HIV/AIDS INTERVENTIONS AND THEIR IMPLICATIONS ON SUB-NATIONAL POPULATION PROJECTIONS IN KENYA

BY

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DECLARATION

This PhD thesis is my original work and has never been presented in any other institution for academic award or otherwise. All cited work is referenced.

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DEDICATION

This PhD thesis is dedicated to my wife Tabitha Ngina, to my children Victor and Caleb, to my mum Ruth Mwikali, to my late father Nthenge Mweki, to my siblings; Milka, Grace, Joel, Sarah, Daniel and Benard. Your moral support and encouragement gave me the strength to complete this thesis.

ABSTRACT

Kenya has experienced rapid population growth since the first count in 1897. Regional variations in the population growth have been witnessed over the years and population projections done to predict what the future would be. Although these population projections exist, variations in the tempo of population growth continue to persist across the regions of Kenya. HIV prevalence also persists. However, county specific population projections are lacking even as more and more interventions to address HIV/AIDS scourge are initiated. Population projections are crucial for development planning at the county level since Kenya has devolved system of governance. This study focused on generating county specific population projections taking into account the effect of HIV and AIDS interventions. The study had three objectives. The first objective focussed on generating population projections without taking into account the effect of HIV and AIDS and associated interventions. The second objective emphasised on generating county specific population projections while incorporating county HIV prevalence rates. The third objective focused on generating county population projections while incorporating both county level HIV prevalence rates and the levels of uptake of HIV/AIDS interventions.

Three data sets were used in this study, namely: the 2009 Kenya Population and Housing Census (KPHC) data, the 2012Kenya AIDS Indicator Survey (KAIS) and the 2014 Kenya Demographic and Health Survey data. Three methods of analysis were used namely: Ratio share method, the standard cohort component approach to population projections and the HIV enabled cohort component method of projecting populations.

The Initial analysis showed that for all counties, population will continue to grow over the projection period (2009-2030). The findings of the study also revealed that both HIV/AIDS epidemic and the interventions initiated to mitigate the effects of the HIV/AIDS in Kenyan population will continue to affect population growth at the county level in Kenya. In absence of HIV/AIDS, population size and life expectancy at birth in all counties are higher than they are when HIV prevalence's are included. When HIV/AIDS interventions are included in population projections, both population size and life expectancy at birth are consistently higher than they are when only HIV/AIDS is included but they are lower than it is the case in the absence of HIV/AIDS scenario.

As far as fertility projections are concerned, the results indicated that HIV/AIDS will lead to fertility reduction across all the counties. Counties with relatively high HIV prevalence are projected to experience relatively high percentage reduction in TFR while counties with relatively low HIV prevalence on average showed modest percent reduction in TFR.

When HIV/AIDS and programs were introduced in population projections at the county level, the results indicated that these programs are indeed influencing population change at county level although the effectiveness of these programs varied across the counties. Counties currently experiencing low uptake of HIV/AIDS interventions are expected to record the highest percent reduction in TFR by 2030. On the other hand, counties currently saturated with HIV/AIDS interventions are expected to record relatively low percent reduction in TFR by 2030

The key limitation of the study is that the model used could not produce projections of net migrants at sub national level. At the sub national level, migration plays a key role in population growth since different regions may experience different in flows and out flows of migrants. Consequently, the effect of HIV and AIDS on migration flows at sub national level could not be ascertained. The study therefore focused on mortality and fertility projections at sub national level.

The study recommends that population projections for future planning should take into account the role of HIV and AIDS related programs. The study also recommends that further research should focus on how to take into account migration as a major cause of population growth especially in urban areas where population growth will occur not only by natural increase but also by migration. The ASSA2008 model used in this study needs to be structured to capture more determinants of fertility and mortality such as contraceptive prevalence rates and poverty levels. The model also needs to be tested in countries with low HIV prevalence to test its universality.

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ABBREVIATIONS AND ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
AIM	AIDS impact module
ARIMA	Auto regressive integrated moving average
ART	anti-retroviral treatment
ASSA	Actuarial Society of south Africa
CBR	Crude Birth Rate
CCMPP	cohort component model of population projection
CCR	Cohort Change Ratio
GOK	Government of Kenya
CPR	Contraceptive Prevalence Rate
HAART	Highly Active Anti-retroviral treatment
HIV	Human immunodeficiency virus
IEC	Information and education campaigns
IIASA	The International Institute for Applied Systems Analysis
IMR	Infant Mortality Rate
IPC	International Programs Centre
KAIS	Kenya Aids Indicator Survey
KNBS	Kenya National Bureau of statistics
KPHC	Kenya Population and Housing Census
MGDS	Millennium development goals
MTCTP	Mother to child transmission probability
NACC	National AIDS Control Council
NASCOP	National AIDS and STI Control Program
NCPD	National Council for Population and Development
PRB	Population Reference Bureau
RUP	Rural/ Urban projection
SDGs	Sustainable Development Goals
SQL	Structured Query Language
STIs	sexually transmitted infections
TFR	Total Fertility Rate
U5MR	Under five Mortality Rate
UN	United Nations
UNAIDS	Joint United Nations Program on HIV/AIDS

UNPD	United Nations Population Division
UNFPA	United Nations Population Fund
USCB	United States Census Bureau
VBA	Visual Basic Application
VCT	Voluntary Counseling and Testing
WB	World Bank
WHO	World Health organisation

CHAPTER ONE
INTRODUCTION

1.1Background of the Study

There is an increasing demand for projections not only of population size but also of the distribution of the household sizes, types, and the living arrangements for socio economic planning, business policy and scholarly analysis (Zeng et al, 2010).According to UNFPA (2004)population projection is a demographic exercise that consist of empirically based computation of the future population size based on specific assumptions that pertain to changes in the growth of population or its components (mortality, fertility, and migration). Population estimates are used by policy makers and planners in government throughout the world to determine future demand for food, water, security, energy, and services. Population estimates are also used to forecast future demographic features of a population. In addition, these population forecasts not only assist policy makers when determining major tendencies that affect economic development but also help them when crafting development strategies useful in implementation of various projects (PRB, 2001). Better projections of demographic trends provide valuable intelligence to guide planning and should be a major policy goal (Moffit, 2000).

Most national governments prepare population projections for their own use although there are a few international organisations whose population projections cover the whole world, regions as well as individual countries. These organisations include: -The United Nations (UN), the World Bank, and the US Census Bureau (PRB, 2001). Future trends in the size of population , age –sex compositions, births and other demographic variables are needed not only when preparing projections on the future demand for resources such as food, water, energy and other services like education and health but also when assessing the environmental impact of rising consumption of natural resources (PRB, 2001; Kaneda and Bremner, 2014). The demand for sub-national population especially those of counties have increased among researchers (Crowley, 2004). The sub-national households and population projections are useful in allocation of public funds, allocation of various types of resources, devising plans geared towards developing infrastructure and public amenities, marketing research, planning on production of household-related goods and services, and making of decisions relating to the expansion or downsizing of local enterprises(Zeng, 2010).Accurate estimates of the exact number of people who require pensions and health care is crucial in designing optimal social security systems (PRB, 2001).

Growth or decline of a population of any country or area occurs when three demographic factors namely, mortality, migration and fertility interact. Hence to produce future population projections, demographers must make assumptions about the future changes in the current birth rates, death rates, immigration and emigration. These assumptions though based on research and expert opinion are not clear (Kaneda and Bremner, 2014). Of the three demographic factors, fertility has the highest effect on future size of the population particularly in developing countries with high birth rates. In countries with high fertility , demographers usually assume that fertility will follow a similar pattern of decline and eventually stabilise in every country at about two children per woman a term called “replacement level” fertility (PRB,2014). Fertility has continued to be very high in many countries in Sub-Saharan Africa, declining slowly or not at all. High fertility in Sub-Saharan Africa has been attributed to high demand for children (PRB, 2014; NCPD, 2014). Consequently, fertility assumption in Sub-Saharan Africa tend to be less reliable thus necessitating the United Nations to publish multiple projections in a span of every two years based on three assumptions namely: the low fertility variant, the medium fertility variant and the high fertility variant. The medium projection variant assumes that fertility will decline due to increased use of family planning methods in countries with predominantly large families and that there will be slight increase in fertility in some countries with less than two children per woman on average (UN, 2015). In the low fertility variant, it is assumed that in each country, on average the number of children each woman would bear is one-half less than the medium variant while the high fertility variant assumes that the number of children each woman will bear on average is one-half more than that in the medium variant (Kaneda and Bremner, 2014). While the latest world population projections are based on the medium projection variant (UN, 2015), majority of the countries in Sub-Saharan Africa are yet to start their fertility transition (Bongaart and Bulatao, 2000).

Mortality is incorporated into population projections by assuming that death rates will continue to decline while life expectancy will continue to increase. In areas where HIV prevalence rate is very high, mortality is assumed to be highly affected by HIV for many years although at a declining rate. On the other hand, international migration is extremely unpredictable and hard to incorporate into the projection assumptions because many countries lack reliable and accurate record on migration flows. Consequently, it may be deduced that the contemporary migration levels will continue for a while and then start declining slowly (Kaneda, 2014).

When producing population projection demographers face a number of challenges which include: estimates which are certainly unclear, the current demographic scenario is not perfectly known and future changes in the key components of population change namely; births, deaths and net migrants which are prone to unpredictable influences. Social, economic, political, technological, and scientific advancements have an effect on birth rates, death rates, and migration rates and consequently influence population growth. Deliberate social policies including decisions about provision of public health services, policies relating to the provision and accessibility of family planning methods, as well as regulations on immigrations also affect population growth to a large extend (Bongaart and Bulatao, 2000). Complete vital registration statistics in many developing countries are also lacking necessitating the use of indirect methods of computing demographic statistics and then these estimated statistics are used in population projections.

HIV/AIDS epidemic also poses as a key challenge in population projections. AIDS was first diagnosed in 1981and since then; HIV/AIDS epidemic has grown to become a serious health and development challenge in the whole world (UNAIDS 2013). HIV can affect fertility and mortality in a number of ways. For instance, studies have shown that adults who are HIV-sero positive experience substantially higher mortality that their counterparts who are HIV sero negative and that children born to HIV sero positive mothers experience higher infant mortality compared to those born to HIV sero negative mothers. Fertility also tend to be lower among HIV sero negative mothers compared to that of HIV sero positive mothers (Nunn et al., 1997; Gray et al., 1998;Sewankambo et al., 1994; Zaba and Gregson, 1998; Todd et al., 1997; Wachter, Knodel, and Van Landingham, 2002; Carpenter et al., 1997; Hunter et al., 2003; Terceira et al.,2003; Lewis et al., 2004; Timaeus and Jasseh, 2004; Zaba et al., 2007;Garenne et al., 2007; Clark et al.,2008; Gregson et al.,2007).Because of this, global and national initiatives have been established and implemented to reduce the HIV/AIDS epidemic. These initiatives include, incorporating HIV/AIDS in the global development goals such as MGDS and SDGs, scaling up information and education campaigns, initiating programs geared towards preventing HIV transmission from mother to child, increased condom use and social marketing, male circumcision campaigns and anti-retroviral treatment. The population effects/impacts of most of these initiatives and programs are not incorporated in the current population projection methodologies.

The earliest systematic global population projections were carried out around 1945 (Notestein, 1945), although a number of national level population projection efforts began almost a half a century earlier (O'Neill et al, 2001). While a number of institutions are involved in population projections, the United Nations (UN) has played a leadership role in production and dissemination of all population projection results since 1950's. The other institutions involved in population projections include; The United States Census Bureau(USCB), The Word Bank (WB), The International Institute for Applied Systems Analysis(IIASA) (O'Neill, 2001) and The Actuarial Society of South Africa (Dorrington et al., 2006) . However, the latter has focused on both national and sub-national projections whereas the other institutions named above have been focusing on global population projections.

Although a number of population projection methodologies exist, the cohort component approach to population projections has all along been used to generate long term global population projections. Cohort component approach works by grouping original population of a country into cohorts desegregated by sex and age (Zeng, 2010). The cohort component method of population projection is a step by step process which involves progressively updating the population of each age and sex-specific group on the basis of assumptions relating to fertility, migration and mortality. Each cohort is made to survive to the subsequent age group by subjecting it to the prevailing age-specific mortality rates. Other than the cohort component method, micro simulation method is also used in population projections. Micro simulation methods however differ from the cohort component method in that each individual is treated independently. In addition, contrary to the cohort component method which treats each cohort as a homogenous group and uses average probabilities of birth, death and migration, the micro simulation method uses repeated random experiments and treats each individual separately (Zeng, 2010).

HIV/AIDS pandemic has emerged and affected both fertility and mortality. This has then necessitated development of new and existing models for use in simulating the population effect of HIV prevalence and incidence on the demographic composition of countries. Population projection models which incorporate HIV prevalence usually incorporate behavioural aspect making it possible to estimate how HIV spreads throughout the population and the people who are vulnerable to the disease (Roos, 2013).Models for projecting HIV/AIDS can either be stochastic or deterministic (Robinson et al., 1997; Roos, 2013). SimulAIDS is a good example of stochastic model. Robinson et al., (1997) used SimulAIDS model successfully to estimate the percentage of HIV infections attributable to sexually transmitted diseases in rural Uganda. SimulAIDS model can simulate a population with a set of characteristics including; age, type of sexual partnership and the identity of all sexual partners. In a simulation exercise, the probability of each vital event occurring is specified and the status of the whole population is updated (Robinson et al., 1997; ROOS, 2013). On the other hand, deterministic models consist of simulation type of models and the curve fitting models. A good example of a simulation model is the ASSA model (Johnson and Dorington, 2006; Dorington et al., 2005). Good examples of the curve fitting models are the EPP/spectrum packages (Stover,2004), the abacus software developed by the United Nations Population Division (UNPD) and the Rural/ Urban projection (RUP) software developed by the International Programs Centre (IPC) of the US census Bureau (Mulder &Johnson, 2005). All these deterministic models apply the cohort-component method of population projections (Dorington, 2006; Mulder & Johnson, 2005).

In Kenya, population has grown from 2.5 million in 1897 to 38 million in 2009.According to the Kenya population and housing census of 2009, the annual growth rate of 3.0 percent implies that every year approximately one million people are added to the Kenyan population (KNBS, 2010). This annual increase in population is high considering the geographical size of the country. In addition, population size and growth vary by regions in Kenya. Since population projections are important in development planning not only at national level but also currently in the devolved governments, projections of population size have been developed/produced using the spectrum package provided by the Futures Group International. The package includes a population projection module (DEMPROJ) and an AIDS impact module (AIM) that incorporates the impact of HIV/AIDS (CBS, 2002). RUPHIV/AIDS model developed and maintained by the U.S. Census Bureau has also been used by the Kenya national bureau of statistics (KNBS) to project the Kenyan population. Both Spectrum package and RUPHIV/AIDS model incorporates uptake of ART and probabilities of transmitting HIV from mother to child during delivery while carrying out population projections (Mulder and Johnson, 2005). The Kenyan Government however has made significant steps geared towards mitigating the impact of HIV/AIDS in its population. These efforts include; improvements in treatment of HIV infected persons particularly provision of Highly Active Anti-retroviral treatment (HAAT) as well as increase in more interventions such as improvement in treatment of sexually transmitted infections (STIs), information and education campaigns as well as social marketing, increased voluntary counselling and testing, voluntary medical male circumcision (NACC and NASCOP,2014). These interventions are likely to shape the future population projections in Kenya.

This research therefore aims at determining sub-national population projections in Kenya while incorporating not only the effect of HIV/AIDS in population projections but also the population effect of programs/initiatives initiated to reverse the effect of HIV/AIDS in Kenyan population.

1.2 Problem Statement

Population growth in Kenya is high when compared to the area size and level of socio –economic development. Based on the Kenya population and housing report of 2009 on population projections, about one million people are added to the Kenyan population annually (KNBS, 2010). Variation in the tempo of population growth is evident among regions in Kenya. For instance, while the results from the preliminary analysis of the 2009 population and housing census data indicate that the 2009 KPHC data were quite complete and accurate results from some districts particularly those in upper parts of Rift valley regions and those of counties in North Eastern province exhibited abnormal population growth which remain unexplained. Mortality, fertility and migration rates are the key determinants of changes in population and they vary by regions. For instance, although total fertility rate for the whole country has declined to 3.9 and as per the 2014 Kenya demographic and health survey, mortality rates are improving; huge differentials in TFR still exist per county (KNBS, 2015). The same differentials exist in terms of net migration with Nairobi and Rift valley regions recording the highest number of net migrants (KNBS, 2010). These differentials in mortality, fertility and migration seem to persist at a time when the provision of health care has been devolved to the county governments yet projections of the same at current devolved systems remain undocumented. Currently, population and health services are controlled at county levels and the uptake of these services vary by counties. For example the contraceptive prevalence rate which is a key indicator of the success of family planning programs which in turn may affect fertility and mortality as well as HIV infection varies by counties.

Prior efforts have been made to produce sub-national population projections in Kenya but, still much need to be done to produce more authentic and near to reality estimates. For example the current population projections based on the 2009 Kenya Population and Housing Census focuses on projected estimates of county population size yet projections of fertility indicators like TFR and mortality indicators like expectations of life which are crucial in devising development policies and programs at county level are not done. The projections are produced using the standard cohort component methodology with aid of software's (RUPHIVAIDS and Spectrum suite of model) which factors the uptake of ART and mother to child transmission rates as the only interventions put in place to reduce the effect of HIV/AIDS in Kenyan. However, since the emergence of HIV pandemic in Kenya the government has put in place various interventions (namely: Prevention of mother to child transmission probabilities, Information and education campaigns, Voluntary Counselling and Testing campaigns, Provision of anti-retroviral treatment and syndrome management of sexually transmitted infections) to mitigate the effect of HIV/AIDS in populations. The uptake of these interventions also varies by counties in Kenya and their impact in population projections at county level in Kenya remains unknown.

Given the high rate of population growth at both national and regional levels in Kenya, regional variations in the components of population change, huge regional disparities in access to health care, epidemiological challenges particularly the emergence of HIV pandemic which not only vary by region (NASCOP, 2014), but also affect the key components of population change (Sewankambo et al., 1994; Nunn et al., 1997; Carpenter et al., 1997; Gray et al., 1998;Zaba and Gregson, 1998; Todd et al., 1997; Wachter, Knodel, and Van Landingham, 2002; Hunter et al.,2003; Terceira et al.,2003; Lewis et al., 2004; Timaeus and Jasseh, 2004; Zaba et al., 2007;Clark et al.,2008; Gregson et al.,2007; Garenne et al., 2007) namely fertility mortality and migration, and given that the Kenyan government has put in place interventions to curb HIV/AIDS pandemic and that uptake of the interventions vary by regions in Kenya, this research builds on existing research by examining future county specific population trajectories in presence of HIV/AIDS and as more program interventions geared towards reversing the effect of HIV in Kenyan population become widely available. This is because development planning has been transferred to counties and consequently to sub counties in Kenya which then calls for projections of demographic indicators at lower levels so that planners and policy makers can easily allocate resources, expand infrastructure, and avail the required amenities and human resources.

1.3 Research Question

The study seeks to answer the following research question: ‘what are the implications of the current HIV/AIDS interventions on future key demographic characteristics (fertility rate and life expectancy) at sub national level?’

1.4Objectives of the study

1.4.1General objective

The general objective of this study was to determine the implications of the current HIV/AIDS interventions on key sub national population characteristics in Kenya.

1.4.2Specific objectives

The specific objectives of the study were to:

1. Compute county specific population projections using known methods without incorporating HIV and AIDS;
2. Compute county specific population projections incorporating the effect of HIV/AIDS;
3. Compute county specific population projections incorporating HIV/AIDS and the effect of interventions;
4. To estimate the contribution of HIV/AIDS interventions on future county fertility levels.
5. Estimate the contribution of HIV/AIDS interventions on future county life expectancy at birth.

1.5Justification for the study

Population projections are useful in planning not only at national level but also at county level. With the devolved system of governance in Kenya, population projections of this nature will guide in decision making at county level because increase in population size would mean more demand for health services (which are already devolved to counties), schools, and even security.

Kenya is a country with significant cultural differences and socio-economic characteristics. Access to education and health varies from one region to another. The same is replicated in terms of infrastructure with some regions having better infrastructure than others. Consequently, the current demographic situation in Kenya is varied. Some regions have very high fertility and mortality rates while others have low mortality and fertility rates (KNBS, 2015). Despite this scenario, apart from population size, the existing population projections in Kenya are national in scope and fail to capture regional variations. Therefore, by generating county specific demographic estimates, results of this study will go a long way in guiding formulation and implementation of county specific population policies which can guide development of specific programmes to accelerate development at sub-national level so that some regions don't lag behind instead of making just blanket national policies which fail to capture regional variations.

Population projections generated from the 2009 Kenya population and housing census data were grounded on the assumption that fertility will continue to decline gradually nationally, declining from 4.7 in 2010 to 4.6 in 2015 and eventually reaching 4.1 in 2030. The same pattern of gradual decline was assumed to be replicated at county level. However, the 2014 Kenya Demographic and Health Survey recorded a TFR of 3.9 which was far much lower than expected while some counties showed an increase in TFR which remain unexplained. This scenario is evident at a time when access and uptake of health care and reproductive health particularly family planning not only vary by counties but also have been devolved to county level. At the same time, this is happening at a time when HIV/AIDS which has been found to affect not only fertility but also mortality and migration vary by counties. In addition, uptake of interventions geared towards mitigating the effect of HIV/AIDS varies by counties. This study therefore is very relevant since it explains the role of program interventions in affecting county population projections in the era of HIV/AIDS.

National development can be accelerated only if population issues are factored in the development agenda. While population dynamics, gender and reproductive health issues have been integrated in national development strategies and despite the fact that substantial steps have been made in effort to contain Kenyan population growth to be in tandem with its economic growth and development potential, the Kenyans development blueprint, Kenya vision 2030 does not capture population issues yet they are needed to achieve it (NCPD, 2013). National development can also be accelerated if the gap in inequality in sub national development is minimised. This study is therefore very relevant because it will generate county specific population projections that can be used to guide formulation of sub-national policies to accelerate economic development at county level which in effect will translate to national economic development.

The study also provides a better understanding of the effect of HIV/AIDS on the population projections in Kenya by incorporating more interventions in demographic projections which are lacking in the existing population projections in Kenya. These interventions include: improvement in the treatment of sexually transmitted infections (STIs), information and education campaigns (IEC) as well as social marketing, voluntary HIV counselling and testing (VCT), voluntary medical male circumcision and highly active anti-retroviral treatment (HAART) (Dorrington, 2006; NACC and NASCOP, 2014).Uptake of these interventions vary by region.

1.6 Scope and limitation of the Study

This study is sub-national in scope. Urban and rural population projections are not done although uptake of HIV/AIDS interventions in urban areas is relatively different from that in rural areas. At the sub- national level, the study focuses on deriving county specific population projections particularly, population sizes, total fertility rates and life expectancy at birth. HIV/AIDS epidemic is also incorporated in projections in this study because studies have shown that HIV/AIDS affect the components of demographic change particularly mortality and fertility (Nunn et al., 1997; Carpenter et al., 1997;Sewankambo et al., 1994;Zaba and Gregson, 1998; Todd et al., 1997; Wachter, Knodel, and Van Landingham, 2002; Hunter et al.,2003; Terceira et al.,2003;Gray et al., 1998 Lewis et al., 2004; Zaba et al., 2007;Clark et al.,2008; Garenne et al., 2007; Timaeus and Jasseh, 2004;Gregson et al.,2007). Since the most current population and housing census was done in the year 2009, population projections in this study begins from 2009, which forms the base population. The projections are then extended to the year 2030 which has been set as Kenya's deadline for achieving a national long-term development blue print for creating a globally competitive and prosperous country with a high quality of life (GoK, 2007). The Key demographic parameters used in this study are: Projected population, mortality and fertility. Projected mortality includes life expectancy at birth while fertility comprise of projected total fertility rates (TFR).

In implementing this study, the key limitation encountered was lack of a set of agreed methods for projecting migration flows at sub-national level. Consequently, only projections of population size, fertility and mortality are done in this study.

1.7 Organization of the thesis.

This thesis is arranged in terms of six chapters. Chapter one focuses on the general introduction of the study, statement of the research problem, study objectives as well as justification for the study. Scope and limitation of the study is also extensively discussed in this chapter.

The second chapter focuses on literature review. It starts by discussing the uses of population projections both to national and devolved governments as well as approaches to population projections. Then population projection methods and software's are extensively discussed. Regional trends in both fertility and mortality are discussed to form basis for fertility and mortality projections. The chapter also presents the challenges encountered by demographers in population projections both at the national level and in the current devolved governments. Towards the end of the chapter, the effects of HIV/AIDS on population projections and the program interventions initiated to mitigate the effect of HIV/AIDS in Kenyan population are discussed. The chapter concludes by presenting conceptual and operational frameworks adopted in the study.

Chapter three discusses the methodology adopted in the implementation of the study. Specifically, the sources of data used in the study as well as data quality checks are extensively discussed. The chapter concludes by discussing the methods used in generating sub-national population projections.

Chapter four presents results of the analysis on non HIV/AIDS population projections. Because of limited data at the county level, the chapter starts by producing national and provincial level population projections to obtain base data for use in sub-national (county level) population projections. After obtaining county level base data, county specific non HIV/AIDS population projections are then presented and discussed. This chapter also forms basis for chapter five.

Chapter five focuses on county specific population projections incorporating HIV/AIDS and the effect of interventions. This is accomplished by creating "HIV/AIDS county population projections scenario" and "HIV/AIDS and interventions county population projection scenario". The results are compared with those in chapter four to point out how county population projections would be if there was no HIV/AIDS, how they would be if the current HIV prevalence rates were to continue un abated and how those county population projections would look like if current uptake of interventions geared towards mitigating the effect of HIV/AIDS on Kenyan population were to continue.

Chapter six is the last chapter in this thesis. The chapter presents summary of key findings and makes study conclusions. Based on these findings and conclusions, policy recommendations and those for further research are made.

CHAPTER TWO
LITERATURE REVIEW

2.1Introduction

This chapter aims at reviewing relevant literature so as to give the study conceptual and empirical basis. The main focus is on methods of projecting population, fertility and mortality at sub-national level. The chapter also examines the uses of population projections, the institutions that have been involved in population projections, the models that have been used in population projections, challenges in population projections particularly the role of HIV/AIDS in producing population projections and the interventions put in place to mitigate the effects of HIV and AIDS on the Kenyan people.

2.2Uses of population projections

Population projections are useful in a variety of ways: first, they can be used to predict future population change. Projections and planning are closely intertwined. At county level, projections can be used to guide decision making since increased population would lead to rise in demand for health services, schools and security. Population projection can also affect future population growth since counties projected to experience rapid population growth may attract not only job seekers but also businesses which are expanding. Second, they can raise our understanding of the factors that influence change in population. That is, the "what if" role of population projections. For instance, population projections would help demographers and policy makers establish the likely effect of increasing or declining birth rates on a county's population size and age-decomposition. Third, they can act as a source of information on possible future scenarios based on diverse but sensible assumptions. This is because it is not possible to be always sure of what the future portends. For this reason, it is imperative to consider population projections under various assumptions. Factoring the implications of diverse assumptions in population projections enables demographers and policy makers' get ideas about possible variation's in future population projection values. Fourth, population projections are crucial when making rational decisions especially those concerned with the distribution of money meant for managing education and health care services as well as services concerning increase or decrease in taxes across counties (George et al., 2004). Variations in population size and composition have numerous social, economic, political and environmental consequences. For instance, while national level projections of population are used when planning for Medicare obligations and social security (George et al., 2004), in our devolved system of governance, county governments are responsible for planning of all aspects of development except for security, primary, secondary and higher education. However, early childhood education is the responsibility of county government.

