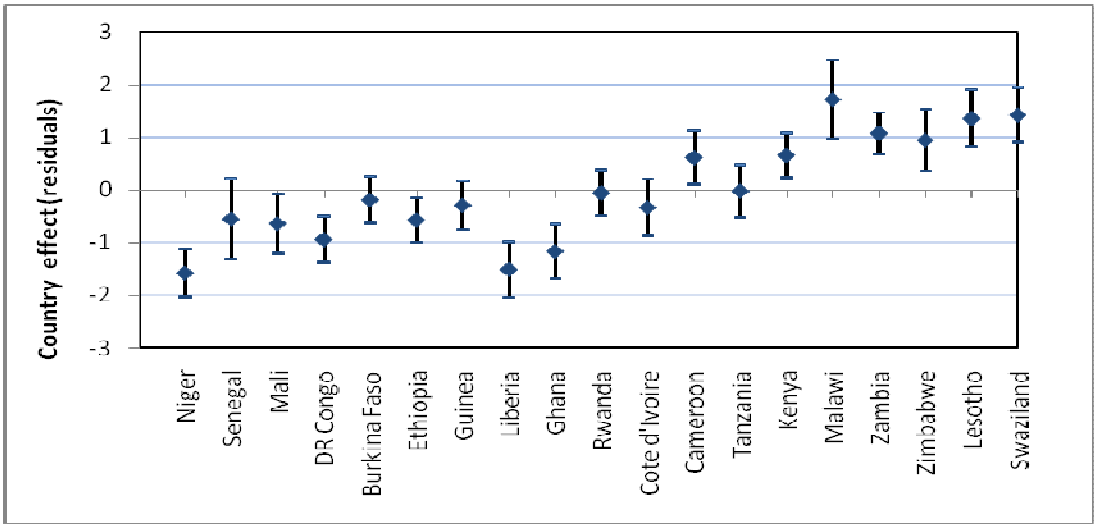
Figure 1a: Simultaneous confidence intervals (95%) of country effects – Females (Model 0)



There are significant differences in the risk of HIV infection across countries in SSA. In particular, three of the Southern Africa countries (Swaziland, Lesotho and Zimbabwe) have significantly higher risks of HIV infection than all the other countries included in the analysis, except Zambia and Malawi with which the simultaneous confidence intervals overlap (Figure 1a).

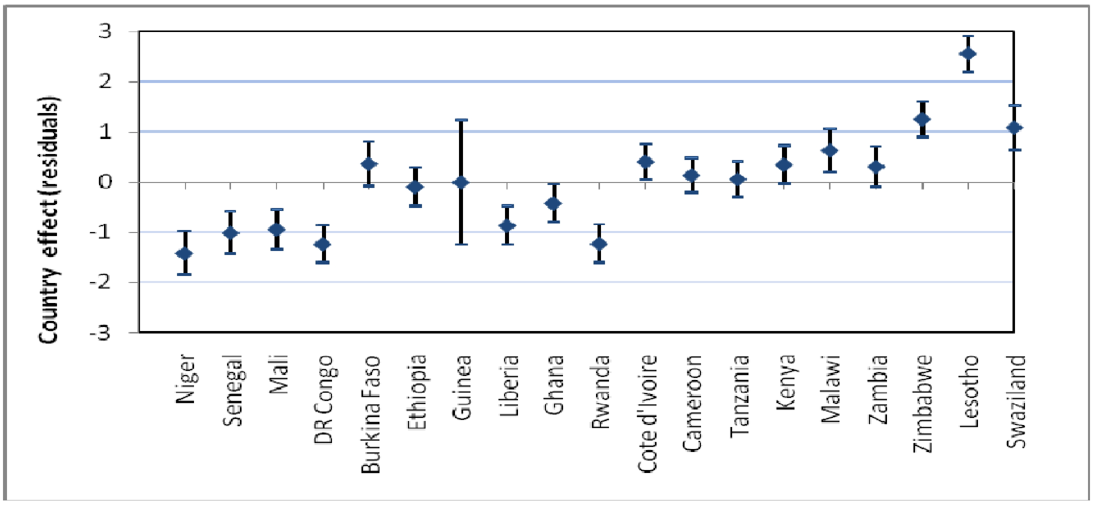
Figures 1b-1d suggest that there remains significant variations in the country risk factors after background characteristics, HIV/AIDS awareness/stigma and sexual behaviour factors are taken into account. However, the introduction of various sets of factors does modify the risk of HIV infection for specific countries. For instance, controlling for background socio-economic and demographic factors (Figure 1b) leads to a notable reduction in the risk of HIV infection in Liberia and Ghana, and an increase in the risk for Malawi. This may suggest that the lower HIV prevalence observed in Malawi compared to, say, Swaziland or Lesotho, is most likely due to Malawi having a higher proportion of women in the lower risk socio-economic and demographic sub-groups. On the other hand, the higher HIV prevalence observed in Liberia and Ghana, compared to countries such as Senegal or Burkina Faso, is mainly due to the former countries having a higher proportion of women in the higher risk sub-groups with respect to background characteristics. Overall, women in Niger (lowest risk) have a significantly lower risk of HIV infection that their counterparts of similar socio-economic and background characteristics in all the other countries, except Senegal, DR Congo, Liberia and Ghana.

