Spatial distribution and analysis of factors associated with HIV infection among Young People in Eastern Africa: Applied to the MEASURE Demographic and Health Survey data collected between 2007 and 2011.

By

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A thesis submitted in partial fulfilment of the requirements for the degree of

MASTER OF SCIENCE

IN

EPIDEMIOLOGY AND BIOSTATISTICS

UNIVERSITY OF THE WITWATERSRAND

JULY 2013

University of the Witwatersrand, Faculty of Health Sciences,

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JULY, 2013

Declaration

I, **Lucy Andere Otwombe** declare that this research report is my own work. It is being submitted for the degree of Master of Science in Epidemiology in the field of Biostatistics and Epidemiology in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Date: 16th July 2013 Signature____________________

Dedication

This work is dedicated to my parents John and Beatrice Chimoyi who have always supported my pursuit of knowledge, my siblings Carole, Anne and Sylvia, my husband Kennedy and our lovely twins Liam and Ivanna for their steadfast love. I thank the Lord, Almighty for providing me with the above-mentioned people that have enriched my life in immeasurable ways.

Abstract

Introduction: Assessing risk of HIV amongst young people requires knowledge of the spatial distribution of the disease and its association with demographic, socioeconomic, behavioural, and biological factors. The objective of this study was to press forward with such knowledge by analyzing the spatial distribution of HIV prevalence in relation to the demographic, social and behavioural factors reported in the MEASURE Demographic and Health Surveys conducted in four Eastern Africa countries from 2007-2011.

Methods: The study was a cross-sectional study design where data were obtained from MEASURE DHS databases of Ethiopia (2011) Kenya (2008-2009), Tanzania (2007-2008) and Uganda (2011). Statistical analysis employed Stata ™ 12 software to perform descriptive analysis for overall characteristics of the study sample. Bivariate analytical tests compared statistical significant differences between the covariates and outcome. Univariate and multiple variable logistic regression models were used to explore factors that were significantly associated with HIV prevalence in young people. Spatial logistic regression analysis was aided by the Bayesian Software BayesX version 2.1 to perform spatial random effect modelling which was used to account for any unexplained spatial autocorrelation in the study area results. Spatial analyses was performed to examine the spatial distribution of the disease using geostatistical techniques such as; spatial autocorrelation and spatial. Final outputs were visualised using Geographical Information Systems techniques (GIS).

Results: The results showed variations of HIV prevalence not only within countries but also across the countries. Each country was characterised by different factors that were associated with HIV prevalence among young people. Across the study area, behavioural factors were significantly associated with HIV. Presence of an STI, a proxy for high-risk sexual behaviour, {(Kenya: POR=13.46; 95% BCI; 2.92-64.41, Uganda: POR=6.83; 95% BCI; 4.14-16.34)} and an early coital debut were significantly associated with HIV in the study area. On the other hand, circumcision (Uganda: POR=0.30; 95% BCI; 0.12-0.80) and condom use provided a protective effect on HIV among The young people. Spatial distribution of HIV in Eastern Africa was mapped at a regional level in aspects of crude prevalence estimates, excess risk and spatial risk. The spatial distribution of HIV was non-random and clustered with significant Moran's I for Kenya (0.189, p<0.001) and Tanzania (0.056, p=0.04). Cluster analysis revealed a number of significant geo-spots of HIV in Ethiopia (n=53, p<0.001), Kenya (n=34, p<0.001), Tanzania (n=4, p<0.001), and Uganda (n=32, p<0.001).

Conclusions: Since majority of the significant associations were observed in the behavioural category, HIV prevention interventions should be aimed at behavioural change amongst young people. The use of spatial risks maps can help policy makers target interventions in areas where they are greatly needed. A future study which focuses on the distribution of HIV/AIDS in East Africa over space and time is recommended to understand how behavioural change will affect the spread of the disease.

Acknowledgements

I would like to acknowledge and express my sincere gratitude to my supervisor, Dr. Eustasius Musenge for his guidance and tremendous assistance during the writing of this research. I have not only enhanced my statistical skills but also acquired greater knowledge of spatial analysis for which, i am greatly indebted to him.

I would like to express my deepest thanks and appreciation to the MEASURE DHS team for giving me an opportunity to use their data to write my research report.

Immense gratitude is also accorded to Mr. Peter Nyasulu, the M.Sc. course coordinator, for his unwavering support and guidance during my studies and to other lecturers at the School of Public Health, University of Witwatersrand, Johannesburg.

I would also like to express profound thanks to Mrs. Angeline Zwane for taking care of all administrative issues which enabled the smooth running of this programme.

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Abbreviations

AIC	Akaike Information Criteria
AIDS	Acquired Immune Deficiency Syndrome
AIS	Aids Indicator Survey
AOR	Adjusted Odds ratio
BCI	Bayesian Credible Intervals
CAR	Conditional Autoregressive
DALY	Disability Adjusted Life Years
DHS	Demographic Health Survey
DIC	Deviation Information Criteria
ELISA	Enzyme-Linked Immuno-Sorbent Assay
FGM	Female Genital Mutilation
GIS	Geographical Information System
GPS	Geographical Positioning System
HIV	Human Immunodeficiency Virus
LMIC	Low and Middle Income Countries
MCMC	Markov Chain Monte Carlo
NACC	National AIDS Control Council
NASCOP	National AIDS & STI Control Program
POR	Posterior Odds Ratio
SES	Socio-Economic Status
SSA	Sub-Saharan Africa
STI	Sexually Transmitted infections
UNAIDS	Joint United Nations Programme on HIV/AIDS
UNICEF	United Nations International Children's Emergency Fund
USAID	United States Agency for International Development
WHO	World Health Organisation

Definition of terms

- **Adolescence:** A period where an individual undergoes a physical, emotional, sexual and social change that results in maturity (Kabiru and Orpinas, 2009) which gives rise to increased independence and a greater sense of individuality (Kaaya et al., 2002).
- **Clustering:** Grouping of health events situated closely together in relation to time and/or space (Graham et al., 2004).
- **Demographic and Health Surveys:** These are nationally- representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health and nutrition.
- **GIS (Geographical Information System):** This is a series of tools for the acquisition, storage, retrieval, analysis and display of spatially referenced data (Graham et al., 2004, Moodley, 2010).
- **GPS (Global Positioning System):** A device that collects spatially distributed data in real time (Moodley, 2010).
- **Spatial Analysis:** Analytical technique which accounts for spatial variations inherent in spatial data which can be used for statistical inference (Graham et al., 2004)
- **Spatial Data:** This is data that is based on two continuous dimensions i.e. longitude and latitude (geo-referenced) or sometimes three dimensions including altitude (Moore and Carpenter, 1999).
- **Young people:** Individuals who include adolescents (10-19 years) and young adults (20-24 years) (Napierala-Mavedzenge et al., 2011).

Chapter 1 : Introduction

Background information

HIV/AIDS is positioned among the most important public health problems in Sub-Saharan Africa (SSA) for being a major cause of chronic infections and premature deaths (UNAIDS/WHO, 2006). HIV/AIDS has decreased life expectancy and the quality of life of humankind and is a serious impediment to economic development (Moise and Kalipeni, 2012). Whereas great strides have been made to prevent the HIV/AIDS transmission in adults and infants, at least half of all new HIV infections arising in the developing nations are among adolescents (Gray, 2010). It is reported that, 72% of an estimated 2 million adolescents living with HIV/AIDS worldwide, live in SSA (UNICEF, 2011). In East Africa, the HIV-prevalence ranges from 3-7% according to the 2010 Joint United Nations Program on HIV/AIDS (UNAIDS) (UNAIDS, 2010). The recent Demographic and Health Surveys (DHS) conducted in the Eastern Africa region reported the prevalence ranging from 5.7-6.4%, and varying greatly across regions (CSA and ICF, 2012, KNBS and ICF, 2010, NBOS and ICF, 2010, UBOS and ICF, 2012). The 2010 USAID report on the HIV/AIDS health profile in East Africa indicated that compared to males, female adolescents in Ethiopia were 1.4 times at risk of HIV infections whereas in Kenya and Tanzania, the prevalence of HIV in young women was 4 times higher than in young men (USAID, 2010). A study conducted in Kenya reported different HIV prevalence among older adolescents (15-19) females (3.5%) and males (1.8%) respectively (Amornkul et al., 2009). For this reason, effective interventions are required to equip adolescents with the skills and knowledge to protect them from acquiring HIV infections even as they transition to adulthood (Babalola, 2011).

Majority of the studies that report on HIV issues such as Demographic and Health Surveys (DHS), UNAIDS or USAID reports, have generalised the HIV sero-prevalence according to regions and yet due to variations, differences of high and low prevalence exist within any given region (Westercamp et al., 2010). In SSA, the epidemiology of HIV among young people varies widely across regions, as well as between and within countries (Napierala-Mavedzenge et al., 2011). To identify these differences, researchers should employ spatial analytical methods where areas of low or high HIV prevalence are identified (Graham et al., 2004) and evaluated for disease aggregation in particular locations (Anselin, 1992). The application of spatial analysis and Geographical Information Systems (GIS) in identifying and visualising clusters and spatial distribution of diseases (Toprak and Erdoğan, 2008), is one of the methods that is being used in public health and epidemiological research to manage and analyse health data (Law et al., 2004, Rojas, 2007, Westercamp et al., 2010). GIS techniques generate maps which usually provide a more comprehensive display of the pattern and magnitude of disease from local to global scales (Law et al., 2004).

The spatial structure of HIV/AIDS can influence the study of the epidemic, future spread of the disease, the nature and success of the interventions (Tanser et al., 2009, Wand et al., 2011). Spatial epidemiologists endeavour to develop models which will spatially and temporally link diseases transmission, morbidity and mortality (Gewin, 2004). These models allow for future predictions of disease patterns thereby empowering intervening bodies to bring about disease control (Graham et al., 2004).

Problem Statement

Young people in SSA (10-24 years), including both younger (10-14 years) and older adolescents (15-19 years) and particularly young women, are vulnerable to HIV risk (Cowan and Pettifor, 2009, Pettifor et al., 2005, Wilson et al., 2010, Ferrand et al., 2009). The highest burden of HIV infection in the world is observed in Eastern and Southern Africa (Ferrand et al., 2009). Adolescents are reportedly at a high risk of HIV infections as has been reflected in various community-based serological surveys and national HIV/AIDS surveillance reports (Konde-Lule et al., 1997). Although being identified as a risky age-group, very little in terms of intervention research has been carried out on adolescents (Naranbhai and Karim, 2006). A study conducted by Steinbeck and others., reported that although DHS studies collect data and information on individuals aged 15-49 years, this information is largely underutilized especially where adolescents were concerned (Steinbeck et al., 2009). In addition, lack of participation of this age-group in trials results in lack of adequate data for adolescent research studies and the available studies have combined the child and adolescent groups making it difficult to determine outcomes specific to adolescents (Steinbeck et al., 2009).

Across the countries, the adolescence HIV prevalence varies (Buve et al., 2002) as a result of variant proximate, distal and biological factors associated with HIV infections which can be identified by using spatial analysis (Chapman et al., 2010, Lewis et al., 2007). Although health scientists and researchers have embraced the use of spatial data in determining the risk of diseases, little has been done to increase the uptake of spatial techniques in health sciences (Graham et al., 2004). Jacquez (2000) identified some of the reasons for this slow uptake as: - lack of spatial training for epidemiologists, lack of GIS packages for health applications and the limited studies that demonstrate the potential of GIS techniques in addressing health problems (Jacquez, 2000). The use of spatial analysis in the proposed research is aimed at emphasizing the need for identifying high HIV prevalence regions or clusters which can then be the primary targets for interventions that can be carried out within adolescents.

Rationale of the study

Young people's perception of invulnerability leads them to experiment with risky behaviours (Meschke et al., 2002, Rosenberg et al., 1999, Wilson et al., 2010). These behaviours may lead to poor reproductive health outcomes including the potential risk for Human Immunodeficiency Virus/Acquired Immunodeficiency Disease Syndrome (HIV/AIDS) infection and other Sexually Transmitted Infections (STIs) (Babalola, 2011). Perinatal (Gray, 2010) and nosocomial transmissions (Coovadia and Mantell, 2010) have also been cited as some of the major means of HIV spread in young people.

In SSA, young people constitute a large proportion of individuals that are at risk of HIV infections through sexual transmission (Babalola, 2011) and this has had repercussions for the overall course of the epidemic (Zaba et al., 2000). Strict ethical principles that protect adolescents result in relatively small numbers of HIV/AIDS trials conducted in SSA on this age-group (Jaspan et al., 2006) which is disproportionate to the burden of disease (Siegfried et al., 2005). Other complexities that challenge the participation of young people, particularly adolescents in studies are: - recruitment and retention, issues around consent, assent and confidentiality and parental support in adolescent research (Steinbeck et al., 2009). There is an urgent need to prioritize interventions that target young people against HIV infections (Law et al., 2004). Understanding the risk factors for HIV/AIDS infection will assist in the formulation of effective preventative measures that target adolescents (Babalola, 2011). To reduce the current epidemic trends, focus must concentrate on prevention and treatment as well as developing strategic and structured approaches that reduce HIV risk in young people, particularly, adolescents (Naranbhai and Karim, 2006).

Spatial analysis may be useful in understanding the spread of HIV/AIDS infection by assisting in the identification of factors behind the spread of the disease, describe the geographical distribution and identify significant geo-spots of HIV/AIDS in East Africa regions (Touray et al., 2010). Furthermore, analysing spatially-referenced data requires researchers to estimate the effect of factors on diseases specific to different regions while accounting for spatial autocorrelation of the data (Best et al., 2005). This can be overcome by using Bayesian-based conditional autoregressive (CAR) modelling such as spatial clustering, spatial smoothing and spatial autocorrelation which incorporates the spatial structure of the data into the analysis for small area variations (Graham et al., 2004).

Literature Review

Human Immuno-deficiency Virus / Acquired Immune Deficiency Syndrome (HIV/AIDS) in Sub-Saharan Africa

According to the 2012 UNAIDS Report on the Global AIDS epidemic approximately 34.0 million people are living with HIV. SSA continues to be severely affected with 69% of all global HIV cases reported (UNAIDS, 2012). HIV/AIDS affects people in the most productive phases of their lives contributing to high medical costs and psychological problems resulting from stigma and discrimination (Wilson et al., 2010) increasing burden on the local and global economy. WHO defines burden of disease as the effects of a disease on premature death and disability which can be further extended to describe the effects of disease not only on households but also on the society. The 2011 WHO health situation analysis reports the greatest burden of disease seen in the African region with approximately 511 DALYs per every 1000 population with 12.4% of this DALYs resulting from HIV/AIDS (WHO/UNAIDS/UNICEF, 2011).

In SSA, the HIV/AIDS epidemic as seen in Figure 1.1 varies geographically with the southern Africa sub-region reportedly having the most severe HIV epidemics worldwide ranging from 9.8% to 26% (UNAIDS, 2012). The eastern Africa region is seen as having a stable epidemic where the HIV prevalence is reported as between 6% and 7%. In central and western Africa region, the HIV prevalence is as low as 2% and as high as 5% (UNAIDS, 2012). The east African region has reported a decline in new incident cases and subsequently a drop in the prevalence by 25%. Since 2000, the HIV prevalence in Kenya and Uganda dropped from 14% to 5% and 15% to 6.5% respectively (UNAIDS, 2010).

HIV/AIDS in SSA is largely spread through heterosexual contact with women reporting higher HIV prevalence when compared to men (Niëns and Lowery, 2009). This difference has been reportedly caused by the disparities in gender inequality causing females to become infected at an early age as a result of intergenerational and transactional sex (Wilson et al., 2010). Other modes of transmission observed in the SSA region include parenteral and perinatal (Coovadia and Mantell, 2010, Gray, 2010).

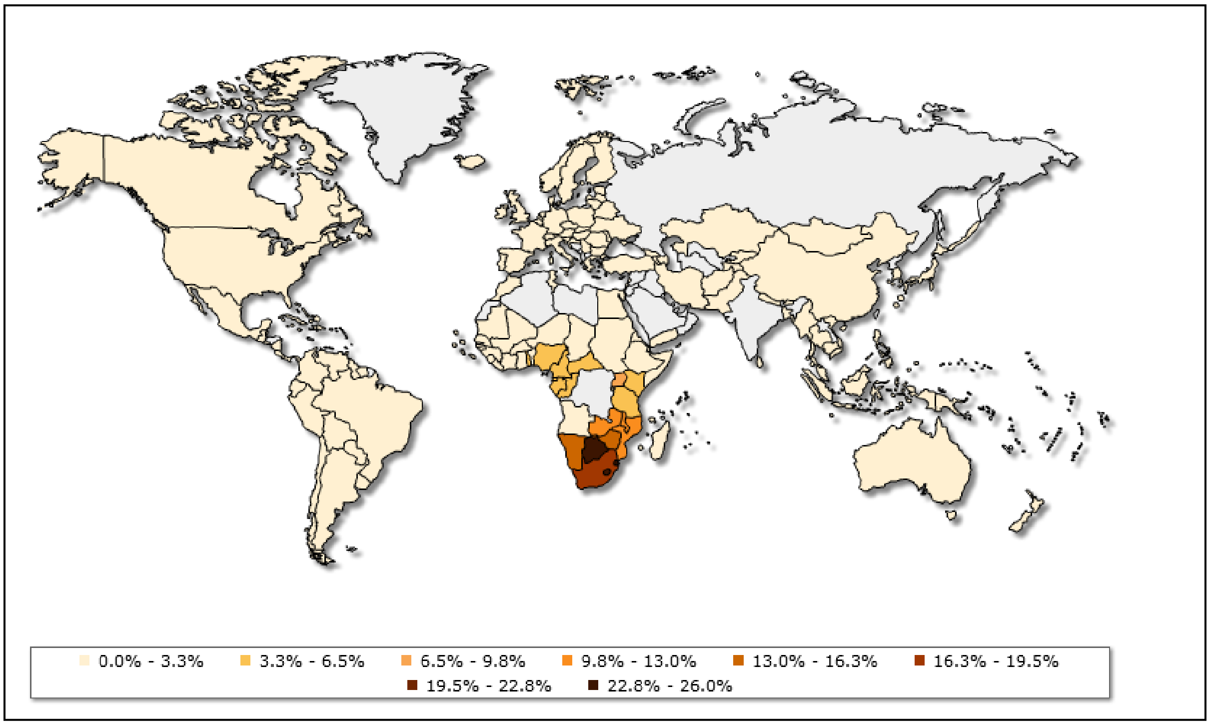


Figure 1.1: Map showing the adult HIV/AIDS prevalence rate (UNAIDS, 2012)

HIV Prevalence among young people in SSA

The UNAIDS 2010 report on young people reported an estimated 5 million youth (15–24 years) were living with HIV in 2008, with approximately 80% residing in SSA. The overall HIV prevalence among youth in SSA was estimated at 1.4% in males and 3.4% in females. In East Africa, the prevalence of HIV among youth from various population surveys conducted from 2004-2009 varied across the region (Table 1.1). The long duration of infectivity is highest among the young people where the reported prevalence was highest and low in in regions reporting a decline in incident HIV infections (Napierala-Mavedzenge et al., 2011). Since there are differences in the factors leading to HIV prevalence and phase of the HIV epidemics in East Africa, the risk of acquiring HIV among young people also differs, depending on which region a young person resides. These variations across and within regions are associated with socio-demographic, biological and behavioural factors (Buve et al., 2002, Chapman et al., 2010, Msisha et al., 2008b)

Table 1.1: Eastern Africa estimates for HIV prevalence among young people aged 15–24 years, from population-based survey data in selected countries, 2004–2009

	HIV Prevalence (%)		
Country	**Overall**	**Males**	**Females**
Ethiopia	0.7	0.2	1.1
Kenya	2.9	1.1	4.5
United republic of Tanzania	2.4	1.1	3.6
Uganda	2.9	1.1	4.3

Factors associated with HIV/AIDS prevalence among young people

Young people in SSA are vulnerable to HIV infections due to a combination of these various factors; poverty, experimental behaviour, socio-cultural factors, gender inequity and lack of proper and adequate knowledge (Michielsen et al., 2010, Niëns and Lowery, 2009). Understanding the epidemiology of HIV among young people provides a platform for stakeholders to discuss the interventions that target the prevention of HIV among this age-group (Wilson et al., 2010). Several articles have addressed the proximate, biological and distal factors associated with HIV prevalence among adolescents and young adults which have been known to cause disparities during the reporting HIV prevalence (Amornkul et al., 2009, Babalola, 2011, Kabiru and Orpinas, 2009).

Proximate determinants such as multiple sexual partnerships (Rosenberg et al., 1999), with limited condom use (Chapman et al., 2010) and age at first sex debut (Kelly et al., 2003) have been associated with HIV prevalence. Since there is varied sexual behaviour at individual-level such as numbers, types, patterns of sexual partnerships, frequency and types of sexual intercourse among different sub-populations, The HIV prevalence differs among groups of individuals living within the same area (Auvert et al., 2001).