2.3 Mortality Projections

The Lee-Carter model is often regarded as the current gold standard method of fitting mortality trend (Li and Chan, 2007). The Lee-Charter model assumes that changes in mortality trends overtime are determined by a single parameter only (the mortality index). Mortality index is determined by selecting an appropriate time series (Lee and Carter, 1992).

The Lee-Carter model describes the logarithmically transformed age-specific rate of death *($m_{x,t}$)* as the sum of the age-specific component which is independent of time *(a_x)*, and the product of time varying parameter *(k_t)*, the mortality index, that summarizes the general level of mortality. The model also has an additional age specific component *(b_x)*. (b_x) represent the rate of change of mortality index.

The Lee-Carter model is mathematically represented as:

$$\ln(m_{x,t}) = ax + b_x k_t + \varepsilon_{x,t} \qquad \ldots\ldots\ldots\ldots 1$$

The final term $\varepsilon_{x,t}$ is called the error term. It represents the age specific influences which are not captured by k_t. (Li and Chan, 2007).

The Lee-Carter model has been criticized by Girosi and King (2007). They asserted that the model only capture the first and last data points and so it produces age profiles which are not only less but also less smooth overtime regardless of the trends that exist in empirical data. This causes the age profiles to eventually deviate from any given baseline.

The Lee – Carter model was specifically developed for U.S. mortality data, 1933-1987. Lee and Carter have been recognized by demonstrating that except for a few exceptions, national log mortality data will always fairly follow a linear age path.

2.4 Fertility projections

Fertility projections have been an area of concern over the years. The UN has been producing deterministic total fertility rates (TFR) projections. The projected TFRs are then decomposed into age specific fertility rates (ASFRs) using fertility schedules. The ASFRs are then combined with projections of mortality and international migration using cohort method of population projections (Alkema et al., 2006). Deterministic projections are based on expert opinion. They are often biased about the future course of mortality, migration and fertility.

Miller (2006) made improvement on the deterministic approach by developing the random country model (RCM). The RCM is based on collective experience of UN member countries as a basis for projecting future demographic trends and for measuring uncertainty around these trends

Alkema et al., (2011) used Bayesian projection approach to produce county specific TFR for all countries. Using the approach, the evolution of TFR was decomposed into three phases: pre-transition high fertility, the fertility transition and the post-transition low fertility.

Fosdick and Raftery (2014) extended the Bayesian model to include probabilistic projection of aggregate TFR. This was done by modelling the correlation between country forecast errors as a linear function of time invariant covariates.

The Gompertz model in the Bayesian framework has also been used by Pandey and Singh (2015) to determine past and future trends in ASFR of Utter Pradesh state in India.

2.5Methods of population projection

Methods of projecting population can either be objective or subjective. Subjective methods of population projections are those that don’t clearly identify the data, the underlying assumptions and the techniques used in projections. This makes it hard for other analysts to replicate the results exactly. On the other hand objective methods are those where by the data, the projection techniques and the underlying assumptions are explicitly stated. Consequently, it is easy for other population analysts to use them to establish whether the results can be replicated exactly. While subjective methods are frequently used to produce some types of forecasts such as changes in technology and geopolitical events, they are rarely used in projecting population (Smith et al., 2013). This section focuses on objective methods particularly those that have been used in producing sub-national populations elsewhere namely: Cohort-component; trend extrapolation; structural models and micro- simulation.

2.5.1Cohort component method of population projection

The cohort-component models of population projections originated from the work of Cannan (1895) and are the most popular of all population projection methods. They are called cohort component models because they work by dividing the population into cohorts. Then the key factors that lead to population change namely mortality, fertility and migration affecting each cohort are modelled (Wilson, 2011).The method is straightforward and easy to implement. Because of this, governments and organisations involved in development planning use it to estimate the future population size and composition. Moreover, development planners use it to assess how population size and composition is likely to change when different program interventions and assumptions are introduced (Thomas and Clark, 2011).

While at the national level net migration is taken to be zero, migration at sub regional level has always been a challenge. This is because different regions experience different rates of migration. Consequently, there exist various categories of cohort-component models differentiated on the basis of how they handle migration data and the migration data they use. The standard multi-regional cohort component models which allow for inclusion of migration flows between points of origin and destination (disaggregated by age and sex) are recommended to demographers interested in generating population projections for sub-regional areas. This is because at sub regional level, age schedules of fertility, mortality and migration rates are unstable. Moreover, data requirements at sub regional levels are usually very extensive. Seemingly, at the county level, the cohort-component methods that make use net number of migrants, net migration rates, migration pool, out-migration flows and in – migration shares, bi-regional migration flows are recommended (Wilson, 2011). There are two main types of migration data: (i) movement migration data and (ii) transition migration data. Movement migration data focuses on movements of people across a geographical boundary while transition migration data deals with the number of people who have changed physical address between two points in time (who have not emigrated, died or immigrated in the period). While Cohort – component models based on transition data have been used elsewhere, all cohort- component population projection models used in this thesis are those that use movement migration data (Wilson 2011).Suppose net migration cohort model is used, then for all cohorts except infants in the age interval [x , x + 5] at a given time say *t*,population is estimated using the equation:

$$ {}_5P_x^s(t) = {}_5P_{x-5}^s(t-5) - {}_5d_{x-5,x}^s \, {}^5/_2 \left({}_5P_{x-5}^s(t-5) + {}_5P_x^s(t) \right) + {}_5N_{x-5,x}^s(t-5,t) \quad \ldots\ldots 2 $$

This equation can further be simplified as:

$$ {}_5P_x^s(t) = \frac{\left(1 - {}^5/_2\ {}_5d_{x-5,x}^s\right)\ {}_5P_{x-5}^s(t-5) + {}_5N_{x-5,x}^s(t-5,t)}{\left(1 + {}^5/_2\ {}_5d_{x-5,x}^s\right)} \qquad \ldots\ldots 3 $$

The last open ended age group's projections are ascertained by taking the sum of the projections of the cohort transiting to the last age group in the projection interval and the projections of the cohort starting in the final age group and surviving within it. The births occurring in the projection interval are then obtained by subjecting the female population in the child bearing ages to the prevailing age- specific fertility rates. Net migration number cohort model has been applied by Statistics British Columbia and in New Zealand's sub national projection (Wilson 2011). In Kenya, Kiema et al (2011) used the cohort-component method to project primary school-age population (GOK, 2011).

Because HIV epidemic has emerged and has become a global population and health challenge, demographers have been concerned about the impact of the epidemic on population growth. This has necessitated modification of the standard cohort component method. Among the modifications to the standard cohort component approach was done by Heuveline (2003) who created a multi-state version of the standard cohort component model of population projection (CCMPP).CCMPP incorporates the epidemic in population projections. The multistate version of the CCMP works by classifying the populationon on the basis of time duration since HIV infection. Then a set of age specific incidence parameters are used to pass on the disease to the HIV sero negative individuals and to move them to the first HIV sero-positive group in the shortest time possible. The model also has extra parameters estimated using maximum likelihood techniques. These parameters are used to govern the linkage between HIV sero-status and fertility (Thomas and Clark, 2011). The HIV enabled CCMPP applies a fixed survival schedule to the infected population to estimate the model parameters. Since estimated age pattern of HIV incidence may be sensitive to the life table used for the infected population (simply because the incidence parameters are estimated using data on HIV prevalence, which is a function of incidence and survival), Thomas and Clerk (2011) extended the Heuveline CCMPP by including more parameters that governs the survival of the HIV/AIDS infected population. Thomas and Clerk (2011) also factored the effect of expanding antiretroviral treatment programs on survival status of HIV infected population. Basing their study on a rural population residing in South Africa, they used the HIV- enabled CCMPP. The results were presented in form of a Leslie matrix.

The key strength of the cohort component method of population projection is that it projects the key determinants of population change. This in turn allows demographers to draw on specialised knowledge of each of the components of population change (O'Neill et al., 2001). Despite this strength the cohort component model makes it difficult to develop a reasonable range of births, deaths, and local migration flows. This limitation is however overcome by linking the local (county) population projections and the related assumptions to the national population projections.

2.5.2The Shortcut cohort methods

This method of population projection somehow resembles the cohort component method of population projections. The only difference is that it aggregates the demographic components of change. Hamilton and Perry (1962) were the first demographers to describe this method. They did so by proposing a simple method for projecting population by age from one decennial census to the next. According to Hamilton and Perry (1962) except for babies born in the course of the projection interval, for all cohorts, the population of a cohort aged between x-5 and x at time t-5 is equal to the population of that cohort which is currently aged x to x+5 at time t+5 multiplied by a Cohort Change Ratio(CCR). It is expressed mathematically as follows:

$$ {}_5p_x(t) = {}_5p_{x-5}(t-5)\,{}_5CCR_{x-5,x}(t-5,t) \quad \ldots\ldots 4 $$

CCR is computed using the formula:

$$ {}_5CCR_{x-5,x}(t-10,t-5) = {}_5P_x(t-5)\,/\,{}_5P_{x-5}(t-10) \quad \ldots\ldots 5 $$

For the model to work, comprehensive data relating to two populations differentiated by sex and age five years apart are required. Herbert (2011) used the shortcut cohort technique to estimate the primary school age population in counties in the former Nyanza province. The findings of the study revealed that all sub-counties in the lake region would continue to record increase in primary school-age population.

2.5.3 Trend Extrapolation

Trend extrapolation approach to population projections works by fitting mathematical models to historical data. The models are then used to generate future population estimates. Trend extrapolation methods are broadly classified into three main groups: Simple extrapolation methods, complex extrapolation methods and the ratio extrapolation methods (Smith et al., 2013). These are discussed as under.

Simple extrapolation methods

Simple extrapolation requires data at two points. The method encompasses three methodologies namely: The linear change, the exponential change and the geometric change. Linear change method of population projection assumes that population at a future date increases or decreases by a constant. This average absolute change in the base period is obtained using the following formula:

$$\Delta = (P_1 - P_b)/(y) \ldots\ldots 6$$

Δ Denotes the mean absolute change, P_1 denotes the population at the launch year, P_b denotes the base year population, while y denotes the number of years between launch year and the base year. So when this approach is used then projection at a future date is ascertained as follows:

$$P_t = P_1 + [(z)(\Delta)] \ldots\ldots 7$$

In equation 7, P_t refer to the target year population. P_1 is the launch year population; z is the number of years included in the projection period while Δ is the mean absolute change computed from the base period.

In geometric change approach to trend extrapolation, it is assumed that change in population will occur by the same proportion over a given time in the future just as it happened during the base period. The formula for computing average rate of population change when geometric method is applied is given by the formula:

$$r = [(p_1 / p_b)^{(1/y)}] - 1 \ldots\ldots 8$$

In equation 8, r denotes the average rate of geometric change, P_1 is the launch year population, P_b is the base year population while y represent the number of years in the base period. Population projections are then obtained using the following mathematical relationship:

$$p_t = (p_1)[(1+r)^z] \ldots\ldots 9$$

In equation 9, P_t is the target year population, P_1 is the launch year population, r is the average rate of geometric change while z denotes the number of years included in the projection period.

In exponential change approach, population change is assumed to be occurring continuously but not at discrete intervals. During the base period the rate of population change is computed as follows:

$$r = [\ln(p_1 / p_0)]/(n) \ldots\ldots 10$$

In equation 10 *r* represent the average annual rate of exponential change, ln represent the natural logarithm, P_1 is the current year population, P_0 is the base year population, and n is the number of years in the base period. Using exponential method, population projection is computed as:

$$P_t = (p_1)(e^{rz}) \quad \ldots\ldots 11$$

Where P_t represents the targeted yearpopulation,P_1 is the launch year population, e is a mathematical constant known as the base of the natural logarithm, r represent the average exponential rate of change computed for the base period, and z is the number of years in the projection horizon (George M.V et al., 2004). This approach was used by Ondieki (1989) to project the population of Nairobi and the implications it has for housing. The finding of the study revealed that housing needs were increasing in tandem with the increase in population.

Complex extrapolation methods

Logistic curve, polynomial curve, linear trend and ARIMA time series are complex extrapolation methods. In logistic approach the demographer can explicitly put an upper asymptote on the ultimate population size for a given locality. The approach yields an S-shaped pattern. The S- shaped pattern signifies that any population will always start by exhibiting periods of slow growth rate which are then followed by periods of increased growth rate and lastly, the growth rate starts to decline. Eventually, the growth rate approaches zero as the population tends towards its upper asymptote. The issue of population growth reaching limits is not only intuitively plausible but also consistent with the Malthusian theory and other theories of controlled growth in population (Smith et al., 2013). Logistic curve approach was popular in the early years of the twentieth century. Though its usefulness in population projections has been questioned, studies have shown that it often provides reasonably accurate population forecasts (Dorn 1950; Leach 1981). Keyfitz (1968) proposed a logistic curve defined by three parameters. The three parameters logistic curve is mathematically expressed as:

$$Y = a / [1 + b(e^{-cX})] + cf \quad \ldots\ldots 12$$

In equation 12, Y represents the population, X denotes the time duration, *a* represents the population limit also called upper asymptote *b* and *c* are parameters defining the shape of the logit curve, e is a mathematical constant called the base of the natural logarithm and cf is an adjustment factor (Smith et al 2013).Just like the other trend extrapolation methods, logistic models rely on two basic assumptions: First, that changes in future population are directly and smoothly guided by past changes in population, and second, that past relations remain constant over time. However, there are two major weaknesses associated with this model. First and foremost, it is not easy to develop accurate approximations of the parameters in the model. Secondly, small variations in the parameters can lead to huge variations in population estimates. Because of these weaknesses, logistic models are usually unpopular in population projections. Nevertheless, Wekesa (1989) used a four parameter logistic model, these weaknesses notwithstanding, to project the Kenyan population. He then analysed its implications not only in the educational sector but also on the school enrolment. The findings of the study revealed that some provinces have consistently high retention rate while others have poor retention rate.

ARIMA (autoregressive integrated moving average) are complex trend extrapolation methods which have been used by demographers over the years to analyse and produce population projections. Mathematically, an autoregressive integrated moving average model can be written as ARIMA (c, d,e) where c represents the number of autoregressive terms, d denote the order of differencing and e stand for number of moving average terms. In many cases, c,d and e assume values of 0,1 or 2. In autoregressive models part of the preceding value is included in the current value. For example, consider the function:

$$Y(t) = \Phi Y(t-1) + c + \in(t) \quad \text{.....13}$$

In equation 13 Φ represents an autoregressive parameter and c is a constant while $\in$ is a random error. This is a good example of AR (1) since it contains a single autoregressive term and is deficient of both integration and the moving average terms. A moving average model usually contains not only the present error term but also part of the preceding error term. ARIMA models are not popular in population projections and only few of demographers have used them. In most cases, ARIMA models are used to estimate such variables as TFR and mortality indices. Among the few scholars who have applied ARIMA models to produce national and sub-national level population forecasts are Tayman et al., (2007) who evaluated the applicability of ARIMA(1,1,0), ARIMA(0,1,1), ARIMA(2,2,0), ARIMA(0,2,1), ARIMA(0,2,2) and ln(ARIMA,0,1,1) in forecasting the population of selected US states. Tayman et al., (2007) established that out of the six ARIMA (1, 1, 0) and ARIMA (0, 1, 1) are the most accurate.

Ratio share methods

Ratio-share methods are also called comparative methods. When this method is used, the smaller region's population is expressed as a percentage of the larger region's population. For instance, the population of a county may be expressed as a percentage of the national population. The commonly used ratio methods are: Constant –share method, share of growth method and shift –share method.

Constant share method holds constant the smaller unit's share of the larger unit's population at a level observed in the launch year. The mathematical notation for constant share technique is:

$$P_{it} = (\frac{P_{il}}{P_{jl}})(P_{jt}) \text{ ....} 14$$

Wherein P_{it} denote the population estimate for smaller region, (*i*) represent the target year, P_{il} refer to population of the smaller region in the launch year, P_{jl} denote the population of the parent region (j) in the launch year; and P_{jt} denote the projection of the parent region in the target year. The constant share technique is appropriate for regions with poor records since it requires historical data from only one point in time. The key weakness of constant share method is that it assumes that smaller regions will always increase at the same rate as that of the parent population (George et al., 2004).

The shift share approach deals with changes in population share. The shift share technique is expressed mathematically as:

$$P_{it} = \left(P_{jt}\right)[(P_{il} / P_{jl}) + ((z / y)(P_{il} / P_{jl}) - (P_{ib/P_{jb}})))] \text{ ....} 15$$

i in equation15 represent the smaller region, j is the number of years in the projection horizon for the parent region, y represent number of years in the base period and *b, i* and *t* represent the base, launch, and target years, in that order. However, this approach has weaknesses. First and foremost, the approach can bring about significant population loss in the region where population grew very slowly or declined during the base period. This happens particularly for projections that cover long periods of time. Secondly, it can lead to negative numbers or even extremely high projections for regions that have been experiencing rapid population growth.

On the other hand, the share of growth method focuses on the share of population growth rather than the size of the population. The method is based on the assumption that, the contribution of smaller area to change in population of the parent region will be the same throughout the projection horizon just as it was during the base period. Mathematically, share of growth model is expressed as:

$$P_{it} = \left(P_{il}\right) + [(P_{il} - P_{ib}) / (P_{jl} - P_{jb}))(P_{jt} - P_{jl})] \text{ ....} 16$$

The parameters presented in equation 16 are the same as those presented in equation 15.

Trend extrapolation techniques whether simple or complex are more frequently used for projecting total populations rather than for projecting the populations of sub-groups (George et al., 2004).

Trend extrapolations are more advantageous when compared to other techniques of population projections. First, their data requirements are very few (except the ARIMA and polynomial). Second, they are quick and easy to use. Third, they are suitable when dealing with: incomplete data series, highly constrained budgets and time and the information on population characteristics is not vital. Fourth, they are appropriate when one is interested in producing population forecasts that cover short time horizons.

Despite these strengths, the trend extrapolation methods possess numerous weaknesses. First, they fail to justify differences in demographic structure and they don’t account for the variations in the components of population growth. Second, they do not provide adequate data on the demographic features of the projected population. Third, except the logistic model which supports the Malthusian view of population growth, all other trend extrapolation techniques lack theoretical back ground. Consequently, they can’t be linked to the theories of population growth. The shortcoming listed above limit demographers interested in analysing the causes of population growth and modelling the impact of changing a particular variable or assumption from using the trend extrapolation methods. Besides, their use can result in impractical or even illogical results even for population projections covering a relatively short time horizon (Smith, Tayman and Swanson, 2013).

2.5.4Structural Models

Structural models apply statistical methods that base population changes on one or more parameters. Structural models are very useful among planners and policy makers because of their capabilities to account clearly for the impact of dynamics such as rents, housing, wage rates, rates of employment and land use. There are several ways of expressing structural models. First, there are those structural models which focus on the total population only. A good example of this is when demographers base population growth on the spatial distribution of opportunities for employment and price of housing within a country. Second, there are structural models which concentrate on definite components of population change such as migration. An example of this is when projections of migration in a specific county are based on the estimated variations in employment and wage rates. Structural models can be broadly classified into two categories namely: economic-demographic models and urban systems models. Economic-demographic models are useful when projecting both population size and economic activities for states, counties, metropolitan areas and labour market areas. On the other hand, urban systems models are primarily employed when estimating the population size, land use, housing requirements, economic activities, and transportation patterns for census tracts, block groups, blocks, and other small geographic regions (Smith et al., 2013).

Structural models are commonly used in the US partly because of federal legislations which decree their use. They are also commonly in use in Australia (Smith et al., 2001).

2.5.5 Micro simulation

Micro simulation focuses on the projection of individuals or households but not on the projection at the level of population as a whole. Each individual is treated independently. They make use of repeated experiments but not the average probabilities. The method can simulate live events (divorce, marriage, births, leaving household, etc.) for each individual. To reduce computational demands micro simulation method relies on a sample data but not the entire population. The output is then scaled to match with the size of the total population (O'Neil et al., 2001; Wilson, 2011).

Micro simulation models have some weaknesses. First, their data requirements are extensive and in many cases exceed what is available. Second, the models usually suffer from technical complexity; they are computationally rigorous and require very many person years to be fully developed. Lastly, the approach is time consuming because of the huge data requirements and the task is always repeated once new data is available.

The strengths of micro simulation models are: One, detailed projection output which gives users huge amount of flexibility in terms of disaggregation. Two, modelling is carried out at the individual level hence; there is no accumulation bias and discrepancy among the variables (Wilson, 2011; O'Neil, 2001).

2.6Population Projection Software

This section discusses the software that are available and can be used or have been used for demographic projections. Although an extensive discussion is made of available software for demographic projections, the list is not exhaustive. The software presented in this section are evaluated on the basis of three essential benchmarks namely: Availability of the software to the public, the models ability to fulfil the user needs and whether the data required as input into the model is available.

2.6.1 ASSA2008 model

ASSA2008 model is a successor of ASSA2003 model designed and developed by the AIDS committee of the actuarial society of South Africa (ASSA). The model has been used to carry out demographic projections in South Africa and Botswana (Dorrington, 2006). ASSA2008 is an open source spread sheet- based model. It is programmed in VBA (visual basic application) for excel. Consequently, a user who has knowledge in visual basic and Microsoft excel can comfortably use it.

The model adopts cohort component approach to demographic projections. It incorporates not only the effect of HIV/AIDS but also the contributions of programs towards mitigating the effect of HIV/AIDS in populations. Demographic, epidemiological and behavioural assumptions are applied to an initial population. Then, the changes in that initial population categorised by both ages and years are obtained. Population projections starts by categorising the population by sex, into three different and distinct age groups: the young which comprises of individuals aged 13 years and below, the adult comprising of those individuals aged between 14 and 59 years and the old which comprises of those aged 60 and above years. For each distinct age group, different demographic, epidemiological and behavioural assumptions are made. Then single age and single year projections for each age group are done. The adult group which in real sense comprise of the sexually active population is split into four distinct HIV risk groups distinguished by the frequency of exposure to the hazard of getting HIV infection through heterosexual action.

Five interventions are modelled in ASSA2008 model namely: improvement in treatment of sexually transmitted infections (STIs), voluntary HIVcounselling and testing (VCT), preventing transmission of HIV from mother to child (PMTCT), anti- retroviral treatment (ART), and information and education campaigns and social marketing.

The model generates detailed output which include: the numbers of HIV infected people by sex and age group, number of people suffering from AIDS and other diseases, HIV prevalence rates per risk group, HIV incidence rates, mortality measurements comprising of life expectancy, number of people able to access HIV and AIDS prevention and treatment programmes and number of both children and adults in various stages of AIDS infection. The outputs can be produced for each individual age and year. This makes the model to be extremely flexible. Demographers can also easily customize the model to produce any additional outputs from the original data.

The rate at which the HIV infection spreads is modelled to be a function of both the frequency of sexual exposure and the probability of contracting the HIV in a single sexual encounter. The risk of HIV/AIDS infected individual infecting those who are HIV negative is presumed to vary depending on how long the individual has been infected and whether the individual is using or not using ART. The ASSA2008 model identifies four risk groups. Any individual belongs exclusively to one. The risk groups are: first, the high risky sexual behaviour group. This group is denoted by 'PRO'. It includes people whose probability of contracting HIV is very high. People included in this group are those whose sexual behaviour resembles that of commercial sex workers. Second, the middle risky group. This group is denoted by 'STD'. Third, the low risky sexual behaviour group. This group is denoted by 'RSK.'It includes individual engaged in low levels of sexual behaviour but are still at risk of contracting HIV since on average they have at least one new partner per year and once in a while engage in unprotected sex. Lastly, we have the 'not at risk' group. This category is denoted by "NOT." It includes persons who are completely not exposed to the risk of contracting HIV infection since they don't engage in sex at all.

The risk of infection is therefore modelled to be a function of: the odds of a male partner belonging to a specific HIV risk group, the likelihood of a female partner belonging to a certain risk group, the relative risk of a male transmitting HIV to a female partner during a single sexual contact in all risk groups, the probability of transmitting the HIV virus from a female to male partner in a single act of sex, transmission probabilities per sexual contact for different combinations of risk group encounters, the number of new partners per year and the annual number of contacts per new partner, the number using condom in each risk group by age, the effectiveness of condoms in preventing HIV transmission during sexual act, the relative frequency of sex, the frequency of condom's use and the levels of HIV infectiousness in various stages of HIV disease.

Survival of HIV infected persons is modelled to be a function of the age at which the individual got HIV infection. Young people tend to survive longer when compared to older people. After HIV infection, HIV/AIDS survival is again split into six identifiable stages of the disease. The first four stages of the disease resemble those included in the WHOHIV clinical staging system, which are: the acute HIV infection, the early disease stage, the late disease stage and the AIDS stage. The fifth stage includes people who are receiving Highly Active Anti- Retroviral Therapy (HAART) while the sixth stage epitomises people who have stopped using HAART. It is assumed that, the time that an individual spends in each of the first four stages and the sixth stage follow a Weilbull distribution. The odds of death or discontinuation of HAART in the fifth stage is the same for each year except for the year in which treatment begins, when this probability is thought to be significantly higher.

The main advantages of the ASSA model is that, the parameters and assumptions can be easily changed. The assumptions which can be changed include: the roll out of MTCTP, the uptake of HAART and the level of uptake of VCT services.

2.6.2 SPECTRUM PLUSS EPP Model

SPECTRUM PLUSS EPP Model is a windows-based set of packages which are designed to help policy makers address policy problems pertaining to population dynamics. It is used widely by UNAIDS/WHO to prepare population estimates for most countries. The model was developed and is preserved by the futures Group International which changed its name to Futures Institute.

The SPECTRUM Model comprises of a number of modules. However, the modules of interest in this study are DemProj and AIDS impact module (AIM). DemProj is a population projection package which adopts the standard cohort component approach to population projection. It (DemProj) is used to produce population projections which do not incorporate HIV/AIDS. Then AIM module is used to include the effect of HIV/AIDS into these projections.

To generate an AIM module, the following are required: first, a series of HIV prevalence rates among the adults (males and female 15-49 pooled) for the whole projection duration from the start of the epidemic. Second, the number of new infections each year disaggregated by sex and age. Consequently, the major weakness of AIM is that, the prevalence produced by the model is used as an input into the model.

2.6.3 The EPP Program

The program was developed by UNAIDS/WHO for use in population modelling and estimation. The program is compiled in Java. It fits an epidemiological model to an observed HIV prevalence data collected overtime using maximum likelihood techniques. Bayesian procedures are then used to approximate the level of uncertainty surrounding the epidemic curve (Brown et al., 2010). The program estimates trends in HIV prevalence overtime for both generalised and concentrated epidemics. This is achieved by fitting a curve to available surveillance data. For generalised epidemics, the trends in HIV prevalence are estimated by fitting an epidemiological model to surveillance data by partitioning the population into geographical subdivisions such as provinces. Several HIV trends are created for each of the geographical division. Then the individual curves are pooled to produce a national estimate of HIV prevalence overtime (UNAIDS/WHO, 2009). The UNAIDS reference group decided that a four parameter model is suitable for fitting the HIV epidemic curves (UNAIDS/WHO, 2009). The four parameters are:

t_0 Denoting the date when the epidemic started,

r This is the force of HIV infection. Large values of *r* lead to rapid upsurge in HIV prevalence rate and a smaller value of *r* lead to insignificant increase in the HIV prevalence,

f_0 Denotes the initial portion of the mature population which is at risk of HIV infection and

ϕ Is a behavioural factor signifying how the ratio of new entrants in the adult population exposed to the risk of HIV infections is likely to change overtime? If ϕ is negative it signifies that individuals are reducing their risk of becoming HIV positive and consequently the fitted curve will tend to show a sharper decline after reaching its upper asymptote. If ϕ is zero it implies that the proportion at risk of HIVwill not change and the prevalence of HIVwill start declining after reaching the peak as people start to die of the disease.