Figure 1b: Simultaneous confidence intervals (95%) of country effects – Females (Model 1)



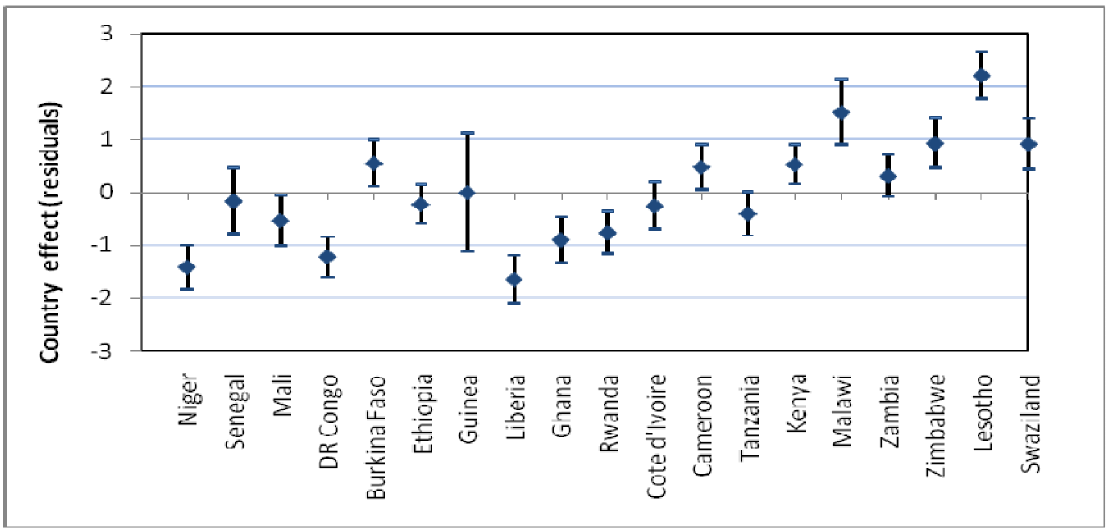
Introducing the HIV/AIDS awareness and stigma factors (Figure 1c) appears to have a notable but opposite effect on the risk of HIV infection in Rwanda and Lesotho. The risk for Rwanda is considerably reduced once the HIV/AIDS awareness/stigma factors are controlled for, such that the risk of infection is significantly lower for women in Rwanda than their counterparts of similar background and HIV/AIDS awareness and stigma characteristics in some of the countries with overall lower prevalence such as Burkina Faso and Ethiopia. On the contrary, the risk for Lesotho is considerably increased when the HIV/AIDS factors are controlled for, such that the risk of infection is significantly higher than all the other countries, including Swaziland.