In SSA, HIV is primarily transmitted through sexual intercourse (Babalola, 2011, Chapman et al., 2010, Kaaya et al., 2002, Meschke et al., 2002). Biological factors such as immature genital tracts, presence of STIs and cervical ectopy increase the risk of HIV infection and transmission, particularly in young women (Amornkul et al., 2009, Gray et al., 2001). In

SSA, sexual intercourse in presence of genital ulcers continues unabated despite the existence of the HIV epidemic (O'Farrell, 2002). Male circumcision is one of the most influential factors affecting HIV prevalence by reducing the direct risk of HIV acquisition by as much as 60% in men and indirectly in women (Auvert et al., 2005, Bailey et al., 2007, Gray et al., 2007).

Socio-demographic factors which are also distal factors have been positively or negatively associated with HIV prevalence. Education has been identified as a social vaccine against HIV/AIDS infections among adolescents (Jukes et al., 2008). School going adolescents, especially females are less likely to engage in risky behaviour making them less vulnerable to HIV infections compared to school drop-outs (Kabiru and Orpinas, 2009). Social Economic Status (SES) has been positively associated with certain HIV-risk factors, including multiple sexual partnerships and premarital sex (Fortson, 2008, Fox, 2010) through transactional sex (Jaspan et al., 2006) and intergenerational sex (Muula, 2008). A positive relationship between urbanisation and HIV is explicable as higher-risk sexual behaviours are likely to be more common in urban areas than in rural areas (Msisha et al., 2008b). Urbanization which is associated with proper transport infrastructure has been linked to the rapid spread of HIV in SSA. This has been known to enable the HIV transmission through a well-known high risk population, the truck drivers (Msisha et al., 2008a). It has also been shown in literature that geographical factors such as proximity to geographical features, major transport and trade routes and national borders are instrumental in understanding the risk of HIV infections in populations (Montana et al., 2007). Religion has been seen to have an influence on the attitudes towards HIV (Zou et al., 2009). Previously, many studies in Africa correlated the risk of HIV infection and religion where religious beliefs influenced the behaviour among the Muslims and Pentecostal Christians that led to low HIV prevalence rates (Garner, 2000, Gray, 2004).

Spatial Analysis and HIV/AIDS

Spatial epidemiology was founded on the premise that individuals who lived in close proximities were generally exposed to similar factors which were likely to affect detected outcomes (Musenge et al., 2013). Bayesian geostatistical methods are increasingly utilised in spatial analysis, disease mapping and consequently, decision-making. Their flexibility enables them to integrate spatial correlation and modelling of fixed and random variables (Best et al., 2005). In so doing, using Bayesian geostatistical analysis provides researchers with a tool for the identification of high prevalent areas where great variations exist in disease epidemic (Clements et al., 2006). Spatial modelling introduces a random effect at any observation in a particular location which creates a spatial correlation on the distribution of the random effects (Vounatsou et al., 2009). This provides correct estimates of parameters tested, predicts risk at non sampled locations and estimates heterogeneity in areal data (Tanser et al., 2009, Wand et al., 2011). Spatial analyses such as spatial smoothing, spatial autocorrelation and cluster analysis are widely used in spatial epidemiology (Wang et al., 2012). Spatial smoothing is used to reduce the random variation that is characteristic on small area data (Rojas, 2007). Spatial autocorrelation is usually performed to determine whether the occurrence of a disease occurs randomly or by chance (Ord and Getis, 2001).

Spatial clustering identifies whether cases of diseases are aggregated at certain geographic locations (Tiwari et al., 2006, Westercamp et al., 2010). Studies conducted on spatial clustering and mapping of communicable diseases are becoming the preferred method of creating public health awareness on disease burden and the risks posed to populations (Kamara, 2008) which enables the establishment of spatial associations between potential risk factors and populations (Bautista et al., 2008). Using clusters to identify high risk determinants behind the spread of a disease may assist in guiding health and policy planners in developing and allocating resources for HIV prevention programs among adolescents (Bautista et al., 2008, Touray et al., 2010, Wand et al., 2011).

Geographical Information Systems (GIS) and HIV/AIDS

More studies on HIV/AIDS epidemic have been seen to concentrate on the biomedical aspect of the disease rather than focus on how to better approximate the magnitude of the disease geographically (Moise and Kalipeni, 2012).

In developed countries, well organised GIS systems for health surveillance data are already established and which is not the case in developing countries (Kandwal et al., 2009). Geographical analysis of diseases in the developed countries began in the 18th century, where Dr. John Snow mapped cholera deaths in relation to London's water pumps. This exercise not only tracked the source of outbreak of cholera but also convinced authorities to take action against the disease and demonstrated to future epidemiologists the value of maps as both a research and a communication tool (Snow, 1855). In Africa, there is still little use of GIS technology in HIV sero-prevalence research and this is partly because of the inadequate means of data collection and monitoring which is coupled by limited technological resources (Kalipeni and Zulu, 2008). Several researches have used GIS techniques to display the unequal distribution of STI across geographical areas and this has been viewed as a critical step in understanding the spread of the infections and its prevention (Tanser et al., 2009). The study by Weir et al., (2002) utilized GIS technology to determine whether current sexually transmitted infections or AIDS prevention programs were appropriately placed for intervention as well as identifying where individuals with high rates of new partner acquisition could access prevention programs in Cape Town, South Africa (Weir et al., 2002). In Tanzania, a study characterised the HIV transmission according to several villages which formed the basis for an aggregated analysis of geographical and social patterns relevant to HIV transmission in the study areas (Killewo et al., 1994). GIS has also been used to generate malaria models that show its occurrence according to seasonal patterns and the intensity of the disease transmission with a view to estimate morbidity and mortality (Tanser and Le Sueur, 2002). Mapping of vectors habitats and infection rates has been used in intervention programmes which include the management and control of malaria in malaria endemic regions (Beyers et al., 1996). In South Africa, GIS has been used to map tuberculosis cases in the Western Cape and rural KwaZulu-Natal in order to analyse childhood tuberculosis and the distribution of treatment points respectively (Tanser and Wilkinson, 1999). In Kenya, GIS has been used to model the utilisation of health services with a view to increase the effectiveness of malaria treatment coverage (Noor et al., 2003).

Research Question

Can spatial analysis be employed to delineate high risk areas and identify the factors associated with HIV-prevalence among young people in Eastern Africa between 2007 and 2011?

Aim of the study

The main aim of the proposed research is the identification of areas of HIV sero-prevalence clusters by applying spatial analytical techniques among young people in Eastern Africa.

Objectives

1. To display the spatial distribution of HIV sero-prevalence among young people within each Eastern African country without adjusting for covariates between 2007 and 2011.
2. To investigate and analyse the presence of HIV sero-prevalence spatial clusters in Eastern Africa between 2007 and 2011.
3. To determine factors associated with HIV sero-prevalence among young people in Eastern Africa adjusting for spatial random effects within these countries between 2007 and 2011.

Summary of key points

- Approximately half of all the new HIV infections arising from the developing world are among young people, mainly adolescents.
- HIV/AIDS in SSA is mainly spread through heterosexual contact with females more disproportionally affected than males.
- The epidemiology of HIV/AIDS among young people varies widely across regions as a result of different proximate, distal and biological factors.
- Spatial analysis of diseases is one of the methods being used in public health and epidemiological research to manage and analyse health data.
- GIS produces maps that display the variations of diseases across geographical regions.

Chapter 2 : Materials and Methods

MEASURE Demographic and Health Survey

The MEASURE Demographic and Health Survey (DHS) project is an on-going collaboration between the United States Agency for International Development and country-specific agencies to conduct nationally representative household sample surveys with coverage of a range of population health indicators in low- and middle-income countries (LMIC) (Corsi et al., 2012). These surveys collect information on fertility levels and preferences, marriage, sexual activity, awareness and use of family planning methods, maternal and child health, breastfeeding practices, nutritional and anaemia status of women and young children, childhood mortality, use of bed nets and anti-malarial, awareness and behaviour regarding HIV/AIDS and other sexually transmitted infections (STIs), female genital mutilation (FGM), and adult and maternal mortality. DHS surveys also collected spatial co-ordinates of the de-facto communities where respondents reside. These co-ordinates are used to construct geographic variables useful for spatial analysis. Apart from the Standard DHS, data from other surveys such as the AIDS indicator surveys (AIS), malaria indicator surveys (MIS) and key indicators surveys are also collected by MEASURE DHS.

DHS respondents are selected using a two-stage sampling process from stratified urban and rural areas. The first stage involves the selection of a number of Enumeration Areas (EAs) selected from a list of clusters created from a recent population census (Aliaga and Ren, 2006). The second stage involves selecting households from a household list in the selected

EAs where all the household members of reproductive ages 15-49 (females) and 15-54 (males) were selected (Aliaga and Ren, 2006).

Study Area

The study area consists of four Eastern Africa countries namely; Ethiopia (2011), Kenya (2008/2009), Tanzania (2007/2008) and Uganda (2011) where the DHS were carried out as seen in Figure 2.1.

Ethiopia

Ethiopia, which borders Kenya to the north, is about 1.1 million square kilometres (Ethiopia DHS, 2011). It lies between 9.4969^{o}N and 36.8961^{o}E. Ethiopia is divided into eleven regional states namely; Tigray, Affar, Oromiya, Somali, SNNP, Amhara, Gambela, Harari, Addis Ababa, Dire Dawa and Benishangul-Gumuz (CSA and ICF, 2012). The 2007 Population and Housing census revealed that Ethiopia has approximately 74 million people with 51% being male and 49% female with 85% living in the rural areas with a significant proportion of the population being under 15 years of age (CSA, 2008). Furthermore, the 2012 Population Reference Bureau detailed that 1.0% males and 1.9% females of reproductive age are living with HIV/AIDS (PRB, 2012).

Kenya

Kenya, which is also situated in the eastern part of the African continent and lies between 5 degrees north and 5 degrees south latitude and between 24 and 31 degrees east longitude has a total surface area of 582,646 square kilometres. It is divided into eight provinces namely; Nairobi, Coast, Central, Eastern, Western, North Eastern, Nyanza and Rift Valley (KNBS and ICF, 2010). The 2009 National Population and Housing Census reported that approximately 39 million people inhabit Kenya with a slightly larger proportion of females compared to men and approximately 43% of the population is below the age of 15 years (KNBS, 2010). The 2012 Population Reference Bureau showed that approximately 4.9% males and 7.6% females of reproductive age are living with HIV/AIDS (PRB, 2012).

Tanzania

The United Republic of Tanzania is the largest country in the East African Region with a total surface area of approximately 940,000 square kilometres. It is made up of Tanzania (Mainland) and Zanzibar (Island in the Indian Ocean) which are divided into 21 and 5 regions respectively (NBOS and ICF, 2010). Tanzania lies between 5.6944^{o}S and 36.3223^{o}E. The 2002 Tanzania Population and Housing census showed that approximately 34 million people live in The United Republic of Tanzania with 60% of living in the rural areas (NBOS, 2006). The sex ratio is 95.5 males to every 100 females and approximately 44.2% of the population is below 15 years (NBOS, 2006). The 2012 Population Reference Bureau stated that 4.5% males and 6.8% females of reproductive age are living with HIV/AIDS (PRB, 2012).

Uganda

Uganda is the smallest country in this study area with a total surface area of approximately 241, 039 square kilometres lies between 1.1027^{o}N and 32.3968^{o}E. It is landlocked and divided into 8 regions namely; West Nile, North, Eastern, Central 1 and 2, Western, South West and East Central (UBOS and ICF, 2012). The 2002 Population and Housing census reported a population of approximately 24.4 million inhabitants with 88% living in rural areas. The sex ratio was reported as 95 males per every 100 females with the female population (51.2%) slightly higher than the male population (48.8%) (UBOS, 2006). Uganda has a high fertility rate with approximately 49% of the total population below 15 years. The 2012 Population Reference Bureau reported that 5.3% males and 7.7% females of reproductive age are living with HIV/AIDS (PRB, 2012).

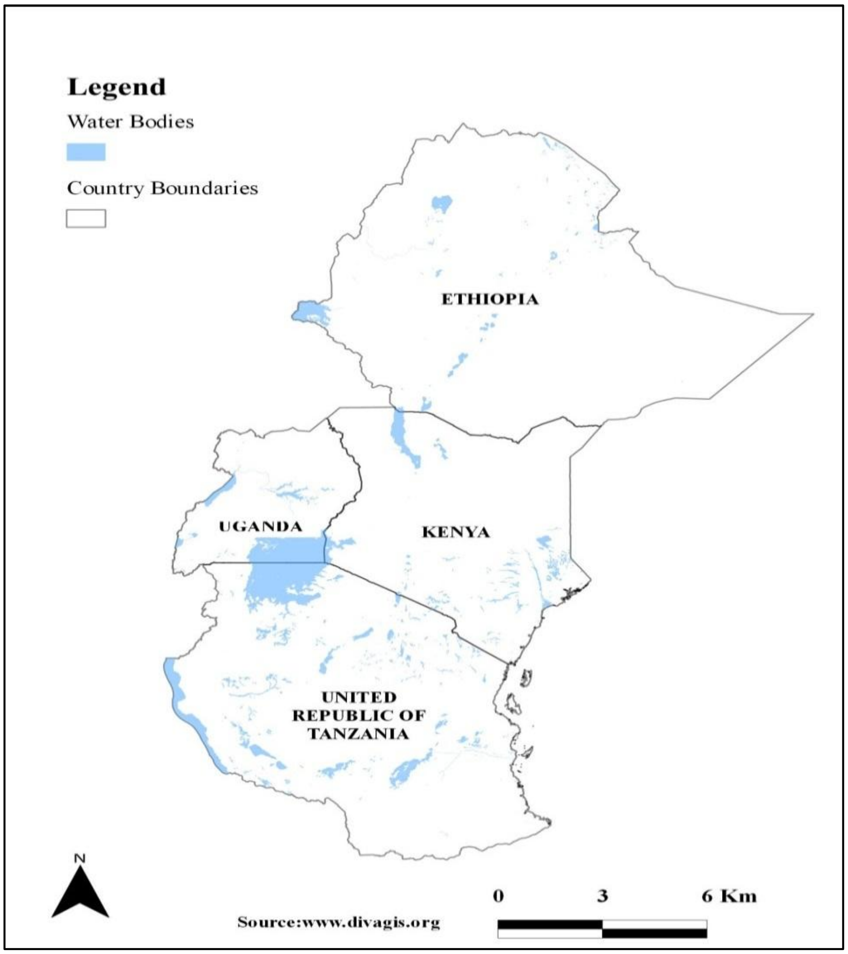


Figure 2.1: Geographical map of four Eastern Africa countries making up the study area.

Data Collection

Data for the original study was collected by use of comprehensive questionnaires and was extracted from the DHS (www.measuredhs.com). The shape files used in this study were obtained freely from the HIV Spatial Data Repository (www.hivspatialdata.net) and DIVA GIS (www.diva-gis.org) websites. Three datasets were used namely; standard DHS datasets which had socio-demographic information on the individual and household levels including a male dataset, AIS dataset which had indicators for effective monitoring of HIV through data from HIV prevalence and the GPS dataset for geo-referenced information of the households that participated in the DHS survey. Before downloading any dataset from the DHS website, a free registration process and identification of the relevant surveys was required. Datasets were then downloaded at no cost and stored safely in an external drive before and during analysis in line with ethical requirements. The data from the AIS was obtained after a blood sample was drawn for HIV testing and geographical coordinates for spatial analysis were obtained following the capturing of GPS locations during the survey by the Gramin eTrex legend H GPS receiver (CSA and ICF, 2012, KNBS and ICF, 2010, NBOS and ICF, 2010, UBOS and ICF, 2012). HIV status was measured by the standard HIV testing procedure where dried blood spots from finger pricks were tested in the laboratory using the Vironostika Anti-HIV-1/2 Plus enzyme linked immune-absorbent assay (ELISA) test kit (DADE Behring HIV-1/2). Blood samples where the ELISA results were reactive were considered positive (CSA and ICF, 2012, KNBS and ICF, 2010, NBOS and ICF, 2010, UBOS and ICF, 2012).

Outcome and Exposures

Measurements were categorized into exposure and outcome variables based on the available variables in the data. Exposure was determined by demographic such as age, sex, marital status, religion, education level and place of residence of study participants; and socio-economic factors such as, family assets, housing structure/type and parent or care giver's occupation. The socio-economic factors were later combined to derive the SES component in the analysis. Behavioural factors such as high-risk sexual behaviour (multiple sex partners, substance abuse, transactional sex, condom use, age at first sex debut) were included. Biological factors included in the study were the presence of STI. The outcome variable was the HIV sero-status.

Conceptual Framework

This study investigates the non-spatial and spatial distribution of HIV prevalence among young people (15-24 years) in Eastern Africa using data collected by MEASURE DHS in relation to demographic, social and behavioural factors at different points in time. These factors form a conceptual framework, which has its roots in demography, by organising different influencing factors in a meaningful way. A modified conceptual framework was formulated using the proximate determinants framework by Boema and Weir (2005) which described three levels of factors that influence HIV transmission among young people in Eastern Africa (Boerma and Weir, 2005). In this study, the underlying (distal) factors were defined as those linked with demographic and socio-economic at a household level and influenced the biological factors indirectly through the behavioural factors. The behavioural factors encompassed both proximate and biological factors at an individual level which influenced the biological factors directly (Boerma and Weir, 2005). Each of the factors was also associated with HIV prevalence. Spatial factors were added to the framework as the unobserved factors which operate through the other three factors to influence HIV transmission among young people in Eastern Africa. The conceptual model is illustrated in Figure 2.2.

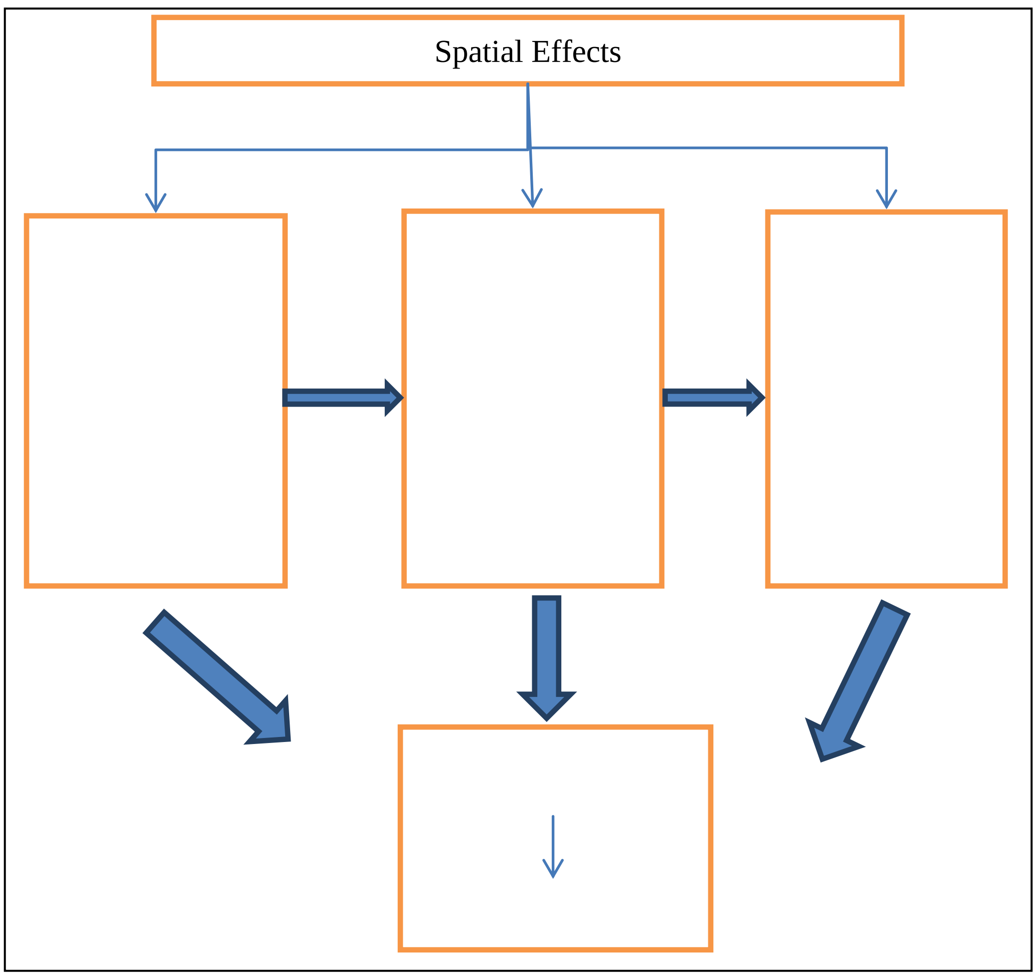


Figure 2.2: Proximate determinant conceptual framework for factors associated with HIV prevalence among East African youth

Study Design

The study employed secondary analysis on the cross-sectional data from four countries which participated in DHS from 2007 to 2011.