In low level and the concentrated epidemics, a fifth parameter denoted by d is included. This parameter accounts for the withdrawal of individuals from the higher risk population groups. The EPP version 2009 computes incidence from HIV prevalence by considering the number of persons in receipt of antiretroviral treatment (Brown et al., 2010). The estimates produced by EPP are then exported to spectrum and are used to generate more estimates of HIV epidemic in a country (UNAIDS/WHO, 2009).

The inputs into DemProj are: base population, past and future TFR, life expectancies at birth and net immigrants categorised by age groups. Besides, the user has to select from a list of the standard mortality and fertility tables, the life table with a shape closest to that of the country being modelled. Incas a user is not certain of these input requirements, the software have capabilities of allowing users to apply “Easy Proj.”Easy Proj facilitates construction of a projection using input data obtained from the UN Population Division’s most recent projections estimates. However, research has shown that these input estimates have some errors which make them unreliable. The software allows users to invoke their user defined “shapes” of mortality and fertility rates by age. However, as far as mortality is concerned, this involves editing the two files and this is not recommended for a novice.

As far as AIM is concerned, the number of AIDS deaths is estimated from the HIV prevalence rates. This is done by applying assumptions relating to: one, the ratio of female to male HIV prevalence. Two, the ratio of prevalence rates by age. Finally, the proportions of infected persons who are estimated to survive each year since the infection.

AIM also permits assumptions to be made about the relationship between HIV and fertility and how fertility is likely to improve due to the provision of ART and PMTCT. Just like with ASSA model, Spectrum has some flexibility as regards MTCTP. However, with the Spectrum model, the setting with regard to changes in the transmission rates and probabilities are limited and fixed. As a result, the user cannot openly modify them. The user can only choose one of the default settings regarding the median breastfeeding interval (0-6 months, 7-17 months, or over 18 months). Although the user can replace most of these assumptions, country specific estimates are usually lacking. This in effect forces users of the model to rely on the default assumptions.

The key strengths of spectrum model are: it is very easy to use, minimum user input is required to run the projections, it is difficult to be accidentally altered and , since it is the one used by UNAIDS/WHO to produce projections, its use encourages conformity with the WHO/UNAIDS standards.

The Spectrum/EPP model has numerous weaknesses. First, the demographic and epidemiological projections are done independently of each other. There is no guarantee of consistency between the demographic and epidemiological modelling. Consequently, there is high likelihood that changes might be taking place in the epidemiological projections that are inconsistent or even incompatible with those being produced in the demographic projections. For example ART is introduced in AIM but not in EPP yet output from EPP is used as input in AIM. Second, the Spectrum model is a compiled program. Anyone using model is restricted to inputting data only without changing the default assumptions. As a result, the model is restricted to only short term projections. Third, the model does not allow inclusion of the effect of STDs on HIV endemic. In fact, the model does not categorise the population in terms of risk groups. This makes it impossible to capture the role of interventions in affecting behaviour change. Fourth, the modelling of HIV/AIDS interventions programs is very partial despite the fact that there exist another package 'GOAL' which is used to price the cost of interventions. However, 'GOAL' works with output from Spectrum and there is no guarantee that the assumptions between 'GOAL' and Spectrum are consistent.

2.6.4 Abacus

Abacus is demographic software applied by the United Nations Population Division (UNDP) to generate population estimates for products published and disseminated throughout the world. Abacus operates using Structured Query Language (SQL) server databases. Because of this reason, it is used internally by UNDP staff (Mulder and Johnson, 2005). The program applies the cohort component method. Population projections are produced in 5-year intervals. A separate module called abcDIM has been added to integrate epidemiological effect of HIV/AIDS on the population. AbcDIM models the epidemic and the demographic consequences associated with it by single years of age and time. The final results are then integrated into abacus to produce a combined population projections which includes the impact of HIV/AIDS (Mulder and Johnson, 2005).

2.6.5 Rural Urban Projections

The Rural Urban Projections (RUP) software was developed by the International Programs Centre (IPC).It is used to produce population projections for internal projects. The program is disseminated to other statistical agencies as part of IPC'S program of technical assistance and capacity building. Processing of output is done using DOS based FORTRAN program. It also has an Excel based interface which is implemented using visual basic for application. This makes the program flexible and easy to use (Mulder and Johnson, 2005). RUPHIV/AIDS module has been designed and incorporated to model the epidemic and project the demographic impact. Results from RUPHIVAIDS are incorporated to RUP to produce a combined population projection including the impact of HIV/AIDS.

2.6.6 NAGELKERKE'S Model

The model's primary purpose was to gauge the comparative merit of diverse stratagems used in preventing and treating HIV. The model has reasonably few data input requirements. The model is encoded using model maker and has been fully described by Nagelkerke et al., (2001).

Nagelkerke model is deterministic in nature. Like in all deterministic models, when this model is used, population projections proceed by splitting the population into a number of groups. Each population group represent: different levels of risky sexual behaviours, different sexes, different stages of HIV infection and different strains of HIV).

The model makes use of few demographic assumptions which include: the initial size of the population in each compartment at the start of the epidemic, a constant (with respect to both age and time), non AIDS mortality rate and the rate at which individuals' transit to the sexually active population.

The model cannot be regarded as demographically sophisticated. Consequently, the model is unsuitable for use in population projections or in assessment of the demographic effect of the epidemic.

2.6.7 SimulAIDS Model

SimulAIDS model was developed by INSERM U88 (Paris) in partnership with the School of Public Health in Kinshasa (Zaire) and Tulane University (USA). This is a stochastic and micro simulation model. The model is used to model the underlying forces of transmitting not only HIV but also other sexually transmitted infections in heterosexual populations.

Since SimulAIDS is stochastic and micro simulation in nature, each individual in the population separately determines the population characteristics. Over 100 parameters are required, as input into the model. The parameter inputs are categorized as: demographic, general sexual behavior, infections through sexual contacts, infections through unsterilized injection, blood transfusion infections, mother to child transmission probabilities of HIV transmission and prognosis for HIV infected individuals.

Each iteration in a specific projection usually takes 1 to 5 days. Since SimulAIDSis a stochastic model it must be run many times in order to define the distribution of possible results.

The model is programmed based on the following assumptions: First, that the demographic parameters are independent of the level of HIV infection. Second, that both fertility and mortality rates will remain constant overtime. This makes the model unsuitable for producing long-term projections.

The model takes into account intervention strategies and establishes their efficiency in combating the spread of the HIV epidemic. The interventions modeled in SimulAIDS are: improved treatment of STD, the health seeking behavior of individuals with STDs, decline in the frequency with which one timesex partnership occurs and increased condom usage among the one time sex partners. The model has been employed in assessing the likely effect of HIV inoculations.

The HIV infected person is presumed to be more infectiousness during the first few weeks of infection. Then, infectiousness drops to lower levels before rising again a few months before progressing to AIDS (in many cases, sexual activities are anticipated to come to an end after this). The model is also capable of simulating the effects of other STDs on vulnerability of individuals to HIV infection.

SimulAIDS allows for modeling of three types of relationships namely: First and foremost, lasting sexual relationships (applying to married individuals). Secondly, temporary sexual relationships. Lastly, the one-time sexual affair. Married individuals are presumed to be less likely to engage in temporary and one time sexual relationships. Although different users assume different survival times for HIV infected persons, duration of survival among HIV infected individuals is categorized into four consecutive stages. First, the severe stage. This stage comprise of the first few weeks of infection. At this stage, the HIV the infected person is regarded to be extremely infectious. Second, the asymptomatic period. Third, the pre- AIDS (symptomatic) period. Lastly, the AIDS phase.
It is assumed that the total time spent in both stage two and three follows a uniform distribution while the time spent in stage one and four is fixed. Robinson et al (1997) used the SimulAIDS

model to simulate the percentage of HIV infections that can be accredited to STDs in a rural area in Uganda.

2.6.8 iwgAIDS Model

The iwgAIDS demographic model was developed by Stanley, Seitz and Way of the Interagency Working Group in 1989 (Stanley et al., 1989). The model has been used by Seitz to explore the epidemiological impact of prophylactic vaccines administered in mature epidemic environments such as Kampala, Uganda and Thailand.Several demographic and epidemiological dimensions are applied to analyze the population effect of the HIV/AIDS epidemic.

It is a deterministic model which is very sophisticated. The data required to fit the model successfully is very extensive. The model assumes that, the risk of HIV infectiousness significantly increases in the initial four weeks of contracting the HIV infection. Then it decreases considerably in the asymptomatic stage of HIV infection.

When the early symptoms of AIDS start showing up, it is assumed that HIV infectiousness will increase again and sexual activities will continueregardless of the emergence of the AIDS defining symptoms. The model can also be used to simulate other sexually transmitted infections which are presumed to increase an individual's susceptibility to HIV and HIV infectiousness

Three types of partnerships are modeled in iwgAIDS just as it is the case with SimulAIDS. The partnerships included in iwgAIDS model are: long-term partnerships for people in stable marriage unions, short- term sexual relationships and "one-off" sexual relationships. Different types of sexual relationships are also allowed in the model. The age of an individual is thought to affect the frequency of changing sexual partners, the frequency of engaging in sexual intercourse, the types of sexual partners and the mode of sexual contact.

The model directly allows for inclusion of HIV program interventions and considers their impact on the epidemic. HIV infected individuals are thought to survive through three stages: First, the acute phase (which lasts for four weeks). Second, the pre-AIDS phase and lastly, the AIDS phase.

2.6.9 Comparisons of the software used in demographic projections

When choosing a model for demographic projections, the guiding principle should be determining whether it can lead to achievement of the study objectives and whether there is sufficient data to act as input into the model. In this study, the objective is to derive sub- national (county specific) population projections. To achieve this objective, a model that takes into account of not only theHIV/AIDS epidemic and migration data but also all interventions that the Kenyan government has initiated to mitigate its effect on population is needed. The model should incorporate both demographic and epidemiological modeling in the same module rather than modeling the two separately. The ASSA2008 model robustly satisfies all these requirements. The ASSA2008 can produce county level population projections which is the main objective this study. Besides, the effects of interventions on the future course of the epidemic can easily be ascertained since interventions are directly allowed in the projection. Moreover, since the model is extremely flexible, it can be customized with ease to produce extra output for use in assessing the economic effect of the epidemic and in health management programs.

If the population under study comprise of more than 10, 000 individual, it is absolutely difficult to apply simulation models in such populations. Since all counties in Kenya have more than 10 000 people, the use of SimulAIDS model in this study is not tenable even though the model is capable of generating detailed output.

iwgAIDS model and Spectrum/ EPP are limited in terms of interventions which can be included during demographic projections. On its part, Spectrum also models demographic and epidemiological projections separately and sometimes it is possible that changes are occurring in one module which may not be compatible with the other module.

Nico NagelKerke's model is not structured on the basis of age and this makes it insufficient from demographic perspective. Thus the output generated may be insufficient for assessing the economic impact of the epidemic and for use in health management programs.

In terms of data availability, the ASSA2008 model requires various demographic, epidemiological and behavioral assumptions. Both SimulAIDS and iwgAIDS have a large number of parameters and is unlikely that there is sufficient data to allow one to estimate all these parameters. The assumptions in ASSA2008 model can easily be changed and more assumptions can be added.

Spectrum on the other hand suffers from numerous draw backs. First, there are restrictions on input. For instance, the user cannot easily change some assumptions like non-AIDS mortality. Second, the model does not model behavior of HIV infected persons. Third, the program interventions modeled are few. Fourth, when compared with ASSA2008, the model has extremely limited interface capabilities. For example, there is no connection between EPP and AIM. This makes Spectrum capable of generating inconsistent results. In addition, the future dynamics of the epidemic is not one of key outputs from the model but it is governed by the user's point of view of the epidemic. These inherent flaws in the spectrum model have made users to doubt its accuracy. Hence, if the performance of each model was to be assessed on the basis of flexibility, transparency and usability, then certainly the most appropriate model for incorporating the effect of HIV/AIDS on population projections at county level in Kenya is the ASSA2008 model.

2.7Regional level trends in fertility and mortality in Kenya.

2.7.1 Introduction

Having discussed the approaches to demographic projections, the projections methods and projections models, it is important to discuss the regional level trends in mortality and fertility in Kenya for the purpose of forming empirical basis for this study. The future is informed by the past and the present. In this subsection therefore, regional trends in fertility and mortality in Kenya are examined.

2.7.2 Regional Trends in fertility in Kenya

Fertility plays a key role in population growth together with mortality and migration. Study of fertility is imperative in appreciating the past, the contemporary and prospective developments in population size, structure and growth. Fertility and other reproductive health constituents such as antenatal care, delivery, post natal care and sexual health are interrelated (GoK, 2013). In addition, drastic changes in fertility may trigger undesirable changes in other processes of human life. This section therefore examines the current fertility as well as trends in total fertility rates at the regional level in Kenya to form a basis in counties fertility projections in Kenya.

There has been a consistent and substantial fall in TFR at provincial level in Kenya. For example, according to the 2009 Kenyan Census, all provinces recorded a decline in TFR between 1999 and 2009. TFR even dropped by more than 10 percent in Central province, Coast province, Eastern, Rift Valley and North Eastern Provinces. Nairobi, Nyanza and Western Provinces recorded the lowest drop in TFR between 1999 and 2009. The low drop in TFR in Nairobi is expected because the population there enjoys higher standards of living. The low drop in TFR Nyanza Province could be attributed to high incidences of HIV/AIDS in the region leading to high maternal and infant mortality rates (KNBS, 2012). The rate of fertility decline varies by subpopulations (province, urban/rural, education). According to Brass and Jolly, 1993, among the provinces in Kenya, Central province recorded the highest overall reduction in total fertility (31 per cent) followed by coast province (27 percent).

Huge differentials in TFR also exist across the counties in Kenya. Kirinyaga County has the lowest TFR of 2.3 while Wajir County has the highest TFR (7.8). Counties in the semi-arid counties in parts of Northern Kenya tend to have the highest TFR (KNBS, 2015). The same pattern is replicated in terms of coverage of HIV testing where Nairobi has the highest coverage at 90 percent, while HIV testing is lowest in Mandera County at 37 percent. Coverage of HIV testing is lowest in counties constituting the North Eastern province and those in the north Rift including, West Pokot, Turkanaand Samburu (KNBS, 2015).

Three possible and plausible explanations for the observed fertility decline in Kenya have been advanced. First, the increased contraceptive prevalence (Blacker, 2002; Brass and Jolly 1993; Ekisa and Hinde, 2005; KNBS, 2015). Second, changing attitudes towards large family size. This is attributable to the high cost of bringing up many children (Robinson, 1992). Third, changes in cultural norms that support high fertility due to modernization (Watkins, 2002; Mutuku, 2008).

While significant progress has been made to increase the contraceptive prevalence rate (CPR) in Kenya, regional variation in CPR still persist. For instance, according to KNBS (2015), contraceptive prevalence rate is highest among currently married women residing in Central region (73 percent) followed by those residing in the Eastern region (70 pecent). North Eastern region has the lowest contraceptive prevalence rate (3 percent) and is home to Wajir County which has the highest TFR (7.8). Kirinyaga County with the highest contraceptive prevalence (81 percent) has the lowest TFR (2.3). CPR is lowest` in most of the counties in northern Kenya including: Wajir and Mandera (2 percent each), Garisa (6 percent), Turkana (10 percent), and Marsabit (12 percent).Regions with the highest contraceptive prevalence rate also turn out to be regions with low total fertility rates.

2.7.3 Regional level trends in child mortality in Kenya

Under- five mortality rate (U5MR) is a fundamental indicator of a general welfare of the child, including health and nutrition status. If under five mortality rate is low, it implies that there is extensive exposure of child survival initiatives and high levels of social- economic development (UNICEF, 2014).Globally, substantial progress has been made to lower under five mortality rate. Consequently, U5MR reduced by 49 percent globally between 1990 and 2013. That is, from 90 deaths per 1,000 live births in 1990 to 46 deaths per 1000 live births in 2013. In spite of these gains, child survival is still an urgent global concern.

Since child survival remains an urgent concern, child mortality has been incorporated in the Sustainable Development Goals (SDGs). The SDG target relating to child survival advocates ending all avoidable deaths of infants and children under five years of age by 2030. All countries are aiming at reducing neonatal mortality to at least less than 12 deaths per 1,000 live births and under-five mortality to less than 25 deaths per 1,000 live births (UNCEF, 2015).

In Kenya, while improvement in Infant Mortality Rates (IMR) has been recorded with IMR dropping from 120deaths per 1000 live births in 1963 to 39 deaths per 1000 live births in 2014, nearly 1 in every 26new children die before celebrating their first birth day and approximately 1 in every 19 children to do not survive to age 5(KNBS, 2015).

There is high regional gap in infant mortality in Kenya with some regions adjacent to Lake Victoria region inhabited by Luo and Luhyia and the Coast Province which is largely inhabited by the Mijikenda having higher infant mortality rates when compared to otherregions and ethnicgroups. In Kenya, child mortality fell rapidly in the early 1960s. Up to 1980the yearly rate of decline in (U5MR) was about 4 percent annually. However in the early 1980sthe rate of decline slowed to almost 2 percent annually. The 1998 Kenya Demographic and Health Survey data clearly exhibited that, instead of decline in U5MR, the U5MRin fact increased by almost 25 percent from the late 1980s to mid-1990s. This trend coincided with other emerging developments particularly stagnation in growth of per capita income, decline in levels of immunization, drop in school enrolment, and the advent of HIV/AIDS epidemic (Hill et al., 2001).

The upsurge in infant, child, and under- five mortality rates was attributedto: the HIV/AIDS epidemic, increase in poverty, declining coverage of child immunisations, increase in childhood malnutrition, severe effects of the economic hardships and cost recovery programs linked to structural adjustment programs, decline in the use of some maternal care services, inability of the public health system to provide health care services and the ethnic clashes which rocked some parts of Rift Valley, Coast, Nyanza and Western provinces (Ikamari, 2004). According to the 2014 KDHS, the level of under-five mortality is 52 deaths per 1,000 live births while infant mortality rate is 39 deaths per 1,000 live births. These rates observed from the 2014 KDHS depict a reduction in the levels of childhood deaths when compared with the rates witnessed in the 2008-09, 2003, and 1998 KDHS surveys. For instance, IMRreduced to 39 deaths per 1,000 live births in 2014 up from 52 deaths per 1,000 live births in 2008-09. On the other hand, U5MR declined to 52 deaths per 1000 live births in 2014 up from 74 deaths per 1000 live births in 2008-09 (KNBS, 2015).

2.7.4 Trends in life expectancy at birth

Life expectancy at birth is a pointer of thegeneral mortality situation in a country or region. In Kenya, there has been a steady decline in life expectancy at birth since 1984 (NCPD, 2013), and now it stands at 59.9 among males, 63.1 for females and 61.5 for both sexes. This makes Kenya to be ranked 159 globally in relation to life expectancy (WHO, 2014). The decline in life expectancy in Kenya was attributed to HIV/AIDS endemic which has adversely affected the well-being and survival of many Kenyans. Despite the fact that the prevalence of HIV has declined from 6.7 percent in 2003 to 5.6 percent in 2012 (NASCOP, 2014), they are still too high. Influenza and Pneumonia are some of the major causes of death in Kenya (WHO, 2014).

2.8 Challenges in demographic projections in Kenya

The most ideal source of data relating to infant and under-five mortality is derived from the vital registration systems. This is because, such systems collect data continuously and they cover the entire population. In Kenya, however, vital registrations systems are not only incomplete and inaccurate but also untimely to carry out this exercise (NCPD, 2013). Therefore data relating to infant and child mortality is retrospectively obtained from their mothers by conducting a census or household survey (NCPD, 2013). While these censuses cover the total population of a country, they are usually carried out in intervals of 10 years and the collected data has a limited scope and depth. To overcome this challenge household surveys which include the demographic and health surveys and the Multiple Indicator Cluster Surveys (MICS) are used as the principal source of data on infant and child mortality in Kenya (NCPD, 2013).

HIV/AIDS epidemic also poses as a key challenge in population projections. AIDS disease was first diagnosed in 1981. Since then, HIV/AIDS has eroded the progress made over the years in prolonging life expectancy in Kenya. Emergence of HIV/AIDS made life expectancy drop from around 64 years to 43.7 years. HIV/AIDS has affected life expectancy through child mortality. This is because many babies' usually contract HIV infections from their HIV infected mother during delivery andas a resultTHEY die early (NCPD, 2013). In absence of HIV/AIDS, U5MR in Kenya was 118 per 1000 live births but with AIDS U5MR was estimated at 98 (UNAIDS, 2006). Almost 20% of all maternal deaths in Kenya are attributable to HIV/AIDS (WHO; UNICEF and WB, 2012).

According to the 2012 Kenya AIDS Indicator Survey (KAIS), national HIV prevalence is estimated at 5.6 percent among Kenyans aged 15 to 64 years. The burden of HIV varies by region with Nyanza province having the highest recorded prevalence level at 15.1%.HIV prevalence is lowest in North Eastern region at 2.1%. Urban areas have consistently recorded higher HIV prevalence than the rural areas (NASCOP, 2014).

Studies have shown that HIV/AIDS is associated with the components of population change particularly fertility and mortality(Sewankambo et al., 1994; Carpenter et al., 1997; Nunn et al., 1997;Todd et al., 1997; Gray et al., 1998;Zaba and Gregson, 1998; Wachter, Knodel, and Van Landingham, 2002; Hunter et al.,2003; Terceira et al.,2003; Lewis et al., 2004; Timaeus and Jasseh, 2004;Garenne et al., 2007; Zaba et al., 2007;Clark et al.,2008; Gregson et al.,2007;).

To overcome the challenges posed by HIV/AIDS in population projection, this study incorporates not only the HIV prevalence at county level but also the likely impact of government interventions geared towards mitigating the impact of HIV/AIDS in Kenyan population. Sections 2.8, 2.9, and 2.10 discusses how HIV affect fertility, mortality and age structure respectively while section 2.11 discusses the interventions put in place mitigate the adverse effect of HIV/AIDS in Kenyan population.

2.9 HIV/AIDS and Fertility change

HIV AIDS can either increase fertility among women or lead to reduction in fertility. Fertility of HIV affected individuals increases when they try to hasten their reproductive decision with the view that they may not live long (Setel 1995). Studies have also shown that decision to terminate a pregnancy is not based on ones HIV sero-status but on whether the pregnancy is wanted or not (Johnson, 1994). Childbirth occurs due to exposure to unprotected sex (which escalates the risk of contracting HIV), and so HIV/AIDS can lead to fertility reduction through an infection evading motive. Studies have also shown that, HIV/AIDS in men causes progressive damages to sperms morphology and functions (Krieger et al., 1991; Gresenguet et al.1992; Crittenden et al, 1992; Politch et al., 1994; Setel, 1995). Although in the initial stages of HIV infections many HIV positive men may still retain seminal parameters consistent with fertility, they eventually experience low sperm count leading to reduced fertility. As the disease advances, the motility and quality of sperms reduces. Studies in Central African Republic have revealed that high rates of seminal deformities are more likely to affect fertility among men as HIV/AIDS disease becomes more severe (Gresenguet et al., 1992). Existing studies reveal that HIV positive women may experience negative fertility outcomes such as miscarriages, spontaneous abortions, and stillbirths. These eventually lower their fertility rates (De Cock et al., 1994; Temmermanet al., 1994). At advanced stages of thedisease, HIV infected women are likely to experience unstable menstrual periods (strecker et al., 1993). Miscarriage would occur if the HIV virus damages the placenta, embryo or the fetal thymus gland making the mother susceptible to opportunistic infections during pregnancy (Gregson et al 1998).

HIV/AIDS infected women may suffer from polymenorrhea (short menstrual cycles) and oligomenorrhea (prolonged menstrual cycles). Women with these conditions are at high risk of tubal infertility (Frankel et al., 1997; Sobel, 2000).

According to Zaba and Gregson (1998), HIV-positive women experience reduced fertility than the HIV-negative women across all age groups except the youngest age –group, and the degree of difference escalates with women's age and duration of epidemic. In absence of contraceptives, HIV- Positive women experience lower relative risk of fertility largely as a result of foetal loss arising from infection with HIV and co-infections with other sexually transmitted ailments.

HIV/AIDS infects both men and women. HIV positive persons especially those who have transitioned to AIDS are more likely to be less fertile when compared to those who are HIV negative. At advanced stages of HIV infection, women are more likely to have an anovulatory cycle (a condition where by a woman experiences menstrual cycles but the ovaries fail to release an egg). HIV positive women most likely suffer from amenorrhea. Amenorrhea is a medical condition characterised by failure to receive menstrual cycles among women of reproductive ages

(Vitaly and William, 2011). On the other hand HIV infected men may suffer from inflamedtesticles and are more likely to produce inadequate testosterone levels. HIV infected men also have decreased sex drive and since HIV infection lead to decrease in CD4 (white blood cell), they are likely to experience: low sperm volume, high sperm motility and low sperm count. These conditions affect fertility (Clayton, 2011).

Fertility desires can also be influenced by an individual's awareness of HIV/AIDS sero-status. High AIDS awareness influence the individuals age at first sex, frequency of sex, use of condoms and the rate of remarrying (Vitaly and William, 2011).

HIV/AIDS can lead to fertility reduction by affecting sexual activities outside of stable unions. Sexual activities outside of stable have been a subject of interest in population and health studies. This isbecause; existence of multiple sexual partners is a key determinant of the rate at which HIV is spread. Ng'weshemi et al., (1996) studied male factory workers in Tanzania in the early 1990's. The findings of the study showed that individual's probability of having a "casual sex partner" declined from 10% to 5%.

HIV/AIDS is also likely to affect post-partum behaviours among women affected by the disease. This occurs particularly when they stop breastfeeding fearing that they may pass the virus to the child. The same concern may also apply to non-infected section of the population who don't know their HIV sero-status or may be suspect that they may be seropositive. A study in this respect was done by Gregson and others (1997) in rural Zimbabwe. The findings of the study showed that women who perceive their risk of HIV infection to be higher are less likely to breastfeed. Undeniably, many women who perceive themselves to be at higher risk are in fact not infected. Holding all factors constant, decreased breastfeeding will definitely lead to increased fertility (Stecklov, 1999).

HIV/AIDS lead to premature death of women in reproductive age, their spouses and their children. This would then lead to population level changes in fertility rates. HIVAIDS has also been recognised as one of the leading causes of maternal mortality globally (Vitaly and William, 2011), Were fertility rates to be un-affected by AIDS mortality, then the selective loss of adults in the reproductive ages can be expected to lead to reduction in the crude birth rate (CBR)-the ratio of total births to total population- since the death of adults in the reproductive age would have a large proportionate impact on the numerator than the denominator of this ratio. The general fertility rate (GFR) is also responsive to the impact of AIDS mortality on age structure, in this case the age structure of women of reproductive age (UN, 2000; Zaba and Gregson, 1998)

Fertility levels can also be altered by HIV/AIDS through the structure of the marriage market, which is affectedby either female or male mortality (UN, 2000).

2.10 HIV/AIDS and Mortality Change

HIV suppresses the immune system of the victims and so people who suffer from it are susceptible to other illnesses. In Kenya, U5MR rose byapproximately25 percent between the late 1980s and the mid-1990s. This increase in U5MR was attributed to HIV/AIDS among other factors (Ikamari, 2004). HIV/AIDS is also linked to maternal mortality. 9% of all maternal deaths in Sub-Saharan Africa are attributable to HIV/AIDS.

The decline in life expectancy in Kenya since 1984 has also been attributed to HIV/AIDS epidemic which has adversely affected the health and lives of many Kenyans (WHO, 2014).

2.11 Effects of HIV/AIDS on age and sex structure

Most of the deaths related to AIDS infections are concentrated in the 25 to 45 age groups. These are the ages where most of the victims are actually parents and experienced workers. So if deaths occur at these ages, then it might distort the age structure of the affected countries. For example because of increase in AIDS related mortality in southern Africa people aged between 20 and 49 years accounted for about three-fifths of all deaths between 2000 and 2005, up from just one-fifth of all deaths between 1985 and 1990 (Ashford, 2006). This also has implication on dependency ratio since there will be more dependants relative to the number to support them.