Figure 1c: Simultaneous confidence intervals (95%) of country effects – Females (Model 2)



Introducing the sexual behaviour factors (Figure 1d) does not considerably alter the country risk factors. However, the risk for Tanzania is notably reduced, compared to Cameroon, as is Zambia compared to Malawi, suggesting that Tanzania and Zambia have relatively higher proportions of women in the higher risk sub-groups with respect to sexual behaviour factors, compared to Cameroon and Malawi, respectively. For instance, once sexual behaviour factors are controlled for, women in Zambia have a lower risk of infection than their counterparts in Malawi with similar characteristics.

Figure 1d: Simultaneous confidence intervals (95%) of country effects – Females (Model 3)



The patterns of country risk factors observed for males (Appendices iiia-d) are generally consistent with those observed for females, although the background socio-economic and demographic factors have a weaker effect on the country risk factors.

Discussion, conclusions and recommendations

We recognize potential data limitations that should be borne in mind while interpreting our findings. The first relates to the problem of causality since the cross-sectional nature of the data makes it impossible to determine the time sequence of key events of interest, i.e. whether the HIV infection preceded various risk factors, or whether the observed relationships are due to the effect of predisposing conditions associated with both HIV and the risk factors. Hence, we focus on the associations, rather than causal relationships. Secondly, we recognize possible selectivity bias due to differential non-response rates for specific sub-groups of the population. Random non-response is unlikely to create bias but selective non-response by specific high risk sub-groups may lead to bias in the observed relationships between HIV infection and respective risk factors. Coverage of HIV testing in various countries by gender examined in preliminary analysis show reasonably high response rates and no clear systematic patterns that are likely to create bias. However, it is important to exercise caution when interpreting results for specific subgroups (e.g urban residents or those with higher educational attainment) or countries (e.g Malawi and Zambia) with significant refusals or overall non-response rates. Further bias may result because HIV sero-positive individuals who are in poverty are more likely to develop AIDS symptoms and die earlier, since they would be less able to afford anti-retroviral drugs. Hence, HIV-positive individuals interviewed may represent a select sub-group who are better off socio-economically, distorting the observed risk factors of HIV.

The main objectives of this paper were to: (i) determine the socio-economic and demographic risk factors of HIV infection among males and females in sub-Saharan africa; (ii) explore the role of proximate factors relating to HIV/AIDS awareness/stigma and sexual behaviour factors in explaining the background risk factors; and (iii) examine national and subnational variations in HIV infection. For both males and females, the risk of HIV infection was relatively higher among urban residents, those in middle or richer households, and those who are not circumcised. Overall, the background socio-economic factors appeared more important for HIV infection among females than males. For instance, educational attainment and gender of household head were significant for females and not males, and the association between household socioeconomic status and the risk of HIV infection was stronger for females. The risk of HIV infection was significantly higher for women living in female headed households or with primary level education compared to their counterparts in male headed households or with no formal education.

The results show mixed patterns with respect to the proximate factors relating to HIV/AIDS experience and sexual behaviour factors. There is no evidence of a significant association between HIV/AIDS awareness and HIV infection, once important background socio-economic and demographic as well as other HIV/AIDS experience factors are controlled for. However, lower HIV/AIDS stigma at both individual and regional level are associated with a higher risk of HIV infection. In addition, men who personally know of someone living with or dead of AIDS have a lower risk of HIV infection than their counterparts of similar background characteristics who had no personal acquintance with AIDS victims. The association between most of the sexual behaviour factors and HIV infection conform to what might be expected. For both males and females, the risk of infection was higher among the previously married (widowed or divorced/separated), those who initiated sexual activity at a younger age, had multiple sexual partners or had premarital sex.