Study Population

The study population was young people who included adolescents aged between 15-19 years and young adults aged 20-24 years in the four eastern Africa countries from 2007 to 2011 who consented to HIV testing during the DHS period.

Eligibility Criteria

The study used the following inclusion criteria;

- datasets for the years that had complete GPS and AIS variables
- data with geocoded variables
- study population between 15-24 years
- data with a HIV test result

Similarly, the exclusion criteria employed in this study was;

- data without geocoded variables
- data without a HIV or an indeterminate HIV test result

Sample Size

The total sample size was 25,897 respondents aged 15-24 years, who lived in the four Eastern Africa countries during the period in which the DHS was being conducted (2007-2011). The sample size per country was as follows; Ethiopia (10,456); Kenya (2,455); Tanzania (5,468) and Uganda (7,518). A pooled analysis was required to increase the power of the study hence enabling the detection of accurate estimates.

Data Management

Data for individuals aged 15-24 years in this study was extracted from the respective DHS country database. Data cleaning was performed in Stata^{TM} Version 12 where new variables were created, non-plausible values set to missing and the validation of variables using from other variables (StataCorp, 2012). Three datasets from each country namely; GPS, HIV and the standard DHS dataset including Household member, Individual recode and Male recode sub-datasets were merged using a unique identifier and used for within country level analysis.

Data Analysis

Statistical analysis was carried out using different approaches depending on the type of analysis required at each step and tables of results produced. Standard logistic regressions were carried out in place of survey methods because difficulties in convergence were detected hence producing non-plausible results that displayed the parameter estimates only.

Descriptive and bivariate analysis

The tables of results were summarized by country with Tables 3.1-3.3 incorporating results from descriptive and bivariate analysis. To investigate factors associated with HIV prevalence among young people in the study area, descriptive statistics were performed to summarize the overall characteristics of the study participants. Frequencies and percentages {n (%)} were used to describe categorical variables whereas mean (standard deviation) or median (interquartile range) described continuous variables. Bivariate analyses which included chi-square, independent t-test and their non-parametric equivalents were used determine whether the relationship between the outcome and explanatory variables was large enough to rule out sampling error. Significant relationships were depicted by a p-value of < 0.05.

Univariate and multiple variable analysis

Univariate logistic regression analyses were performed to evaluate the effect of each factor on HIV prevalence in young people in Eastern Africa. Only factors with significant p-values (5% significance level) were included in the multiple variable analyses. A multiple variable logistic regression was performed without a spatial component to determine which factors were associated with HIV prevalence in young Eastern Africans and to also adjust for any confounding that would be present during analysis. The tables 3.4 – 3.6 displayed results of the unadjusted and adjusted regression models. Odds Ratios with 95% CI {OR (95% CI)} were reported for both analyses. An increase greater than 10% in the parameter estimates after adjusting indicated presence of confounding. Interactions terms were created between variables and found to be insignificant in the multiple variable models. Likelihood Ratio tests were used to compare different models. Hosmer-Lemeshow test was used to determine the best model fit. A p-value more than 0.05 suggested that the selected final model was good because the expected value was different from the observed value. Residuals were checked to ascertain the presence of any pattern in the final model and also to detect any presence of outliers which may indicate biasness in the results. Any outliers were thereafter removed. This data analysis was performed in Stata 12™.

Spatial analysis was conducted using three approaches using different as discussed in the sub-sections below. The Conditional Autoregressive approach was employed using the Moran and Geary indices and Bayesian modelling. The spatial scan approach was used to identify any clusters of HIV in the study area. Once this was ascertained, spatial autocorrelation techniques were employed to determine the randomness of the HIV infection. Finally, Bayesian modelling was used to explore the spatial factors associated with HIV among young people in eastern Africa.

Distribution of HIV prevalence in the study area

This entailed describing the HIV prevalence of each of the countries in the study area by use of maps. The maps depicted the overall HIV prevalence (15-54 years) and that of the study population (15-24 years).

Identification of clusters in the study area

This approach was to identified and detected clusters of HIV in the study area where analysis was performed on area-based data aggregated to cluster level and a Poisson-based model was used to estimate spatial clustering of the outcome. The number of HIV cases in any area is assumed to follow a Poisson distribution according to the known underlying population at risk (Kulldorff et al., 2005). The Kulldorff and Nargawalla spatial scan statistic of the SaTScan^{TM} version 8.0 was used to achieve these analyses (Kulldorff, 2006). The ability of carrying out spatial analysis usually depends on the availability of three specific files (case, population and coordinates). The case file comprising of region names or ids and cases (HIV +), the population file which includes the total population of the study area and the coordinates file comprising of region names, latitude and longitude locations of all the clusters within the study area. The clusters were classified into primary and secondary which had a significant p-value and those with insignificant p-value were classified as insignificant.

Spatial autocorrelation of HIV prevalence in the study area

This was investigated by use of the local and global spatial auto-correlation using the Geary (G) and Moran (M) indices respectively. These statistics were computed to test the null hypothesis of no significant clustering of HIV sero-positive in the area of study. The computation of the above mentioned statistics was achieved by using the ‘spdep’ package (Bivand, 2013) in the R-Cran software version 2.15.2 (R Development Core Team, 2012).

The Geary C statistic was useful in identifying local patterns of HIV distribution in the study area and varied from a scale of 0-2 with a value less than one denoting a positive spatial autocorrelation, a value more than one indicating a negative spatial autocorrelation and a value of 1 showing a random pattern (Geary, 1954). Geary's *C* can be computed as follows (Geary, 1954):

$$C = \frac{N\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - x_j)^2}{2(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij})\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad \text{……………………………………………… Equation 2.1}$$

Where:

N = Total sample size

n = the number of observations at locations i or j.

W_{ij} = a weight indexing location of *i* relative to *j*

x_i = the DN value at location i

x_j = the DN value at location j

The Moran I on the other hand, described the overall spatial dependence of HIV prevalence over the study area whose values ranged from -1 to +1 (Moran, 1950). A positive spatial autocorrelation (+1) referred to a map pattern where geographical features of similar value tended to cluster together, a negative spatial autocorrelation showed a map pattern in which geographical units of similar values were scattered throughout the map and a statistically insignificant spatial autocorrelation depicted a random distribution (Ord and Getis, 2001). The general formula for computing Moran's *I* is (Moran, 1950):

$$I = \frac{N\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(x_j - \bar{x})}{(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij})\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad \text{…………………………………..………Equation 2.2}$$

Where:

N = the total sample size

n = the number of values to be taken into account at each location

$\overline{X}$ = the mean of the variable

X_i = the variable value at a particular location

X_j = the variable value at another location

W_{ij} = a weight indexing location of *i* relative to *j*

Bayesian Modelling

The third approach was employing Bayesian regression modelling for investigating the effects of spatial random effects by allowing for the joint analysis of categorical variables and spatial structured variation (Belitz et al., 2012). Since the outcome is binary, the main statistical model used a spatial Bayesian Binomial regression model which was applied to estimate the effect of covariates on the probability of being HIV sero-positive. The Bayesian models were of the form (Clements et al., 2006):

$$\gamma_i \sim Binomial(n_i, \pi_i) \quad \text{Equation 2.3}$$

Where γ_i is the observed number positive at location i, n_i is the number tested at location i andπ_i is unknown prevalence at location i. The ordinary non-spatial and the spatial logistic regression models were given by equation 2.4 and 2.5 respectively (Kazembe et al., 2006).

$$log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 v_i \quad \text{Equation 2.4}$$

and

$$log\left(\frac{\pi_i}{1-\pi_i}\right) = \beta_0 + \beta_1 v_i + S_i \quad \text{Equation 2.5}$$

Where:

π_i = unknown or predicted prevalence of HIV sero-positivity
β_o = intercept
β_i = regression parameter
v_i= covariate
S_i= spatial random effect

The Bayesian spatial random effect modelling was also used to account for unexplained spatial autocorrelation in the study area results (Belitz et al., 2012). This was made possible by using a Bayesian estimation based Markov chain Monte Carlo (MCMC) simulation with the aid of Metropolis Hastings (MH) steps (Belitz et al., 2012) using the BayesX software version 2.1. Convergence was achieved after 10,000 iterations and 1,000 burn-ins. The standard measure of effect (Posterior Odds Ratios) and their credible intervals (confidence intervals) of 2.5% and 97.5% were reported. The posterior odds ratio were determined after the exponentiation of the posterior means that were calculated according to the distance in unit terms of standard deviation from the average region values from the BayesX regression. Model goodness of fit was assessed using the Deviance Information Criterion (DIC), a Bayesian analogue to the Akaike Information criterion (AIC). This evaluated whether adding a spatial random effect would improve the non-spatial model with a smaller the DIC value indicating a better fit (Best et al., 2005).

Finally, a standard Geographical Information System (GIS) programme was used to translate the outputs into maps that depicted clustering and distribution of HIV prevalence in young people in eastern Africa for the observed period (2007-2011). The output maps were produced using a projected co-ordinate system, WGS Zone 84 in Quantum GIS version 1.8.0 (QGIS, 2013).

Ethical Considerations

This was a secondary data analysis for which the protocol was submitted for review to the Wits Ethics on Human Subjects Committee, University of Witwatersrand, Johannesburg, South Africa and thereafter granted (M120856) (Appendix A). Ethics approvals for primary studies were obtained from The ICF Macro Institutional Review Board in collaboration with respective National Ethics Review Committees for the study areas (CSA and ICF, 2012, KNBS and ICF, 2010, NBOS and ICF, 2010, UBOS and ICF, 2012). Permission was also sought from the Measure DHS ICF International to use the data for secondary analysis.

Summary of key points

- DHS are nationally representative surveys that collect a wide range of demographic and health data on individuals of reproductive age (15-49 years) females and (15-59 years) males.
- The study design was cross-sectional using secondary data on a study population that included all young people (15-24 years) who consented to HIV testing in the study area during the 2007-2011 DHS periods.
- Various statistical techniques were used to answer different objectives in the study which included; logistic regression (non-spatial), Bayesian regression (spatial random effects), Geary and Moran statistic (spatial autocorrelation) and Kulldorff and Nargawalla spatial scan statistic (cluster analysis).
- Mapping outputs were generated using GIS techniques.
- All statistical tests were performed at 95% confidence interval and a p-value less than 0.05, implied significance.

Chapter 3 : Results

This chapter presented the factors that were associated with HIV prevalence among young people in Eastern Africa in three sections. The first section (3.1) provided a description of the socio-demographic and behavioural characteristics of these young people. The non-spatial and spatial factors associated with HIV prevalence were discussed in the second (3.2) and third (3.3) sections respectively.

Descriptive and bivariate summaries of the study participants

Demographic characteristics of the study participants

A total of 1,142 HIV sero-positive individuals were included in the study and were distributed as follows; Ethiopia (217), Kenya (180), Tanzania (212) and Uganda (533). The median age of participants was approximately 19 years across all the four countries. There were slightly more females than males living with HIV/AIDS in the study area which is more than half the population of the study area as seen in Table 3.1. Majority of participants in the study area live in rural areas with those with HIV significantly found in rural areas of Ethiopia ($p<0.001$), Tanzania ($p=0.007$) and Uganda ($p=0.019$) Literacy levels were shown by a large proportion of participants possessing primary school education and fewer individuals progressing beyond secondary school. In Ethiopia, the study population was largely Orthodox (n=113, 76.4%, $p<0.001$) when compared to other religions. The predominant religion in Kenya and Uganda was Protestant {(n=101, 73.2%, $p=0.004$) and (n=247, 46.4%)} respectively. There were no observations reported for religion in the original Tanzania DHS dataset. Those young people who were married {Ethiopia: n=64, 42.7%, $p<0.001$), Kenya: n=122, 67.8%, $p=0.005$), Tanzania: n=138, 68.0%, $p<0.001$) and

Uganda: n=319, 60.0%, p<0.001)} reported a high prevalence of HIV/AIDS compared to other marital status. The Table 3.1 overleaf provides a summary of the demographic characteristics of the study area.

Table 3.1: Descriptive and bivariate analysis of the demographic factors associated with HIV/AIDS in East African adolescents and young adults

Country	**Ethiopia**			**Kenya**			**Tanzania**			**Uganda**		
Variable : HIV +	n(%); **Median (1QR)[a]**	Total	P-value	n(%); **Median(1QR)[a]**	Total	P-value	n(%); **Median(1QR)[a]**	Total	P-value	n(%); **Median(1QR)[a]**	Total	P-value
DEMOGRAPHIC FACTORS												
Gender												
Male	85(41.1)	4,447	**0.666**[NS, c]	79(43.9)	1,079	**0.986**[NS, c]	85(40.1)	2,482	**0.114**[NS,c]	224(42.0)	3,208	**0.755**[NS, c]
Female	122(58.9)	6,009		101(56.1)	1,376		127(59.9)	2,986		309(58.0)	4,310	
Place of residence												
Urban	59(28.5)	3,465	**0.000** [***, c]	52(28.9)	703	**0.938**[NS,c]	64(30.2)	1,233	**0.007** [**,c]	147(27.6)	1,762	**0.019** [**, c]
Rural	148(71.5)	6,991		128(71.1)	1,752		148(69.8)	4,235		386(72.4)	5,756	
Education Level												
None	35(23.3)	2,747	**0.000** [***, c]	9(6.5)	277	**0.008**[**, c]	27(13.3)	1,156	**0.000** [***,d]	82(15.4)	846	**0.000** [***, c]
Primary	77(51.3)	1,778		87(63.0)	924		162(79.8)	3,206		314(59.0)	4,253	
Secondary	28(18.7)	611		29(21.0)	385		10(4.9)	918		114(21.4)	1,793	
Higher	10(6.7)	437		13(9.5)	130		4(2.0)	87		22(4.14)	592	
Religion												
Catholic	0(0)	31	**0.000** [***, d]	29(21.0)	336	**0.004** [**, d]	-	-	-	218(41.0)	2,970	**0.161**[NS, d]
Muslim	16(10.8)	2,104		3(2.2)	265		-	-	-	60(11.3)	1,069	
Orthodox	113(76.4)	2,554		-	-		-	-	-	1(0.2)	22	
Protestant	19(12.8)	815		101(73.2)	1,068		-	-	-	247(46.4)	3,375	
Traditional	(0)	29		-	-		-	-	-	3(0.6)	26	
None	-	-		5(3.6)	37		-	-	-	3(0.6)	21	
Marital Status												
Never married	12(8)	959	**0.000** [***, c]	50(27.8)	679	**0.005** [**, c]	6(3.0)	748	**0.000** [***, c]	31(5.8)	1,079	**0.000** [***, c]
Married	64(42.7)	3,747		122(67.8)	1,718		138(68.0)	4,061		319(60.0)	5,417	
Widowed	41(27.3)	393		4(2.2	8		31(15.3)	205		115(21.6)	506	
Separated/divorced	33(22)	474		4(2.2)	41		38(13.7)	353		67(12.6)	482	
Age (Years) Median(IQR)	19.19(2.75)[b]		**0.674**[NS, b]	19.14(2.79) [b]		**0.238**[NS, b]	19.01(2.93) [b]		**0.837**[NS, b]	18.98(2.86) [b]		**0.083**[NS,b]

[a] Median [b]Rank-sum test [c]Chi-square test [d]Fisher's exact test [NS]- >0.05- Not significant (NS) [*=] <0.001 ;[**=]>0.001 - <0.01; [*=]>0.01- <0.05**

Social characteristics of the study participants

Fewer participants were classified as having a high Socio-Economic Status (SES) in the study area. A larger number of participants were categorised as having a middle SES in Ethiopia (n=75, 54%, p<0.001) when compared to the other Eastern Africa countries where majority of the participants were classified as poor (58%, 63% and 57% for Kenya, Tanzania and Uganda respectively). Majority of the HIV positive study participants had an irregular exposure to media sources which included newspapers, radio and television as seen in Table 3.2. Uganda reported the highest proportion of study participants with nearly 74% having an irregular media source when compared to 52%, 68% and 60% for Ethiopia, Kenya and Tanzania respectively.

In Kenya 23/38 (59%, p<0.001) and Uganda 145/185 (78%, p=0.014), the proportion of HIV positive individuals who were not circumcised was greater in comparison to Ethiopia 22/183 (42%, p=0.007) and Tanzania 25/59 (12%, p=0.003). A summary of the social characteristics in the study area is described in Table 3.2 overleaf.

Table 3.2:Descriptive and bivariate analysis of the social factors associated with HIV/AIDS in East African adolescents and young adults

Country	**Ethiopia**			**Kenya**			**Tanzania**			**Uganda**		
Variable : HIV +	n(%)	Total	P-value	n(%)	Total	P-value	n (%);	Total	P-value	n(%)	Total	P-value
SOCIAL FACTORS												
SES												
High	7(5.0)	193	**0.000** $^{***, a}$	4(3.0)	122	**0.079** $^{NS, b}$	5(2.4)	148	**0.023** $^{*, a}$	8(1.6)	142	**0.036** $^{*, a}$
Middle	75(54.0)	1,301		52(39.4)	568		70(34.7)	1,378		209(41.4)	2,567	
Low	57(41.0)	3,638		76(57.6)	972		127(62.9)	3,715		288(57.0)	4,392	
Regularly exposure to two or more media sources												
None	60(40.5)	3,461	**0.000** ^{***,a}	28(20.3)	395	**0.308** $^{NS, a}$	42(21.3)	1,565	**0.000** $^{***, a}$	67(15.1)	886	**0.756** $^{NS, a}$
Irregular	77(52.0)	1,890		94(68.1)	1,064		119(60.4)	3,178		328(73.7)	4,772	
Regular	11(7.4)	192		16(11.6)	252		36(18.3)	569		50(11.2)	728	
Circumcised												
Yes	158(87.8)	11,973	**0.007** ^{*,a}	16(41.0)	586	**0.000** $^{***, a}$	34(57.6)	1,426	**0.003** $^{**, a}$	40(21.6)	1,080	**0.014** $^{*, a}$
No	22(12.2)	995		23(59.0)	142		25(42.4)	490		145(78.4)	2,562	

[a]Chi-square test [b]Fisher's exact test [NS]- >0.05- Not significant (NS) [*=] <0.001 ;[**=]>0.001 - <0.01; [*=]>0.01- <0.05**

Behavioural characteristics of the study participants

The median age of coital debut ranged from 15-17 years among the study participants with Kenya reporting the youngest median age (15 years) and Uganda reporting a slightly older median age of 17 years. Majority of the HIV positive individuals from Ethiopia (n=113, 63%, $p<0.001$), Kenya (n=82, 61%, $p<0.001$), Tanzania (n=102, 67%, $p<0.001$) and Uganda (n=362, 71%, $p<0.001$) reported their age at coital debut from 15-19 years. The proportion of HIV prevalence was higher in individuals who engaged in risky sexual behaviour. Tanzania (83%) and Kenya (73%) have the highest proportion of individuals who engage in multiple sexual partnerships. Very few participants engaged in transactional sex in the study area with the countries reporting a proportion less than 10% (see Table 3.3). Although more than half of the population of HIV individuals in the study area was not using condoms, the percentage was seen to be generally high, in Ethiopia (76%), Tanzania (85%) and Uganda (81%) when compared to Kenya (69%). More than half of the study population did not report any Sexually Transmitted Infections (STI) as seen in Table 3.3. A large number of participants did not report the use of alcohol during sex across the study area. The proportions were varied across the region with Kenya reporting the least at 22% and Ethiopia reporting the highest at 85%. Similarly, a large proportion of participants in the study area were not current tobacco users. Table 3.3 gives a summary of the behavioural characteristics of the study area.