AIDS disease affects women more than men in some regions. When the HIV affected women die their families are robbed of the primary caregivers. In sub-Saharan Africa and the Caribbean, HIV is predominantly transmitted through heterosexual contact. In these regions, HIV infections are significantly higher among women than men (PRB, 2006).

HIV is likely to change the proportion of women to that of men since majority of the individuals affected by the virus are women. Globally, 48% of all adults living with HIV reside in Sub

Saharan Africa and 59% of all adults living with HIV infections are women. The rates of HIV infection tend to peak among women 5 -10 years earlier than in men. There is also empirical evidence to show that HIV infected women are more likely to die earlier than their male counterparts (WHO, 2004; UNAID, 2006).

Since fertility is significantly lower among HIV infected females when compared to their uninfected male counterparts, there ishigh likelihood that fertility rates will decline. It is also likely that HIV-positive children born to HIV infected mothers will seldom reach childbearing age (UN, 2002; Epstein, 2004; UN, 2007)

The impact of AIDS related mortality on the number of potential births is likely to reshape the age structure in regions adversely affected by HIV. For example, the share of population is predicted to be lesser than it would have been in absence of HIV for some age groups. In South Africa for example, certain age groups are anticipated to account for smaller shares of the population by 2015 than they would have if there was no AIDS.

2.12Interventions to address HIV Pandemic

2.12.1Introduction

The first signs of HIV/AIDS related ailments were recordedin the early 1980s. Since then global and national efforts have been made to address the HIV epidemic. Some of the global initiatives targeting HIV and AIDS epidemic include: Incorporating HIV in the sustainable development goals (SDGs), sanctioning of the global health sector strategy (GHSS) on HIV/AIDS (2011-2015) and, formulating the UNAIDS strategy 2011-2015 on HIV.

In Kenya HIV/AIDS was declared a national disaster in 1999. Consequently, the National AIDS control Council was established to coordinate multi-sectorial response to the growing HIV epidemic (NACC, 2011). The response is guided by a strategic plan that seeks to harmonise and align HIV – related activities of various stakeholders and partners. The HIV response is also anchored on engaging both the civil society and people living with HIV. The National AIDS and STI Control Programme within the ministry of Health administer most of the HIV-related services in Kenya (NACC, 2011). This sub section describes the key interventions that the Kenya government has undertaken in response to the HIV/AIDS pandemic.

2.12.2 Information and education campaigns (IEC) and Social Marketing

The information and education campaigns and social marketing activities are geared towards increasing the use of condoms. Condom social marketing (CSM) started in the mid-1980s and was seen as an ideal method of minimising the spread ofHIV/AIDS (UNAIDS, 2000). For many countries affected by HIV,social marketing initiatives and projects have made condoms not only widely available but also affordable and acceptable to the sexually active individuals in high and low risk groups. The joint United Nations programme on HIV/AIDS (UNAIDS) leads in advocating for global action on HIV/AIDS. UNAIDS garners support for social marketing programmes. At the national level, UNAIDS encourages governments and NGOs to support, develop and implement HIV/AIDS prevention and social marketing initiatives within their countries. Some of the leading social marketing organisation collaborating with UNAIDS are: The Population Services International (PSI), The Female Health Company which manufactures female condoms and the Futures Group Europe (FGE) (UNAIDS, 2000). In Kenya promotion of condom use was started 1990 by Population Services International (PSI). This entailed; creation ofa cheap brand, establishment of a distribution system and creating demand through media campaigns. In 1997, after a two year ban on condom communication, PSI/ Kenya started a let's talk campaign which targeted the 15-24 year males, encouraging partner communication on sexual matters and condom use.

In 1998, the Sema Nami (Talk to Me) movement was started to address barriers to use of condoms. The campaign also focused on increasing both availability and accessibility of condoms. According to the 2014 KDHS, condom use varies by province with Nairobi province having the highest condom prevalence rate.

2.12.3 Prevention of mother to child transmission (PMTCT)

Although 77% of all new infections are as a result of heterosexual intercourse, in Kenya women are more affected by the epidemic than men. According to the2010 UNAIDSestimates, 57.5% of the 1.6 million Kenyans living with HIV were women. The 2010 National HIV indicators for Kenya estimated that 87,000 HIV-positive mothers and their new-borns were in need of PMTCT services in 2010. In absence of interventions, the probability of a mother transmitting HIV to her child is 20 to 45 %. This risk tends to be highest in populations where breastfeeding is prolonged. However, this risk reduces to between 2% and 5% when comprehensive interventions are provided (NASCOP, 2012). The national PMTCT program in Kenya began in 2002. Since then more than 5000 health facilities (>60%) now offer PMTCT services. With this commitment from the government, the uptake of PMTCT services in Kenya have increased to 61% and the revised PMTCT guidelines have been rolled out. Moreover, the PMTCT services have been integrated within antenatal, maternity and child welfare facilities. Consequently, over 81% of all expectant women in Kenya have access to HIV counselling and testing services and 78 % of the HIV-positive women can now access antiretroviral (ARVs) for prophylaxis.

In 2012, Kenya adopted the WHO guidelines that advocate for thecommencement of antiretroviral therapy during gestation period andvisiting antenatal clinic at least four times during pregnancy. The objective of this guideline is to maximise on the support that can be given in order to successfully prevent HIV transmission. Consequently, the number of new paediatric HIV infections in Kenya has reduced by 29% since 2009. About sixty seven percent of expectant women who are HIV sero positive have access to ARVs. In addition, the national scaling up of the Option B+ strategy for lifelong treatment is underway. The key challenge however lies in maintaining women on antiretroviral drugs all through the lactating period. This is because by the six-week, the mother to child transmission rate of 7% increases to 17% at the end of breastfeeding. Nevertheless there is increased paediatric care with 72% of the infants highly exposed to HIV receiving timely infant diagnosis and 41% of the children aged 0 to 14 years infected with HIV currently having access to treatment and care. Waiving maternity users fees has contributed to 50% rise in institutional deliveries (UNAIDS, 2015). Nevertheless, around 40,000 infants are born with HIV each year in Kenya despite improvements in the availability of antiretroviral therapy and PMTCT services.

While there is a decline in MTCT rate amid many challenges, there still exist huge regional disparities in the coverage of effective PMTCT interventions (NASCOP, 2012). The national level statistics suggest that in 2011, 80% of HIV sero-positive expectant women had access to some form of ARV prophylaxis. In addition, 63% of infants exposed to HIV had access to ARV prophylaxis.

2.12.4 Anti-retroviral Treatment (ART)

AIDS was first reported in Kenya in 1984. Significant drop in HIV prevalence has been recorded with HIV prevalence rate fallingto6% in 2012up from to 14% in 1998 (MOH, 2005; GoK, 2014). Despite this drop in HIV prevalence rate, the disease has continued to negatively affect all the sectors of Kenyan economy. In the initial years of the HIV epidemic, major program interventions were geared towards: preventing new infections through creation of

HIV/AIDS awareness and advocating for behaviour change. A large number of HIV/AIDS victims only had access to palliative care because the cost of antiretroviral drugs was not only prohibitive but also beyond the reach of many. However, of late there has been wide spread availability of ARVs. This has consequently changed the fortunes of people living with HIV/AIDS (MOH, 2003). Ultimately, the goal of ART is to lower the probability of transmitting HIV transmission by reducingHIV concentration in the body thus rendering the recipients less infectious. As part of response to HIV epidemic, government through the Ministry of Health has devised guidelines that contain all critical updates that a health care provider requires when using antiretroviral drugs to treat and prevent HIV infections (NASCOP, 2014). The MOH has also reviewed these existing guidelines on HIV infection, prevention and treatment to be consistent with the latest guidance issued by WHO in June 2013.WHO guidelines advocates the following: First, early HIV diagnosis in all population groups. Second, earlier introduction to antiretroviral therapy for children, adolescents and adults including HIV infected pregnant and breastfeeding women, HIV infected spouses and sexual partners in sero-discordant relationships. Third, the use of simplified once –a-day fixed –dose-combination ARVpill to improve adherence and finally, routine viral load testing for all clients on ART (NASCOP, 2014). In Kenya ART services have been availed through the initiatives of the GOK, faith based organisations, non-governmental organisations (NGOs) and by the private sector. Initially, ART services were provided in 15 pilot sites in the late 2003. Experience from these sites led to the scaling up of the program (MOH, 2005).

2.12.5 Voluntary Counselling and Testing

In Kenya testing for HIV and counselling of HIV infected persons was introduced in 2001 (NASCOP, 2008). The goal of HIV testing and counselling (HTC) was to act as the starting point towards preventing, caring and treating HIV related ailments. In 2010, Kenya embraced the UNAIDS concept of universal access (NASCOP, 2008). Voluntary confidential counselling and testing targets behaviour change. People who know their HIV status are empowered to make knowledgeable resolutions relating to their sexual lifestyle that would otherwise prevent them exposing themselves to HIV infection. The Ministry of Health responded to HIV epidemic by incorporating voluntary counselling and testing into the public health care system national strategic plan of 1999 (NASCOP, 2001).

HTC program initially started with three pilot sites that were established in government health facilities. The good reception of this program provided strong basis for the development of the national strategies and principles, which in turn led to the rapid growth that was observed in the first three years of implementation. Consistent with international commitments and a declaration from UNAIDS, Kenya set the goal of having 80% of its population aware of their HIV status by 2010(NASCOP, 2008). According to 2014 KDHS, more women (83%) than men (71%) aged 15 to 49 years reported having gone for HIV testing and received the test results. Huge differentials in HIV knowledge of sero status exist between counties. For example, 83.4% men aged 15-49 years in Nairobi county know their HIV sero status while 44% of men aged 15-49 years in counties in North eastern region know their HIV status (KNBS, 2015).

2.12.6 Syndromic Management of STDs

Globally, over 448 million incident cases of sexually transmitted infections (STIs) (syphilis, gonorrhoea, chlamydia and trichomoniasis) which are curable occur each year (WHO, 2011). The burden of STIs is greatest in Sub-Saharan Africa.STIs can augment HIV infectiousness and susceptibility through a number of mechanisms and consequently facilitate transmission of HIV (Otieno et al., 2014). The WHO has recommended the diagnostic tools and procedures that different countries and regions should adapt to properly manage STIs. However, so many health facilities in developing countries lack both the equipment and trained workers to carry out aetiological diagnosis of STIs. To address this challenge many developing countries have developed and promoted, a syndromic based approach to managingSTI patients as an easy and inexpensive approach for diagnosis of STI (Otieno et al., 2014). Syndromic management approach operates by identifying consistent groups of clinical symptoms and easily recognisable signs (syndromes). Then, treatment that will deal with the majority or the most serious organisms responsible for producing a syndrome is provided. In 2003, WHO devised a simple algorithm for guiding health practitioners when implementing syndromic management of STIs. In the same year, the WHO guidelines were further reviewed to focus solely on syndromic management. Kenya has adopted these guidelines for national programme along with other countries (Otieno et al., 2014).

According to WHO (2011) improvement inthe treatment of STD through syndromic management of STD would lead to reduced risk of HIV transmission. This is because other STDs present in either HIV-negative or HIV –positive partner increases the relative risk of HIV transmission. Syndromic management of STDs was introduced in Kenya in 1995 as an STI projected which was funded by the World Bank. The project was later implemented fully in the field in 1999by making available syndromic care and treatment in nearly all public clinics. In this study, it is assumed that all public health facilities managing STDs follow syndromic management method.

2.12 Conceptual framework

This section presents the conceptual framework adopted in this study. The Study adopts the framework developed by Raymer et al., (2012) for projecting UK population and migration statistics. The model isdeemed appropriate in this study because of its elaborate nature in explaining how population change over time. According to this model, change in population of any nation or region can be influenced by broader social, cultural and natural environments. The complexity of this change can be amplified by variety of possible data sources from which population counts may be derived. According to Raymer et al., (2013), demographic out puts in any geographical area arises through interaction of a number of components namely: Data, concepts, processing and estimation, and Outputs. The model is presented in figure 2.1.

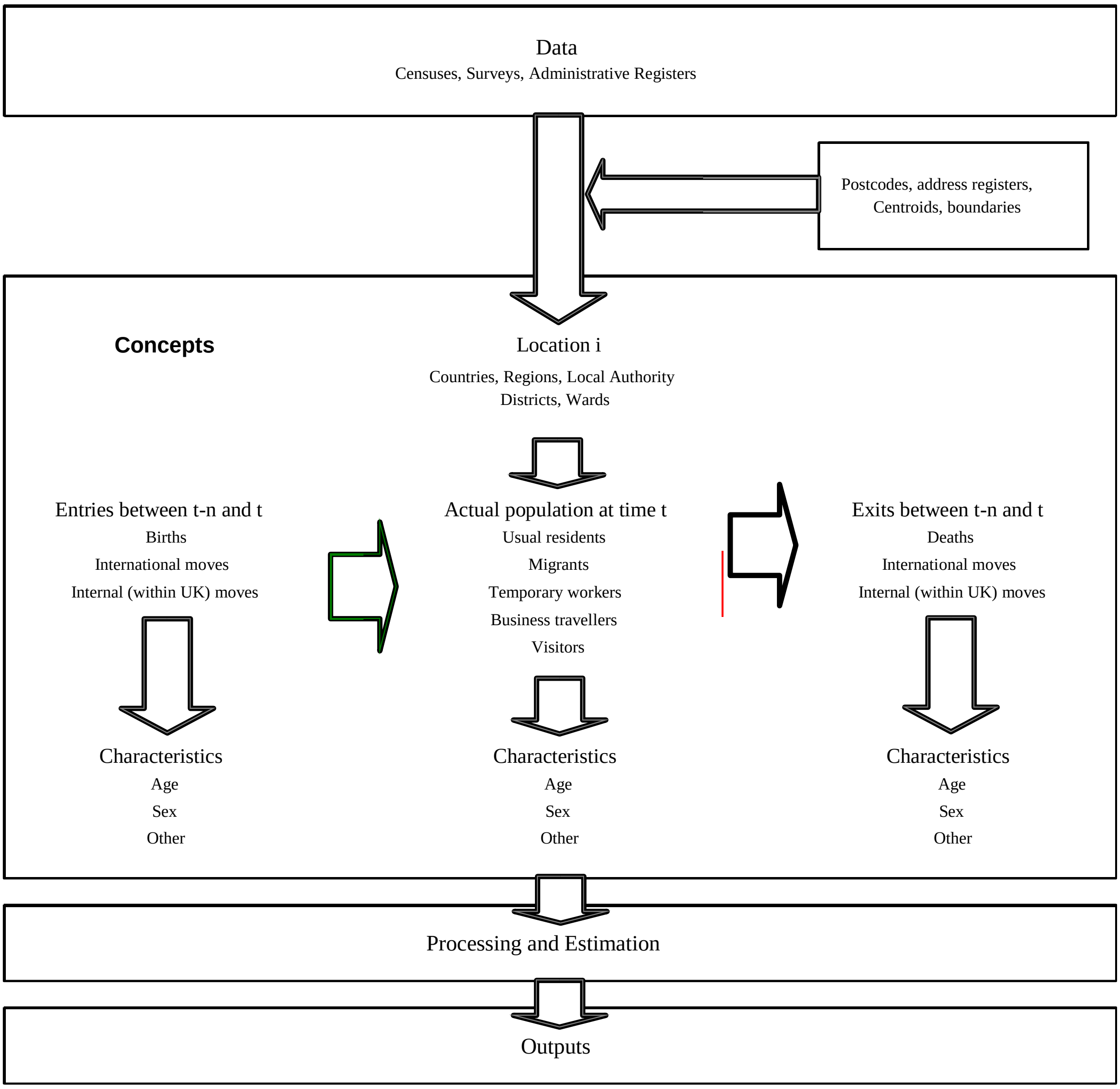

Figure 2.1: Conceptual framework for population projections adopted from Raymer et al., (2012)

From the model presented in figure 2.1, data is the information gathered about the population at a particular time. The main source of population data in Kenya are censuses, surveys and vital registration. Vital registrations are the best sources of population data since they capture vital events as they occur. However, in Kenya like in many developing countries vital registration is incomplete, making demographers to turn to censuses and surveys as the second alternative. From these data the attributes of the population are obtained, key among these attributes being age and sex.

Concepts refer to particular type of population or migrant statistics like usual resident, educational attainment, people under welfare scheme, and non-citizens in a country. Concepts of population can vary depending on the objective of the demographer. But all the same, all types of population estimates can be related to the actual population at time *t* in location *si*milarly, migration concepts can be linked to the movement of people in and out of location *I* between two time points. To project the population of a particular locality, one need to consider the types of entries and exits (including births and deaths) between time points t-n and t where n is the width of the time interval.

Processing involves matching the concepts to data. At times, estimation is needed to combine data. The outcome of data processing and estimation is called output. Demographic outcomes include fertility statistics (including TFR, CBR) and mortality statistics (including Childhood mortality rates and expectations of life).

2.14 Operational Framework

For the purpose of this study, the conceptual framework presented figure 2.1 is modified to incorporate behaviour change that can be attributed to programs/interventions in population projections. This is informed by the fact that HIV/AIDS affect the components of population change and HIV and fertility share the same proximate determinants (UN, 2002) and that up-take of these interventions vary by regions in Kenya. Further, the united nations recommend that in populations where HIV prevalence is greater than 1% (as it is the case in Kenya), then HIV should be incorporated in population projections.

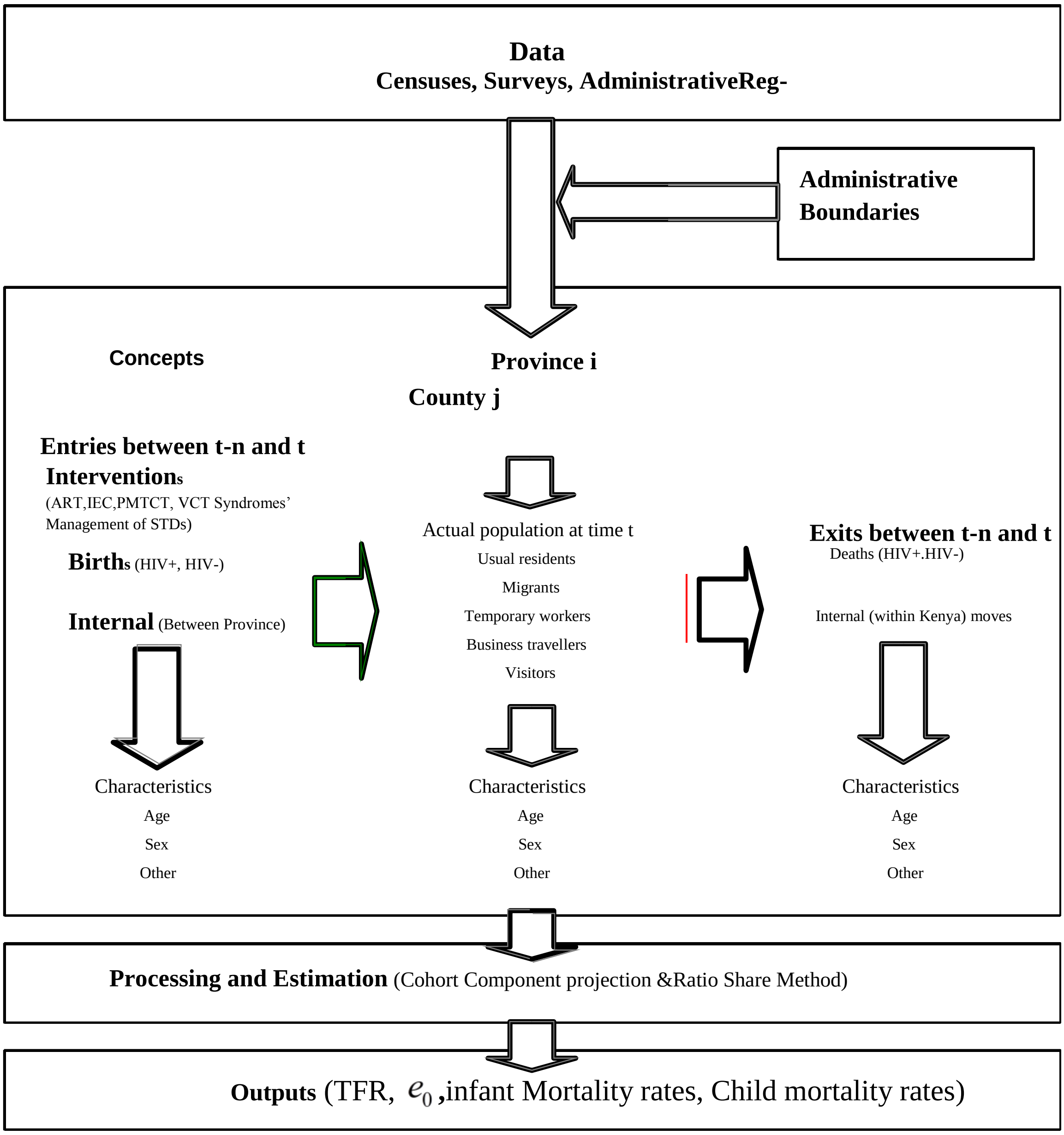

Figure 2.2: Modified Conceptual framework for sub-national population[1] projections adopted from Raymer et al., (2012).

2.15Summary of Literature Review

The review of literature shows that, while population projections have been done in Kenya, the findings are not conclusive. Apart from projections of population size which has been extended to the sub-national level, all other demographic projections in Kenyan are national in scope. Sub-national projections of mortality and fertility which are key components of population change remain undocumented. Kenya is a country with significant cultural differences and socio-economic characteristics and existing data show that mortality and fertility vary by region of residence (KNBS, 2015; CBS, 2002).

A number of challenges arise when doing population projections in Kenya. First and foremost, the existing vital statistics are incomplete, inaccurate and untimely to compute infant and child mortality. This makes information relating to infant and childhood mortality to be obtained retrospectively from mothers by conducting a census or a household survey (NCPD, 2013). Second, requisite data and information on migration and its causes and consequences at sub-national level in Kenya is missing. Data and information on maternal mortality at sub-national levels in Kenya is also missing. Third, causes of death data that can be used to determine the burden of disease is missing. Likewise, data linking poverty, inequality, population and reproductive health indicators is missing (NCPD, 2013). Fourth, HIV/AIDS is a major challenge in population projections in Kenya. Studies have shown that HIV/AIDS is associated with the components of population change particularly fertility and mortality (Sewankambo et al., 1994; Nunn et al., 1997; Carpenter et al., 1997; Gray et al., 1998;Zaba and Gregson, 1998; Todd et al., 1997; Wachter, Knodel, and Van Landingham, 2002; Hunter et al.,2003; Terceira et al.,2003; Lewis et al., 2004; Timaeus and Jasseh, 2004; Zaba et al., 2007;Clark et al.,2008; Gregson et al.,2007; Garenne et al., 2007).

Kenyan government recognising the role of HIV/AIDS in demographic change has put in place intervention to mitigate the negative effect of this pandemic. These interventions include Prevention of Mother to child Transmissions (PMTCT), information and education campaigns (IEC) and social marketing, Anti-retroviral treatment (ART), voluntary counselling and testing, and Syndromic management of STDs. While these interventions affect HIV prevalence, fertility and mortality, the current demographic projections do not take into account all these interventions.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter discusses the methodology employed in the implementation of the study. Section 3.1 extensively discusses the data sources and the data quality checks. Section 3.2 examines the quality of the 1999 and 2009 Kenya Population and housing censuses, section 3.3 gives a synopsis of the quality of 2007 and 2012 KAIS data, section 3.4 reviews the quality of 2008 and 2014 KDHS data while section 3.5 presents the methodology adopted in the implementation of this study.

3.2 Sources of data

The study makes use of provincial base populations, mortality data, fertility data, migration data, HIV/AIDS data, and contraceptive prevalence data. Base population data, mortality, fertility and migration data are drawn from the 1999 and 2009 Kenya Population and housing censuses (CBS, 2002; KNBS, 2010). HIV prevalence data comes from the 2007 and 2012 Kenya AIDS indicator surveys (KAIS). The 2008/2009 and 2014 Kenya Demographic and Health Surveys (KDHS) are used in this study for the purpose of obtaining contraception prevalence rates and to model sex activity function since HIV transmission is not only a function of the age at first sexual intercourse but also the frequency of condom use during sexual acts.

3.3 Quality of the1999 and 2009 Kenya Censuses Data

Before making use of any data, the investigator should first ascertain its quality. Demographic data whether collected in Kenya or elsewhere may suffer from errors which may emanate from problems with the manner in which the data was collected or may arise owing to logistical issues during data collection. These then give rise to coverage and content errors which essentially vary in nature and magnitude from one place to another and one region to another. Coverage errors arise when some elements of the population are omitted while content errors arise from misreporting or misclassifying events. If these errors are not corrected, then estimates made using these data are likely to be unreliable (KNBS, 2012).

Errors in census data may arise when some of the people interviewed fail to remember their exact age or when some people fail to report their actual age correctly. Population categorised by age and sex is one of the basic information needed for future planning. Given the centrality of age sex composition with regard to social- economic characteristics, it is very important that information on age - sex composition be extremely accurate. Hence, it is extremely essential to assess the age and sex composition of the reported population before undertaking population projections. It is on the basis of this that both content errors and coverage errors are evaluated (KNBS, 2012).

3.3.1 Coverage errors

These are errors which occur through: omitting a unit which in essence should have been included; including a unit more than once; or including a unit which should not have been included at all. Sex ratios are commonly used to check for coverage errors. Sex ratios are calculated by dividing the male population in a given age group by the female population in the same age group, and then the results are multiplied by 100. The larger the departure of this ratio from values close to 100, the larger the possibility of errors in the data. Sex ratios below 100 denote under-coverage while those above 100 imply double counting.

3.3.2 Content errors

In developing countries, population data usually suffer from age misreporting which usually could be as a result of a respondent incorrectly declaring his or her age or an interviewer estimating the age of a respondent who does not know his or her age. Hence, there is always a need to evaluate the accuracy of the age distribution and correct for deficiencies whenever necessary. The approaches used to evaluate age misreporting include digit preference and age ratios.

Digit preference also called age heaping result from deliberate miss-statement or ignorance of age on the part of the respondent. To detect the presence of age heaping, some indices are computed. The common being Myer's Index which was used on Kenyan data in both the 1999 and 2009 Censuses. Myer's index assesses digit preference in all the 10 terminal digits (0-9). Terminal digits (0and 5) were highly preferred with zero having the highest preference particularly among the women. Most people avoided reporting ages ending with digits 1 and 9.

Age ratios for the 5-year age groups can also be used to detect age misreporting. If no age misreporting occurs, age ratios tend to be similar throughout the age distribution and they tend to be values close to 100.
Accuracy of a census data can also be tested using the age accuracy index. By use of empirical analysis of age and sex declaration in censuses from a number of developed and developing countries, it is agreed among demographers that the age and sex structure of the population

canbe either accurate, inaccurate or highly in accurate. It is accurate if the joint score index is less than 20.It is inaccurate if the computed joint score is lies between 20 and 40 and highly inaccurate in case the index value is above 40. Accuracy index for the 2009 census data was 23.9 (KNBS, 2012) implying that it was fairly accurate. The 1999 Census data gave an accuracy index of 26.4(CBS, 2002) implying that the census was satisfactorily reported. However as per the 2009 census data regional differentials in accuracy index exist by province. Only western province fell in the category of accurate reporting. North Eastern province had an index of 108 denoting highly inaccurate reporting (KNBS, 2012). The accuracy index of the data in both the 1999 and 2009 censuses is clearly elaborated in the 1999 and 2009 analytical reports on population projections and need not be repeated in this thesis.