There is little evidence that the proximate factors included in the analysis play a significant role in most background risk factors, except for the risk among younger women or for women in female headed households for whom sexual behaviour factors play an important role. The relatively lower risk of HIV infection among younger women aged 15-24 years, compared to older women, is partly explained by sexual behaviour factors. In particular, the significanly lower risk of HIV infection among women aged 20-24 years compared to older women of 45 years or older of similar background characteristics diminishes when sexual behaviour factors are controlled for. Also, the strikingly high risk of HIV infection among women in female headed households, compared to their counterparts of similar characteristics in male headed households is largely explained by sexual behaviour factors.

Overall, there are significant variations in the risk of HIV infection across countries in sub-Saharan Africa, and to a lesser extent across regions within countries. About 30 per cent of the total variation in the risk of HIV infection is attributable to country level factors, while less than five per cent is due to regional level factors. The variations across countries are partly explained by individual and contextual background socio-economic characteristics, as well as HIV/AIDS awareness/stigma factors. Controlling for background socio-economic characteristics does modify the country risk factors, especially for women. The relative risk of HIV infection among women in countries such as Liberia and Ghana are lowered when background socio-economic factors are controlled for, suggesting that these countries have a relatively higher proportion of sub-groups with high risk background characteristics. On the other hand, countries such as Malawi appear to have a relatively lower proportion of sub-groups with high risk background characteristics, leading to a raised relative risk when these factors are controlled for. For males, it is the HIV/AIDS awareness/stigma factors, rather than background socio-economic factors, that play a notable role in modifying the country risk factors. In particular, the relative risk of HIV infection among both males and females in countries such as Lesotho and Burkina Faso are considerably increased when HIV/AIDS awareness/stigma factors are controlled for.

This paper has established the general patterns in risk factors of HIV infection across countries in sub-Saharan Africa, as well as identified specific areas for further investigation. The areas identified for further research include issue specific as well as country specific analyses. The patterns in country variations observed in this paper call for more in-depth country-level analysis to better understand the patterns of risk factors in individual countries, especially those that exhibit distinctive patterns when specific sets of factors are taken into account. While the general patterns for sub-Saharan Africa region are useful for informing international efforts aimed at addressing the HIV/AIDS epidemic, in-depth analyses at individual country level are particularly important for national efforts in specific countries.

Among the recommended issue specific research areas for further investigation, there are areas where on-going further analysis are already underway. These include: the gender disparity, risk factors among young women and the role of early marriage, and association between HIV infection and poverty/wealth. With respect to the gender disparity, interesting differences have been noted between males and females (e.g. socio-economic factors being more important for females than males; the risk of HIV infection among young females, but not males, increased when sexual behaviour factors are controlled for; gender for household head significant for females and not males; never married women, but not men, have a higher risk of HIV infection than married counterparts; and early marriage being associated with an increased risk of infection for women, but reduced risk for men), all of which call for further investigation to better understand the gender disparity in HIV infection.

Also of particular interest are the patterns of HIV infection observed among young people, especially women, and the role of sexual behaviour factors including early marriage. The results do not support the arguement that early marriage exposes young women to an increased risk of HIV infection (WHO, 2003), especially as their partners are often older with more sexual experience. It is particularly fascinating to note that early marriage among women is assocated with a reduced risk of HIV infection, even after experience of premarital sex is controlled for. On-going further analysis will help better understand the link between early marriage and the risk of HIV infection, taking into account the role of other sexual behaviour factors, especially early sexual activity among those who marry early, and higher premarital sex among those who marry later.

One area that has generated interesting debate and still remains to be better understood is the link between poverty/wealth and the risk of HIV infection (Holmqvist, 2009). While it has been argued that poverty increases vulnerability to HIV infection especially among women, empirical evidence presented in this paper and elsewhere suggest that the risk of infection is higher among individuals living in wealthier households. One particuar area of interest relates to the uban poor who have in separate studies shown relative disadvantage compared to their non-poor counterparts with respect to most public health outcomes. On-going further analysis in a separate paper focuses on this group to establish if the urban poor in sub-Saharan Africa experience comparative disadvantage with respect to HIV infection.