Table 3.3: Descriptive and bivariate analysis for the behavioural factors associated with HIV/AIDS in East African adolescents and young adults

Country	**Ethiopia**			**Kenya**			**Tanzania**			**Uganda**		
Variable : HIV +	n (%); **Median(1QR)**[a]	Total	P-value	n(%); **Median(1QR)**[a]	Total	P-value	n (%); **Median(1QR)**[a]	Total	P-value	n(%); **Median(1QR)**[a]	Total	P-value
BEHAVIOURAL FACTORS												
Sexual behaviours												
Age at sex debut (continuous)	16(15-18)[a]		**0.000*****	15(14-18)[a]		**0.104**^{NS}	16(15-18)[a]		**0.209**^{NS}	17(15-18)[a]		**0.542**^{NS}
Age at sex debut												
None	16(8.9**)**	3,641	**0.000**^{***,c}	1(0.7)	148	**0.000**^{***,c}	3(2.0)	355	**0.000**^{***,c}	2(0.4)	322	**0.000**^{***,c}
8-10	2(1.1)	67		1(0.7)	15		3(2.0)	14		1(0.2)	80	
11-14	23(12.8)	791		38(28.2)	197		30(19.6)	331		80(15.6)	851	
15-19	113(62.78)	1,949		82(60.7)	917		102(66.7)	2,080		362(70.8)	4,613	
20-24	26(14.4)	465		13(9.6)	202		15(9.7)	425		68(13.3)	1,057	
Multiple sexual partners												
Yes	210(59.5)	9,842	**0.098**^{NS,b}	101(73.2)	1,346	**0.108**^{NS,b}	169(83.3)	4,574	**0.377**^{NS,b}	375(71.2)	6,030	**0.000**^{***,b}
No	143(40.5)	5,615		37(26.8)	367		34(16.7)	782		152(28.8)	1,422	
Transactional sex												
Yes	6(3.5)	134	**0.057**^{NS,b}	3(7.7)	8	**0.014**^{**,c}	5(8.6)	129	**0.775**$^{NS.b}$	16(9.6)	91	**0.000**^{***,b}
No	168(96.5)	8,982		36(92.31)	553		53(91.4)	1,559		151(90.4)	3,160	
Currently using condoms												
Yes	52(24.3)	294	**0.000**^{***,b}	12(30.8)	142	**0.068**^{NS,b}	24(14.2)	458	**0.064**^{NS,b}	71(18.7	561	**0.000**^{***,b}
No	162(75.7)	9,580		27(69.2)	586		145(85.8)	4,117		309(81.3)	5,501	
Other behaviours												
STI or STI symptom within past year												
Yes	20(5.6)	366	**0.000*****	25(18.3)	103	**0.000*****	21(10.5)	223	**0.000**^{***,b}	232(46.4)	1,787	**0.000**^{***,b}
No	336(94.4)	14,949		112(81.7)	1,599		179(89.5)	5,088		268(53.6)	5,477	
Used alcohol during sex												
Yes	32(15.0)	1,209	**0.223**^{NS}	18(18)	177	**0.142**^{NS}	26(15.4)	386	**0.001**^{***,b}	122(32.1)	1,404	**0.000**^{***,b}
No	182(85.0)	8,658		82(22)	1,162		143(84.6)	4,171		258(67.9)	4,658	
Current tobacco user												
Yes	13(3.6)	418	**0.269**^{NS}	5(3.6)	27	**0.044***	-	-	-	1(5.3)	38	**0.188**^{NS,c}
No	345(96.4)	15,082		113(96.4)	1,689					18(94.7)	202	

[a]Rank-sum test [b]Chi-square test [c]Fisher's exact test ^{NS}- >0.05- Not significant (NS) *** $^{=}$<0.001 ;$^{**=-}$>0.001 - <0.01; $^{*=}$>0.01- <0.05

Factors associated with HIV/AIDS prevalence in the study area

This subsection explores the relationship among factors that are closely associated with HIV sero-positivity in the study area from 2007 to 2011. Univariate and multiple variable models were fitted to explore for various associations with demographic, social and behavioural factors. The categories in each factor associated with HIV/AIDS that were significant in the adjusted model were reported in the Tables 3.4– 3.6.

Demographic factors of the study participants

Table 3.4 shows the demographic factors associated with HIV prevalence among the young people in Eastern Africa between 2007 and 2011. Although females were between 1-25% more likely to be infected with HIV/AIDS across the region when compared to their male counterparts, gender was not associated with HIV sero-positivity. Living in the rural areas provided a protective factor against HIV sero-conversion with significant associations observed in Ethiopia {OR=0.19 (95% CI: 0.14-0.26)}, Tanzania {OR=0.66 (95% CI: 0.49-0.89)} and Uganda {OR=0.79 (95% CI: 0.65-0.96)}. Although an association did not exist between age and HIV prevalence, results from Kenya and Uganda showed that an increase in age reduced the chances of acquiring HIV/AIDS by 3% {OR=0.97 (95% CI: 0.92-1.02)} and {OR=0.97 (95% CI: 0.94-1.00)} respectively. Ethiopia, Kenya and Uganda showed significant associations between education level and HIV sero-positivity. In Uganda, education gave a protective effect against HIV/AIDS with the level of protection increasing with every progress in education level. In Ethiopia, participants with primary and secondary school education were approximately four times likely to have HIV/AIDS compared to those who did not have any education {OR=3.51 (95% CI: 2.34-5.25) and OR=3.72 (95% CI: 2.24-6.16)}. Individuals with tertiary education on the other hand were 1.1 times more likely to be HIV positive when compared to those who had no education. In Kenya and Tanzania, individuals with primary and tertiary education were three and two times more likely to acquire HIV/AIDS in comparison to those without education {OR for primary education for Kenya=3.10 (95% CI: 1.54-6.24) and OR for tertiary education for Kenya=3.31 (95% CI: 1.38-7.96)} and {OR for primary education for Tanzania=2.23 (95% CI: 1.47-5.36)} respectively. Across the region, religion played a protective factor against HIV/AIDS prevalence as seen in Table 3.4. In Ethiopia and Kenya, participants were 0.4 and 0.12 times less likely to acquire HIV/AIDS if they were practising Muslims than those in Orthodox and Catholic denominations respectively. Married, widowed and divorced/separated participants were more likely to acquire HIV/AIDS in comparison to never married participants. This observation was significantly observed in all countries with the exception of Kenya. In Ethiopia, one was 1.4, 9.2 and 5.9 times more likely to be HIV positive if married, widowed and divorced/separated when compared to never married individuals. In Tanzania, one was 4.4, 22.0 and 10.7 times more likely to be HIV positive if married, widowed and divorced/separated when compared to never married individuals. In Uganda, the results in Table 3.4 showed that one was 2.2, 11.9 and 6.2 times more likely to be HIV positive if married, widowed and divorced/separated when compared to never married individuals.

Upon adjusting, place of residence and marital status showed significant associations with HIV prevalence in Ethiopia. Rural areas were still protective against HIV prevalence {AOR= 0.10 (95% CI: 0.02-0.43)} when compared to urban areas. Married individuals were still 3.7 times more likely to be HIV positive in comparison to never married individuals {AOR= 3.71 (95% CI: 1.20-11.0)}. In Kenya, education level and religion were the two factors that demonstrated significant associations with HIV prevalence. The chances of being HIV positive increased if an individual possessed primary {AOR= 2.76 (95% CI: 1.24-6.14)} and tertiary education {AOR= 2.70 (95% CI: 1.02-7.13)} when compared to having no education. Being a Muslim in Kenya protected one from being HIV positive by approximately 86% {AOR= 0.14 (95% CI: 0.04-0.49)}. Similar to Ethiopia, marital status and place of residence were the two factors associated with HIV prevalence among young people in Tanzania. The odds of being HIV positive increased after adjusting with individuals in the rural areas being five times more likely of being HIV positive when compared to those living in urban areas {AOR= 4.93 (95% CI: 1.68-14.55)}. The chances of being HIV positive increased if an individual was widowed or separated/divorced. Widowed {AOR= 42.41 (95% CI: 30.56-57.35)} and separated/divorced individuals {AOR= 33.27 (95% CI: 3.06-36.15)}were more likely seen to be living with the HIV/AIDS and those divorced or separated 33.3 times compared to those who never married. In Uganda, marital status was the only demographic factor associated with HIV prevalence. One was 35% more likely of being HIV positive if married in comparison to those who never married {AOR= 1.35 (95% CI: 1.54-9.76)}. The chances of being HIV positive increases five times if participants were separated or divorced than when they were never married {AOR= 5.44 (95% CI: 1.65-17.92)}.

Table 3.4: Demographic factors associated with HIV/AIDS among East African adolescents and young adults

Country	**Ethiopia**		**Kenya**		**Tanzania**		**Uganda**	
Variable: HIV +	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR(95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**
DEMOGRAPHIC	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Gender								
Male	1.00(ref)	-	1.00(ref)	-	1.00(ref)	-	1.00(ref)	-
Female	1.06(0.80-1.41)	-	1.01(0.74-1.36)	-	1.25(0.95-1.66)	-	1.03(0.86-1.23)	-
	0.666^{NS}		**0.986** ^{NS}		**0.115** ^{NS}		**0.755** ^{NS}	
Place of residence								
Urban	1.00(ref)	1.00(ref)	1.00(ref)	-	1.00(ref)	1.00(ref)	1.00(ref)	-
Rural	0.19(0.14-0.26)	0.10(0.02-0.43)	0.99(0.71-1.38)	-	0.66(0.49-0.89)	4.93(1.68-14.55)	0.79(0.65-0.96)	-
	0.000****		**0.938** ^{NS}		**0.007*****		**0.019****	
Education Level								
None	1.00(ref)	-	1.00(ref)	1.00(ref)	1.00(ref)	-	1.00(ref)	-
Primary	3.51(2.34-5.25)	-	3.10(1.54-6.24)	2.76(1.24-6.14)	2.23(1.47-3.36)	-	0.74(0.58-0.96)	-
Secondary	3.72(2.24-6.16)	-	2.43(1.23-5.21)	-	0.46(0.22-0.96)	-	0.63(0.47-0.85)	-
Higher	1.81(0.89-3.69)		3.31(1.38-7.96)	2.70(1.02-7.13)	2.01(0.69-5.90)	-	0.36(0.22-0.58)	-
	0.000****		**0.070***		**0.483** ^{NS}		**0.000******	
Religion								
Catholic	-		1.00(ref)	1.00(ref)	-	-	1.00(ref)	-
Muslim	0.17 (0.10-0.28)	-	0.12(0.04-0.40)	0.14(0.04-0.49)	-	-	0.75(0.56-1.01)	-
Orthodox	1.00(ref)		-	-	-	-	0.60(00.08-4.49)	-
Protestant	0.51(0.32-0.84)	-	1.11(0.72-1.70)	-	-	-	0.99(0.82-1.20)	-
Traditional	-		-	-	-	-	1.65(0.49-5.52)	-
None	-		1.65(0.60-4.57)	-	-	-	2.10(0.61-7.20)	-
	0.000****		**0.030****				**0.607** ^{NS}	
Marital Status								
Never married	1.00(ref)	1.00(ref)	1.00(ref)	-	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)
Married	1.37(0.74-2.55)	3.7(1.21-11.0)	1.03(0.74-1.46)	-	4.35 (1.91-9.89)	-	2.22(1.27-3.89)	1.35(1.54-9.76)
Widowed	9.19(4.77-17.69)	-	13.08(3.23-52.94)	-	22.03(9.05-53.63)	42.41(30.56-57.35)	11.87(6.28-22.43)	-
Separated/divorced	5.90(3.02-11.54)	-	1.41(0.50-4.03)	-	10.65(4.37-25.98)	33.27(3.06-36.15)	6.18(3.32-11.49)	5.44(1.65-17.92)
	0.000****		**0.103** ^{NS}		**0.000******		**0.000******	
Age (Years)	1.02(0.96-1.06)	-	1.03(0.92-1.02)	-	0.80(0.95-1.05)	-	0.82 (0.94-1.00)	-
	0.674 ^{NS}		**0.238** ^{NS}		**0.837** ^{NS}		**0.084** ^{NS}	

<0.10; **<0.05; *** <0.01; *<0.001;** ^{NS} **– Not Significant**

Social factors of the study participants

Table 3.5 shows the social factors associated with HIV prevalence among the young people in Eastern Africa between 2007 and 2011.

The association between SES and HIV prevalence among young people in Eastern Africa was significant in Ethiopia ($p<0.001$), Tanzania ($p=0.034$) and Uganda ($p=0.053$). In each of the countries, the chances of being HIV positive increased for participants in the low SES when compared to participants in the high SES category. However, these associations were not significant.

Chances of being HIV positive increased with regular exposure to more than two media sources compared to participants not exposed to any media sources as shown in Table 3.5. In Ethiopia, the regular exposure to two or more sources of media reported an OR of 3.4 (95% CI: 1.78-6.67) whereas in Tanzania an OR of 2.4 (95% CI: 1.58-3.66) was reported. The odds of being HIV positive decreased if participants were circumcised compared to uncircumcised individuals. The association was significant across the study area (see Table 3.5). Upon adjusting, Tanzania reported a significant association between regular exposure to two or more media sources and HIV prevalence. Chances of being HIV positive after adjusting for confounders increased and an AOR of 9.1 (95% CI: 3.21-25.65) was reported.

Table 3.5: Socio-economic factors associated with HIV/AIDS Among East African Adolescents and young adults

Country	**Ethiopia**		**Kenya**		**Tanzania**		**Uganda**	
Variable: HIV +	Univariate OR(95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR(95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**
SOCIAL	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
SES								
High	1.00(ref)	-	1.00(ref)	-	1.00(ref)	-	1.00(ref)	-
Middle	1.6(0.74-3.58)	-	3.0(1.05-8.38)	-	1.5(0.61-3.85)	-	1.5(0.72-3.07)	-
Low	0.4(0.19-0.94)	-	2.5(0.90-6.96)	-	1.1(0.41-2.51)	-	1.2(0.57-2.42)	-
	0.000******		**0.518** NS		**0.034****		**0.053****	
Regularly exposure to two or more media sources								
None	1.00(ref)	-	1.00(ref)	-	1.00(ref)	1.00(ref)	1.00(ref)	
Irregular	2.4(1.71-3.40)	-	1.3(0.82-1.97)	-	1.4(0.99-2.02)	-	0.9(0.69-1.19)	-
Regular	3.4(1.78-6.67)	-	0.9(0.47-1.68)	-	2.4(1.55-3.86)	9.1(3.21-25.65)	0.9(0.62-1.31)	-
	0.000******		**0.946** NS		**0.000********		**0.558** NS	
Circumcised								
No	1.00(ref)	-	1.00(ref)	-	1.00(ref)	-	1.00(ref)	1.00(ref)
Yes	0.3(0.17-0.68)	-	0.1(0.07-0.28)	-	0.5(0.27-0.77)	-	0.6(0.45-0.92)	0.7(0.44-1.01)
	0.000******		**0.000********		**0.003******		**0.015******	

<0.10; **<0.05; *** <0.01;*<0.001; NS – Not Significant**

Behavioural factors of the study participants

From the results in Table 3.6, it is evident that a linear increase in age at coital debut of the participants subsequently increased their chances of being HIV positive significantly. This was observed with participants from Ethiopia {OR=1.10 (95% CI: 1.06-1.15)}, Tanzania {OR= 1.03(95% CI: 1.00-1.07)} and Uganda {OR= 1.03(95% CI: 1.01-1.06)}. When age at sex debut is categorized, Ethiopia (p-value <0.0001) and Uganda (p-value=0.009) show significant associations. The odds of being HIV positive in Ethiopia increased 16.6{OR= 16.6 (95% CI: 4.30-64.40)} and 10.8 {OR=10.8 (95% CI: 4.29-27.26)} times when participant's coital debut was between the ages of 8-10 years and 15-19 years respectively. In Uganda, the chances of being HIV positive increased 16.6 {OR=16.6 (95% CI: 4.06-67.94)} and 13.6 {OR=13.6 (95% CI: 3.38-54.94) times when the age at sex debut was between the ages of 11-14 and 15-19 years respectively.

Table 3.6 further shows that the chances of being HIV positive increased when individuals engaged in multiple sexual encounters compared to those with a single or no partner. A significant association was seen in Ethiopia and Uganda where the chances of being HIV positive increased almost 15 {OR=14.9 (95% CI: 8.38-26.57)} and 2{OR=2.4 (95% CI: 1.85-3.20)} times for individuals who used practised multiple sexual partnerships respectively. In Kenya, the likelihood increased 8.6 times {(OR=8.6 (95% CI: 1.98-37.50)} and in Uganda the probability increased 4.3 times {(OR=4.25 (95% CI: 2.42-7.47)}. Using condoms during sexual intercourse reduced the chances of being HIV positive across the study area with significant associations observed in Ethiopia, Tanzania and Uganda. The probability of having HIV/AIDS in young people decreased by 60% {OR=0.4 (95% CI: 0.31-0.59)}, 16% {OR=0.84 (95% CI: 0.58-1.23)} and 45% {OR=0.55 (95% CI: 0.48-0.68)} respectively when using condoms during sexual intercourse compared to those who did not use condoms.

The association between the presence of STIs and HIV prevalence was highly significant in the study area as seen in Table 3.6. In all the four countries, the chances of being HIV positive were increased when an STI was present. Although not significant, young people in Ethiopia were 1.9 times more likely to be HIV positive if they had STIs {OR=1.90 (95% CI: 0.92-3.98)}. In Kenya, one was 4.3 times more likely to have HIV/AIDs if they have suffered from an STI {OR=4.3 (95% CI: 2.60-6.94)}. Young people in Tanzania and Uganda were almost 3 times more likely have the HIV/AIDS virus if they suffered an STI compared to those who did not have STI symptoms {OR=2.85 (95% CI: 1.78-4.58)} and {OR=2.90 (95% CI: 2.14-3.49)} respectively.

Significant associations between alcohol use during sex and HIV were observed in all countries in the study area with an exception of Kenya. The probability of being HIV positive increased approximately 2 times when using alcohol before sexual encounters when compared to those individuals who were sober during sexual intercourse in Tanzania {OR=2.03 (95% CI: 1.32-3.13)} and Uganda {OR=1.62 (95% CI: 1.29-2.03)}. There were no significant associations observed between tobacco use and HIV prevalence within the study area.

The behavioural factors that were associated with HIV prevalence in Ethiopia following multivariable analysis were coital debut at ages between 8-10 years, alcohol use during sexual intercourse {AOR=2.7 (95% CI: 1.0-7.4) and having multiple sexual partners {AOR=8.1 (95% CI: 2.0-33.2)} as seen in Table 3.6. HIV prevalence in Kenya and Tanzania was increased 4.42 and 6.70 times respectively if respondents were likely to have suffered an STI within the previous one year after adjustment {AOR=4.42 (95% CI: 2.65-7.36)} and {AOR=6.70 (95% CI: 3.22-15.24)}. Upon, adjusting for potential confounders, the HIV prevalence of the Ugandan respondents was more likely to increase 2.5 {AOR=2.51 (95% CI: 1.20-5.23)}, 2.0 {AOR=1.96 (95% CI: 1.17-2.45)} and 2.5 {AOR= 2.45 (95% CI: 1.69-3.54)} times if respondents practised transactional sex, used alcohol during sexual intercourse and suffered an STI within the last one year respectively.