3.4Adjusting census data for quality

Since the preliminary analysis of the 2009 Kenya population and housing data for North Eastern province showed massive anomalies which included 8.8 percent annual growth rate, it was necessary to adjust the census data to generate a smoothed age and sex distribution as per UN recommendations and principles. Light smoothing technique were applied to data relating to the following provinces: Coast, Nairobi, Eastern, Nyanza, Central, Rift Valley, Eastern and Western while strong smoothing techniques were applied to data from North Eastern province. These smoothed population data from the various counties were added up to produce national smoothed estimate of population (KNBS, 2012). Procedure for generating smoothed population for counties, provinces and the whole country are extensively covered in the 2009 analytical report on population projections and need not to be repeated in this thesis. Therefore, base population in this study is drawn from the smoothed 2009 Kenya population and housing census data.

3.5 Quality of 2008/2009 and 2014 Kenya Demographic and Health Survey (KDHS) data.

Estimates of mortality are likely to be affected by both sampling and non-sampling errors. Non sampling errors arise from problems which occur in the course of collecting or processing data relating to mortality. Estimates on mortality rely on full reports on children who have died and accurate information on their age at the time of death. Misquoting or miss recording the exact age at which death occurred distort the age pattern of mortality particularly when the net effect of age misreporting arise from children transiting from one age group to the next. Mortality trends are also distorted by displacement of dates of birth. Displacement of dates of birth occurs when an interviewer records a death as occurring in a different year knowingly. This happens when an interviewer tries to simplify the workload because live births which occur during the five year preceding the interview are likely to elicit many additional questions. January 2009 was set as the cut-off for asking these questions in the 2014 KDHS questionnaire. Primary analysis of the 2014 KDHS data showed that the calendar year ratio for the living children was 86 while for the dead children was 78 for the year 2009.In comparison, the calendar year ratios for the living children was 113 and for the deceased was 118 suggesting that some level of births from 2009 to the previous year. The same pattern was also detected in the 2008/2009 KDHS indicating that possibly interviewers were transferring births out of the five-year reference period to lessen their workload (KNBS, 2015).

Survey data also suffer from a problem of selective omission of births of infants who did not survive from birth histories and this automatically leads to underestimation of mortality rates. This problem arises when mothers are unwilling to talk about their children who have already died due to either grieve or cultural stigma. Primary analysis of the 2014 KDHS data indicated that death of infants' were not massively underreported. So the KDHS 2014and KDHS 2008 is reliable for use in this study.

3.6 Projection Methodology

This study focuses on generating county specific population projections. Population changes as a result of interaction of three major components namely: fertility, mortality and net migration. Each of these components of population change is however singly and collectively affected by HIV prevalence. Fertility, mortality, migration and HIV prevalence are separately projected in this study.

3.6.1 Mortality projections

Projecting mortality involves projecting males and females' future life expectancies. This is achieved by computing infant and childhood mortality as well as adult mortality. Data on infant and child mortality come from the Brass questions where mothers are asked to report the number of children they have given birth to and the number which is still alive. With the mother's age and some modelled relationships, these numbers are converted into probability ofa child surviving from birth to a specific average age. Consequently it becomes possible to compute infant and childhood mortality rates. The problem with Brass technique is that it produces results which are seemingly biased downwards in AIDS epidemic.Non-AIDS mortality rates are projected based on exponential extrapolation of the trend in estimates derived in the 2009 census.

Adult mortality is derived from the deaths that have been reported by households to have occurred in the preceding year or so. The 2009 census estimates of adult mortality are used in this study.

3.6.2 Projections of fertility

Fertility is concerned with population increase through births and is measured using a number of measures, the common measure being the total fertility rate(TFR).TFR which is essentially the number of children a woman of child bearing age is expected to give birth to if she was to be subjected to the prevailing age specific fertility rates. To produce fertility projections, the trends of TFR over time are produced. Then, theTFRs produced are translated into age specific fertility rates.

3.6.3 Projecting Migration

While it is easy to take international migration as a small component of the national demographic balancing equation at national level, at sub national level, this is not the case. This is because different regions within the same country may experience different inflows and outflows of migrants due to different opportunities which might exist in different regions. Migrations are also influenced by policies and migration regulations and practices of different countries. The 2009 census showed high internal migration (migration between provinces). For this reason, net migrants per province based on the 2009 census are taken into account in this study.

3.7 Projection methods adopted.

Three methodologies are applied in this study namely: Ratio share Method, standard cohort-component method and the HIV-enabled cohort-component model of population projections (CCMPP).CCMPP was created by Heuveline in 2003 and extended by Thomas and clerk (2011) to derive county level population projections in Kenya. Section 3.7.1 presents the ratio share method, section 3.7.2 presents the standard cohort component method of population projections while section 3.7.3 presents the HIV enabled cohort-component method of population projections.

3.7.1 The ratio share method

Ratio share method is used in this study to generate base data at county level. This is informed by the fact that the study is sub national in scope. In particular, the study focuses on county population projections. As a matter of fact the counties in Kenya came into existence after promulgation of the new constitution in the year 2010. It can be recalled that, the latest Kenya population and housing census was done in the year 2009. As a result, to obtain base data at county level there is need to carry out trend extrapolation employing ratio share approach. Ratio share method used in this study is based on the assumption that since counties are nested on former provinces and provinces nested on the country, then each county contributes a share of the population to that of the entire province. The mathematical function relating to ratio share model as applied in this study is presented in equation 14.

The key strength of this method as it relates to this study is that it requires data from only one point in time hence it facilitates computation of county base data. However, the method has a number of weaknesses. First and foremost, it assumes that the smaller region is growing in tandem with growth in the larger area which is not always the case. Secondly, it is deficient in regard to the information relating to the projected population characteristics. In fact, this method is more adequate only when generating estimates of population size but not on other demographic indicators like TFR. Thirdly the model does not have theoretical back up and so it impossible to link it to the theories of population growth.

Based on the strengths and weaknesses highlighted, this model was used to generate base data at county level. To achieve the study objectives it is necessary to apply other mathematical models which are discussed in the succeeding sections.

3.7.2 The standard cohort- component method of population projections

The standard cohort component of method of population projections is used in this study to generatenon HIV/AIDS population projections at county level. To carry out the population projections, the population is first divided into cohorts and then the demographic components of change namely; fertility, mortality and migration are modelled. While a number of standard cohort models exist, the study being sub national in scope adopts the multi – regional standard cohort models to take into account migration flows between sub regions. The mathematical functions relating to the standard cohort component method are presented in equations 2 and 3. However, the standard cohort method is deficient in incorporating the effect of HIV/AIDS in population projections yet HIV/AIDS is a key challenge affecting population projections at sub-national level. This inherent weakness necessitates the use of the HIV/AIDS enabled cohort component method of population projections which is discussed in subsection 3.7.3.

3.7.3 HIV enabled Cohort component method of population projection (CCMPP)

This method is used because it has capabilities for incorporating not only the HIV prevalence rates but also the effect of program interventions. The method was advanced by Heuveline (2003) and uses HIV incidence parameters to infect individuals who are HIV negative, transitioning them to HIV positive state within the shortest period possible. This approach is useful in computation of "with HIV/AIDS county population projections scenario." This scenario is a key step in isolating the effect of HIV related interventions on county specific population projections. However, the Heuveline approach to population projections does not incorporate program interventions, hence the modifications to Heuveline (2003) work as proposed by Thomas and Clark (2011) is incorporated. Thomas and Clark (2011) advanced the work of Heuveline (2003) to include the effect of antiretroviral treatment in population projections. ARTs form part of the key interventions initiated by the Kenyan government to reverse the effect of HIV/AIDS in its population. The key weakness of Thomas and Clerks approach is that it does not incorporate other key interventions initiated by the Kenyan government in its bid to mitigate the effect of HIV/AIDS in Kenyan population. The interventions lacking in the work of Thomas and Clark (2011) are: information and education campaigns, prevention of mother to child transmission probabilities, voluntary HIV counselling and testing and syndromic management of sexually transmitted infections. Based on the deficiency of the works of Heuveline (2003) and Thomas and clerk (2011), modifications were made to include the following interventions in county specific population's projections: information and education campaigns, prevention of mother to child transmission probabilities, voluntary HIV counselling and testing and syndromic management of sexually transmitted infections. The motive behind this was to isolate the effect of these interventions on population projections at county level in Kenya.

Under CCMPP approach to population projections, the future population of a county is obtained by adding births and persons moving into that county during the projection period to the existing population. Then the number of dead persons and those moving out of the county are subtracted. Fertility, mortality and migration rates are then projected in five year intervals for 17 age groups.

The mathematical notation relating to the cohort component method is represented in equations 2 and 3.

For populations with HIV prevalence rate that is greater than 1%, the United Nations recommend that mortality should be projected while incorporating the impact of HIV/AIDS (Shryock and Siegel, 2004). As a result, HIV prevalence's are introduced per province. Then, a set of age specific incidence parameters are used to infect people who are HIV negative transitioning them to the first HIV positive category in the shortest possible duration. Since the main mode of HIV transmission in Kenya is through heterosexual union, introducing HIV infections into the projections starts with modelling sexual activities. Sex activity is a function of average age at first sexual intercourse, prevalence of the infection in the age group and probability of infection within an age group. Thus, for an individual aged x years in a given province, probability of HIV infection according to Dorrington et al., 2010, is modelled as:

$$S(x) = \frac{(x-c)e^{-b(x-a)^2}}{c} \quad \ldots\ldots 17$$

In equation 17;
S(x) is the probability of HIV infection for an individual aged x years in a province.
a is the median age of first sexual contact
b is the prevalence of HIV by age
c is a scale factor so set such that s(x)=1

To start the projection, the population is first categorised in terms of duration of HIV infection. Five HIV duration groups are identified. The first four groups namely: less than 5 years, 5 to 9 years, 10 to 14 years, and 15 and above years represents those people who are already HIV sero positive. The fifth category includes individuals who are HIV sero negative. In addition, the population is further categorised into seventeen age groups (0 to 4, 5 to9,.., 80+).Then, the probability of transmission of HIV in a particular risk group is computed. These probabilities are then related to fertility and mortality to give the influence of the epidemic on fertility as well as the force of mortality.

HIV infection depends on the risk of exposure to the virus and individual are classified into four risky groups based on the risk of exposure to the virus namely: High exposure, medium exposure, low exposure and not exposed. Highly exposed persons are those in high level of exposure like commercial sex workers while not exposed persons are those not engaged in sex at all.

Suppose an individual is in risk group *i* and is aged x years, then the probability of that person being infected with HIV in the year is modelled as:

$$1-\left\{1-a(x)\left(1-\sum_{j=1}^{4} w_{ij}\sum_{y=14}^{59} h(y/x)\sum_{t=1}^{6} P_{tj}(y)\left[1-T_{tij}(y)\right]^{n_{ij}\sqrt{s(y)D_t}} -\left(1-\sum_{j=1}^{4} w_{ij}\sum_{y=14}^{59} P_j(y)h(y/x)\ \right)\ \right)\right\}^{m_i\sqrt{s(x)}}$$

……………………………………………………………………………………………18

In equation 18;

a(x) =1 for women aged over 25 and for men it is a factor denoting the increase in probability of HIV infection per partnership in women aged x years.

w_{ij}: proportion of partners in risk group j.

$P_j(y)$: proportion of persons aged y-year old who are HIV positive and arein risk group j.

$P_{tj}(y)$: proportion of persons aged y-year old who are in risk group *j*, are HIV sero positive and in stage *t* of the disease.

t:represent the stage of the disease. Six stages of HIV are defined in this study. The first four stages are similar to those stated in the WHO Clinical Staging System. Stage 5 includes those people receiving anti-retroviral treatment (ART) while the 6thstage includespersons who have discontinued ART.

$h(y/x)$: Proportion of partners aged y.

n_{ij} : Number of sexual acts a person is likely to have with each partner in risk group j.

S(x): Sex activity indexas at age x.

m_i : Number of sexual partners a person has per year.

D_t : Factor by which the amount of sex is reduced in stage t of disease.

$T_{tij}(y)$: Probability of an HIV positive person aged y-years, in stage t of the disease and in risk group*j*transmitting the virus to a partner in risk group *i*, during a single act of sexual contact.

$T_{tij}(y)$ is computed as follows:

$$T_{tij}(y)=r_{ij}.I_t\left[1-(1-\left[1-f_j(y)\right]R_t)e\ \ \right]$$ ……………………………………………………..19

In equation 19;

r_{ij} Represent the odds of an individual i being infected with HIV during a single act of un-protected sex with a person in risk group j.

$f_j(y)$: Odds of condom use by a partner

e: Effectiveness of condom in preventing transmission of HIV

I_t : Factor denoting the increase in the hazard of HIV transmission in each single act of unprotected sex in stage *t* of the disease.

R_t: Factor signifying the reduction in acts of unprotected sex in stage t of the disease (Dorrington et al., 2010).

3.8 Program interventions and behaviour change

Theeffects of both prevention and treatment programs on unsafe sexual behaviour arepermitted. HIV transmission likelihoods and survival of individuals infected with HIV is also permitted. Five interventions are modelled in this study namely: improvement in treatment of sexually transmitted infections; information and education campaigns (IEC) and social marketing; voluntary counselling and testing (VCT); mother to child transmission prevention (MTCTP) and anti-retroviral treatment (ART). The rate of phase in of these programs per province and county is modelled in this study. For example, individuals seeking MTCTP and ART services are counselled and tested before joining the program and so the behaviour change that take place under VCT program is assumed to occur under MTCTP and ART programs. STDs increases the risk of HIV transmission in both HIV+ and HIV- individuals and so improvement in treatment of STDS reduces the risk of HIV transmission. On the contrary, ARTs lowers the concentration of HIV in the body making the individual less infectious.

3.9 HIV force of mortality

Individuals infected by HIV experience additional force of mortality different from those individuals who are HIV negative.

Let the population be subdivided into 17 age groups such that a=1,2,3,..,17 corresponding to the age groups 0-4,5-9,..,80+.Let d represent affiliation of an individual to the HIV duration groups where $1 < d < 5$correspond to HIV-, HIV+ for 0-4 years,.., HIV+ for more than 15 years, then individual sick with HIV(d>1) experience extra force of mortality that is not experienced by those in the HIV- state (d=1). This mortality differential is projected as follows:

$$n_{a+1,}d = 2, t+1 = n_{a,d=1,t} s_{a,d=1,t} i_{a,t} s_{a,d=2} \text{.......} 20$$

$$n_{a+1,}d > 2, t+1 = n_{a,d-1,t} s_{a,d=1,t} s_{a,d>2} \text{.......} 21$$

Where $S_{a,d>1} < 1$; survival in the HIV+ state is reduced compared to the HIV- state.

3.10 HIVand Fertility projections

To incorporate HIV in fertility projections, non-HIV fertility rates are multiplied by a factor that is determined as follows:

$$\text{Fertility adjustment factor} = (a-b)c^{d}$$

………………………………………………………………………………………….22

Where

a is a factor so set to imply that those getting pregnant are only those having sex without use of condoms

b denote the initial impact of the virus on fertility

c denote the impact of the virus on fertility overtime

d denote the duration of infection.

3.11 County specific projections

To produce county specific projections, ratio method particularly constant share method is used. Constant share method holds constant the county’s share of the provincial population at a level observed in the launch year. See equation 14.

3.12. Computer programs used in the study

This section presents the computer software used in the implementation of the study. Guided by the study objectives and data availability at county level, a number of computer software’s were used. This section analyses the software’s used and makes recommendation on the most superb software for generating sub national population projections. Subsection 3.12.1 discusses the MORTPAK for windows version 4.3, sub section 3.12.2 discusses the RUPHIV/AIDS software while subsection 3.13.3 analyses the ASSA2008 demographic and epidemiological software.

3.12.1 MORTPAK for Windows (2013) version 4.3

Mortpak for windows version 4.3 was developed by the United Nations Secretariat Population Division, Department of Economic and Social Affairs. The model is programmed using the standard cohort component technique of population projections. In this study the model is used to generate single year national and provincial population projections. This is done so as to produce base data to be used in county population projections. To produce the population projections, data requirements include: base year population, the launch year, sex ratio at birth, model life tables, user defined q(x,n) values, age specific fertility rates, age and sex specific migration patterns as well as assumed mortality, fertility and migration level both at base year and launch year. Input data is derived from the primary analysis of 2009 Kenya Population and Housing Survey conducted by the Kenya National Bureau of Statistics on behalf of the Kenyan government.

The Mortpak software is limited in terms of output generated. In particular, the software is able to facilitate generation of projections of population size both in single and five year age groups throughout the projection period (2009-2030). In addition, the model was useful in generation of number of births, deaths and migration. To generate projections of the other demographic parameters particularly TFR and e(0), trend extrapolation methods employing sine curves and ratio method as proposed by Arriaga (1994) were used. This analysis helped to generate non HIV/AIDS county population projections.

The Mortpak software is silent on the role of HIV/AIDS in affecting population projections both at national and sub national level yet there is wealth of evidence linking HIV/AIDS to fertility, mortality and even migration change. Thus, to achieve the other study objectives, RUPHIV/AIDS model and the ASSA2008 model are employed in this study. Subsection 3.12.2 explores the capabilities of RUPHIV/AIDS while subsection 3.11.3 explores the capabilities of the ASSA2008 demographic and epidemiological software.

Computation procedure proceeds as follows:

1. Identification of the application for use. In this case the PROJCT
2. Defining the launch year
3. Keying in the base year population
4. Stating the projection interval
5. Stating the open age group of base population

6. Including county life table
7. Age specific fertility rates
8. Running the projections

   The output include but is not limited to population by age and sex and life expectancies

3.12.2 RUP and RUPHIV/AIDS model

RUP adopts cohort component approach of population projection. The program was developed by IPC of US census bureau in 1982. The model has been used to generate population projections for internal use although it is also available to other agencies interested in producing population projections. It has excel-based interface making it easy to use for users who have knowledge in demography as well as skills in Microsoft excel. RUP and RUPHIVAIDS are used for the purpose of incorporating HIV/AIDS in county level population. The inputs in RUP program include: total population disintegrated by age and sex (5-year age groups), fertility data (ASFRs, TFRs, Births), Mortality data (Mx, q_x, e_0, deaths both by age and sex), net migration. How RUP works is extensively covered by Mulder and Johnson (2005).

The RUP program is used to generate inputs into RupHivAids Module. How RupHivAids works is extensively discussed by Mulder and Johnson (2005) page 25. However, for the purpose of this study, RupHivAids helped generate the "with HIV/AIDS" county specific population projections. The Key limitation of RupHivAids as applied in this study rests on the number of interventions incorporated in modelling the demographic impact of HIV/AIDS in population projections. In its part, RupHivAids factors in only Mother to child transmission rates for each projection year and proportion of adults in need of ARTs who will receive it each projection year. Given that the Kenyan government has put in place other interventions to mitigate the adverse effects of HIV/AIDS in its population through devolving the health function such as information and Health campaigns, voluntary HIV counselling and testing in addition to syndromic management of sexually transmitted infections, and because of the deficiencies inherent in RupHivAids, the ASSA2008 model is also used in a bid to achieve the other study objectives.

The steps are:

1. Defining the tool for use in this case the PROJE0 and PROJTFR

2. Defining the base year
3. Entering the national population estimates
4. Doing the computation

The output include but is not limited to projected TFR and e(0) by single year.

3.13 ASSA2008 model

The ASSA2008model was developed by the AIDS committee of the actuarial society of South Africa. ASSA2008model adopts the HIV enabled cohort component method of population projections. The software is programmed using visual basic and has a Microsoft excel interface. This capability makes it easy to use by demographers who possess Microsoft excel skills. The ASSA2008 model is used because of its capability in incorporating not only HIV/AIDS epidemic in population projections at county level but also because it allows the effect of interventions geared towards mitigating the effect of HIV/AIDS in county population projections. The following interventions are incorporated in the model: prevention of mother to child transmission prevention, voluntary counselling and testing, anti-retroviral treatment, information and education campaigns and social marketing and improved treatment for sexually transmitted infections. These interventions are incorporated in the projection procedure to produce county specific population projections that integrate boththe effect of HIV and the role of programs in reversing the effect of HIV/AIDS at county level in Kenya. The Key strengths of this model as applied in this study are: it is flexible, the default parameters are easily changeable, demographic and epidemiological projections are incorporated in the same module and unlike the RupHivAids model it incorporates more interventions geared towards mitigating the impact of HIV/AIDS in Kenyan population.

To carry out the projections the following steps are involved:

i. Defining the initial population for each county
ii. setting the assumptions
iii. Including the interventions
iv. Modelling the sexual activity function for each county
v. Including mortality, fertility data
vi. Stating the launch year
vii. Then calibration

The following assumptions are implied:

i. Condom effectiveness is 95%
ii. Perinatal transmission rate is 20%
iii. Breast milk transmission rate is 16%

The output include but is not limited to TFR and e(0) by single years.

CHAPTER FOUR

COUNTY SPECIFIC POPULATION PROJECTIONS WITHOUT TAKING INTO ACCOUNT HIV AND AIDS

4.1: Introduction

This chapter presents the results of the analysis on the non HIV/AIDS county population projections. In particular, non HIV projections of population size, fertility and mortality are presented. This is achieved by applying a number of methodologies. First, the standard cohort component method was applied to produce both national and provincial estimates of the population size. The cohort component method was deemed appropriate because: it is flexible when it comes to population projections; it can incorporate many application techniques, types of data, and assumptions regarding future population change; it can be applied at any level of geography, from nations down to states, counties, and sub county areas; it provides projections not only of total population but also of demographic composition and individual component of growth. Secondly, due to limited demographic data at county level, trend extrapolation methods particularly simple extrapolation and the ratio share method were used to produce county demographic projections. Because of limited data at county level, it was necessary first to generate both national and provincial population projections to produce base data for county specific population projections. Section 4.2 presents' the national population projections, section 4.3 presents provincial population projection, section 4.4 focuses on county population projections while section 4.5 and 4.6 focuses on fertility and mortality projections respectively.

4.2: National Population Projections

Because of limited data at county level, national population projections were generated for use as input data at the county level. National projections were used to gauge the suitability of the model. National population projections were done usingthe standard cohort component method for projecting population by age and sex. The procedure involved following cohorts by single years of age. The interpolated values of central death rates from life tables are used to estimate the number of deaths and to subtract them from each cohort. The procedure also takes into account net migration. In short, the methodology follows a group of people in an age group at a point in time as they survive and become older, at the same time accounting for the three demographic components of change namely: births, deaths and migration.

Table 4.1 shows the projection results under a set of assumptions. The assumptions are as envisioned in the Sessional Paper No. 3 of 2012 on population policy for national development. Key among these assumptions is that the total fertility rate (TFR) will fall to a low of 2.6 by

2030, while life expectancy will reach 64 years by 2030. National non HIV/AIDS population projections are as presented in Table 4.1.

Table 4.1 National Population Projections, Kenya, 2010-2030.

Year	Males	Females	Total
2010	19065606	19443860	38509466
2011	19619596	19993110	39612707
2012	20180832	20551022	40731855
2013	20749280	21116897	41866177
2014	21323642	21689263	43012905
2015	21902688	22266758	44169446
2016	22485307	22848162	45333469
2017	23070371	23432268	46502639
2018	23656845	24017980	47674825
2019	24243778	24604302	48848080
2020	24830269	25190102	50020371
2021	25415212	25774279	51189492
2022	25997505	26355863	52353368
2023	26576191	26933834	53510026
2024	27150216	27507081	54657297
2025	27718242	28074229	55792471
2026	28280320	28635278	56915597
2027	28836661	29190377	58027038
2028	29385868	29738106	59123974
2029	29926322	30275950	60202272
2030	30456195	30801792	61257987

Source: Analysis of 2009 KPHC data

As expected, Table 4.1 shows that Kenyan population is projected to continue growing. It is estimated that the population of Kenya is 46.5 million as at 2017 and will be 50.02 million by 2020, 55.8 million by 2025 and 61.3 million by 2030. This is to be expected since TFR is still high and infant and childhood mortality have been showing improvements over the years.

Table 4.2 compares the projections produced in this study with those generated by KNBS (2012) and the United Nations population division to gauge the suitability of the model

Table 4.2: Comparison among national projections generated in this study and those from The UN and KNBS(2012)

	Year			
	2015	2020	2025	2030
UN(Median assumption)	47236.27	53491.69	60063.16	66959.99
KNBS	44156.58	50319.25	56998.89	63859.55
DATA	44169.45	50020.37	55792.47	61257.99

Source KNBS(2012), analysis of 2009, KPHC

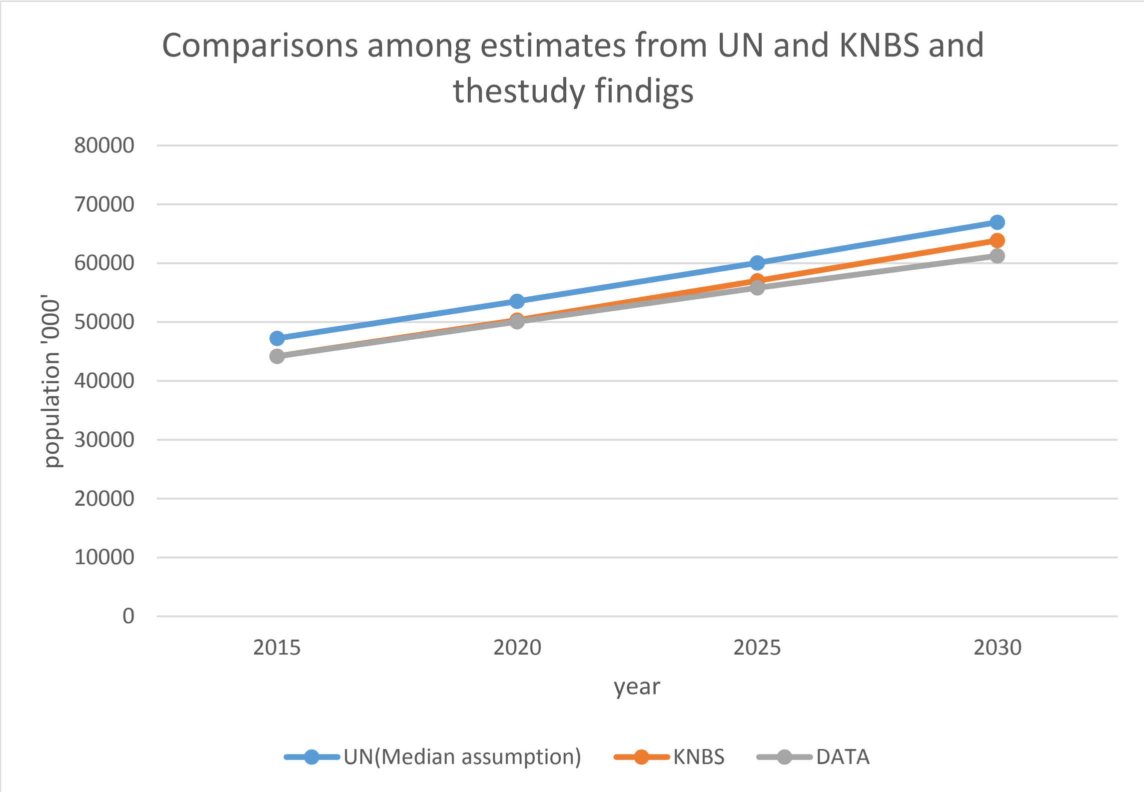

Figure 4.1: Comparison among research data and findings from KNBS, 2012 and UN estimates

Results presented in table 4.2 and figure 1 indicate that the national projections generated in this study are close to those produced by the KNBS (2012) The slight variations in the estimates could be attributed to the fact that the results presented here do not include the effect of HIV and AIDS while those computed by KNBS (2012) include the effect of HIV/AIDS. However, they are slightly lower than those produced by UN under medium variant. The models are therefore deemed to be superb enough for use in population projections in this study.