References

Auer, C. (1996) "Women, Children and HIV/AIDS" In L.D. Long & E.M. Ankrah (eds.) *Women's Experiences with HIV/AIDS: An International Perspective*. New York: Columbia University Press.

Barnett, T. and Whiteside, A. (2002). AIDS in the Twenty-First Century: Disease and Globalization. Palgrave Macmillan.London.

Boerma, J.T and S.S Weir (2005) "Integrating demographic and epidemiological approaches to research on HIV/AIDS: the proximate determinants framework" *The Journal of Infectious Diseases* 191(Supp 1):S61-7.

Goldstein, H. (2003) *Multilevel statistical models* (3rd edition). London: Arnold.

Goldstein, H. & Healy M.R.J. (1995) "The graphical representation of a collection of means" *Journal of the Royal Statistical Society, A*, **158**: 175-7.

Gray, R. H., Kiwanuka, N., Quinn, T. C., Sewankambo, N. K., Serwadda, D., Mangen, F. W., Lutalo, T., Nalugoda, F., Kelly, R., Meehan, M., Chen, M. Z.; Li, C., Wawer, M. J. (2000). "Male circumcision and HIV acquisition and transmission: cohort studies in Rakai, Uganda" *Aids* 14(15): 2371-81.

Hargreaves, J.R.; Bonell, C.P.; Boler, T.; Boccia, D.; Birdthistle, I.; Fletcher, A.; Pronyk, P.M.; Glynn, J.R. (2008) "Systematic review exploring time trends in the association between educational attainment and risk of HIV infection in sub-Saharan Africa" *AIDS* (22(3):403-14

Hargreaves JR, Glynn JR (2002) "Educational attainment and HIV-1 infection in developing countries: a systematic review" *Trop Med Int Health* 7:489-498

Hargreaves, J. R., Morrison, L. A., Chege, J., Rutenburg, N., Kahindo, M., Helen Weiss, H.A., Hayes, R. and Buve, A. (2002) "Socioeconomic Status and Risk of HIV Infection in an Urban Population in Kenya." *Tropical Medicine and International Health* 7(9):793-802

Holmqvist, G (2009). "HIV and Income Inequality: if there is a link, what does it tell us?"International Policy Centre for Inclusive Growth Working Paper No.54. Poverty practice, Bureau for Development Policy, UNDP.

Kimuna, S. R. and Djamba, Y. K. 2005. "Wealth and Extramarital Sex Among Men in Zambia." *International Family Planning Perspectives* 31(2):83-89.

Malcolm, A., et al. (1998) HIV-Related Stigmatization and Discrimination: Its forms and contexts, *Critical Public Health*, 8, 4.

Mishra, V., Assche, S.B., Greener, R., Vaessen, M., Hong, R., Ghys, P.D., Boerma, J.T., Van assche, A., Khan, S., and Rutstein, S (2007) "HIV infection does not disproportionately affect the poorer in sub-Saharan Africa" *AIDS,* Suppl. 7:S17-28

Ntozi, J. and M. Lubega (1992) " Patterns of sexual behaviour and the spread of AIDS in Uganda" Pp. 315-33 in *Sexual Behaviour and Networking: Anthropological and Socio-Cultural Studies on the Transmission of HIV*, ed. T. Dyson. Liège: Editions Derouaux-Ordina.

Orubuloye, I. O., P. Caldwell and J. C. Caldwell (1993) “The role of high-risk occupations in the spread of AIDS: truck drivers and itinerant market women in Nigeria” *International Family Planning Perspectives* 19:43-48, 71.

Population Reference Bureau (PRB) (2008) *World Population Data Sheet*.

Rasbash Jon, Fiona Steele, William Browne & Bob Prosser (2005) *A users Guide to MLwiN*, Version 2.0. Centre for Multilevel Modelling, University of Bristol.

Rosenthal D, Smith A, and Visser R. (1999). “Personal and social factors influencing age at first sexual intercourse”. *Archives of Sexual Behavior.*28:319-333.