Table 3.6**:** Behavioural factors associated with HIV/AIDS Among East African Adolescents and young adults

Country	**Ethiopia**		**Kenya**		**Tanzania**		**Uganda**	
Variable: HIV +	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**	Univariate OR (95% C.I) **P-Value**	Multiple variable AOR (95% C.I) **P-Value**
BEHAVIOURAL	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Sexual behaviours								
Age at sex debut (continuous)	1.10(1.06-1.15)	-	1.03(0.99-1.07)	-	1.03(1.00-1.07)	-	1.03(1.01-1.06)	-
	0.000****		**0.118^{NS}**		**0.055****		**0.003*****	
Age at sex debut								
None	1.00(ref)	1.00(ref)	1.00(ref)	-	1.00(ref)	-	1.00(ref)	-
8-10	16.6(4.30-64.40)	24.6(3.6-170.2)	10.5(0.62-177.13)	-	32.00(5.79-176.78)	-	2.03(0.18-22.62)	-
11-14	3.6(1.18-11.22)	-	35.1(4.76-259.13)	-	11.69(3.53-38.70)	-	16.60(4.06-67.94)	-
15-19	10.8(4.29-27.26)	-	14.4(1.99-104.52)	-	6.05(1.91-19.18)	-	13.63(3.38-54.94)	-
20-24	7.9(2.45-23.47)	-	10.1(1.31-78.17)	-	4.29(1.23-14.95)	-	7.9(2.68-45.14)	-
	0.000****		**0.273^{NS}**		**0.173 ^{NS}**		**0.009*****	
Multiple sexual partners								
No	1.00(ref)	1.00(ref	1.00(ref)	-	1.00(ref)	-	1.00(ref)	1.00(Ref)
Yes	14.92(8.38-26.57)	8.1(2.0-33.2)	1.9(0.94-3.87)	-	1.51(0.97-2.36)	-	2.43(1.85-3.20)	3.49(2.14-5.71)
	0.000****		**0. 072****		**0.377 ^{NS}**		**0.000******	
Transactional sex						-		
No	-	-	1.00(ref)	-	1.00(ref)	-	1.00(ref)	1.00(ref)
Yes	-	-	8.6(1.98-37.50)	-	1.15(0.45-2.92)		4.25(2.42-7.47)	2.51(1.20-5.25)
			0.004***		**0.775 ^{NS}**		**0.000******	
Currently using condoms								
No	1.00(ref)	-	1.00(ref)	-	1.00(ref)	1.00(ref)	1.00(ref)	-
Yes	0.4(0.31-0.59)	-	0.7(0.49-1.07)	-	0.84(0.58-1.23)	0.18(3.21-15.23)	0.55(0.45-0.68)	-
	0.000****		**0. 109 ^{NS}**		**0.066****		**0.000******	
STI or STI symptom within past year								
No	1.00(ref)	-	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)	1.00(ref)
Yes	1.9(0.92-3.98)	-	4.3(2.60-6.94)	4.42(2.65-7.36)	2.85(1.78-4.58)	6.70(3.22-15.24)	2.90(2.41-3.49)	2.45(1.69-3.54)
	0.000****		**0.000******		**0.000******		**0.000******	
Used alcohol during sex								
No	1.00(ref)	1.00(ref)	1.00(ref)	-	1.00(ref)	-	1.00(ref)	1.00(ref)
Yes	2.2(0.22-2.35)	2.7(1.0-7.4)	1.5(0.87-2.55)	-	2.03(1.32-3.13)	-	1.62(1.29-2.03)	1.96(1.17-2.45)
	0.006***		**0.145 ^{NS}**		**0.001******		**0.000******	
Current tobacco user								
No	1.00(ref)	-	1.00(ref)	-	-	-	1.00(ref)	-
Yes	0.8(0.24-2.39)	-	2.7(0.99-7.13)	-	-	-	0.28(0.04-2.13)	-
	0.631 ^{NS}		**0.052***				**0.217 ^{NS}**	

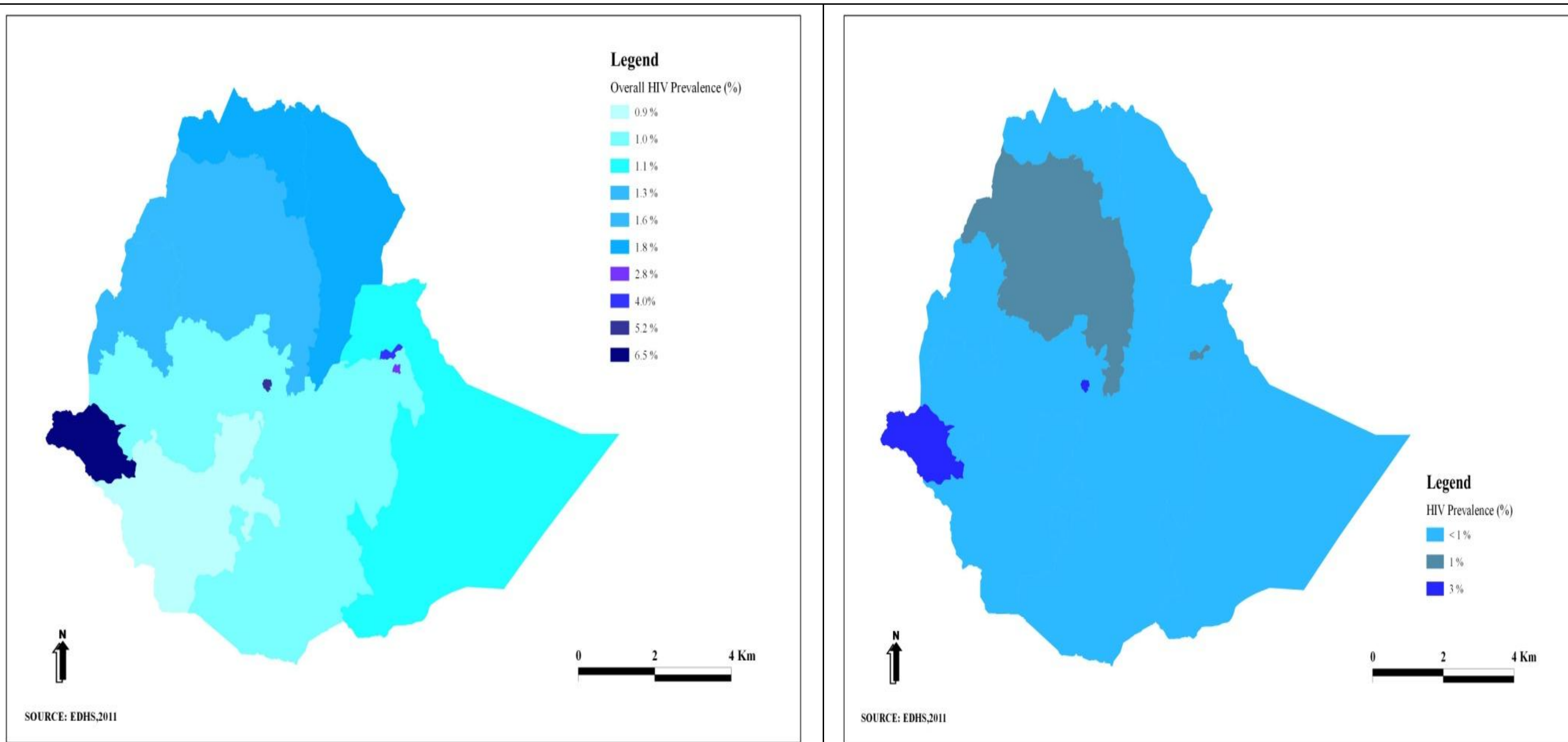
<0.10; **<0.05; *** <0.01; *<0.001; NS – Not Significant**

Spatial analysis of factors associated with HIV/AIDS prevalence in the study area

This subsection describes the results from the spatial analysis starting from a geographical display of the HIV prevalence across the study area in sub-section 3.3.1. The prevalence is depicted into two; the overall HIV prevalence (15-54 years) as per the respective DHS studies and the HIV prevalence of young people (15-24 years) as per this study. Sub-section 3.3.2 shows results from spatial autocorrelation from the Geary C and Moran I statistics. These results depicted whether a clustered or random pattern of HIV existed in the study area. Sub-section 3.3.3 presents the graphical representation of clusters of HIV in the study area from SaTScan analysis. The clusters are classified as primary, secondary or insignificant. Finally, the last section presents the results of the factors associated with HIV prevalence among young people in the study area after adjusting for spatial random effects using the Bayesian regression.

This study provides evidence of consistent and significant spatial variations of HIV at a regional level in Eastern Africa. These HIV estimates from the study show clear differences across the regions; The HIV prevalence is highest in the darker blue coloured regions and lowest in the lighter blue coloured regions as seen in the prevalence maps. The spatial distribution of HIV prevalence in the four Eastern Africa countries is illustrated in Figures 3.1-Figure 3.10. These figures show the presence of spatial variations of HIV prevalence and this knowledge is useful to existing HIV prevention programs (Yeshiwondim et al., 2009).

Spatial Distribution of HIV prevalence across Ethiopia



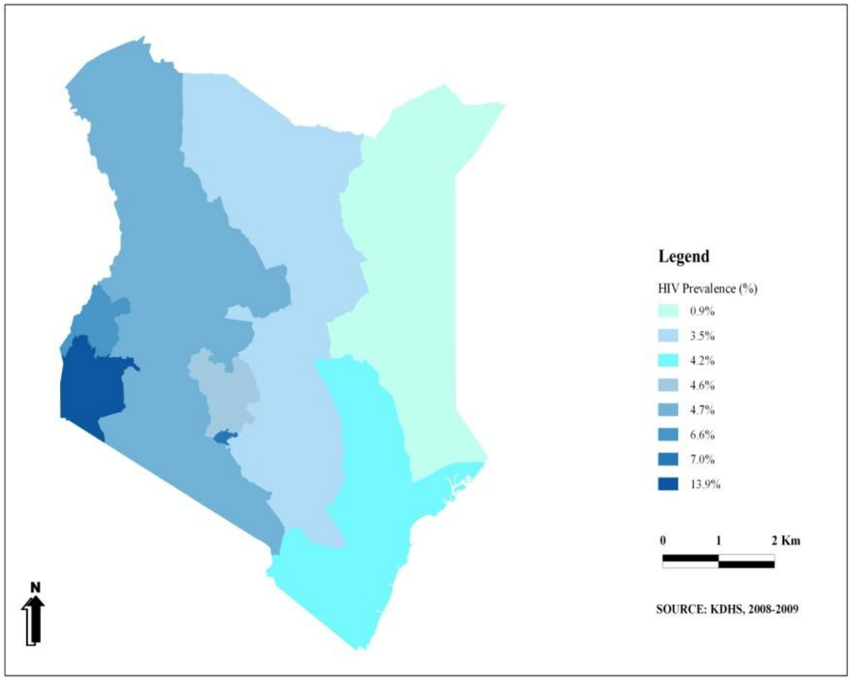
3.1(a) Overall HIV prevalence (15-54 years)

3.1 (b) HIV prevalence (15-24 years)

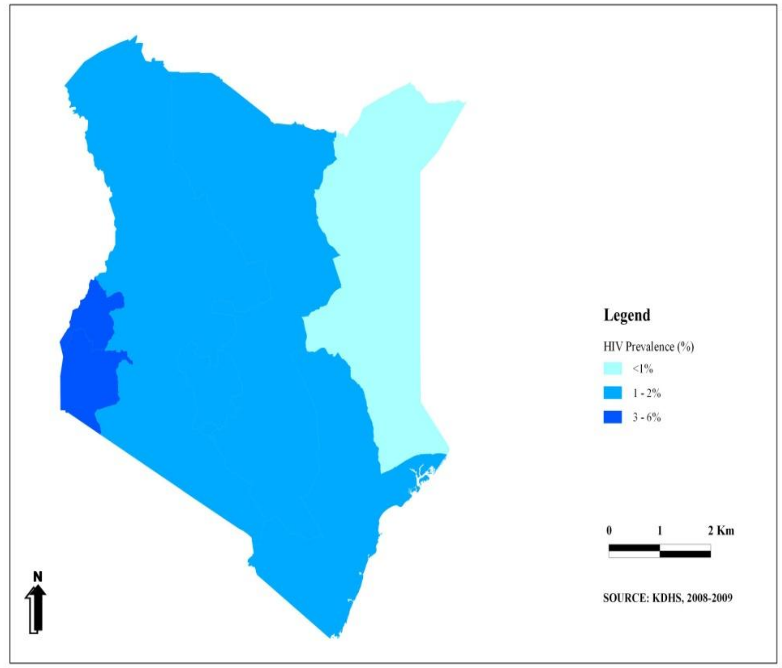
Figure 3.1: Estimated HIV prevalence rates for 15-49 and 15-24 age groups in Ethiopia 2011

Figure 3.1a shows the overall prevalence of HIV as estimated by the 2011 Ethiopia DHS. The prevalence ranges from 2%-6% with the highest rates seen in Addis Ababa, Amhara, Dire Dawa and Gambela. Figure 3.1b shows that HIV prevalence rates in young people range from <1% -3% with the highest rates reported in the same regions shown in Figure 3.1a.

Spatial Distribution of HIV prevalence across Kenya



3.2 (a) Overall HIV prevalence (15-54 years)

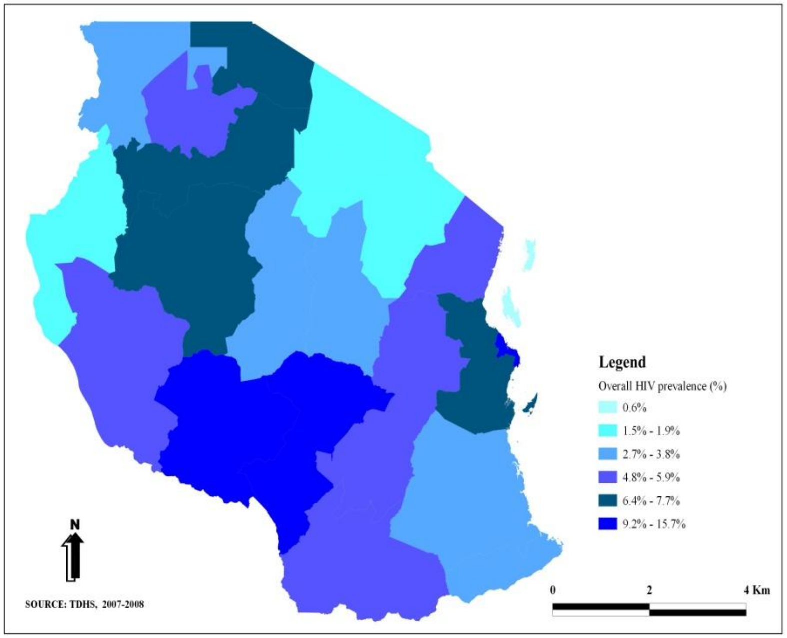


3.2 (b) HIV prevalence among 15-24 year olds

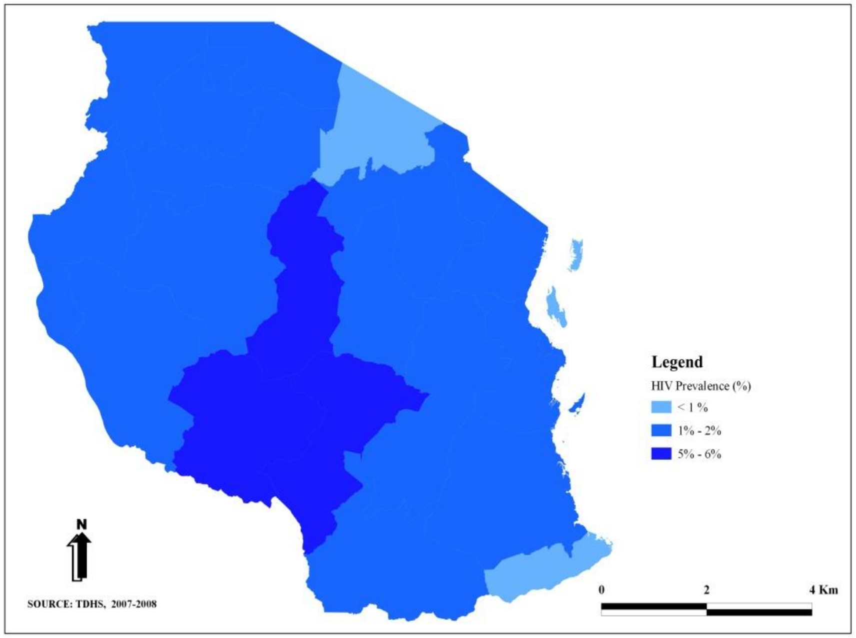
Figure 3.2: Estimated HIV prevalence rates for 15-49 and 15-24 age groups in Kenya 2008-2009

The estimated HIV prevalence according to the Kenya DHS study conducted in 2008-2009, reported a rate of between 0.9% - 13.9% with higher prevalence rates (darker blue regions) seen in Nyanza, Western and Nairobi provinces as depicted in Figure 3.2a. Low levels of HIV sero-positivity (lighter blue regions) was observed in the Eastern part of Kenya. The same pattern of HIV prevalence was observed among the young people (Figure 3.2b) with a HIV prevalence rate ranging from <1%-6%.

Spatial Distribution of HIV prevalence across Tanzania



3.3 (a) Overall HIV prevalence (15-54 years)

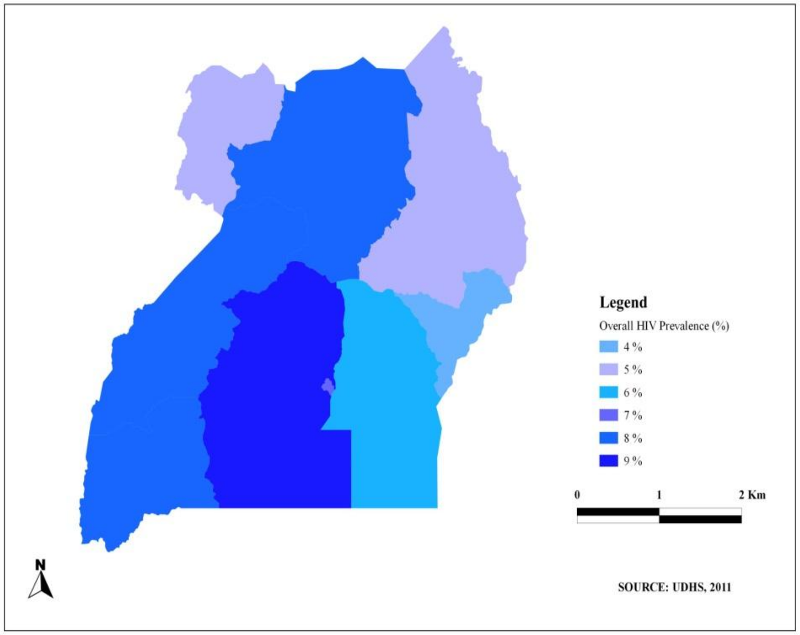


3.3 (b) HIV prevalence of study population (15-24 years)

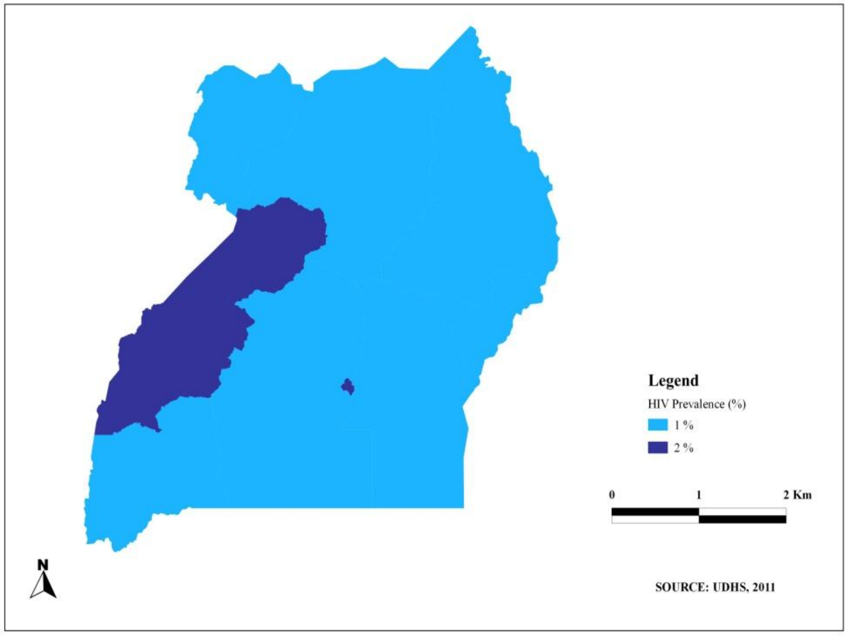
Figure 3.3: Estimated HIV prevalence rates for 15-49 and 15-24 age groups in Tanzania 2007-2008

The HIV prevalence in Tanzania according to the 2007-2008 DHS ranged from 0.01-0.157. Higher prevalence (>10%) areas were observed in Mwanza, Shinyanga, Mara, Tabora, Ruvuma and Dare Salaam regions of Tanzania (see Figure 3.3a). The HIV prevalence among young people in Ethiopia ranged from <1% – 6% with the highest prevalence observed across the central regions (see Figure 3.3b). Low prevalence was seen in the Indian Ocean islands of Pemba and Unguja which form Zanzibar which are predominantly Muslim.

Spatial Distribution of HIV prevalence across Uganda



3.4 (a) Overall HIV prevalence (15-54 years)



3.4 (b)HIV prevalence among Ugandan Youth (15-24 years)

Figure 3.4: Estimated HIV prevalence rates for 15-49 and 15-24 age groups in Uganda 2011

High HIV prevalence in Uganda during the 2011 DHS was observed in the darker blue coloured regions in Figure 3.4. The HIV prevalence estimated from the DHS survey across the regions ranged from 4% - 9% (see Figure 3.4a). In this study, the HIV prevalence among the young people was between 1% and 2% (see Figure 3.4b). Kampala and Western regions reported a slightly higher prevalence (2%) whereas the rest of the country reported a slightly lower prevalence of 0.01.

Spatial Autocorrelation HIV prevalence in Eastern Africa

A significant Geary C statistic indicated that the any clustered patterns found in the study area had only a slight chance of being the result of a random possibility (Rojas, 2007) as summarised in Table 3.7 below. In the study area, Kenya was the only country that showed the presence of clustered patterns of HIV prevalence with positive autocorrelations (0.799; p < 0.001) and Ethiopia showing random spatial distribution (1.089; p=0.984).

Table 3.7: Local clustering indexes for neighbourhood-level

Country	**Geary C Statistic**	**Standard Deviation**	**P-value**
Ethiopia	1.089	-2.165	0.984[NS]
Kenya	0.799	5.631	<0.001***
Tanzania	0.961	1.064	0.144 [NS]
Uganda	0.935	1.455	0.073 [NS]

[NS] Absence of spatial autocorrelation; * Presence of spatial autocorrelation**

Significant Moran I values suggested that there was a very unlikely possibility that the neighbouring values of HIV prevalence were as a result of a random pattern. In this study, significant Moran I statistics were observed in Kenya and Tanzania and showed positive spatial autocorrelation (0.189; $p < 0.001$) and (0.056; $p = 0.040$). This means that there was clustered pattern of HIV prevalence in these two countries. Insignificant Moran indexes in Ethiopia (0.047; p=0.087) and Uganda (0.043; p=0.199) depicted a random spatial distribution of HIV. The global spatial autocorrelation statistics are summarised in the Table 3.8.

Table 3.8: Global clustering indexes for neighbourhood-level.