4.3 Provincial Population Projections

After deriving the national non-HIV/AIDS population projections, the next task was to compute provincial population projections. The purpose of this was to gauge regional variations in population growth. Provincial Population projections were also deemed to be very necessary in this study for the purpose of generating base data for county projections due to lack of adequate data at county level. To generate provincial population projections, the standard cohort component method of population projections was used. The cohort component method of population projections involved following a group of people in an age group at a point in time as they survive and become older, at the same time accounting for the three demographic components of change namely: births, deaths and migration.

The results of the analysis are as presented in Table 4.3

Table 4.3 Provincial Population Projections.

YEAR	NAIROBI	CENTRAL	EASTERN	COAST	NYANZA	WESTERN	RIFTVALLEY	NORTH EASTERN

2010	3134798	4381751	5765056	1860966	5440230	4332004	7532470	2310018
2011	3309219	4481856	5911892	1900267	5537242	4450017	7775870	2334926
2012	3484055	4583400	6061052	1941438	5641942	4571243	8025230	2362008
2013	3659378	4686228	6211886	1984140	5753524	4695463	8280027	2391279
2014	3835217	4790171	6363946	2028276	5871395	4822450	8539948	2422786
2015	4011565	4895188	6517077	2073798	5995058	4951985	8804826	2456662
2016	4188270	5001337	6671256	2120670	6124089	5083848	9074541	2493095
2017	4365019	5108685	6826446	2168863	6258093	5217776	9348912	2532245
2018	4541443	5217289	6982588	2218331	6396690	5353471	9627668	2574243
2019	4717196	5327161	7139552	2269018	6539479	5490594	9910437	2619178
2020	4891991	5438247	7297042	2320849	6686025	5628761	10196719	2667083
2021	5065528	5550466	7454617	2373731	6835843	5767539	10485906	2717936
2022	5237441	5663728	7611783	2427548	6988442	5906454	10777290	2771664
2023	5407401	5777904	7768045	2482172	7143354	6044994	11070060	2828115
2024	5575263	5892839	7922894	2537447	7300100	6182581	11363214	2887014
2025	5741089	6008317	8075747	2593178	7458058	6318509	11655489	2947948
2026	5905189	6124217	8226262	2649098	7616709	6452182	11945709	3010487
2027	6067957	6240417	8374107	2704963	7775695	6583131	12232791	3074199
2028	6229848	6356647	8518777	2760587	7934580	6710804	12515487	3138573
2029	6391571	6472587	8659902	2815755	8092873	6834649	12792441	3203042
2030	6553635	6587797	8797245	2870196	8249924	6954101	13062113	3266958
Annual growth	0.037	0.020	0.021	0.022	0.021	0.024	0.028	0.017

Source: Analysis of 2009 KPHC data

As shown in Table 4.3, without HIV/AIDS, population in all provinces is projected to grow continuously throughout the projection period. Rift valley province is projected to remain the largest province in terms of population size while Coast province is projected to be the smallest province in terms of population size. Slight variation in terms of provincial population ranking is expected to be witnessed. If the provincial administration was to remain, then the population size in western province would bypass that of central province by 2030. This is to be expected since TFR is relatively higher in western province compared to that in central province.

In terms of annual rate of population growth, the population of Nairobi province is expected to experience the highest annual rate of growth growing by 3.7% per annum.This could be attributed to the fact that Nairobi is the capital city of the republic of Kenya and attracts people from all other regions who go there in search of employment and even better health care. In fact, according to the 2009 Kenya population and housing census, Nairobi province recorded the highest number of net migrants (KNBS, 2012). The population of Rift valley and Western provinces is projected to grow by 2.8% and 2.4% per annum respectively. This is to be expected because these provinces house counties that have recorded high TFR and ideal family sizes. For example, according to the 2014 KDHS, Rift valley province with a TFR of 4.5 house West Pokot county with a TFR of 7.2, Turkana county with a TFR of 6.9, Samburu county with a TFR of 6.3 and Narok county with a TFR of 6.0. Indeed, except three counties namely (Uasin Gishu, Nakuru and Laikipia) all other counties in Rift valley province have TFR of 4 and above. Similarly, all counties in Western province have TFR greater than 4.0(KNBS, 2015).

Coast,Eastern,Nyanza and Central provinces are projected to have annual population growth rates of 2.2%, 2.1%, 2.1% and 2.0) respectively. The lowest rate of annual population growth is projected to be in North Eastern province at 1.7%.

4.4 County Population Projections

After computing the provincial population projections, the next challenge was computing county population projections. Because of limited data at county level, the ratio share method, in particular constant share of provincial population was used to produce county population projections. The methodology involved holding constant the county's share of provincial population at a level observed in the launch year. 2010 is used as the Launch year in this study. The mathematical function relating to constant share method as applied in this study is presented in equation 14

Table 4.4 shows the results of the analysis.

Table 4.4 County Population Projections 2010-2030

Year	2010	2011	2012	2013	2014	2015	2016	2017	2020	2025	2030
Kenya	38509466	39612707	40731855	41866177	43012905	44169446	45333469	46502639	50020371	55792471	61257987
Nairobi	3134798	3309219	3484055	3659378	3835217	4011565	4188270	4365019	4891991	5741089	6553635
Central	4381751	4481856	4583400	4686228	4790171	4895188	5001337	5108685	5438247	6008317	6587797
Nyeri	709595	725806	742251	758903	775736	792743	809933	827317	880687	973006	1066849
Nyandarua	610017	623953	638090	652406	666876	681496	696274	711219	757100	836464	917138
Kiambu	1660366	1698299	1736776	1775741	1815128	1854921	1895144	1935821	2060701	2276717	2496298
Muranga	964170	986197	1008541	1031168	1054040	1077148	1100505	1124126	1196644	1322083	1449593
Kirinyaga	540247	552589	565109	577787	590603	603551	616639	629874	670507	740794	812241
Coast	3396107	3490981	3587395	3685022	3783533	3882654	3982151	4081798	4379968	4869461	5339953
Mombasa	959187	985983	1013214	1040787	1068611	1096606	1124708	1152852	1237066	1375317	1508202
Kwale	663906	682453	701301	720386	739644	759021	778472	797952	856241	951932	1043909
Kilifi	1133208	1164865	1197037	1229613	1262484	1295558	1328758	1362008	1461501	1624834	1781828
Tana River	245301	252154	259118	266169	273285	280444	287631	294828	316365	351721	385705
Lamu	103716	106613	109558	112539	115548	118575	121614	124657	133763	148712	163080
Taita Taveta	290789	298912	307168	315527	323962	332449	340969	349501	375031	416944	457229
Eastern	5765056	5911892	6061052	6211886	6363946	6517077	6671256	6826446	7297042	8075747	8797245
Marsabit	297817	305402	313108	320900	328755	336666	344630	352647	376958	417185	454457
Isiolo	146567	150300	154092	157927	161793	165686	169606	173551	185515	205312	223655
Meru	1387275	1422609	1458502	1494798	1531389	1568238	1605339	1642683	1755925	1943308	2116926
Tharaka	373672	383189	392857	402634	412490	422416	432409	442468	472970	523443	570209
Embu	528000	541448	555109	568923	582850	596875	610995	625209	668309	739628	805707
Kitui	1035831	1062214	1089014	1116115	1143436	1170950	1198652	1226535	1311089	1451002	1580637
Machakos	1123672	1152292	1181365	1210764	1240402	1270249	1300300	1330548	1422273	1574051	1714679
Makueni	904725	927768	951176	974847	998710	1022742	1046937	1071292	1145143	1267348	1380574
North Eastern	2310018	2334926	2362008	2391279	2422786	2456662	2493095	2532245	2667083	2947948	3266958
Garisa	623060	629778	637083	644978	653476	662613	672440	682999	719368	795123	881167
Wajir	661941	669078	676839	685227	694255	703962	714402	725621	764259	844741	936154

Year	2010	2011	2012	2013	2014	2015	2016	2017	2020	2025	2030
Mandera	1025756	1036816	1048842	1061840	1075830	1090873	1107051	1124435	1184310	1309027	1450682
Nyanza	5440230	5537242	5641942	5753524	5871395	5995058	6124089	6258093	6686025	7458058	8249924
Siaya	860216	875556	892111	909754	928392	947946	968349	989538	1057203	1179277	1304488
Kisumu	989514	1007159	1026203	1046499	1067938	1090431	1113900	1138274	1216109	1356533	1500564
Homabay	984293	1001845	1020788	1040977	1062303	1084677	1108023	1132268	1209693	1349376	1492647
Migori	936675	953378	971405	990617	1010911	1032203	1054419	1077491	1151171	1284096	1420436
Kisii	1176791	1197776	1220424	1244560	1270057	1296807	1324718	1353705	1446272	1613273	1784564
Nyamira	610976	621871	633630	646161	659399	673287	687778	702828	750888	837592	926524
Rift Valley	7532470	7775870	8025230	8280027	8539948	8804826	9074541	9348912	10196719	11655489	13062113
Turkana	873575	901803	930723	960273	990417	1021136	1052416	1084236	1182560	1351740	1514873
West Pokot	523709	540632	557969	575684	593756	612172	630924	650001	708946	810370	908168
Samburu	228762	236154	243727	251465	259359	267404	275595	283928	309676	353979	396698
Trans Nzoia	836332	863357	891043	919333	948193	977602	1007549	1038012	1132144	1294112	1450290
Baringo	567516	585854	604642	623839	643422	663379	683700	704371	768247	878155	984134
Uasin Gishu	913027	942530	972756	1003640	1035146	1067252	1099945	1133202	1235966	1412787	1583287
Elgeyo Marakwet	377942	390155	402666	415451	428492	441783	455315	469082	511621	584815	655392
Nandi	769022	793872	819330	845343	871880	898922	926459	954470	1041027	1189959	1333567
Laikipia	407658	420831	434326	448116	462183	476518	491115	505964	551847	630796	706923
Nakuru	1637474	1690386	1744594	1799984	1856488	1914070	1972703	2032348	2216652	2533772	2839556
Narok	868770	896843	925603	954991	984969	1015519	1046627	1078272	1176056	1344305	1506541
Kajiado	701919	724600	747837	771581	795802	820484	845618	871186	950189	1086126	1217203
Kericho	768350	793178	818614	844605	871118	898137	925649	953636	1040117	1188919	1332402
Bomet	745617	769710	794394	819615	845344	871564	898262	925421	1009343	1153742	1292980
Western	4332004	4450017	4571243	4695463	4822450	4951985	5083848	5217776	5628761	6318509	6954101
Kakamega	1698576	1744849	1792381	1841088	1890880	1941670	1993374	2045887	2207034	2477483	2726699
Vihiga	567387	582844	598721	614991	631623	648589	665860	683402	737231	827571	910818
Bungoma	1406776	1445100	1484467	1524806	1566044	1608109	1650930	1694422	1827885	2051874	2258276
Busia	761065	781798	803096	824919	847229	869986	893152	916681	988885	1110063	1221726

Source: Analysis of 2009 KPHC data

As shown in Table 4.4 all counties are expected to experience tremendous increase in population size. Nairobi County will continue to play a leading role in terms of population size. If there was no HIV/AIDS, most of the counties would maintain their rankings in terms of population size by 2030. Table 4.5 presents county population rankings in 2010 and 2030.

Table 4.5: Ranking by most populous counties, 2010 and 2030

Rank	County	2010	Rank	County	2030
1	Nairobi	3134798	1	Nairobi	6553635
2	Kakamega	1698576	2	Nakuru	2839556
3	Kiambu	1660366	3	Kakamega	2726699
4	Nakuru	1637474	4	Kiambu	2496298
5	Bungoma	1406776	5	Bungoma	2258276
6	Meru	1387275	6	Meru	2116926
7	Kisii	1176791	7	Kisii	1784564
8	Kilifi	1133208	8	Kilifi	1781828
9	Machakos	1123672	9	Machakos	1714679
10	Kitui	1035831	10	Uasin Gishu	1583287

Source: Analysis of 2009 KPHC data

Table 4.5 clearly shows that, if there was no HIV/AIDS in Kenya, Nairobi County would be the most populous County by 2030. This is to be expected since Nairobi is a metropolitan county and actually the capital city of Kenya. As a result, it attracts many people from all parts of the country who go there in search of employment. According to the 2009 KPHC, Nairobi County recorded the highest number of net migrants (KNBS, 2012). Apart from Nakuru, Kakamega, Kiambu and Kitui counties, all other top ten most populous counties would maintain their population size ranking by 2030.Marsabit, Samburu, Tana River, Isiolo and Lamu Counties are projected to be the least populous counties by 2030. The findings are however consistently lower than those obtained by KNBS possibly becauseKNBS did not present non HIV/AIDS population projections.

4.5 Fertility projections

Fertility in this thesis refers to the average number of children a woman would give birth to during her reproductive period. Births essentially play a greater role in population growth than any other demographic event because of their multiplier effect since any extra children born nowwill give birth to their own children in the future. Whereas a number of measures can be computed to denote the fertility experience of a cohort, in this study non HIV/AIDS fertility projections are done by projecting total fertility rates (TFR) for national, provincial and county levels.TFR simply represent the sum of the age specific birth rates over all ages of the child bearing period.

To carry out fertility projections both at national, provincial and county levels, the 1999 and 2009 censuses, 2008/2009 and 2014 Kenya demographic and Health Survey (KDHS) fertility estimates were used as input data. At the national and county level, it was assumed that the decline in fertility observed over the years will continue throughout the projection period reaching a lower asymptote of 2.6 at national level as envisioned in the Sessional Paper No. 3 of 2012 on population policy for national development. At the county level, it was assumed that, although the TFR may not necessary plateau at 2.6, steady decline will be witnessed due to devolvement of health functions to the counties. To carry out the projections, interpolation approach employing TFR sine curves was used. TFRSINE curve fitting involved estimating TFR values between two points. That is, the upper point (upper asymptote) and lower point (lower asymptote). Upper asymptote is the point where Total fertility is deemed to have started declining. In this case, the 1999 population and housing census computed TFR was used as the upper asymptote for the purpose of generating national TFR projections. The lower asymptote value of TFR was taken to be 2.6 which is envisioned in the Sessional Paper No. 3 of 2012 on population policy for national development. The 2014, Kenya Demographic and Health Survey data was used for purpose of smoothing the curve. The results of the analysis are as presented in Table 4.6 and Table 4.7.

Table 4.6: Interpolated Total Fertility Rates (Kenya 2010-2030)

Year	TFR
2009	4.4
2010	4.3
2011	4.2
2012	4.1
2013	4.0
2014	3.9
2015	3.7
2016	3.6
2017	3.5
2018	3.4
2019	3.3
2020	3.2
2021	3.1
2022	3.0
2023	2.9
2024	2.8
2025	2.8
2026	2.7
2027	2.7
2028	2.6
2029	2.6
2030	2.6

Source: Analysis of 1999, 2009 KPHC data and 2014 KDHS data

As shown in Table 4.6 and figure 4.2, it is evident that if the tempo of fertility decline currently witnessed in Kenya at national level was to continue, then National TFR would reach a minimum of 2.6 by 2030 then plateau at 2.6.This decline in projected TFR could be attributed to increase in contraceptive prevalence rate (CPR) from 46 percent in 2008-2009 to 58 percent in 2014(KNBS, 2016). The decline in TFR could also be attributed to decline in infant and child mortality. Decline in IMR and U5MR contribute to reduction in TFR when women cease to give birth to too many children as insurance against those who might die early.

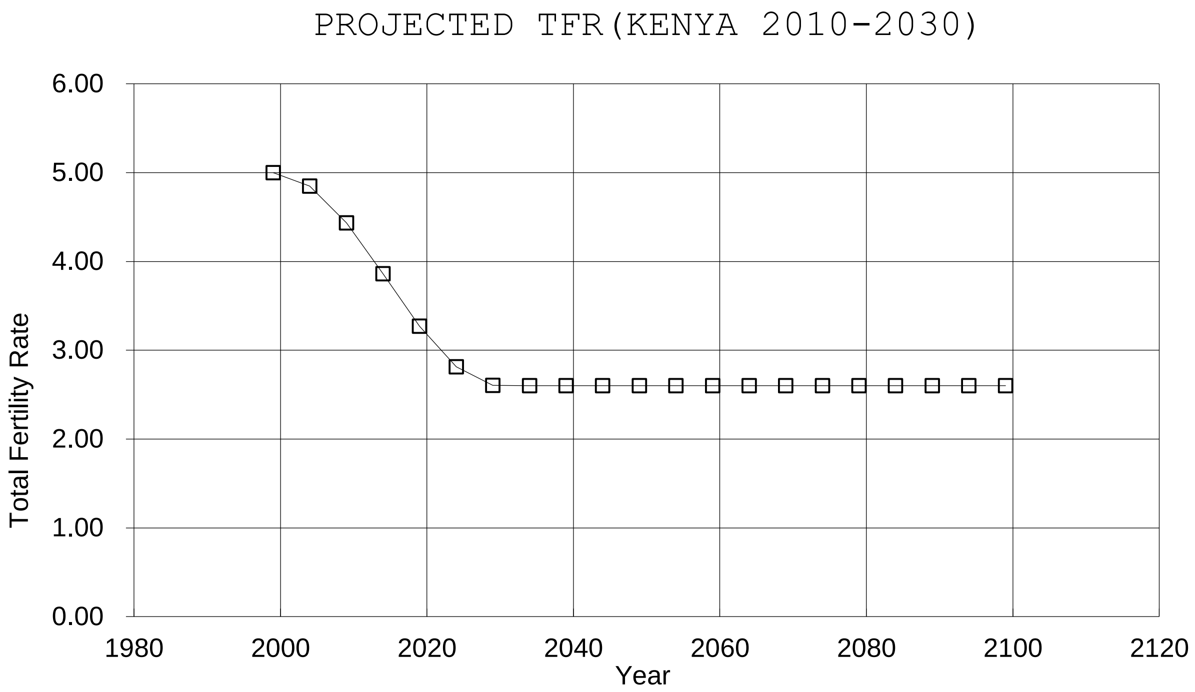

Figure 4.2: Projected TFR (Kenya 2010-2030)
Source: Analysis of 1999, 2008/2009 KDHS, 2009 KPHC data and 2014 KDHS data

4.5.1 County Level TFR projections.

As a result of enactment of a new constitution in Kenya in 2010, the health function was devolved to counties. Because of this reason, it was necessary to carry out fertility projections at county level for the purpose of generating information that can be used for planning at county levels. To carry out the analysis, interpolation method employing sine curve was used. The 2010 Kenya population and Housing census data was used as in put data. To gauge the accuracy of the estimates, projections are first carried out up to 2014 and the results compared with those obtained in the 2014 KDHS. Comparisons are done by carrying out bivariate regression analysis. Results of the analysis are presented in Table 4.7 and Table 4.8.

Table 4.7Bivariate Regression Model Summary.

Model Summary								
R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
				Change Statistics				
				R Square Change	F Change	df1	df2	sig.F change
0.75	0.56	0.55	0.82	0.56	58.31	1	45	0.000

The results indicated a strong and significant positive correlation(r=0.75) between the TFR estimates generated by the model and those obtained in the 2014 KDHS. The adjusted r square generated was 0.55 implying that the model explains more than a half of the variations in the observed TFR values. Based on these results, it is concluded that the model is robust for use in carrying out TFR projections. Table 4.8 presents the 95 % predictive intervals of the 2014 TFR for each county.

Table 4.8: 95% Predictive Interval of the 2014 KDHS County TFR

County	Base year TFR in 2009	TFR projections for Counties in 2014	2014 KDHS TFR	95% CONFIDENCE INTERVALS LOWER BOUND	UPPER BOUND
Nairobi	2.9	2.68	2.7	2.68	2.70
Kirinyaga	3.3	3.00	2.3	2.16	3.14
Kiambu	3.4	3.09	2.7	2.62	3.17
Nyandarua	3.4	3.09	3.5	3.01	3.58
Mombasa	3.4	3.09	3.2	3.07	3.22
Embu	3.7	3.33	3.1	3.06	3.37
Nyeri	3.8	3.41	2.7	2.56	3.55
Tana River	4.7	4.14	5.8	3.82	6.12
Lamu	4.7	4.14	4.3	4.11	4.33
Taita Taveta	4.7	4.14	3.2	3.02	4.32
Nyamira	4.7	4.14	3.5	3.38	4.26
Kisii	4.8	4.23	3.7	3.60	4.33
Machakos	4.9	4.31	3.4	3.22	4.49
Kajiado	4.9	4.31	4.5	4.27	4.54
Nakuru	4.9	4.31	3.7	3.58	4.43
Muranga	5.0	4.39	3.0	2.73	4.66
Kisumu	5.0	4.39	3.6	3.45	4.54
Laikipia	5.0	4.39	3.7	3.57	4.52
Vihiga	5.1	4.47	4.5	4.46	4.51
Uasin Gishu	5.2	4.55	3.6	3.42	4.73
Kericho	5.4	4.71	4.0	3.86	4.85
Tharaka Nithi	5.7	4.96	3.4	3.10	5.26
Siaya	5.7	4.96	4.2	4.05	5.11
Kakamega	5.7	4.96	4.4	4.29	5.07
Makueni	5.8	5.04	3.3	2.96	5.38
Meru	5.8	5.04	3.4	3.08	5.36
Migori	5.9	5.12	5.3	5.09	5.33
Kilifi	6.0	5.20	5.1	5.08	5.22
Kwale	6.0	5.20	4.7	4.60	5.30
Isiolo	6.0	5.20	4.9	4.84	5.26
Nandi	6.0	5.20	4.0	3.77	5.43
Homabay	6.1	5.29	5.2	5.18	5.31

Trans Nzoia	6.1	5.29	5.2	5.18	5.31
Busia	6.1	5.29	4.7	4.59	5.40
Kitui	6.2	5.37	3.9	3.62	5.65
Turkana	6.3	5.45	6.9	5.17	7.18
Garisa	6.4	5.53	6.1	5.42	6.21
Bungoma	6.4	5.53	5.0	4.90	5.63
Marsabit	6.6	5.69	5.0	4.87	5.82
Bomet	6.6	5.69	4.3	4.03	5.96
Elgeyo Marakwet	6.7	5.77	4.1	3.78	6.09
Baringo	7.0	6.02	4.8	4.56	6.26
Wajir	7.1	6.10	7.8	5.77	8.13
Narok	7.2	6.18	6.0	5.97	6.21
Samburu	7.2	6.18	6.3	6.16	6.32
West Pokot	7.5	6.43	7.2	6.28	7.35
Mandera	7.6	6.51	5.2	4.95	6.76

Source: Analysis of 2009 KPHC and 2008/2009 KDHS

The results presented in Table 4.8 further corroborate those presented in Table 4.7. Projections generated by the model are close to those obtained in the most current survey done in 2014. The model is therefore justifiable for use in generating TFR projections at the county level. TFR projections for each county are then generated using the model and the results presented in Table 4.9

Table 4.9 County TFR projections (Kenya 2009-2030)

County	Base year TFR 2009	TFR projections for Counties 2014	2020	2025	2030
Nairobi	2.90	2.68	2.50	2.37	2.28
Kirinyaga	3.30	3.00	2.77	2.59	2.47
Kiambu	3.40	3.09	2.83	2.64	2.52
Nyandarua	3.40	3.09	2.83	2.64	2.52
Mombasa	3.40	3.09	2.83	2.64	2.52
Embu	3.70	3.33	3.03	2.81	2.66
Nyeri	3.80	3.41	3.10	2.87	2.71
Tana River	4.70	4.14	3.70	3.37	3.14
Lamu	4.70	4.14	3.70	3.37	3.14
Taita Taveta	4.70	4.14	3.70	3.37	3.14
Nyamira	4.70	4.14	3.70	3.37	3.14
Kisii	4.80	4.23	3.77	3.42	3.19
Machakos	4.90	4.31	3.83	3.48	3.24
Kajiado	4.90	4.31	3.83	3.48	3.24
Nakuru	4.90	4.31	3.83	3.48	3.24
Muranga	5.00	4.39	3.90	3.53	3.29
Kisumu	5.00	4.39	3.90	3.53	3.29
Laikipia	5.00	4.39	3.90	3.53	3.29
Vihiga	5.10	4.47	3.97	3.59	3.34
Uasin Gishu	5.20	4.55	4.03	3.64	3.39
Kericho	5.40	4.71	4.17	3.76	3.48
Tharaka Nithi	5.70	4.96	4.37	3.92	3.63
Siaya	5.70	4.96	4.37	3.92	3.63
Kakamega	5.70	4.96	4.37	3.92	3.63
Makueni	5.80	5.04	4.43	3.98	3.67
Meru	5.80	5.04	4.43	3.98	3.67
Migori	5.90	5.12	4.50	4.03	3.72
Kilifi	6.00	5.20	4.57	4.09	3.77
Kwale	6.00	5.20	4.57	4.09	3.77
Isiolo	6.00	5.20	4.57	4.09	3.77
Nandi	6.00	5.20	4.57	4.09	3.77
Homabay	6.10	5.29	4.63	4.14	3.82
Trans Nzoia	6.10	5.29	4.63	4.14	3.82
Busia	6.10	5.29	4.63	4.14	3.82
Kitui	6.20	5.37	4.70	4.20	3.87
Turkana	6.30	5.45	4.77	4.26	3.91
Garisa	6.40	5.53	4.83	4.31	3.96
Bungoma	6.40	5.53	4.83	4.31	3.96
Marsabit	6.60	5.69	4.97	4.42	4.06
Bomet	6.60	5.69	4.97	4.42	4.06
Elgeyo Marakwet	6.70	5.77	5.03	4.48	4.11
Baringo	7.00	6.02	5.23	4.64	4.25
Wajir	7.10	6.10	5.30	4.70	4.30
Narok	7.20	6.18	5.37	4.76	4.35
Samburu	7.20	6.18	5.37	4.76	4.35
West Pokot	7.50	6.43	5.57	4.92	4.49
Mandera	7.60	6.51	5.63	4.98	4.54

Source: Analysis of 1999 and 2009 KPHC data

Table 4.9 shows that, if the current fertility experience was to continue uninterrupted and if HIV/AIDS was to play no role in fertility change in Kenya, then all counties would experience steady fertility decline between 2009 and 2030. By 2030, TFR is projected to be lowest in Nairobi County and in the counties in the former central province. Counties in the former North Eastern province and their neighbours in the former Rift Valley province are projected to have the highest fertility by 2030.

A number of arguments can be used to explain the observed projected decline in fertility across all the counties. First, the consistent decline in TFR could be due to changes in the proximate determinants of fertility especially contraceptive use (Ekisa and Hinde 2005; Ezeh and Dodo 2001). According to the 2014 KDHS, knowledge of at least one contraceptive in Kenya is almost universal while more than a half of all currently married women use contraceptive method (KNBS, 2015). Counties with the lowest projected fertility (Nairobi, Kirinyaga, Kiambu, Nyan-darua and Mombasa) also havethe highest contraceptive prevalence. This could explain the low TFR projected in those counties. Counties with highest projected TFR such as Mandera, Sam-buru, West Pokot and Wajir have very low contraceptive prevalence (KNBS, 2015).

Secondly, there has been shift in cultural and societal norms that support high fertility due to modernization (Watkins, 2000). This has been brought about by rising literacy level. Educated women are more likely to use modern contraceptives and negotiate safe sex compared to those with no education. According to the KNBS (2015) KDHS literacy level among fecund women varies considerably by counties. Counties with the highest proportion of literate women also recorded the lowest TFR while those with the lowest proportion of literate women recorded the highest TFR on average (KNBS, 2015).

Thirdly, improvement in childhood mortality. While there exist regional variation in under five mortality rate, results from the 2014 KDHS showed persistent decline in U5MR. This declining trend in U5MR implies that women may no longer need to bear many children fearing that some may die. Hence the decline in fertility.

The finding of this study corroborates those of previous scholars who established that fertility transition has already taken place in Kenya (Ojakaa 2008, Mutuku, 2013). Besides, the findings reveal that fertility transition will be experienced at county level.