Trinitapoli, J. and Regnerus, M. (2006) “Religion and HIV Risk Behaviors Among Married Men: Initial Results from a Study in Rural Sub-Saharan Africa”. *Journal of the Scientific Study of Religion*, 45(4):505-528

UNAIDS & WHO (1998). Report on the global HIV/AIDS epidemic. Geneva.

UNAIDS.2003. “*HIV/AIDS and young people: hope for tomorrow”.* Geneva.

UNAIDS (2008) *Report on the Global AIDS Epidemic*. UNAIDS, Geneva.

Whitehead, M., Dahlgren, G. and Evans, T. (2001). “Equity and health sector reforms: can low-income countries escape the medical poverty trap?”, *The Lancet,358, 833-836.*

World Health Organization (2003) “Gender and HIV/AIDS” Gender and Health. WHO Department of Gender and Women’s Health, Geneva, Switzerland.

APPENDICES

Appendix i(a): HIV testing response rate by age group and gender

Country	Percent of HIV sample tested by age group							
	Women				Men			
	15-19	20-29	30-39	40+	15-19	20-29	30-39	40+
Burkina Faso 2003	90.2	91.7	92.0	93.5	85.7	83.3	86.9	87.1
Cameroon 2004	93.0	91.4	92.1	92.9	93.2	87.9	86.6	89.4
Cote d'Ivoire 2005	80.0	80.2	77.0	79.2	77.2	77.0	73.7	77.5
DR Congo 2007	89.4	91.3	91.7	92.0	86.5	86.8	86.2	89.0
Ethiopia 2005	82.3	82.8	83.9	85.0	74.1	74.4	75.3	78.1
Ghana 2003	88.9	90.1	88.3	89.5	83.3	78.6	78.9	78.7
Guinea 2005	92.5	92.1	92.1	90.8	87.8	83.1	87.6	89.9
Kenya 2003	75.3	77.1	77.8	73.9	75.9	66.2	68.6	71.1
Lesotho 2004	80.7	79.9	83.3	78.5	70.6	65.7	68.1	67.1
Liberia 2007	86.6	86.6	89.2	89.1	78.3	80.1	81.7	83.4
Malawi 2004	65.3	70.7	70.8	75.4	59.8	63.1	65.4	63.3
Mali 2006	92.0	93.3	94.4	92.7	82.4	84.0	85.7	86.3
Niger 2006	90.1	91.6	93.1	93.4	85.7	84.9	84.8	85.6
Rwanda 2005	96.2	96.8	97.8	98.8	95.6	93.6	93.8	97.1
Senegal 2005	84.8	84.7	84.3	83.8	80.9	75.2	70.9	73.5
Swaziland 2006	90.4	85.4	86.4	87.5	87.7	73.7	72.5	78.0
Tanzania 2003	80.9	83.4	85.2	84.9	76.8	76.5	77.0	79.4
Zambia 2007	76.0	76.5	78.3	79.0	72.5	70.2	72.4	75.3
Zimbabwe 2005	76.5	75.5	75.9	76.3	71.4	61.2	58.3	61.8