Country	**Moran I Statistic**	**Standard Deviation**	**P-value**
Ethiopia	0.047	1.356	0.087 ^{NS}
Kenya	0.189	5.851	<0.001***
Tanzania	0.056	1.754	0.040***
Uganda	0.043	1.177	0.119 ^{NS}

^{NS} **Absence of spatial autocorrelation; *** Presence of spatial autocorrelation**

This study revealed strong local and global clustering of HIV in only Kenya and Tanzania. Geary and Moran statistics have been known to be limited in identifying the degree to which high and low values cluster together (Ord and Getis, 2001). As a result, other spatial autocorrelation techniques such as the Getis and Ord G statistic has been used in the identification of hot and cold spots (Ord and Getis, 2001). Therefore, there is cause to further investigate whether any clustering exists in the rest of the study area using SaTScan as discussed in the next section 3.4.3.

Cluster Analysis of HIV Prevalence in Eastern Africa

Table 3.9 provides the results of the spatial scan analysis HIV prevalence across the Eastern Africa region from 2007 – 20011.

Table 3.9: HIV clusters in the Eastern Africa region using spatial scan analysis

Country	**Circle radius**	**Observed cases**	**Expected Cases**	**OR**	**P-value**
Ethiopia	56.67km	50	17.67	3.48	<0.001
Kenya	59.66km	72	15.91	6.88	<0.001
Tanzania	160.09km	15	48.45	10.12	<0.001
Uganda	74.11km	70	37.21	2.14	<0.001

2.2.5.1 Cluster Analysis of HIV Prevalence in Ethiopia

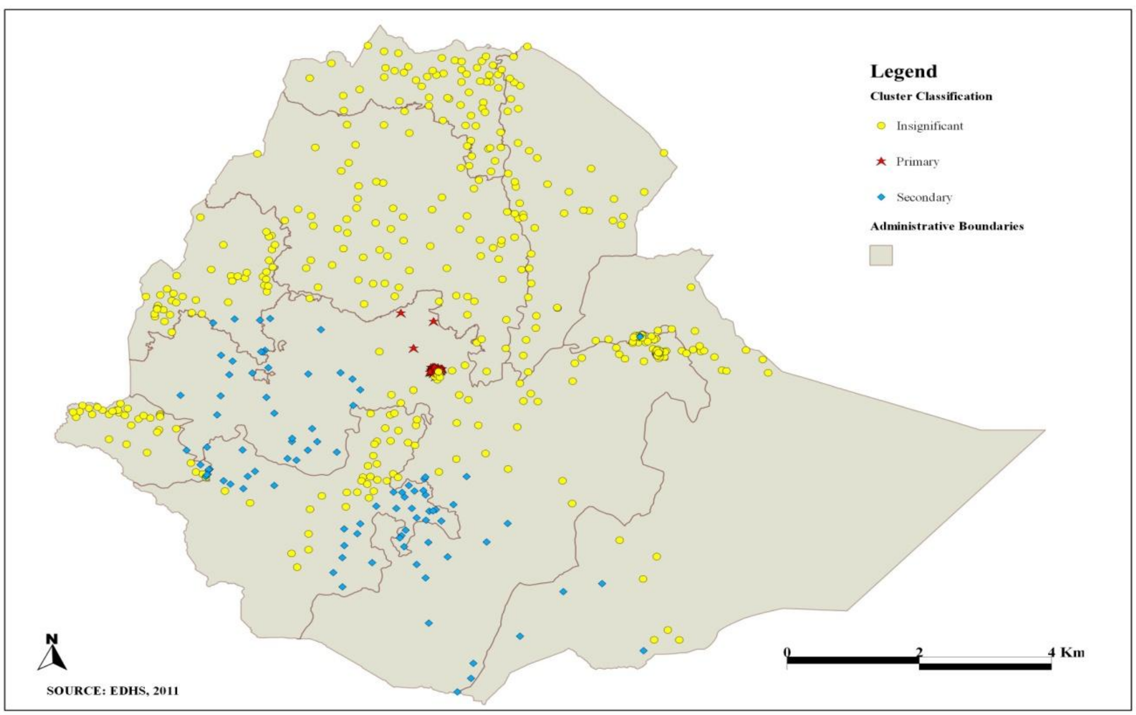


Figure 3.5: The classification of HIV clusters among young people in Ethiopia 2011

During this period, two types of clusters were detected in Ethiopia. The most likely (primary cluster) had a radius of 56.67 km with a p-value of < 0.001. A total of 53 locations in the enumeration areas were found in the cluster with an associated OR of 3.48. This illustrated that the locations in the primary cluster were 3.48 times more likely at risk of having a high HIV prevalence when compared to the other locations. These clusters were observed around the Addis Ababa and Oromiya regions as shown in the map in Figure 3.5. There were a total of four secondary clusters with significant p-values (blue) and several secondary clusters with insignificant p-values (yellow) detected.

2.2.5.2 Cluster Analysis of HIV Prevalence in Kenya

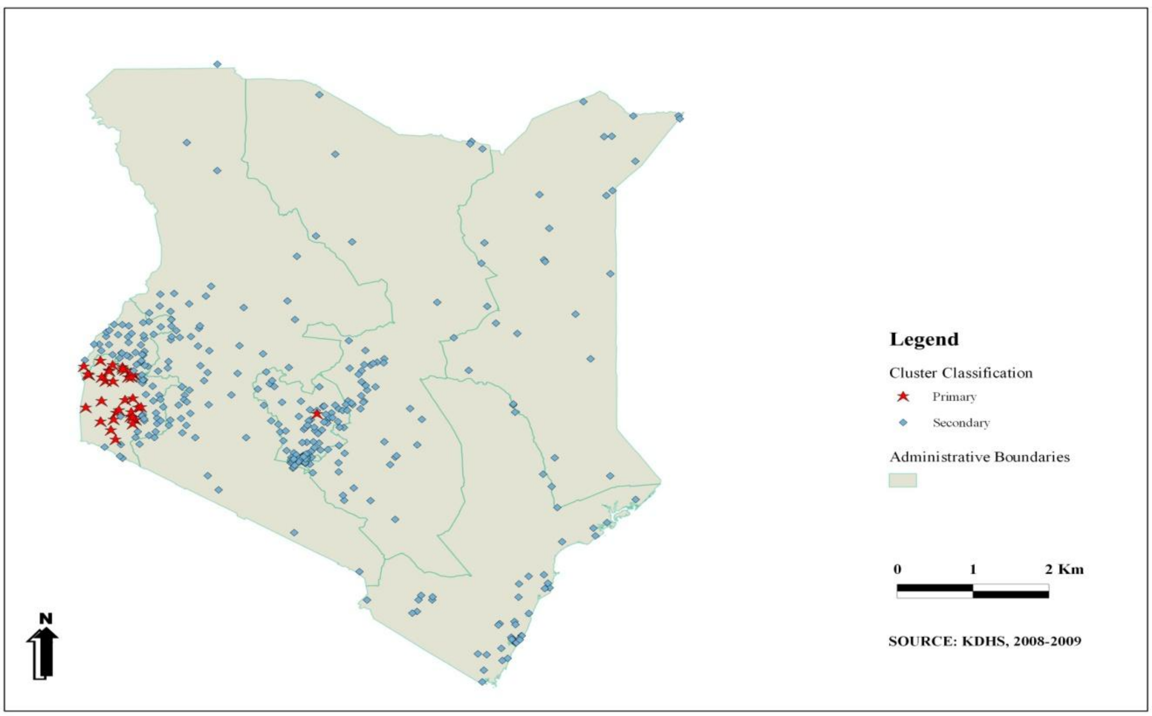


Figure 3.6: The classification of HIV clusters among young people in Kenya 2008-2009

Two types of clusters were also detected in Kenya during the DHS period of 2008-2009. The primary cluster (red) had a radius of 59.66 km with a p-value of < 0.001. A total of 34 locations in the enumeration areas were found in this cluster with an associated OR of 6.88 and were observed around the Central, Nyanza and Western provinces of Kenya as seen in Figure 3.6. This showed that the locations in the primary cluster were 6.88 times more likely at risk of having a high HIV prevalence when compared to the other locations. There was an additional secondary cluster with a significant p-value detected (blue).

2.2.5.3 Cluster Analysis of HIV Prevalence in Tanzania

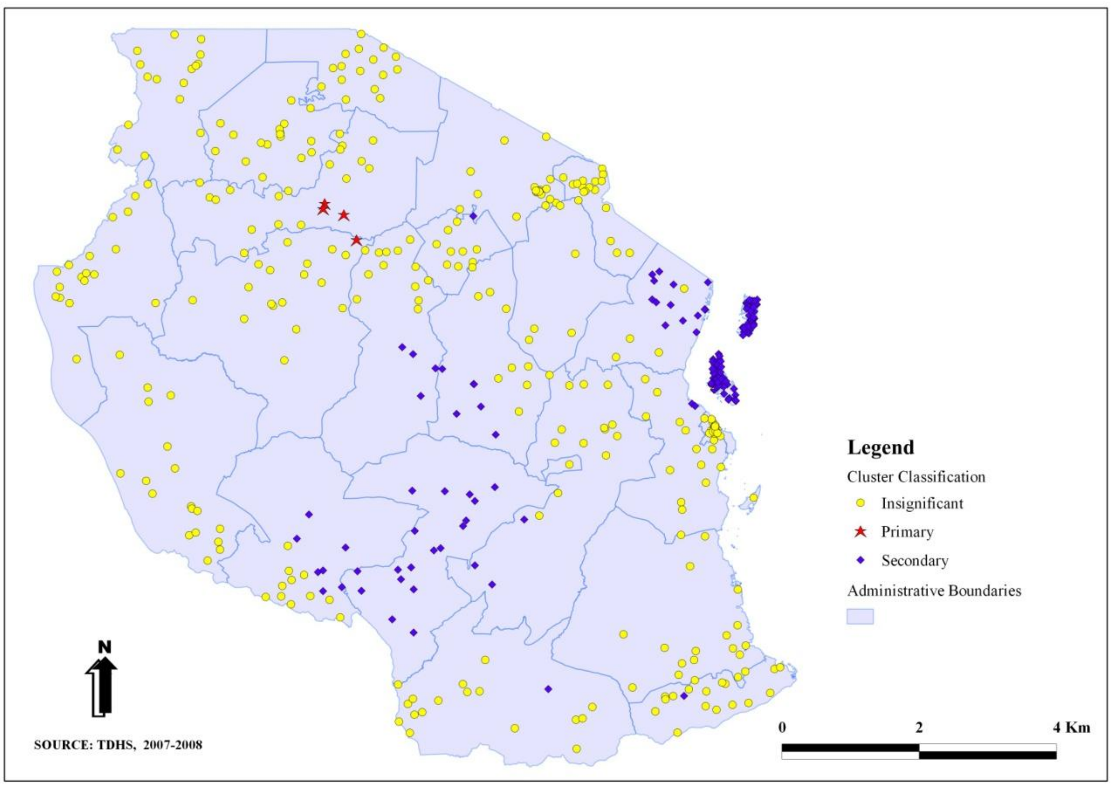


Figure 3.7: The classification of HIV clusters among young people in Tanzania 2007-2008

Two types of clusters were detected in Tanzania during the DHS period of 2007-2008. The primary cluster had a radius of 160.09 km with a p-value of < 0.001. A total of 4 locations in the enumeration areas were found in this cluster with an associated OR of 10.12, this cluster was observed in Tabora and Shinyanga regions of Tanzania (see Figure 3.7). This implied that the locations in the primary cluster (red) were 10.12 times more likely at risk of having a high HIV prevalence when compared to the other locations. Three additional secondary clusters with significant p-values (blue) and secondary insignificant clusters (yellow) with a p-value >0.05 were also detected.

2.2.5.4 Cluster Analysis of HIV Prevalence in Ethiopia

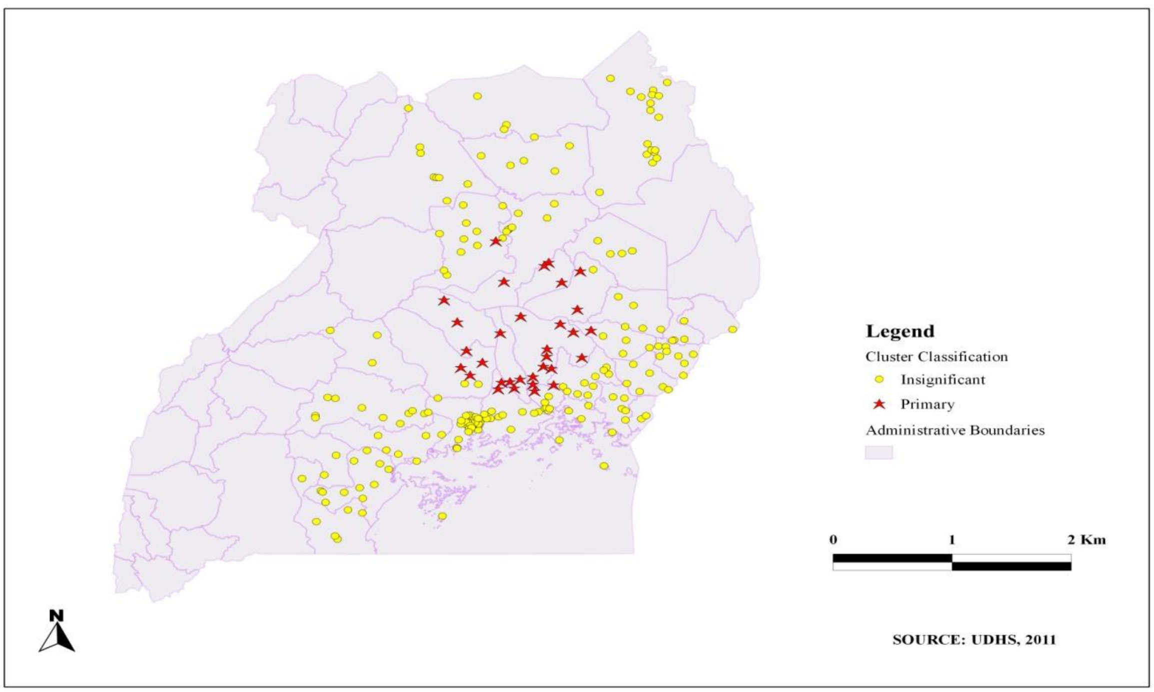


Figure 3.8: The classification of HIV clusters among young people in Uganda 2011

Two types of clusters were detected in Uganda during the 2011 DHS. The primary cluster had a radius of 74.11 km with a p-value of < 0.001. A total of 32 locations in the enumeration areas were found in the cluster with an associated OR of 2.14. This suggested that the locations in the primary cluster were 2.14 times more likely at risk of having a high HIV prevalence when compared to the other locations. There were no secondary clusters with significant p-values detected. Figure 3.8 showed that this primary cluster was situated around the Eastern and Central regions of Uganda.

Bayesian Regression Results of HIV prevalence in Eastern Africa

The variables that showed significant associations after the multiple variable logistic regressions were used in the Bayesian regression. Adjustment was achieved by adding a non-spatial (cluster and household number) and spatial (regions) random effect. The outputs from the MCMC based Bayesian estimations were represented as posterior maps of HIV prevalence that show posterior means. The values of the Posterior Odds Ratio (POR) used in the final risks maps were determined after the exponentiations of posterior means and were summarized in Table 3.10. High risk areas were those that had a POR of more than 1, low risk areas had a POR equal to 1 and very low risk areas with a POR of less than 1. Significant factors with a POR less than 1 were associated with low while those with a POR greater than 1 were associated with high HIV risk areas. Non-spatial and spatial variance was also reported using mean and 95% credible intervals (2.5%, 97.5%). In this study, PORs of residual spatial regional effects were depicted in red and green colour indicating the maximum and minimum POR respectively as illustrated in Figure 3.9 - Figure 3.12.

2.2.6.1 Spatial factors associated with HIV Prevalence among young people in Ethiopia

The factors that influence HIV prevalence in young people in Ethiopia after spatial adjustment while keeping other factors constant, include a young coital debut age (8-10 years) {POR=65.37; 95% BCI=3.32-595.85}, place of residence {POR=0.05; 95% BCI=0.07-0.19}, and lack of condom use during sex {POR=0.77; 95% BCI=0.68-0.89} as shown in Table 3.10. This means that young coital age (8-10 years) and lack of condom use were factors associated with HIV prevalence in high risk areas and being in rural areas was associated with HIV prevalence in low risk areas in Ethiopia.

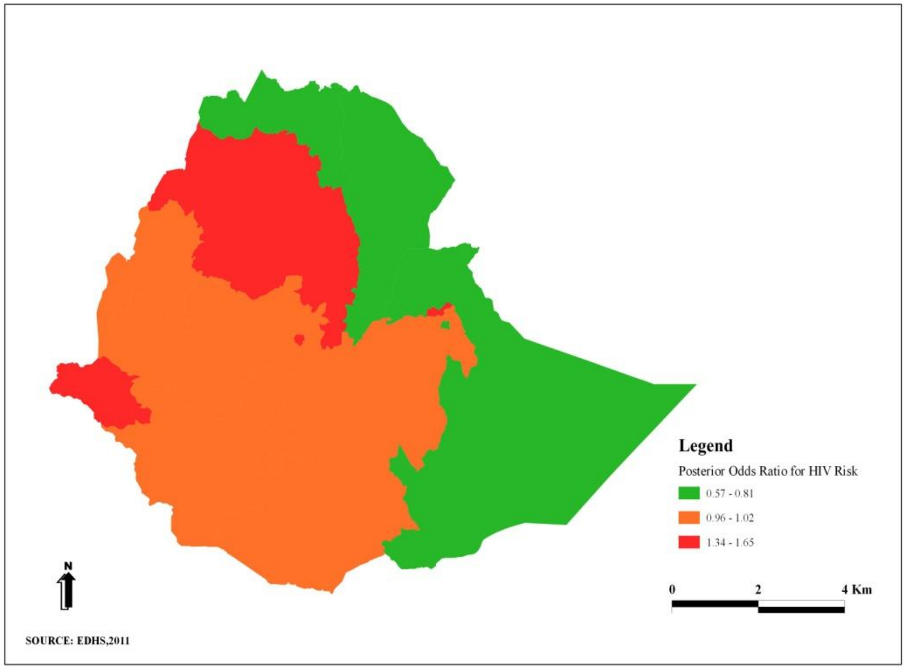
Regional estimates of HIV prevalence in Ethiopia as illustrated in Figure 3.9b indicate that a young person is approximately 65% times more at risk of having HIV/AIDS if living in the red coloured regions with a POR of between 1.02-1.65 whereas in the green coloured areas, one is 43% less likely to be HIV positive when compared to those living in the orange coloured areas.