4.6Mortality Projections

Mortality situation in any given region or country is a general indicator of well-being of the people. Projections of mortality in this study involve projecting the future life expectancy for the country, former provinces and for each of the 47 counties in Kenya. The projections are based on the assumptions that, life expectancy should increase since both infant and child hood mortality rates have been showing improvements. Further it was assumed that since counties are nested within provinces, and provinces are nested within the country (Kenya), then for each sex, the trajectory of life expectancy at birth e(0) in each county will follow that of the parent Province while the trajectory of e(0) for each province will follow that of the country. To carry out the test, extrapolation method was applied to the 2009 Kenya population and housing census data. Extrapolation method was deemed to be the most appropriate method because of limited data at county level. For each projection, the data required included; the base year, the upper asymptote of life expectancy at birth disaggregated by sex; national base year projections of life expectancy at birth and sex specific estimates of county life expectancies at birth. The procedure first involved fitting a linear trend to national life expectancies at birth for each sex. The national projections of e(0) are presented in Table 4.10

Table 4.10: Projected Annual Life expectancy at birth, Kenya (2009-2030)

Year	Male	Female	Both sexes	Female male difference
2009	58.5	61.6	60.0	3.10
2010	58.8	62.0	60.4	3.22
2011	59.1	62.4	60.7	3.34
2012	59.3	62.8	61.1	3.46
2013	59.6	63.2	61.4	3.58
2014	59.9	63.6	61.7	3.70
2015	60.2	64.0	62.1	3.82
2016	60.5	64.4	62.4	3.93
2017	60.7	64.8	62.7	4.05
2018	61.0	65.2	63.1	4.16
2019	61.3	65.5	63.4	4.27
2020	61.5	65.9	63.7	4.38
2021	61.8	66.3	64.0	4.49
2022	62.1	66.7	64.4	4.60

2023	62.3	67.1	64.7	4.71
2024	62.6	67.4	65.0	4.81
2025	62.9	67.8	65.3	4.92
2026	63.1	68.2	65.6	5.02
2027	63.4	68.5	65.9	5.12
2028	63.6	68.9	66.2	5.22
2029	63.9	69.2	66.5	5.31
2030	64.2	69.6	66.8	5.41

Source: Analysis of 2009 KPHC data

Assuming there is no knowledge of HIV/AIDS, life expectancy at birth for males would increase from 58.5 in 2009 to 64.2 in 2030 while life expectance among females would increase from 61.6 in 2009 to 69.6 in 2030. The difference between life expectancy of females and that of males is consistently increasing over the years. This is to be expected since there has been marked improvement in access to reproductive health.

After computing national projections of life expectations at birth, provincial and county projections of life expectancy at birth were computed. The procedure involved formation of a ratio of the complement of the national life expectation at birth for a launch year as well as that of a future year. This ratio represents the extent to which national life expectation at birth approaches the limit over period between launch year and projected year. This relative complement of an estimate of e(0) in relation to a limit e(0) is according to Arriaga (1994) the difference between the two e(0)s at some time t. Now, let:

$t_{0=}$ Launch year

t_{0+n}= future year

k=limit e(0)

k-e(0)= the complement of e(0)

then the ratio= $(K - National\ e(0)t + n)/(K - National\ e(0)_t)$............................. 22

The computed ratio is then multiplied by the complement of county e(0) for year t to obtain estimated reduction in the complement of county/province e(0)from t_0 to t_{0+n}. then, the complement is subtracted from K to obtain an estimate of e(0) for each county and province for the year t_{0+n}

Table 4.11presents the projections of e(0)for provinces and counties in Kenya

Table 4.11 Projected Males e(0) by provinces and Counties, 2010-2030

Province and County	**Base year e(0) 2010**	**Males projected e(0) for Provinces and Counties 2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2025**	**2030**
NAIROBI	**62**	**62**	**62**	**63**	**63**	**63**	**63**	**64**	**64**	**64**	**64**	**66**	**67**
Nairobi	62	62	62	63	63	63	63	64	64	64	64	66	67
CENTRAL	**61**	**61**	**62**	**62**	**62**	**62**	**63**	**63**	**63**	**63**	**64**	**65**	**66**
Kiambu	63	63	63	64	64	64	64	65	65	65	65	66	67
Kirinyaga	61	61	62	62	62	62	63	63	63	63	64	65	66
Muranga	60	60	61	61	61	61	62	62	62	62	63	64	65
Nyandarua	60	60	61	61	61	61	62	62	62	62	63	64	65
Nyeri	60	60	61	61	61	61	62	62	62	62	63	64	65
COAST	**56**	**56**	**57**	**57**	**57**	**58**	**58**	**58**	**58**	**59**	**59**	**61**	**62**
Kilifi	57	57	58	58	58	59	59	59	59	60	60	61	63
Tana River	56	56	57	57	57	58	58	58	58	59	59	61	62
Kwale	58	58	59	59	59	59	60	60	60	61	61	62	64
lamu	58	58	59	59	59	59	60	60	60	61	61	62	64
Mombasa	57	57	58	58	58	59	59	59	59	60	60	61	63
Taita Taveta	53	53	54	54	54	55	55	55	56	56	56	58	60
EASTERN	62	62	62	63	63	63	63	64	64	64	64	66	67
Embu	59	59	60	60	60	60	61	61	61	61	62	63	64
Isiolo	65	65	65	66	66	66	66	66	67	67	67	68	69
Kitui	65	65	65	66	66	66	66	66	67	67	67	68	69
Makueni	65	65	65	66	66	66	66	66	67	67	67	68	69

Machakos	62	62	62	63	63	63	63	64	64	64	64	66	67
Marsabit	65	65	65	66	66	66	66	66	67	67	67	68	69
Meru	62	62	62	63	63	63	63	64	64	64	64	66	67
Tharaka Nithi	60	60	61	61	61	61	62	62	62	62	63	64	65
NORTH EASTERN	49	49	50	50	51	51	51	52	52	53	53	55	57
Garisa	56	56	57	57	57	58	58	58	58	59	59	61	62
Mandera	51	51	52	52	52	53	53	54	54	54	55	56	58
Wajir	42	42	43	43	44	44	45	45	46	46	47	49	51
NYANZA	**49**	**49**	**50**	**50**	**51**	**51**	**51**	**52**	**52**	**53**	**53**	**55**	**57**
Homabay	47	47	48	48	49	49	49	50	50	51	51	53	55
Kisii	57	57	58	58	58	59	59	59	59	60	60	61	63
Kisumu	48	48	49	49	50	50	50	51	51	52	52	54	56
Migori	50	50	51	51	52	52	52	53	53	53	54	56	57
Nyamira	58	58	59	59	59	59	60	60	60	61	61	62	64
Siaya	39	40	40	41	41	42	42	43	43	44	44	46	49
RIFT VALLEY	**57**	**57**	**58**	**58**	**58**	**59**	**59**	**59**	**59**	**60**	**60**	**61**	**63**
Baringo	54	54	55	55	55	56	56	56	57	57	57	59	60
Bomet	55	55	56	56	56	57	57	57	58	58	58	60	61
Kajiado	60	60	61	61	61	61	62	62	62	62	63	64	65
Elgeyo Marakwet	57	57	58	58	58	59	59	59	59	60	60	61	63
Kericho	54	54	55	55	55	56	56	56	57	57	57	59	60
Laikipia	53	53	54	54	54	55	55	55	56	56	56	58	60
Nakuru	52	52	53	53	53	54	54	55	55	55	56	57	59
Nandi	56	56	57	57	57	58	58	58	58	59	59	61	62
Narok	61	61	62	62	62	62	63	63	63	63	64	65	66
Samburu	54	54	55	55	55	56	56	56	57	57	57	59	60

Trans Nzoia	55	55	56	56	56	57	57	57	58	58	58	60	61
Turkana	50	50	51	51	52	52	52	53	53	53	54	56	57
Uasin Gishu	54	54	55	55	55	56	56	56	57	57	57	59	60
West Pokot	54	54	55	55	55	56	56	56	57	57	57	59	60
WESTERN	**52**	**52**	**53**	**53**	**53**	**54**	**54**	**55**	**55**	**55**	**56**	**57**	**59**
Bungoma	57	57	58	58	58	59	59	59	59	60	60	61	63
Busia	51	51	52	52	52	53	53	54	54	54	55	56	58
Kakamega	53	53	54	54	54	55	55	55	56	56	56	58	60
Vihiga	49	49	50	50	51	51	51	52	52	53	53	55	57

Source: Analysis of 2009 KPHC data

As shown in Table 4.11, assuming the effect of HIV to be negligible, life expectancy for males in all counties is expected to increase though at a varying rate. Life expectancy at birth is projected tobe highest in Isiolo County. These findings tend to agree with those of KNBS 2010 who established that Isiolo County has the highest life expectancy. SiayaCounty is projected to have the lowest life expectancy at birth. All counties are expected to maintain their county ranking in terms of e(0) in 2030 if HIV/AIDS had no role to play in population dynamics. Throughout the projection period, male e(0) is expected to be highest in counties in former Eastern, Nairobi and central provinces and lowest in counties in former, Nyanza, North Eastern and Western Provinces some of which have high prevalence of HIV pointing out to a possible link between life expectancy at birth among males in each county and HIV prevalence.

Table 4.12Projected Females e(0) by provinces and Counties, 2010-2030

Province and County	Base year e(0)	Females projected e(0) for provinces and Counties											
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2025	2030
Nairobi	63	63	64	64	65	65	65	66	66	66	67	68	70
CENTRAL	62	62	63	63	64	64	64	65	65	66	66	68	70
Kiambu	64	64	65	65	65	66	66	67	67	67	68	69	71
Kirinyaga	64	64	65	65	65	66	66	67	67	67	68	69	71
Muranga	62	62	63	63	64	64	64	65	65	66	66	68	70
Nyandarua	60	60	61	61	62	62	63	63	63	64	64	66	68
Nyeri	60	60	61	61	62	62	63	63	63	64	64	66	68
COAST	55	56	56	57	57	58	58	59	59	60	60	63	65
Kilifi	62	62	63	63	64	64	64	65	65	66	66	68	70
Tana River	56	57	57	58	58	59	59	60	60	61	61	63	66
Kwale	56	57	57	58	58	59	59	60	60	61	61	63	66
lamu	53	54	54	55	55	56	56	57	58	58	59	61	64
Mombasa	56	57	57	58	58	59	59	60	60	61	61	63	66
Taita Taveta	51	52	52	53	53	54	55	55	56	56	57	60	63
EASTERN	67	67	68	68	68	69	69	69	69	70	70	71	73
Embu	65	65	66	66	66	67	67	67	68	68	68	70	71
Isiolo	70	70	70	71	71	71	71	72	72	72	72	74	75
Kitui	68	68	69	69	69	69	70	70	70	71	71	72	73
Makueni	69	69	70	70	70	70	71	71	71	71	72	73	74
Machakos	69	69	70	70	70	70	71	71	71	71	72	73	74
Marsabit	64	64	65	65	65	66	66	67	67	67	68	69	71

Meru	66	66	67	67	67	68	68	68	69	69	69	71	72
Tharaka Nithi	64	64	65	65	65	66	66	67	67	67	68	69	71
NORTH EASTERN	53	54	54	55	55	56	56	57	58	58	59	61	64
Garisa	65	65	66	66	66	67	67	67	68	68	68	70	71
Mandera	55	56	56	57	57	58	58	59	59	60	60	63	65
Wajir	44	45	46	46	47	48	48	49	50	51	51	55	58
NYANZA	54	55	55	56	56	57	57	58	58	59	59	62	65
Homabay	55	56	56	57	57	58	58	59	59	60	60	63	65
Kisii	59	59	60	60	61	61	62	62	63	63	63	66	68
Kisumu	51	52	52	53	53	54	55	55	56	56	57	60	63
Migori	54	55	55	56	56	57	57	58	58	59	59	62	65
Nyamira	60	60	61	61	62	62	63	63	63	64	64	66	68
Siaya	46	47	47	48	49	50	50	51	52	52	53	56	59
RIFT VALLEY	61	61	62	62	63	63	64	64	64	65	65	67	69
Baringo	59	59	60	60	61	61	62	62	63	63	63	66	68
Bomet	61	61	62	62	63	63	64	64	64	65	65	67	69
Kajiado	64	64	65	65	65	66	66	67	67	67	68	69	71
Elgeyo Marakwet	62	62	63	63	64	64	64	65	65	66	66	68	70
Kericho	59	59	60	60	61	61	62	62	63	63	63	66	68
Laikipia	57	58	58	58	59	59	60	60	61	61	62	64	66
Nakuru	55	56	56	57	57	58	58	59	59	60	60	63	65
Nandi	57	58	58	58	59	59	60	60	61	61	62	64	66
Narok	67	67	68	68	68	69	69	69	69	70	70	71	73
Samburu	65	65	66	66	66	67	67	67	68	68	68	70	71
Trans Nzoia	59	59	60	60	61	61	62	62	63	63	63	66	68

Turkana	55	56	56	57	57	58	58	59	59	60	60	63	65
Uasin Gishu	57	58	58	58	59	59	60	60	61	61	62	64	66
West Pokot	64	64	65	65	65	66	66	67	67	67	68	69	71
WESTERN	54	55	55	56	56	57	57	58	58	59	59	62	65
Bungoma	58	58	59	59	60	60	61	61	62	62	63	65	67
Busia	54	55	55	56	56	57	57	58	58	59	59	62	65
Kakamega	55	56	56	57	57	58	58	59	59	60	60	63	65
Vihiga	49	50	50	51	52	52	53	54	54	55	55	58	61

*Nairobi was a province and has remained as a County of its own. It is the capital city of the republic of Kenya

Source: Analysis of 2009 KPHC data

As far as e(0) among females per county is concerned, Table 4.12 shows that in absence of HIV/AIDS, in 2030, life expectancy at birth would be highest in Isiolo county. This is to be expected since according to the 2009 KPHC, Isiolo County has the highest e(0).Wajir County is projected to record the lowest e(0). This clearly indicates that huge disparities in life expectation at birth by counties among the female population in Kenya are expected to persist throughout the projection period. This points out that there exists huge disparity in access to health care across the counties. Just as it is with males e(0), counties in former Eastern province have remarkable high female e(0) while most those counties in former Nyanza, Western, North Eastern and Coast Provinces.

CHAPTER FIVE

COUNTY SPECIFIC POPULATION PROJECTIONS INCORPORATING HIV/AIDS AND THE EFFECT OF INTERVENTIONS

5.1 Introduction

In this chapter, county specific population projections in Kenya incorporating HIV/AIDS and the effect of interventions are examined. The contribution of HIV/AIDS interventions on future fertility and mortality levels are estimated. To carry out the projections, two scenarios are created. In the first scenario, HIV/AIDS is introduced in the county population projections holding the effect of program interventions constant. In the second scenario, both HIV/AIDS and interventions geared towards mitigating the impact of HIV/AIDS are introduced in the county population projections. The purpose of creating different scenarios is to establish whether the interventions put in place to compact the effect of HIV/AIDS are bearing fruit at the county level and whether the effect of these interventions varies across the counties. Section 5.2 examines county population projections in a 'HIV/AIDS scenario' and county population projections in a scenario where 'HIV/AIDS and program interventions' are incorporated. Section 5.3 focuses on county level fertility projections in a HIV/AIDS scenario as well as the county level fertility projections in a scenario where both HIV/AIDS and programs are factored in. Similarly, section 5.4 pays attention to county level mortality projections incorporating HIV/AIDS in one scenario and county level mortality projections taking into account both HIV/AIDS epidemic and the effect of program intervention in the other scenario.

5.2County Population Projections under HIV/AIDS and interventions scenarios

This section presents the results of the analysis on county specific population projections while incorporating HIV/AIDS and the effect of intervention based on a number of assumptions. First in a no interventions scenario, it is assumed that the main mode of HIV transmission in all counties is through heterosexual union hence median age at first sex in each county based on 2014 Kenya demographic and health survey is used to model sexual activity in each county. It is also assumed that in absence of treatment 50% perinatal transmission of HIV will occur. In addition, it is assumed that 20 percent of babies born to HIV+ mothers are infected at birth. Further, assuming non-aids mortality to be negligible, the median survival time for HIV/AIDS infected individuals is assumed to be 13.8 years. In a no intervention scenario, population projections in each county proceed by holding constant the effect of program interventions geared towards mitigating the effect of HIV/AIDS in Kenyan population. Second, in the interventions scenario, HIV/AIDS prevalence rates and the program interventions geared towards mitigating the effect of HIV/AIDS in counties in Kenya are introduced. The following five interventions are introduced in this scenario: prevention of mother to child transmission probabilities, voluntary HIV/AIDS testing, information and education campaigns, anti-retroviral treatment and syndromic management of STIs. The rate of 'phase in' of these interventions and the year of phase is determined based on the 2008/2009 and 2014 Kenya Demographic and Health Survey Data. Population projections based on "no HIV/AIDS interventions scenario" are subtracted from those based on "HIV/AIDS scenario" to establish whether these interventions are bearing fruit on population projections at county level. The results of the analysis are as presented in Table 5.1

Table 5.1 County population projections incorporating HIV/AIDS and program interventions

		County population Projections incorporating HIV/AIDS					County population Projections incorporating HIV/AIDS program interventions					
S/No	year	2010	2017	2020	2025	2030	2010	2017	2020	2025	2030	Difference in2030
		a	b	c	d	e	f	g	h	i	j	j-e
1	Nairobi	3134798	3411789	3551861	3814554	4102858	3134798	3411787	3551857	3814777	4110565	7707
2	Kiambu	838969	1812088	1889054	2035866	2196259	1660366	1812086	1889051	2036161	2203277	7018
3	Nakuru	1637474	1787252	1863243	2008303	2166918	1637474	1787252	1863248	2008657	2173740	6822
4	Kakamega	1698576	1853548	1932165	2082155	2246442	1698576	1853547	1932164	2082432	2253160	6717
5	Bungoma	1406776	1536956	1603083	1730115	1869100	1406776	1536956	1603083	1730419	1875579	6479
6	Kilifi	1133208	1240144	1294553	1399979	1515120	1133208	1240141	1294546	1400258	1521421	6301
7	Kisii	1176791	1287431	1343713	1452645	1571733	1176791	1287431	1343714	1452972	1577974	6241
8	Homabay	984293	1078581	1126635	1220517	1323105	984293	1078580	1126630	1220813	1329157	6052
9	Kisumu	989514	1084245	1132516	1226763	1329769	989514	1084243	1132514	1227080	1335784	6016
10	Migori	936675	1026918	1072935	1163080	1261563	936675	1026916	1072929	1163375	1267567	6004
11	Mombasa	959187	1051337	1098292	1189977	1289989	959187	1051334	1098285	1190279	1295942	5953
12	Muranga	964170	1056743	1103913	1196000	1296469	964170	1056740	1103905	1196292	1302400	5930
13	Uasin Gichu	913027	1001258	1046249	1134417	1230756	913027	1001257	1046251	1134772	1236648	5892
14	Narok	868770	953242	996343	1081063	1173644	868770	953241	996343	1081404	1179479	5836
15	Turkana	873575	958453	1001754	1086800	1179718	873575	958453	1001757	1087167	1185549	5831
16	Siaya	860216	943961	986697	1070750	1162601	860216	943960	986696	1071089	1168426	5825
17	Trans-Nzoia	836332	918046	959751	1041854	1131548	836332	918046	959755	1042231	1137324	5776
18	Nyeri	709595	780540	816815	888896	967637	709595	780538	816811	889241	973376	5739
19	Nandi	769022	845019	883848	960702	1044690	769022	845018	883849	961061	1050361	5671
20	Busia	761065	836386	874877	951122	1034449	761065	836385	874877	951473	1040111	5663
21	Kericho	768350	844289	883086	959860	1043762	768350	844288	883089	960232	1049415	5652
22	Bomet	745617	819624	857448	932427	1014372	745617	819624	857451	932803	1019982	5610
23	Nyandarua	610017	672501	704512	768747	838969	610017	672499	704511	769114	844533	5564
24	Kajiado	701919	772212	808161	879658	957786	701919	772212	808167	880060	963317	5531
25	Kwale	663906	730972	765304	833895	908887	663906	730968	765289	834154	914416	5529
26	Nyamira	610976	673544	705607	770001	840440	610976	673544	705610	770384	845795	5355

27	Baringo	567516	626391	656590	717538	784251	567516	626391	656595	717936	789488	5237
28	Vihiga	567387	626251	656441	717355	784019	567387	626250	656448	717764	789253	5234
29	West Pokot	523709	578863	607190	664712	727703	523709	578863	607194	665103	732865	5162
30	Kirinyaga	540247	596804	625828	684571	748862	540247	596801	625822	684905	754013	5150
31	Laikipia	407658	452951	476302	524635	577745	407658	452951	476311	525058	582544	4799
32	Elgeyo Marakwet	377942	420710	442790	488789	539394	377942	420710	442799	489211	544107	4713
33	Tana River	245301	276801	293204	328765	368202	245301	276798	293201	329152	372737	4536
34	Samburu	228762	258859	274560	308847	346831	228762	258858	274566	309267	351172	4341
35	Meru	1387275	1515796	1581079	1706605	1846108	1387275	1515795	1581075	1706762	1850205	4097
36	Machakos	1123672	1229796	1283790	1388541	1504997	1123672	1229795	1283792	1388756	1509093	4096
37	Kitui	1035831	1134493	1184730	1282600	1391504	1035831	1134492	1184729	1282801	1395506	4001
38	Mandera	1025756	1123560	1173359	1270369	1378188	1025756	1123562	1173374	1270694	1382161	3974
39	Makueni	904725	992247	1036871	1124415	1221907	904725	992246	1036872	1124639	1225861	3954
40	Lamu	103716	123183	133508	157842	185559	103716	123182	133521	158305	189393	3834
41	Embu	528000	583514	612009	669889	734767	528000	583514	612015	670171	738408	3640
42	Wajir	661941	728836	763066	831502	907970	661941	728837	763081	831824	911559	3589
43	Garisa	623060	686651	719215	784572	857631	623060	686653	719230	784900	861164	3533
44	Tharaka Nithi	373672	416074	437961	483691	535317	373672	416074	437969	483992	538720	3403
45	Marsabit	297817	333776	352423	392221	437410	297817	333775	352426	392504	440676	3266
46	Taita Taveta	290789	326150	344489	383702	428259	290789	326149	344497	384007	431500	3241
47	Isiolo	146567	169675	181839	209692	241975	146567	169674	181849	210016	244892	2917

Source: Analysis 2009 KPHC data

Table 5.1 shows that programs geared towards mitigating the effect of HIV/AIDS in Kenyan population are having impact in all counties in Kenya. The results further indicate that the effect of program interventions put in place to reverse the negative effect of HIV/AIDS in Kenyan population vary by counties in Kenya as does the uptake of these interventions. In all counties, population is projected to be higher in HIV/AIDS intervention scenario than in no HIV/AIDS intervention scenario. Nairobi County is projected to have the highest net increase in population size that is attributable to programs geared towards mitigating the impact of HIV on Kenyan population by 2030.This is to be expected since Nairobi County constitute the capital city of the Republic of Kenya and attracts people from across the country. According to the 2009 KPHC, Nairobi County was the greatest net gainer of migrants (KNBS, 2012). Besides, Nairobi County is endowed with good hospitals, good communication networks and good educational institutions which attract people from across the country. Good hospitals and infrastructure facilitate delivery in the hands of skilled health professionals. This lowers the probability of transmitting HIV from mother to child during delivery.

On the other hand, good communication networks as well as literate population imply that Information and Education campaigns and social marketing programs reach the population. This creates awareness on programs such as voluntary HIV counselling and testing and condom use. As a matter of fact people who know of their HIV sero status are more likely to use life prolonging drugs commonly called antiretrovirals (ARVs) thus reducing HIV/AIDS related deaths.

Tremendous increase in population size attributable to program intervention is also expected to be witnessed in the counties of Kiambu, Nakuru,Kakamega, Bungoma and Kilifi. This is to be expected since according to the 2014 KDHS, knowledge of HIV/AIDS in these counties is almost universal. Counties in the former Nyanza province, Western, Central and Rift valley are projected to record high population attributed to HIV program interventions. These counties also have not only the highest HIV prevalence in the country but also the highest awareness of HIV/AIDS and prevention methods.

Least impact of program interventions geared towards mitigating the impact of HIV/AIDS is expected to be recorded mostly in counties in the former North Eastern and Eastern province and in Taita Taveta County. These counties generally have low awareness of HIV/ AIDS transmission and prevention methodologies (KDHS, 2014).

5.3Fertility Projections under both HIV/AIDS and interventions scenarios

This section presents fertility projections in each county while incorporating not only HIV/AIDS but also the effect of HIV interventions at the county level. This is because fertility plays a bigger role in population change than both mortality and migration. Data from the 2014 KDHS showed huge county variations in total fertility rate as well as uptake of interventions geared towards reversing the devastating effect of HIV/AIDS in Kenyan Population. For example, whereas awareness of HIV is almost universal in all regions, knowledge of HIV prevention methods especially use of condoms and limiting sexual partners vary by region and is lowest in the counties in North Eastern region (KNBS, 2015). Similarly, there exist huge disparity in HIV prevalence between counties with HIV prevalence being highest in counties in former Nyanza province and Nairobi County (NASCOP, 2014).

Although a number of measures can be used to measure fertility, in this study fertility projections at the county level is done by computing total fertility rates which in essence refer to the number of children a woman of childbearing age would have if she was subjected to age specific fertility rates. To generate fertility projections, trends in TFRs are produced. The TFRs are then translated into age specific fertility rates. To integrate HIV/AIDS in TFR projections, HIV prevalence per county are considered. Then, age specific incidence parameters are used to infect HIV negative people and to transition them to the HIV positive group. Since the main mode of HIV transmission is through heterosexual union, introducing HIV/AIDS into fertility projections at the county level commences by modelling sexual activity. Sexual activity is not only a function of average age at first sexual intercourse and prevalence of infection in age group but also the infection probability within an age group. Data on median age at first sexual intercourse for each county in this study comes from the 2014 KDHS.

Since the objective of this section is to determine whether program interventions geared towards mitigating the impact of HIV/AIDS are bearing fruit in terms of fertility projections at county level in Kenya, five interventions are introduced in fertility projections. Consequently, a 'HIV/AIDS and intervention scenario is created.' The interventions introduced are: improvement in treatment of sexually transmitted infections, information and education campaigns (IEC) and social marketing, voluntary counselling and testing (VCT), mother to child transmission prevention (MTCTP) and anti-retroviral treatment. The interventions are introduced by factoring into the TFR projections at county level the rate of phase in of the interventions per county. Table 5.2 presents results of the analysis.