Appendix i(b): HIV testing response rate by educational attainment and gender

Country	Percent of HIV sample tested by education level					
	Women			Men		
	None	Primary	Sec. +	None	Primary	Sec. +
Burkina Faso 2003	93.8	89.3	83.4	87.5	85.9	79.1
Cameroon 2004	95.4	93.2	89.6	90.1	91.5	88.7
Cote d'Ivoire 2005	80.8	79.3	72.7	77.0	78.6	74.1
DR Congo 2007	91.9	92.3	85.9	88.3	88.9	82.0
Ethiopia 2005	85.6	84.8	74.5	77.3	81.7	66.4
Ghana 2003	87.9	91.3	84.1	79.4	82.0	76.3
Guinea 2005	92.7	93.3	90.3	89.5	89.9	85.1
Kenya 2003	74.5	79.1	72.0	69.3	72.7	65.9
Lesotho 2004	79.4	83.9	75.9	67.0	69.7	62.2
Liberia 2007	88.7	88.7	84.6	83.3	83.4	78.3
Malawi 2004	66.9	71.8	70.0	56.7	63.6	64.5
Mali 2006	92.1	92.9	89.9	83.6	85.9	82.3
Niger 2006	92.9	89.7	71.9	85.6	85.8	72.7
Rwanda 2005	97.1	97.7	96.5	95.6	96.8	92.8
Senegal 2005	83.9	85.4	86.1	71.1	78.6	81.1
Swaziland 2006	88.1	91.7	81.1	84.9	85.0	72.6
Tanzania 2003	83.3	84.7	78.2	74.9	79.4	69.1
Zambia 2007	72.9	76.7	77.6	68.1	73.1	70.6
Zimbabwe 2005	74.7	79.2	67.7	45.0	69.7	55.5

Appendix i(c): HIV testing response rate by urban/rural residence and gender

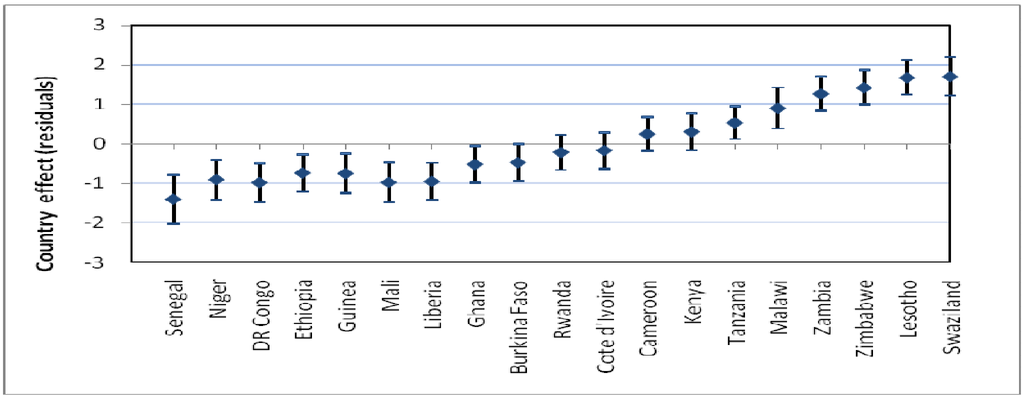
Country	Percent of HIV sample tested by urban/rural residence					
	Women			Men		
	Urban	Rural	Cases	Urban	Rural	Cases
Burkina Faso 2003	83.2	94.3	4575	69.9	89.2	5984
Cameroon 2004	88.4	95.9	5703	85.3	94.6	5676
Cote d'Ivoire 2005	74.6	83.1	5772	66.5	83.9	5148
DR Congo 2007	97.7	87.4	5127	99.7	95.3	4 985
Ethiopia 2005	72.7	88.0	7142	59.5	81.8	6778
Ghana 2003	87.6	90.5	5949	73.7	83.9	5345
Guinea 2005	88.2	94.4	4189	80.0	93.1	5560
Kenya 2003	66.2	81.7	4303	58.4	76.7	4183
Lesotho 2004-05	73.3	83.4	3758	60.7	70.2	3305
Liberia 2007	85.2	88.5	7448	75.2	84.4	6476
Malawi 2004	65.3	71.2	4071	55.7	64.8	3797
Mali 2006	89.5	93.4	5157	78.4	86.9	4643
Niger 2006	85.1	93.7	8738	77.7	89.2	3839
Rwanda 2005	95.8	97.7	5837	91.0	97.1	4959
Senegal 2005	81.9	86.6	5350	73.1	77.9	4375
Swaziland 2006	79.7	91.2	5301	71.7	85.0	4675
Tanzania 2003/4	77.0	86.0	7154	65.0	81.6	6196
Zambia 2007	76.4	77.7	7408	67.8	75.8	7164
Zimbabwe 2005/06	65.1	82.6	9870	49.4	72.4	8761

Source: Constructed from each country's DHS data.