Table 3.10: Bayesian results for logistic regression of HIV prevalence among adolescents and young adults in Eastern Africa (2007-2011)

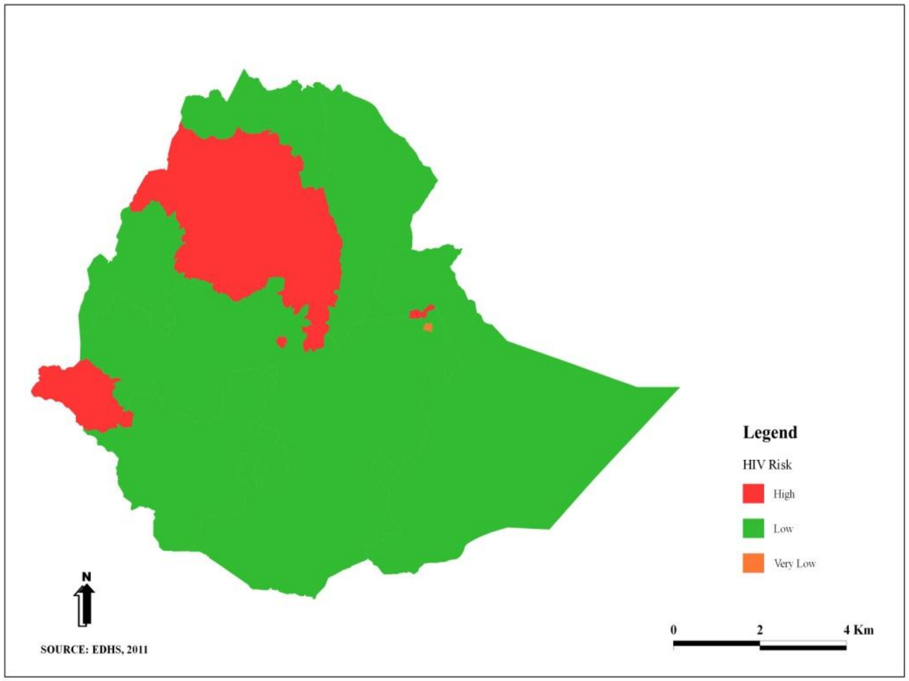
Country	**Ethiopia**		**Kenya**		**Tanzania**		**Uganda**	
Variable	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)
Demographic Factors								
Place of residence								
Urban	1.00(Ref)	1.00 (Ref)	-	-	1.00 (Ref)	1.00 (Ref)	-	-
Rural	0.04 (0.009, 0.04)***	0.05 (0.07, 0.19)***	-	-	1.52(0.35, 6.89)^{NS}	1.49(0.29, 9.97)^{NS}	-	-
Marital Status								
Never married	1.00 (Ref)	1.00 (Ref)	-	-	1.00 (Ref)	1.00 (Ref)	1.00(Ref)	1.00(Ref)
Married	4.22 (0.612, 31.19)^{NS}	3.06 (0.87, 183.09)^{NS}	-	-	34.72 (6.36, 42.47)***	26.51 (6.96, 31.80)***	0.40 (0.19, 0.86)***	0.41 (0.19, 0.89)***
Widowed	-	-	-	-	4.01 (0.18, 64.07)^{NS}	4.14 (0.28, 49.40)^{NS}	-	-
Divorced/separated	-	-	-	-	-	-	3.14 (1.13, 8.74)***	3.07 (1.14, 10.24)***
Education Level					-	-		
None	-	-	1.00 (Ref)	1.00 (Ref)	-	-		
Primary	-	-	1.84 (0.69, 5.16)^{NS}	1.02 (0.46, 2.92)^{NS}	-	-	-	-
Secondary	-	-	-	-	-	-	-	-
Higher	-	-	1.93 (0.32, 14.73)^{NS}	1.28 (0.19, 6.05)^{NS}	-	-	-	-
Religion								
Catholic	-	-	1.00 (Ref)	1.00 (Ref)	-	-	-	-
Muslim	-	-	1.51 (0.53, 3.78)^{NS}	0.65 (0.22, 1.63)^{NS}	-	-	-	-
Social factors								
Regularly exposure to two or more media sources								
None	-	-	-	-	1.00 (Ref)	1.00 (Ref)	-	-
Irregular	-	-	-	-	1.49(0.32, 7.03)^{NS}	1.48(0.45, 5.64)^{NS}	-	-
Regular	-	-	-	-	-	-		
Circumcised	-	-	-	-				
No	-	-	-	-			1.00(Ref)	1.00(Ref)
Yes	-	-	-	-	-	-	0.32(0.17, 0.81)***	0.30(0.12, 0.80)***
Behavioural Factors								
Age at sex debut								
Never	1.00 (Ref)	1.00 (Ref)	-	-	-	-	-	-

Country	Ethiopia		Kenya		Tanzania		Uganda	
Variable	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Non-Spatial Posterior OR (CI: 2.5%, 97.5%)	Random Spatial Posterior OR (CI: 2.5%, 97.5%)
8-10	65.37 (5.85, 828.81)***	85.63 (3.32, 595.85)***	-	-	-	-	-	-
11-14	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-
20-24	-	-	-	-	-	-	-	-
STI or STI symptom within past year								
No	-	-	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)	1.00(Ref)	1.00(Ref)
Yes	-	-	13.74 (2.89, 64.72)***	13.46 (2.92, 69.41)***	46.53 (9.30, 198.34)***	27.39 (2.10, 121.51)***	7.70 (4.41, 15.49)***	6.83 (4.14, 16.34)***
Transactional sex								
No	-	-	-	-	-	-	1.00(Ref)	1.00(Ref)
Yes	-	-	-	-	-	-	2.13 (0.14, 21.39)[NS]	2.44 (0.27, 14.85) [NS]
Condom Use								
No	1.00 (Ref)	1.00 (Ref)	-	-	1.00 (Ref)	1.00(Ref)	1.00(Ref)	1.00(Ref)
Yes	0.64 (0.53, 0.76)***	0.77 (0.68, 0.89)***	-	-	1.11 (0.20, 4.62)[NS]	1.19 (0.34, 4.71)[NS]	0.67 (0.42, 1.50)***	0.51 (0.35, 3.60)***
Alcohol use								
No	1.00 (Ref)	1.00 (Ref)	-	-	-	-	1.00(Ref)	1.00(Ref)
Yes	2.61 (0.60, 13.74)[NS]	2.89 (0.63, 16.78)[NS]	-	-	-	-	1.84 (0.88, 3.44)[NS]	1.84 (0.77, 3.84) [NS]
DIC	96.58	85.36	255.30	269.83	130.38	140.20	599.94	622.91
Non-spatial variance	6.88(2.23, 12.00)[a]	5.94(0.05,11.42) [a]	18.16(13.75,22.56) [a]	14.75(11.05, 18.45) [a]	8.69(4.31, 14.75) [a]	3.61(0.05, 9.28) [a]	16.62(12.98, 19.50) [a]	0.05(0.0001, 0.32) [a]
Spatial variance	-	0.71(0.02, 3.87) [a]	-	1.99(1.90, 14.46) [a]	-	5.69(0.77, 16.69) [a]	-	0.60(0.01, 2.58) [a]

[a] **posterior mean (posterior 2.5% and 97.5%); *** Significant; [NS] Not significant**



3.9 (a) Posterior Odds Ratio of HIV among Ethiopian Youth



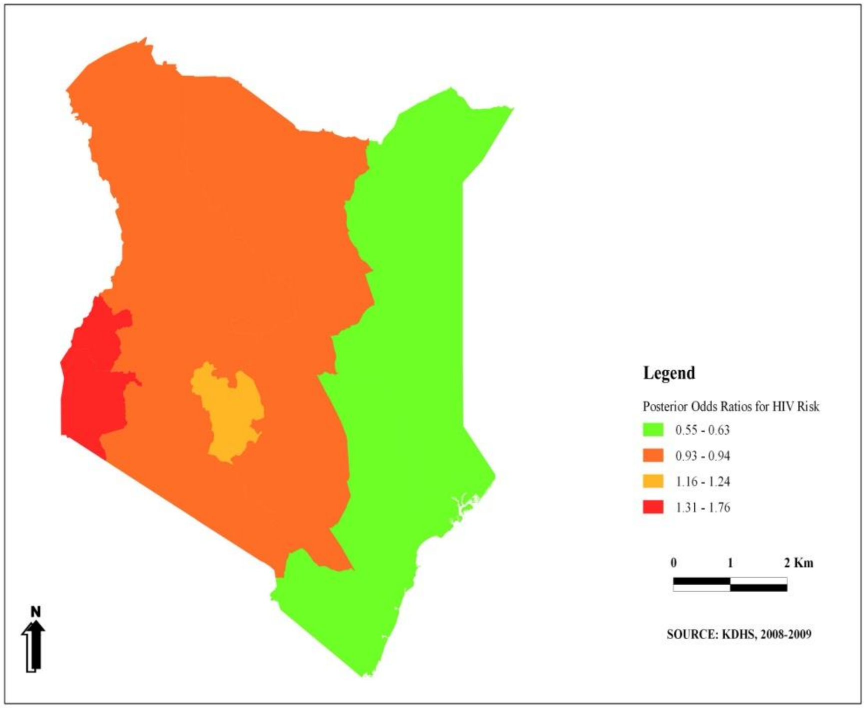
3.9 (b) HIV Risk among Ethiopian Youth

Figure 3.9: Estimated HIV risk among young people in Ethiopia 2011

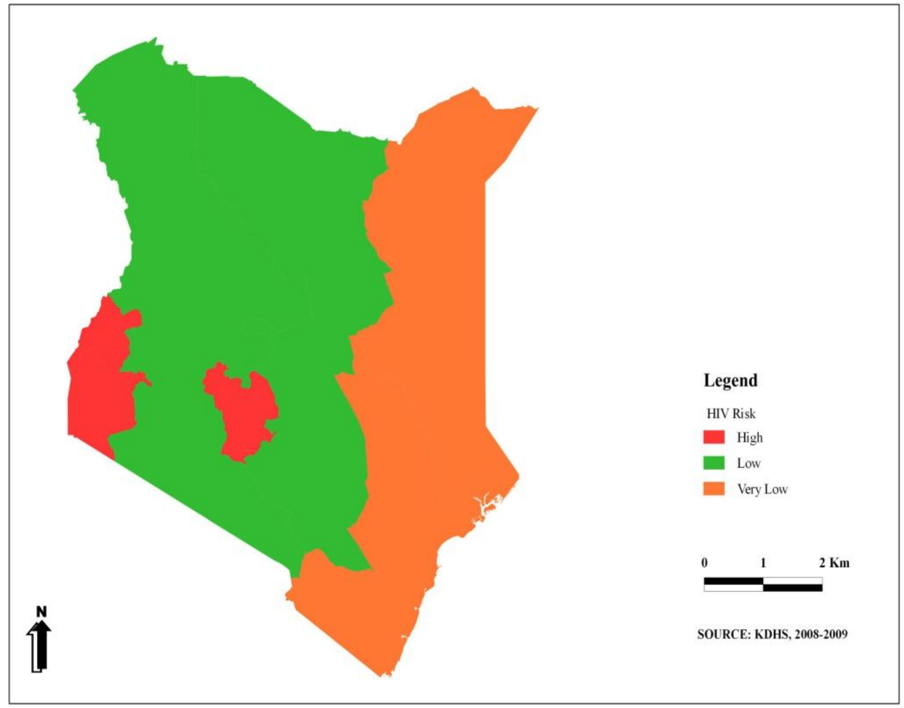
2.2.6.2 Spatial factors associated with HIV Prevalence among young people in Kenya

In Kenya, the presence of STI or an STI symptom was the only factor associated with HIV prevalence among the young people in Kenya after spatial adjustment (POR=13.46; 95% BCI=2.92-69.41) as seen in Table 3.10 in both high and low HIV risk areas. Similar to Ethiopia, regional differences in HIV prevalence across the Kenyan provinces exist, with the red and green coloured regions showing the highest and the lowest levels of HIV infection (see Figure 3.10b) Figure 3.10a suggests that, being in the western and central.

Similar to Ethiopia, regional differences in HIV prevalence across the Kenyan provinces exist, with the red and green coloured regions showing the highest and the lowest levels of HIV infection (see Figure 3.10b) Figure 3.10a suggests that, being in the western and central regions of Kenya, increases the chances of being HIV sero-positive in young people by 76% when compared to young people from the orange coloured regions. Likewise, being in the Eastern region of Kenya reduces the chances of HIV by 45%.



3.10 (a)Posterior Odds Ratio of HIV among Kenyan Youth



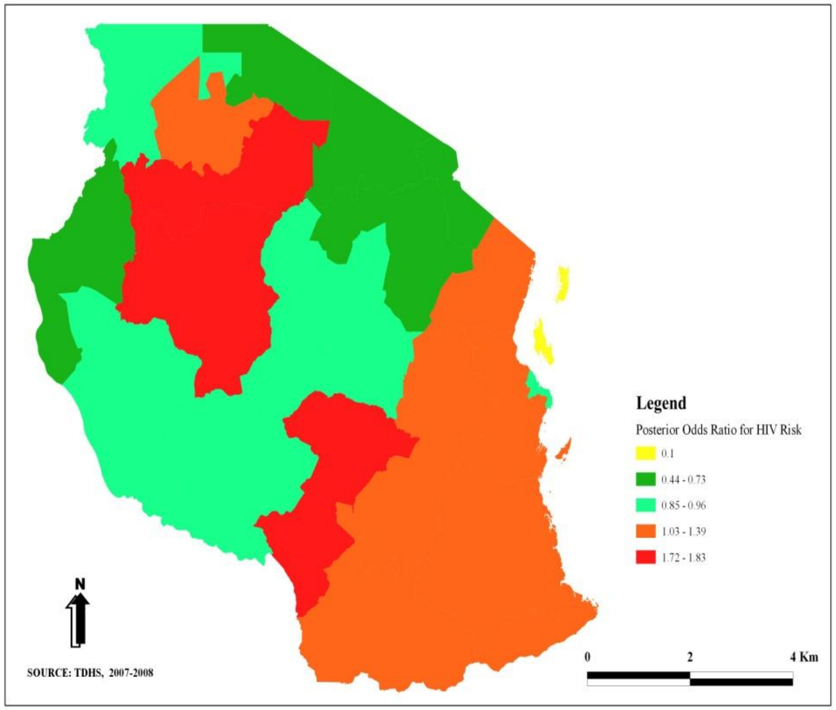
3.10 (b) HIV Risk among Kenyan Youth

Figure 3.10: Estimated HIV risk among young people in Kenya 2008-2009

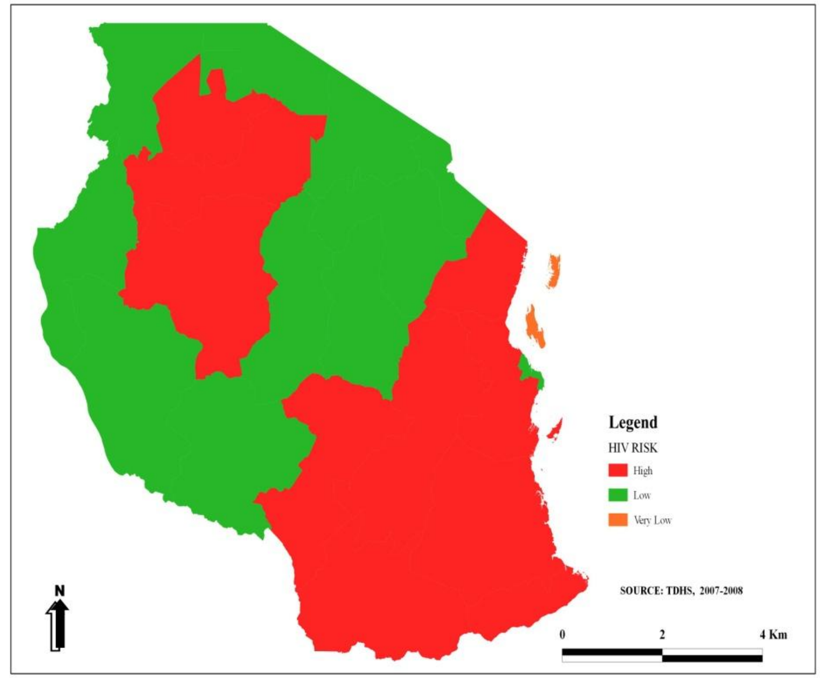
2.2.6.3 Spatial factors associated with HIV Prevalence among young people in Tanzania

The factors that were associated with HIV prevalence among the young people in Tanzania after spatial adjustment as reported in Table 3.10 were married (POR=26.51; 95% BCI=6.96, 31.80) and having exhibited an STI symptom or actually suffering from an STI within the past year (POR=27.39; 95% BCI=0.09, 2.97). These factors were observed in both high and low HIV risk areas in the United Republic of Tanzania.

The POR of HIV prevalence in Tanzania range from 0.1(lowest) to 1.83 (highest) suggesting that there was an 83% chance of being HIV positive for young people living in the red coloured regions and 90% that young people were less likely to be HIV in the green regions of Tanzania as compared to the orange coloured regions (see Figure 3.11a). The overall HIV risk for HIV among young people was illustrated in Figure 3.11b where the risk was seen to increase in regions surrounding a water body (Lake Victoria and Indian Ocean).



3.11(a) Posterior Odds Ratio of HIV among Tanzanian Youth



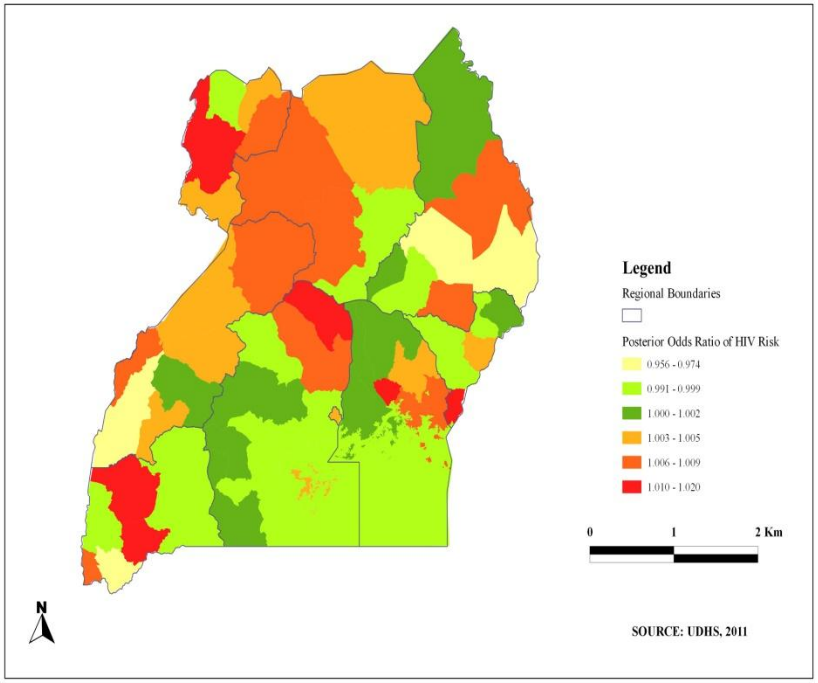
3.11(b) HIV Risk among Tanzanian Youth

Figure 3.11: Estimated HIV risk among young people in Tanzania 2007-2008

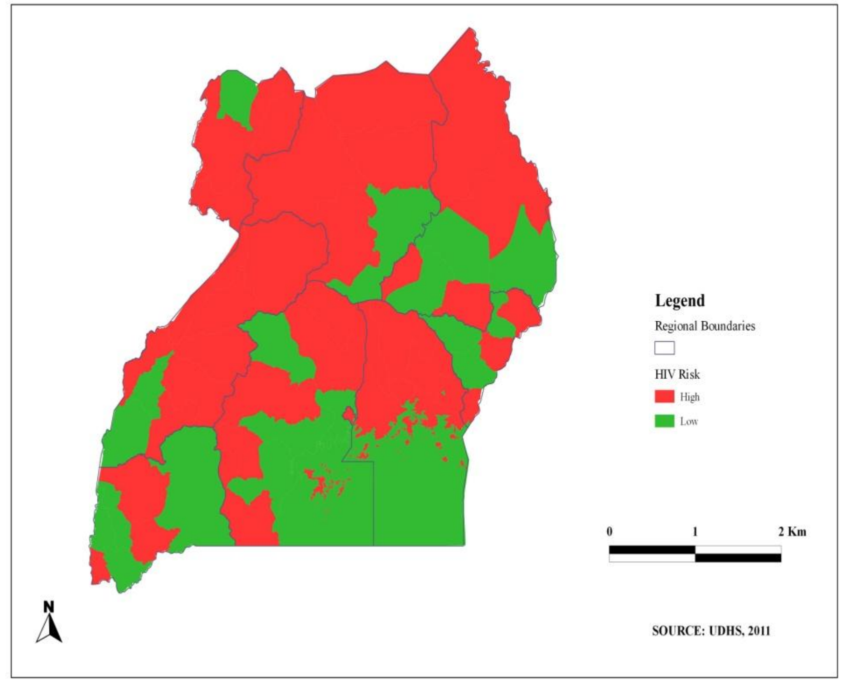
Table 3.10 shows the factors that were associated with HIV prevalence among the young people in Uganda after spatial adjustment. These were being currently married (POR= 0.14; 95% BCI=0.19, 0.89)}, divorced or separated (POR= 3.07; 95% BCI=1.14, 10.24), circumcision {POR= 0.30(0.12, 0.80)}, condom use (POR= 0.51; 95% BCI=0.35, 3.60) and having exhibited an STI symptom or actually suffering from an STI within the past year (POR= 6.8; 95% BCI= (4.14, 16.34).

Being currently married and circumcised are factors associated with HIV prevalence among young people living in low risk areas. The factors which included being divorced/separated, condom use and presence of an STI in the past one year were associated with HIV prevalence in high risk areas of Uganda.

The POR of HIV sero-positivity in Uganda ranges from 0.96 (yellow) to 1.02 (red) as shown in Figure 3.12a. This implies that young people living in high risk areas have a 2% chance of being HIV sero-positive when compared to those living in the dark green coloured regions. Likewise, the risk of HIV decreases by 4% in young people living in low risk areas. Figure 3.12b shows the classification of HIV risk areas with the red and green areas denoting high and low risk respectively. Spatial analysis revealed the absence of a very low risk area in Uganda.



3.12(a) Posterior Odds Ratio of HIV among Ugandan Youth



3.12 (b) HIV risk among Ugandan Youth

Figure 3.12: Estimated HIV risk among young people in Uganda 2011

HIV hotspots among young people in Eastern Africa

The hotspots map showed distribution of aggregated HIV across the study area, the aggregated HIV was defined as a ratio of the observed number over the expected number of cases. Regions in red color had higher prevalence than expected, as indicated by a POR value greater than 1 and a primary cluster classification. In contrary, regions in green color had low HIV prevalence with the POR value less than 1 with secondary and insignificant clusters. These regions therefore showed coldspots of HIV among young people in the study area (Figure 3.13). Regions shown in orange color were of low or negligible HIV prevalence and were only found towards the eastern part of Kenya.

The study area showed presence of significant primary HIV clusters (hotspots) which were mainly seen in high risk areas. Similarly, secondary and insignificant clusters (cold spots) were observed in low and very low risk areas respectively (see figure 3.13). However, in Tanzania and Uganda, there were insignificant clusters which were found in areas depicted as high risk areas. Therefore, further investigation would be required to explain this difference in the results.

Hotspots of HIV were observed in urban areas in this study area. In Kenya, hotspots were observed mainly in the western and central regions of the country. The hotspots were also observed around Lake Victoria mainly in Kenya and Uganda. HIV hotspots in Ethiopia were identified around the central and in small areas towards the east of the country. In Tanzania, the hotspots were situated towards the north of the country.

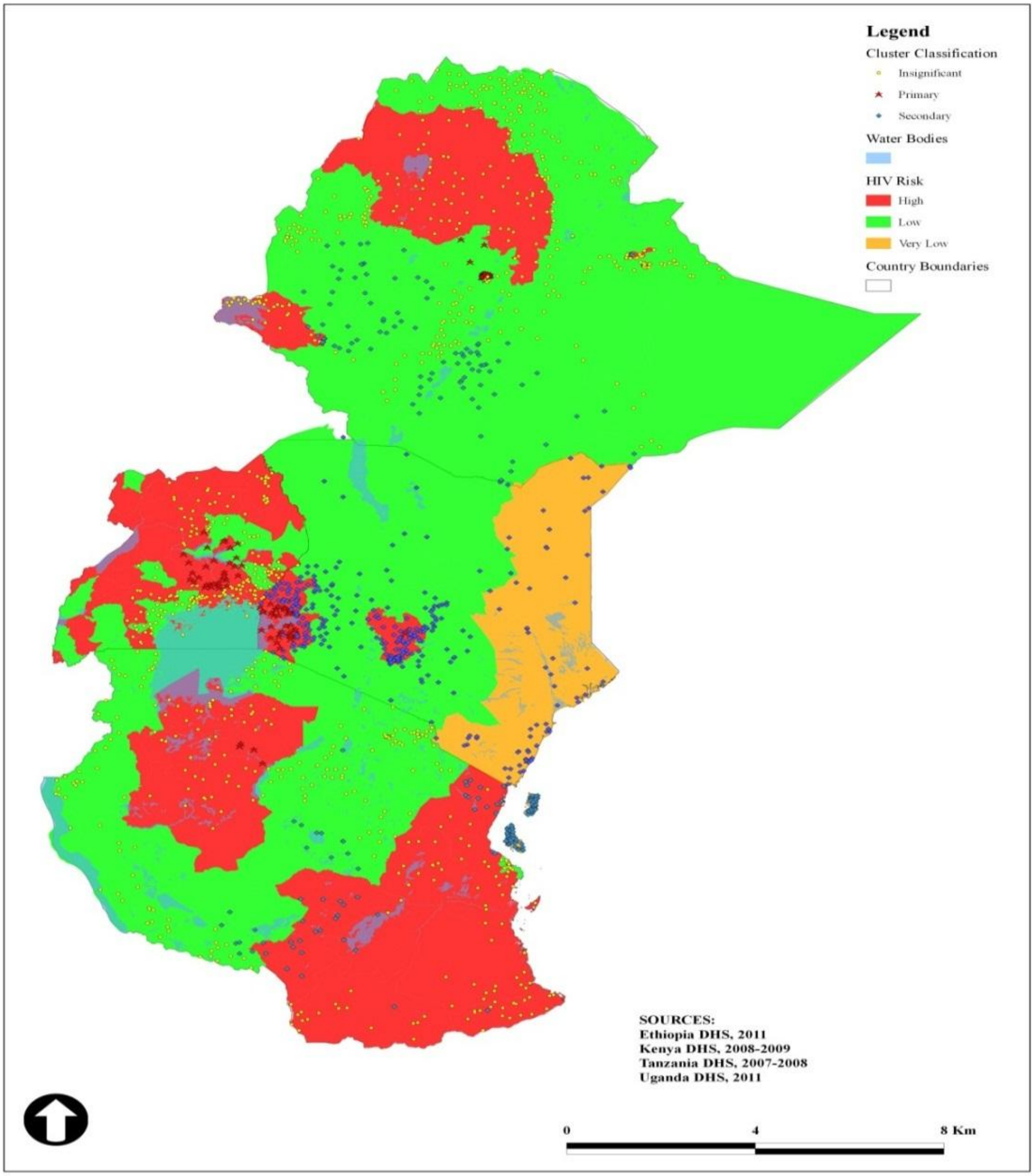


Figure 3.13: Hot spots of HIV prevalence among young people in Eastern Africa

Summary of key points

- Different countries have varied factors that are associated with HIV prevalence among young people.
- Upon spatial adjustment, factors significantly associated with HIV prevalence among young people in;
  - Ethiopia: young coital debut, condom use and place or residence.
  - Kenya: the presence of STI within the past one year
  - Tanzania: currently married and exhibition of STI within past year
  - Uganda: currently or previously married, circumcision, condom use and presence of an STI within past year.
- Clusters of HIV infections were observed across the study area but significant clusters were detected in Kenya and Tanzania.
- Maps showed areas of high HIV prevalence as subsequently being high risk areas and similarly, areas of low prevalence as being low or very low risk areas.
- Uganda was the only country in the study area devoid of very low risk areas of HIV infection.

Chapter 4 : Discussion

This chapter discusses the non-spatial and spatial results of the factors associated with HIV prevalence among young people in Eastern Africa. These factors vary in the different countries in the study area with the exception of presence of STI and marital status, which were seen as significant across the countries. It is important to note that since encountering HIV infections in the young people especially adolescents is a rare occurrence (Doyle et al., 2012), this study used data from four different countries to boost its power, thereby enabling robust inferences that explained the factors associated with HIV prevalence among the youth. The inclusion of the 20-24 years age-group made it possible to identify significant correlations of HIV prevalence among adolescents who were at their earliest exposure to HIV infections (Babalola, 2011).

The overall findings highlight significant provincial/regional differences of HIV prevalence across Eastern Africa. The spatial random effects are interpreted as surrogates for associations for unmeasured factors. Such differences in HIV prevalence by geographical or administrative provinces/regions of a country are very important for provincial/regional planning and for designing of further studies (Kandala et al., 2009).

Demographic factors

This study revealed that the levels of HIV prevalence among the youth differed across the countries as it was expected as this trend agreed with the overall HIV prevalence from the respective DHS studies. Although females were more likely to be HIV positive when compared to males, this association was not significant. This is contrary to what is generally known about overall HIV infections in SSA (UNAIDS, 2012).

HIV prevalence in Eastern Africa is seen to increase with age as was seen in Ethiopia and Kenya. Although this association was not significant, HIV infections were more likely to be seen in older age-groups (20-24) when compared to younger age-groups (15-19). These results were in contrast to the findings from Tanzania and Uganda where an older age-group provided a protective factor against HIV (Magadi and Desta, 2011). This may be due to ineffective PMTCT to reduce the risk of vertical transmission and effective AIDS prevention programmes to create awareness on HIV prevention.

There has been evidence that a positive relationship exists between HIV and place of residence (Msisha et al., 2008b). In this study, this factor was positively associated with HIV prevalence in Ethiopia and Tanzania. HIV prevalence in the rural areas was lower than that in the urban areas with living in the rural areas providing a protective factor against HIV infections than in urban areas. Higher risky sexual behaviours that are common in the urban areas were likely to increase the chances of acquiring HIV infections among the youth (Magadi, 2012).

In this study, a negative relationship between education and HIV was observed in all countries with the exception of Uganda. This implied that HIV prevalence increased with an increase in education. Average levels of education in these Eastern Africa countries were as a result of poverty (Hargreaves et al., 2008). Education and HIV has been investigated and the findings varied with some studies in Africa reporting a positive while others reporting a negative relationship (Kabiru and Orpinas, 2009). School attendance was seen to reduce the level of HIV in males while females reporting having less frequent sex which reduces the risk of HIV infections (Hargreaves et al., 2008, Kabiru and Orpinas, 2009). Educated individuals have been known to engage in risky sexual behaviour as a result of their higher socio-economic status (Hargreaves, 2002). In Uganda, there may be a chance that educated individuals are adopting safe sex practices as using condoms as studies are now reporting greater levels of condom use among educated individuals (Glynn et al., 2004).

This study demonstrated that belonging to a religion in Kenya reduces the chances of being HIV positive. Majority of the studies conducted to investigate the association between HIV and religion report religion being a protective factor with individuals belonging to several religious affiliations showing a decreased risk of HIV infection, partially due to their reduced likelihood of having extramarital partners and pre-marital sex when compared with individuals who do not profess any religion (Trinitapoli, 2009). Muslims in SSA have generally been known to have low risk for contracting HIV infections when compared to other religious denominations (Kagimu et al., 2012).

Results from this study suggest that individuals who were currently or previously married were more susceptible to HIV where the latter includes widowed, separated/divorced individuals. This association was observed in Ethiopia, Tanzania and Uganda. Marriage represents a high-risk HIV factor especially on women who are susceptible as a result of the partner's extramarital affairs and concurrent sexual partners (Babalola, 2011). HIV prevalence varies across the marital status with widowed, divorced and separated individuals having HIV prevalence than their single or married counterparts (Amornkul et al., 2009, Napierala-Mavedzenge et al., 2011). These findings have been seen in this study where high HIV prevalence was likely to be reported in individuals who were widowed or divorced/separated in comparison to the married and single. For widowhood, it may be presumed that their partners would have died as a result of AIDS (Amornkul et al., 2009).

Social factors

Social factors associated with HIV prevalence in this study were identified as socioeconomic status, media exposure and circumcision. Media exposure and circumcision were the only factors that provided significant associations with HIV prevalence and this was only seen in Tanzania and Uganda respectively. In the early epidemics, HIV was generally seen to affect wealthy populations before progressing to affecting impoverished populations (Hargreaves et al., 2012). Many studies have reported the negative association between SES and HIV and this study revealed that individuals with a lower SES were more likely to have high HIV prevalence compared to those of higher SES. A study conducted in Tanzania showed contrasting findings and it was assumed that a better living standard enabled men to sustain multiple sexual relationships thereby increasing the spread of HIV (Msisha et al., 2008a).

Circumcision which is usually associated with certain religions and ethnicities in Africa, has become one of the most influential factors affecting HIV prevalence has been seen to reduce HIV in males by up to 60% and therefore indirectly reducing HIV incidences in women (Auvert et al., 2005, Bailey et al., 2007, Gray et al., 2007, Napierala-Mavedzenge et al., 2011). Similar findings were observed in this study with circumcision providing a protective effect on HIV. In SSA, low media exposure has been associated with a higher risk of HIV infection (Magadi and Desta, 2011). However, in this study all the countries except Uganda reported that HIV prevalence increased with a greater media exposure. This may be due to the fact that majority of the young people must have acquired HIV/AIDS through vertical transmission or the study area being in a generalised epidemic where low levels of risky behaviour may still increase the risks of HIV transmission (NACC and NASCOP, 2012).

Behavioural factors

Early sexual debut and its association with HIV prevalence was observed Ethiopia increased the risk of HIV when compared to late coital debut. In this study, HIV prevalence increased in young people who reported an early coital debut (8-14 years). Studies have shown that young people with little or no education engage in early sexual practises although the risk is higher in females than in men (Doyle et al., 2012). Stockl et al (2012) reported on four main reasons why early coital debut increased the risk of HIV infection in her systematic review of several articles. Firstly, early coital debut extended the duration of sexual activity and this exposed young people to a prolonged duration where their chances of infection increased. Secondly, early sexual debut especially in young women leads to risky sexual behaviour where young women practise unsafe sex by not using contraceptives and having multiple sexual partners. Thirdly, immature reproductive tracts increase the susceptibility of STIs in young women and finally, early sexual debut increases the likelihood of acquiring partners who are at higher risk of HIV through intergenerational sex (Stockl et al., 2013).

In this study, engaging in multiple sexual partnerships showed an opposite association with HIV. This is in contrast in the findings from other studies which report that multiple sexual partnerships are significantly associated with HIV (Uchudi et al., 2012). Likewise, association between transactional sex and HIV was observed in Uganda. This practice is mainly seen in women who would gain financial resources that allow them meet demands associated with their needs (Leclerc-Madlala, 2009). A cluster randomized trial conducted in South Africa on transactional sex and HIV incidences revealed that women who engaged in casual transactional sex had a higher risk of acquiring HIV/AIDS (Jewkes et al., 2012).

Presence of a sexually transmitted infection in the past year has been strongly associated with HIV among young people in this study with all countries with the exception of Ethiopia reporting a strong association. Studies have widely accepted STI as an important factor in the heterosexual transmission of HIV in SSA (O'Farrell, 2002).

Significant associations between alcohol use and HIV were observed in Ethiopia and Uganda. Alcohol use has widely been associated with sexual risks and studies have shown consistent association between alcohol and HIV infection where individuals in southern

Africa who tested HIV positive were seen to abuse alcohol (Hahn et al., 2011, Kalichman et al., 2007).

Spatial factors associated with HIV prevalence in identified hot spots in the study area

In Kenya, presence of hotspots of HIV was observed around the Lake Victoria region, bordering Uganda and in the central region. The western region in Kenya is associated with high multiple sexual partnerships which include polygyny practices and wife inheritance and these practices have been widely associated with HIV infection as well as reporting low levels of male circumcision (Amornkul et al., 2009). The clusters in the central regions were situated in a semi-urban area where the HIV risk is greater than in rural areas (Hargreaves, 2002). The same pattern was also observed around Addis Ababa, an urban area in Ethiopia. Alcohol abuse was also another factor which was prevalent in the central region as individuals are known to indulge in heavy episodic drinking (Gitonga et al., 2012). Cold spots in Kenya were mainly observed in the eastern region which is predominantly Muslim and along the borders with Ethiopia and Tanzania (see Figure 3.13).

The hot spots in Ethiopia were observed in the Addis Ababa and Oromiya regions. Cultural practices among the marginalized Oromo women such as forced marriages at an early age leads to early coital debut which increases HIV risks (Dugassa, 2005). The central part of Uganda which is in close proximity to Lake Victoria, a geographical feature, has hot spots of

HIV clusters and an urban area (Kampala), where studies show the risk of HIV is elevated (Msisha et al., 2008b). Similar to Kenya, studies have shown that the fishing communities around Lake Victoria have high HIV incidences which is mainly explained by their high-risk behaviour (Seeley et al., 2012).

The hot spots in mainland Tanzania were seen in the Tabora and Shinyanga regions. These regions are associated with low levels of male circumcision and high-risk sexual behaviour which include multiple sexual partnerships and early coital debut (Nkya et al., 2006, Nnko et al., 2001). Cold spots in Zanzibar could be associated with religiosity where the low HIV prevalence has been observed in predominantly Muslim areas (Kagimu et al., 2012, Trinitapoli, 2009). Overall, there was no presence of inter transmission of HIV across borders with the exception of the border between Kenya and Uganda.

Strengths and limitations of the study

The strengths and limitation of this study were discussed under the following points;

- **Confounding:** This was dealt with by the use of both multiple regression and addition of a spatial random effect in the model which improved the overall model and the parameter estimates.
- **Robustness of Analysis:** Strengths of spatial Bayesian models are seen when better fitting models are produced in comparison to non-spatial models. The ability of Bayesian analysis to produce results that assist in developing disease risk maps was a great strength in this study.

- **Study design:** The limitations of the study involve those that are inherent with cross-sectional designs which lack comparisons over time. Therefore, a temporal relationship between the factors associated with HIV prevalence cannot be demonstrated in this study. The inability to verify and countercheck the adequacy of the original data for inconsistencies and implausible observations was another limitation of this study.
- **Classification of exposures and outcome:** There may be presence of reporting, information or social desirability bias that is generally observed when study participants report on sexual risk behaviour. Exclusion of certain important variables that were known to be associated with HIV prevalence due to multicollinearity was another limitation of this study and may have compromised the results of the study.
- **Spatial relevance:** The use of large spatial units (regions) during spatial analysis for countries like Kenya and Ethiopia may have resulted in over-smoothing of the estimates which in turn failed to produce more accurate parameter estimates. A final limitation was the lack of coordinates which failed to depict a correct representation of cluster analysis results as seen in Figure 3.8.

Summary of key points

- Education delays sexual debut which in turn lowers HIV risk
- There is a positive and negative relationship between education and HIV infection across the study area.
- Belonging to a religion reduced the chances of HIV infection among young people in the study area.
- Circumcision generally lowers the risk of HIV infections among males which indirectly reduces infections in females.
- Spatial analysis showed geographical differences in HIV prevalence which is very important for planning for further interventions.

Chapter 5 : Conclusions and Future Work

Behavioural, demographic and social factors interact in different ways to produce spatial variations of HIV prevalence in different geographical locations. With this in mind, a comprehensive model which is inclusive of the above-mentioned factors would be vital in understanding the spatial variation of HIV not only in eastern Africa, but in SSA as a whole. Spatial effects are usually a proxy for underlying factors which may be useful in giving leads for further epidemiological research or assist in designing HIV intervention programs (Ji et al., 2013, Kandala et al., 2009).

The proximate-determinants conceptual framework is a useful tool for studies containing demographic and biological variables (Boerma and Weir, 2005). It is important to identify a number of variables that are biological and behavioural in nature when conducting HIV research because biological factors are what constitute the basic reproduction rate of HIV infection (Boerma and Weir, 2005). A lot of significant associations were observed between HIV prevalence and behavioural factors. Since it is not possible to change demographic and social factors, it is suggested that HIV interventions initiated should strongly focus on behavioural change to reduce the transmission of HIV among young people.

Spatial findings from this study can be used for efficient prevention and control of HIV/AIDS not only to the young people but to the general population. The use of risk maps can be used by policy makers to target and develop interventions at a country, regional, district or community level. It is advisable to use lower spatial units, such as districts and counties which may produce more accurate estimations and provide better indications to policy-makers and other stakeholders in identifying which areas may require political support and appropriate health interventions. Appropriate health interventions both at regional and cluster level in the four countries should be aimed at reducing the HIV incidences among young people in East Africa.

As this is the first study that looked at spatial distribution of HIV and the factors associated with the disease among the young people, there is a need for further research that fully investigates the drivers for these factors. It is further recommended that similar studies be replicated to other areas in the sub-Saharan region. Recommendations for interventions are based on the identification of the reasons behind the hotspots in each country in the study area.

Recommendation to policy makers

- Intervention programs should revolve around reducing and preventing the high-risk behaviours associated with young people living in urban areas in all the four countries. Health education on the transmission and prevention of HIV/AIDS to young people living in urban areas must be strengthened and improved to include aspects such as attitude change, better negotiation and decision making skills (Nkya et al., 2006, Nnko et al., 2001). This may be effective in changing sexual behaviour in the long-term.
- Programs that support and empower women in Eastern Africa should be implemented as women are a disadvantage group especially in majority of African communities because of cultural practices. These may include emphasizing on the importance of

educating the girl-child, discouraging early and forced marriages and involving women in health promotion agendas which overall, improves their well-being (Dugassa, 2005).

- In some parts of Kenya and Uganda, the fishing communities were highly associated with high-risk behaviour. Behavioural change interventions to change the attitude of this high-risk population should be reinforced to prevent further transmission of HIV/AIDS.
- There is need for interventions that target alcohol abuse (Seeley et al., 2012) to young males and females as well as establishments that serve alcohol especially in the central regions of Kenya. Education on how alcohol abuse increases HIV risk should be conducted in these areas.
- Interventions are required where low levels of circumcision are still prevalent as observed in some areas in Kenya and Tanzania. These interventions may include educating the community on the medical importance of circumcision (Gray et al., 2007) in the fight against HIV/AIDS and promoting the use of condoms for young people unwilling to undergo circumcision (Glynn et al., 2004).
- Parents or care-givers in the study area should also play a pivotal role in sexual education as studies have posited that adolescents whose parents effectively communicate about sex are more likely to practise safe sexual practices including delaying sexual debut (Ngom et al., 2003). This has been seen to promote primary or secondary abstinence among young people (Santelli et al., 2013).

Conclusions

Recent studies conducted in the West (United States of America), Africa (South Africa) and Asia (Singapore), have looked at the use of social media ad a tool for facilitating HIV/AIDS prevention in young people in high risk areas (Jaganath et al., 2012, Wong et al., 2012, Mpofu and Salawu, 2012). This can be achieved as young people make up the majority of the total population that uses social media for communication purposes (Mpofu and Salawu, 2012). These sites and phone applications such as *MySpace, Facebook*, *Whatsapp*, M*ixit*, to mention but a few, have attracted millions of users and therefore can be an important platform that may be used to address and spread information about HIV/AIDS among youth in Eastern Africa (Jaganath et al., 2012, Wong et al., 2012).

Summary of key points

- Factors associated with HIV prevalence among adolescents interact differently hence producing spatial variations in different geographical areas.
- HIV interventions designed for young people should focus more on behavioural change.
- Disease risk maps can be used to target and develop interventions at different administrative levels of a country.
- There is need to incorporate social media as a means of facilitating HIV prevention among the young people.

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Appendix A: Ethics Clearance Certificate