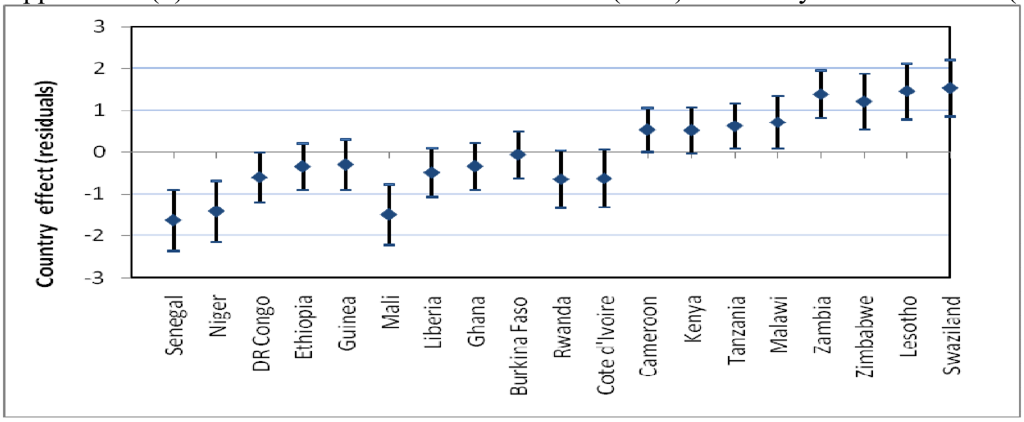
Appendix ii: DHS questions used to derive HIV/AIDS awareness index

Statement	Yes	No
Ever heard of AIDS	1	0
Reduce chance of HIV/AIDS by using condoms	1	0
Reduce chance of HIV/AIDS by having only one sexual partner	1	0
HIV/AIDS can be transmitted through mosquito bites	0	1
HIV/AIDS can be transmitted by sharing utensils	0	1
A health looking person can have AIDS virus	1	0
HIV/AIDS can be transmitted through pregnancy	1	0
HIV/AIDS can be transmitted through breastfeeding	1	0

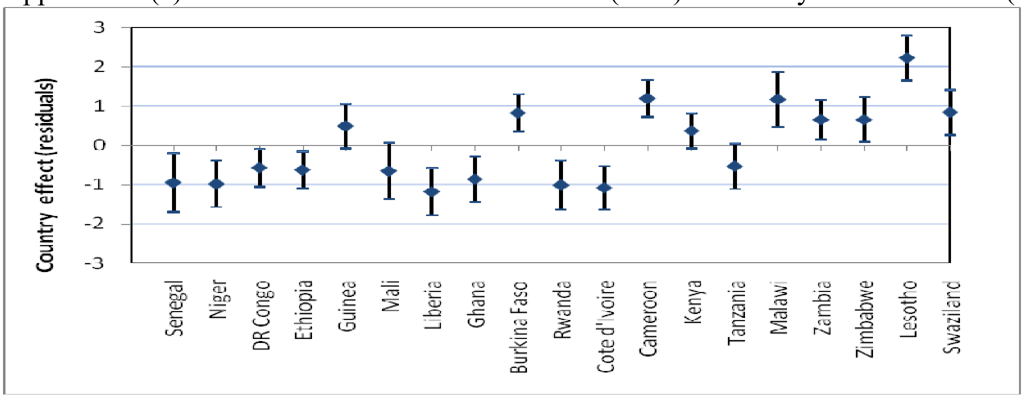
Appendix iii(a): Simultaneous confidence intervals (95%) of country effects –Males (Model 0)



Appendix iii(b): Simultaneous confidence intervals (95%) of country effects – Males (Model 1)



Appendix iii(c): Simultaneous confidence intervals (95%) of country effects – Males (Model 2)



Appendix iii(d): Simultaneous confidence intervals (95%) of country effects – Males (Model 3)