Table 5.2: Counties TFR Projections under both HIV and AIDS intervention scenario

S/N	County	HIV PREVALENCE IN 2014	Base year TFR in 2009	Projected Non-HIV/AIDS TFR in 2030	Projected TFR in 2030 incorporating HIV	Projected TFR in 2030 incorporating HIV and effect of Interventions	Percent projected Change in TFR without HIV/AIDS	% Change in TFR incorporating HIV/AIDS	% Change in TFR incorporating HIV/AIDS & interventions	% reduction in TFR due to HIV	% reduction in TFR due to HIV interventions
1	Nairobi	6.8	2.90	2.28	2.22	2.17	21.46	23.45	25.17	1.99	1.72
2	Kirinyaga	3.3	3.30	2.47	2.24	2.18	25.14	32.12	33.94	6.98	1.82
3	Kiambu	3.8	3.40	2.52	2.28	2.23	25.93	32.94	34.41	7.02	1.47
4	Nyandarua	3.8	3.40	2.52	2.23	2.17	25.93	34.41	36.18	8.49	1.76
5	Mombasa	7.4	3.40	2.52	2.16	2.11	25.93	36.47	37.94	10.54	1.47
6	Embu	3.7	3.70	2.66	2.35	2.26	28.03	36.49	38.92	8.46	2.43
7	Nyeri	4.3	3.80	2.71	2.30	2.23	28.65	39.47	41.32	10.82	1.84
8	Tana River	1.0	4.70	3.46	3.14	2.80	33.10	33.19	40.43	0.09	7.23
9	Lamu	2.3	4.70	3.14	3.01	2.83	33.10	35.96	39.79	2.86	3.83
10	Taita Taveta	6.1	4.70	3.14	2.90	2.72	33.10	38.30	42.13	5.20	3.83
11	Nyamira	6.4	4.70	3.14	2.91	2.75	33.10	38.09	41.49	4.99	3.40
12	Kisii	8.0	4.80	3.19	2.67	2.55	33.49	44.38	46.88	10.89	2.50
13	Machakos	5.0	4.90	3.24	3.09	2.83	33.86	36.94	42.24	3.08	5.31
14	Kajiado	4.4	4.90	3.24	2.97	2.77	33.86	39.39	43.47	5.53	4.08
15	Nakuru	5.3	4.90	3.24	3.21	2.93	33.86	34.49	40.20	0.63	5.71
16	Muranga	5.2	5.00	3.29	3.10	2.84	34.22	38.00	43.20	3.78	5.20
17	Kisumu	19.3	5.00	3.29	2.96	2.83	34.22	40.80	43.40	6.58	2.60
18	Laikipia	3.7	5.00	3.29	3.10	2.89	34.22	38.00	42.20	3.78	4.20
19	Vihiga	3.8	5.10	3.34	3.09	2.87	34.57	39.41	43.73	4.84	4.31
20	Uasin Gishu	4.3	5.20	3.39	3.17	2.94	34.90	39.04	43.46	4.14	4.42
21	Kericho	3.4	5.40	3.48	3.31	3.06	35.53	38.70	43.33	3.18	4.63
22	Tharaka Nithi	4.3	5.70	3.63	3.14	2.91	36.39	44.91	48.95	8.53	4.04
23	Siaya	23.7	5.70	3.63	2.97	2.85	36.39	47.89	50.00	11.51	2.11
24	Kakamega	5.9	5.70	3.63	3.28	3.00	36.39	42.46	47.37	6.07	4.91
25	Makueni	5.6	5.80	3.67	3.24	2.97	36.65	44.14	48.79	7.48	4.66
26	Meru	3.0	5.80	3.67	3.42	3.09	36.65	41.03	46.72	4.38	5.69
27	Migori	14.7	5.90	3.72	3.24	3.08	36.91	45.08	47.80	8.17	2.71
28	Kilifi	4.4	6.00	3.77	3.22	2.95	37.16	46.33	50.83	9.17	4.50
29	Kwale	5.7	6.00	3.77	3.40	3.18	37.16	43.33	47.00	6.17	3.67
30	Isiolo	4.2	6.00	3.77	3.30	3.09	37.16	45.00	48.50	7.84	3.50
31	Nandi	3.7	6.00	3.77	3.38	3.13	37.16	43.67	47.83	6.51	4.17
32	Homabay	25.7	6.10	3.82	3.12	2.99	37.40	48.85	50.98	11.45	2.13
33	Trans Nzoia	5.1	6.10	3.82	3.50	3.23	37.40	42.62	47.05	5.22	4.43
34	Busia	6.8	6.10	3.82	3.24	3.04	37.40	46.89	50.16	9.48	3.28
35	Kitui	4.3	6.20	3.87	3.32	3.07	37.63	46.45	50.48	8.82	4.03
36	Turkana	7.6	6.30	3.91	3.35	3.12	37.86	46.83	50.48	8.97	3.65
37	Garisa	2.1	6.40	3.96	3.51	3.11	38.08	45.16	51.41	7.08	6.25
38	Bungoma	3.2	6.40	3.96	3.34	2.97	38.08	47.81	53.59	9.73	5.78
39	Marsabit	1.2	6.60	4.06	3.86	3.47	38.50	41.52	47.42	3.02	5.91
40	Bomet	5.8	6.60	4.06	3.34	3.11	38.50	49.39	52.88	10.90	3.48
41	Elgeyo Marakwet	2.5	6.70	4.11	3.87	3.51	38.70	42.24	47.61	3.54	5.37
42	Baringo	3.0	7.00	4.25	3.68	3.36	39.26	47.43	52.00	8.17	4.57
43	Wajir	0.2	7.10	4.30	4.25	3.40	39.44	40.14	52.11	0.70	11.97
44	Narok	5.0	7.20	4.35	3.56	3.30	39.61	50.56	54.17	10.95	3.61
45	Samburu	5.0	7.20	4.35	3.64	3.44	39.61	49.44	52.22	9.84	2.78
46	West Pokot	2.8	7.50	4.49	3.82	3.45	40.10	49.07	54.00	8.97	4.93
47	Mandera	1.7	7.60	4.54	4.16	3.49	40.25	45.26	54.08	5.01	8.82

Source: Analysis of 2009 KPHC data, 2012 KAIS data and 2014 KDHS data

The results show that HIV/AIDS will play a key role in fertility transition at the county level in Kenya. If the HIV prevalence and fertility patterns currently witnessed in Kenya were to persist, then HIV/AIDS would lead to fertility decline across all the counties. However, the tempo of fertility decline will vary considerably by regions since most of the counties are in different stages of fertility transition and socio-economic development. Existing studies point that fertility transition has already started in Kenya (Mutuku, 2013). As shown in Table 5.2, with HIV/AIDS, fertility is projected to be lower than it would be if there was no HIV and AIDS in all the counties. These findings are in agreement with those of previous scholars who argued that HIV and AIDS contribute to fertility reduction (Clayton, 2011; Vitally and Williams, 2011; Setel, 1995).

The results further indicated that, most of the counties with the lowest HIV prevalence such as Wajir, Tana River and Marsabit will experience the lowest percent reduction in TFR. These counties also have the lowest contraceptive prevalence (KNBS, 2015). On the other hand, most of the counties with the highest HIV prevalence such as Siaya, Homabay, Mombasa, Kisii showed the highest projected reduction in TFR due to HIV/AIDS pandemic.This is to be expected since previous studies have pointed out that fertility and HIV/AIDS share the same proximate determinants (UN, 2002; Magadi and Agwanda, 2010). High uptake of contraception especially condom use prevents not only child birth but also HIV transmission among fecund women.

The results further indicated that,the rate of fertility decline will vary considerably depending on HIV prevalence, level of fertility and the stage of fertility transition. Counties which are in the final stages of fertility transition showed the lowest projected decline in fertility while those which have begun their fertility transition showed the highest projected decline in fertility. The results seem to corroborate those of Dorrington et al., (2006) who argued that fertility vary by province and HIV prevalence in South Africa.

When HIV interventions are introduced into the projection, the results indicated substantial reduction in the TFR across all the counties. However, substantial variation in the rate of decline was noticeable across all the counties. The rate of decline varied to a large extent depending on the current fertility, HIV prevalence and the uptake of HIV related programs. Counties characterized by relatively high uptake of contraception especially Nairobi county and counties in the former central province recorded the lowest projected decline in TFR due HIV related program interventions. This is to be expected since knowledge of HIV prevention and transmission is almost universal and is unlikely to change before 2030 in these counties. In addition, contraceptive prevalence is far above the national prevalence of 58%.

The results further indicated that, most of the high fertility counties which are also characterized by low uptake of HIV related programs will record the highest projected decline in TFR. This include all the counties in the former North Eastern province (Garisa, Wajir and Mandera), Tana River and Turkana Counties among others. This implies that, if more HIV/AIDS and reproductive health campaigns are initiated in these counties, then uptake of the same is likely to go up and consequently lead to high reduction in TFR as a result of behaviour change. In other words, since the health function is already devolved to counties, as these counties embark on reproductive health campaigns, then uptake of HIV related programs is likely to increase. Consequently, risky sexual behaviour is likely to reduce leading to drop in TFR.

5.4 Mortality Projections under both HIV/AIDS and interventions scenarios.

The objective of this section is twofold. The first objective is to establish whether HIV/AIDS is affecting mortality projections at county level in Kenya. This is because in populations where HIV prevalence is more than 1%, it is recommended by United Nations that mortality projections be done while incorporating the effect of HIV/AIDS (Shryock and Siegel, 2004). The second objective of this section is to determine whetherHIV programs are effective at county level. In this study mortality projection is done by computing life expectation at birth. To carry out the projections, first non HIV/AIDS expectations of life are computed for each county as presented earlier in section 4.6. To incorporate the effect of HIV in the projection process, HIV prevalence per county are introduced and then a set of age specific parameters are applied to infect those people who are HIV negative thus transitioning them to HIV positive category as soon as possible. This is done by holding the effect of program interventions constant in all the counties. Transition to HIV positive category implies that one is sexually active and perhaps involved in unprotected sex since the main mode of HIV transmission in Kenya is through heterosexual unions. Thus the starting point in incorporating HIV in mortality projections at county level in this study is done by modelling sexual activity as earlier discussed in section 3.5.Sexual activity is function of age at sexual debut. Data on age at sexual debut in this study comes from the 2014 KDHS. Results of the analysis are presented in Table 5.3

Table 5.3 County Mortality Projections under both HIV/AIDS and interventions scenario.

	PROJECTED e0 in 2030 incorporating HIV/AIDS						Projected e0 in 2030 incorporating HIV/AIDS and effect of program intervention					
	a	b	c	d	e(d-c)		f	g	h	i	j(g-b)	k(i-h)
S/N	County	e_0 all	e_0 male	e_0 female		S/N	County	e_0 all	e_0 male	e_0 female		
1	Nairobi	62.2	61.7	62.7	1.0	1	Nairobi	66.1	64.9	67.4	3.9	2.5
2	Nyeri	57.9	58	57.8	-0.2	2	Nyeri	65.4	64.3	66.5	7.5	2.2
3	Nyandarua	57.5	57.6	57.3	-0.3	3	Nyandarua	65.2	64.2	66.3	7.7	2.1
4	Kiambu	60.6	60.3	60.8	0.5	4	Kiambu	65.9	64.7	67.1	5.3	2.4
5	Muranga	58.9	58.9	59	0.1	5	Muranga	65.3	64.2	66.4	6.3	2.2
6	Kirinyaga	57.1	57.3	56.9	-0.4	6	Kirinyaga	64.7	63.7	65.8	7.7	2.1
7	Mombasa	58.9	58.9	59	0.1	7	Mombasa	65.6	64.5	66.7	6.6	2.2
8	Kwale	57.3	57.5	57.2	-0.3	8	Kwale	65.4	64.3	66.5	8	2.2
9	Kilifi	59.4	59.3	59.5	0.2	9	Kilifi	65.7	64.6	66.8	6.3	2.2
10	Tana River	54.1	54.6	53.6	-1.0	10	Tana River	64.4	63.6	65.3	10.4	1.7
11	Lamu	51.9	52.6	51.2	-1.4	11	Lamu	63.2	62.6	63.9	11.3	1.3
12	Taita Taveta	57.5	57.7	57.4	-0.3	12	Taita Taveta	64.5	63.7	65.4	7	1.7
13	Marsabit	57.4	57.5	57.2	-0.3	13	Marsabit	64.6	63.7	65.5	7.3	1.8
14	Isiolo	55.2	55.6	54.8	-0.8	14	Isiolo	63.7	63	64.5	8.5	1.5
15	Meru	61.8	61.4	62.3	0.9	15	Meru	65.8	64.6	67	4	2.4
16	Tharaka Nithi	58.4	58.4	58.3	-0.1	16	Tharaka Nithi	62.9	61.7	64.2	4.6	2.5
17	Embu	59.4	59.3	59.5	0.2	17	Embu	65.1	64.1	66.1	5.7	2
18	Kitui	61.2	60.8	61.5	0.7	18	Kitui	65.6	64.5	66.8	4.5	2.3
19	Machakos	61.4	61	61.8	0.8	19	Machakos	65.7	64.5	66.8	4.3	2.3
20	Makueni	60.8	60.5	61.1	0.6	20	Makueni	65.6	64.5	66.7	4.7	2.2
21	Garisa	59.9	59.7	60	0.3	21	Garisa	64.1	63.3	65	4.3	1.7
22	Wajir	57.7	57.8	57.6	-0.2	22	Wajir	64.2	63.4	65.1	6.5	1.7
23	Mandera	61.2	60.9	61.6	0.7	23	Mandera	64.7	63.8	65.7	3.5	1.9
24	Siaya	58.2	58.2	58.2	0.0	24	Siaya	64.5	63.6	65.4	6.3	1.8
25	Kisumu	58.6	58.6	58.7	0.1	25	Kisumu	64.7	63.7	65.6	6	1.9
26	Homabay	58.4	58.4	58.5	0.1	26	Homabay	64.6	63.7	65.6	6.2	1.9
27	Migori	58.2	58.2	58.2	0.0	27	Migori	64.6	63.6	65.5	6.3	1.9
28	Kisii	59.3	59.2	59.4	0.2	28	Kisii	64.9	63.9	65.9	5.5	2
29	Nyamira	57.2	57.3	57	-0.3	29	Nyamira	64.1	63.3	65	6.9	1.7
30	Kakamega	60.4	60.1	60.7	0.6	30	Kakamega	65.2	64.1	66.3	4.8	2.2
31	Vihiga	57.1	57.3	56.9	-0.4	31	Vihiga	64	63.2	64.9	6.9	1.7
32	Bungoma	59.9	59.7	60.1	0.4	32	Bungoma	65	64	66.1	5.2	2.1
33	Busia	57.8	57.9	57.7	-0.2	33	Busia	64.4	63.5	65.3	6.6	1.8
34	Turkana	58.4	58.5	58.4	-0.1	34	Turkana	64.6	63.6	65.5	6.1	1.9

35	West Pokot	56.6	56.8	56.4	-0.4	35	West Pokot	63.9	63.1	64.7	7.3	1.6
36	Samburu	53.4	53.9	52.8	-1.1	36	Samburu	62.5	61.9	63.1	9.1	1.2
37	Tranzoia	58.3	58.4	58.3	-0.1	37	Tranzoia	64.5	63.6	65.4	6.2	1.8
38	Baringo	57	57.2	56.8	-0.4	38	Baringo	64	63.2	64.9	7	1.7
39	Uasin Gichu	58.5	58.5	58.6	0.1	39	Uasin Gichu	64.6	63.7	65.5	6.1	1.8
40	Elgeyo Marakwet	55.7	56.1	55.4	-0.7	40	Elgeyo Marakwet	63.4	62.7	64.2	7.7	1.5
41	Nandi	57.9	58	57.8	-0.2	41	Nandi	64.4	63.5	65.3	6.5	1.8
42	Laikipia	56	56.3	55.7	-0.6	42	Laikipia	63.6	62.8	64.3	7.5	1.5
43	Nakuru	60.5	60.2	60.7	0.5	43	Nakuru	65.2	64.1	66.2	4.7	2.1
44	Narok	58.3	58.3	58.2	-0.1	44	Narok	64.5	63.6	65.5	6.3	1.9
45	Kajiado	57.9	57.9	57.8	-0.1	45	Kajiado	64.3	63.4	65.2	6.4	1.8
46	Kericho	58	58.1	57.9	-0.2	46	Kericho	64.3	63.4	65.2	6.3	1.8
47	Bomet	57.9	58	57.8	-0.2	47	Bomet	64.4	63.5	65.3	6.4	1.8

Source: Analysis of 2009 KPHC data and 2014 KDHS data

When the results in the HIV/AIDS scenario presented in Table 5.3 are compared to the results of the “no HIV” scenario presented earlier in Table 4.10 and Table 4.11, the results show that HIV and AIDS will lead to reduction in life expectancy at birth in all counties. The findings agree with those of WHO (2014) who attributed the decline in life expectancy witnessed in Kenya since 1984 to HIV and AIDS epidemic. The results also revealed substantial variation in life expectancy at birth among the counties. Except in the counties of Mandera, Wajir, Kisumu, Migori and Siaya, life expectancy at birth is projected to be consistently higher in the no HIV scenario than in the HIV/AIDS scenario. This implies that HIV/AIDS epidemic is playing a crucial role in influencing the mortality rates at the county level in Kenya. Among the males, when HIV/AIDS is incorporated in mortality projections, life expectancy at birth in Isiolo County is projected to be 13 years less in a HIV scenario than in no HIV/AIDS scenario by 2030 which implies that HIV/AIDS will lead to 13 years loss of life. Marsabit and Lamu Counties although they have low HIV prevalence take position two and three respectively as far as impact of HIV/AIDS is concerned in terms of affecting mortality at counties. Marsabit County by 2030 is projected to live 11 years less if the current HIV/AIDS prevalence rates were to continue than he would have lived if there was no HIV/AIDS. Similarly, a male child in 2030 at Lamu county is likely to live 10 years less if the current HIV prevalence were to prevail than he would have lived if there was no HIV/AIDS in the county. Surprisingly, all counties in former Western province except Bungoma would experience no change in life expectancy even after incorporating

HIV prevalence in mortality projections. In addition, it is worthwhile to note that life expectancy at birth among males is projected to be higher in HIV/AIDS scenario than in no HIV/AIDS scenario in most of the counties in Nyanza including Homabay county which has the highest reported HIV prevalence rate. This scenario could be attributed to the high uptake PMTCT services and high uptake of high antenatal HIV test uptake (Kohler P.K et.al. 2014).

Among the females, life expectancy at birth is projected to be consistently higher in no aids scenario than it would be in a HIV/ AIDS scenario in all the counties except in Wajir County. The greatest effect of HIV/AIDS is projected to be witnessed in the counties of Isiolo, Samburu, West Pokot, Elgeyo Marakwet, Lamu, Marsabit, Tharaka Nithi, and Kajiando. Isiolo County is projected to live 20 years less that she would have lived if there was no HIV/AIDS. HIV/AIDS is projected not to have any effect on life expectancy at birth in Wajir County perhaps because the county has low HIV prevalence.

When sex differences in life expectancy are examined, the results indicated that HIV and AIDS will narrow the gap between life expectancy among the females and the males across all the counties. This implies that HIV and AIDS are affecting female life expectancy more than male life expectancy in all counties. This is to be expected since HIV prevalence is consistently higher among the females than among the males across all the counties.

When HIV/AIDS interventions are introduced, life expectancy at birth is projected to be consistently higher in “HIV/AIDS and intervention scenario” than in a “HIV/AIDS only scenario” for both males and females across all the counties. However, the effect of intervention varies by counties and gender and is more profound in Lamu, Tana River and Samburu counties. Among the males for example, in presence of government interventions at county level, a child born in Lamu County in 2030 is projected to live 10 years more than he would have lived if such interventions were not put in place. Similarly, among the females, a child born in Lamu County in 2030 would probably be expected to live approximately 13 years more than she would have lived if the current HIV/AIDS prevalence were to continue. Generally, the effect of interventions on life expectancy tend to be more profound in those counties which are rather marginalized and less profound in counties with good infrastructure and low HIV prevalence. This is to be expected since marginalised counties lack good infrastructure, have low development index, high poverty levels and high illiterate rates. All these suppress high uptake of AIDS interventions. Consequently, as these AIDS interventions become widespread in these counties due to adoption of devolved system of governance, it is expected that these counties will experience tremendous increase in life expectance as a result of behaviour change.

When sex differences in life expectancy are examined, the results indicated an increase in the gap between life expectancy at birth among the females and males across all the counties when HIV and AIDS interventions were incorporated in mortality projections. However, the gap between male and female life expectancy at birth varied across the counties. This implies that the effectiveness of HIV and AIDS related programs vary across the counties. Women in counties currently experiencing high uptake of HIV related intervention such as Nairobi and counties in the former Central province are projected to survive longer than their counterparts in other counties which are currently experiencing low uptake of HIV and AIDS related programs.

5.5: Suitability of the model

The ASSA2008 which is the main model used in this study fails to capture other proximate determinants of fertility such as contraceptive use and changes in marriage patterns which affect fertility to a very large extent. The estimated future TFRs did not take into account dynamics in contraception and marital dynamics**.** For example, the huge TFR differences witnessed in counties in the north eastern region may imply that women in those regions enter into marriage at lower ages and consequently they are exposed to the risk of conception for a long period. Hence much of the changes in TFR witnessed in the study may be due to changes in the other proximate determinants of fertility since HIV prevalence is low in those counties.

Secondly, the model used is deterministic and may work well in regions which are equally affected by HIV/AIDS as Botswana and South Africa. These include regions such as Nyanza, Western and Nairobi but not in regions with very low HIV prevalence such as Wajir and Mandera.

Third, other factors which affect fertility and mortality such as poverty levels are not factored in the model. This questions the applicability of the model in developing counties characterised by high poverty levels.

Finally, the projected population size did not directly account for the contribution of migration.

CHAPTER SIX

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

6.1 Introduction.

The study sought to compute county level population projections in Kenya in the era of HIV/AIDS at a time when the health programs to address population and health issues have been devolved to the counties. This was guided by the fact that there has been significant increase in the population in Kenya not only at the national level but also at the regional level. The projection horizon runs from 2009(the date of the most current population and housing census) to 2030the year earmarked for achieving Kenya's vision 2030. To achieve this objective, the following specific objectives were formulated to guide the study:

i) To compute county population projections without incorporating HIV/AIDS.
ii) To compute county specific population projections incorporating HIV/AIDS.
iii) To compute county specific population projections incorporating both HIV/AIDS and effect of program interventions.

6.2 Summary of findings on the county specific population projections without incorporating HIV/AIDS

The first objective of this study was to generate county specific population projections without incorporating the effect of HIV/AIDS and interventions initiated to reduce the impact of HIV/AIDS in Kenyan population. The results of the analysis showed that, in the absence of HIV/AIDS, all counties would continue to experience tremendous increase in population size. Nairobi County is projected to have the highest population size at 6.6million by 2030. Other counties projected to have high population by 2030 include Nakuru (2.8million), Kakamega (2.7million), Kiambu (2.7million), Bungoma (2.2million) and Meru (2.1million). Further, the results indicate that Marsabit, Samburu, Tana River, Isiolo and Lamu counties are projected to be the least populous counties by 2030.

In terms of fertility projections, the study established that, in absence of HIV/AIDS all counties would experience steady fertility decline. This indicates that fertility transition is expected to take place across all counties. However, the tempo of fertility decline varied considerably across all the counties. Counties with highest level of contraception prevalence and high levels of literacy are projected to have the lowest TFR by 2030. The findings of the study revealed that Nairobi County and the counties in the former central province will record the lowest TFR by 2030. Counties in the former North Eastern province and their neighbours in the former Rift – Valley province will record the highest TFR by 3030.

In terms of mortality projections, in the absence of HIV/AIDS, the study established that if HIV/AIDS played no role in population dynamics in Kenya at county level, then expectation of life among males would increase throughout the projection horizon though at a varying rate. Among the males, Isiolo County is projected to have the highest life expectancy at birth while Siaya County is projected to record the lowest life expectation at birth. Generally e(0) among males is projected to be higher in Nairobi County and in counties in the former Central and Eastern provinces. It will be lowest in counties in former Nyanza, North Eastern and Western provinces. Among the females, in absence of HIV/AIDS all counties are projected to record an increase in e(0) throughout the projection period. However, huge variations in life expectancy at birth would be expected throughout the projection period. Life expectancy at birth will be highest in Isiolo County at 75 years and it will be lowest in Wajir County at 58 years.

6.3 Summary of findings on the county specific population projections incorporating HIV/AIDS and the effect of interventions

The second objective of this study was to establish whether programs/interventions initiated to reverse the negative effects of HIV/AIDS in Kenyan population are bearing fruits at the county level in Kenya. The results of the analysis showed that, indeed these programs are having positive impact in population growth and projections at county level. The study findings also revealed that the effect of these interventions in population growth vary by counties. In all counties, population is projected to be higher in HIV/AIDS scenario than in no HIV/AIDS scenario. Nairobi County which doubles as the capital city of the republic of Kenya is projected to have the highest net increase in population size attributable to program interventions by 2030. Tremendous increase in population size attributable to interventions put in place to address the HIV/AIDS scourge is also expected in counties rich in amenities such as Kiambu, Nakuru, and Kakamega. These counties also host some of the large urban centres. The impact of interventions as per as population projections is concerned is projected to be lowest mostly in counties in former North-eastern province and in Taita Taveta County.

As far as fertility is concerned, the study established that fertility response to HIV/AIDS is projected to vary across the counties. The findings of the study revealed that HIV/AIDS will lead to reduction in TFR across all the counties. However, the effect of HIV on fertility reduction tended to vary by the level of HIV prevalence. Counties with high HIV prevalence and relatively low contraception prevalence recorded the highest projected reduction in TFR. On the other hand, counties with the lowest HIV prevalence and low levels of contraception prevalence are projected to record the lowest percent reduction in TFR by 2030

When initiatives geared towards mitigating the effect of HIV/AIDS are incorporated in TFR projections, the study established that TFR will reduce across all counties throughout the projection period. Highest reduction in TFR due to interventions is projected to be witnessed in counties with low uptake of intervention such as contraception. These include most of the counties in the former North Eastern province and their neighbours in the former Rift Valley province. Counties with High HIV prevalence and relatively high contraception prevalence such as Nairobi, Kisii and Mombasa showed lower percentage reduction in TFR attributable to HIV/ AIDS interventions.

In terms of mortality projections, the study established that throughout the projection period HIV/AIDS would lead to decrease in life expectancy at birth in all counties except in Mandera County, Wajir, Kisumu, Migori and Siaya. The study further established that the effect of HIV/AIDS on life expectancy vary by county and gender. Among the females, life expectancy at birth is projected to be consistently high in no HIV/AIDS scenario than in HIV/AIDS scenario in all counties except in Wajir County. However, as far as males are concerned and contrary to expectations, HIV/AIDS is projected to lead to increase in e(0) in all counties in Luo Nyanza.

The study established that, HIV/AIDS interventions would lead to increase in life expectancy at birth among males and females in all the counties. However, the effect of these interventions varies across the counties. The findings indicated that, the greatest change in population growth attributable to HIV/AIDS interventions is being experienced inLamu, Tana River and Samburu Counties.

Generally, the study established that for both sexes,HIV/AIDS interventions are playing key role in affecting life expectancy at birth in those counties which can be regarded as lagging behind in terms of infrastructural development.

6.4 Conclusion

The findings of this study show that the first objective of the study which was generating county specific population projections without incorporating HIV/AIDS and effect of programs was indeed achieved. County specificpopulation projections which do not incorporate HIV/AIDS were generated. The finding indicated that, in absence of HIV/AIDS, all counties in Kenya would record steady increase in population size throughout the projection period. Nairobi County will remain the most populous county throughout the projection period. Other counties projected to have the highest population by 2030 are Nakuru, Kakamega, Kiambu, Bungoma and Meru.

In terms of fertility projections, the findings revealed that in absence of HIV/AIDS, all counties would experience steady fertility decline throughout the projection period. The findings corroborated those of previous researchers who found that fertility transition has already started in Kenya (Mutuku, 2013). The pace of fertility decline however varied considerably by regions and is projected to be more pronounced in counties with low contraception prevalence. This is because the health function has been devolved to counties and consequently reproductive health programs are likely to reach most of the people who are currently unaware of the same in these counties.

The results further established that, in absence of HIV/AIDS life expectancy for both sexes would increase in all counties throughout the projection period. However, huge variations in life expectancy would be evident between counties. Among the males, in absence of HIV/AIDS life expectancy would be highest in Isiolo and lowest in Siaya by 2030. Among the females, by 2030, life expectancy would be highest in Isiolo and lowest in Wajir.

The second and third objectives of this study which were computation of county specific population projections while incorporating HIV/AIDS and program interventions were also achieved. The findings of the study revealed that HIV/AIDS will lead to fertility reduction across all the counties. However, the rate of fertility reduction varied considerably by HIV prevalence. On average, counties with relatively high HIV prevalence recorded the highest percentage reduction in TFR throughout the projection period while counties with low HIV prevalence on average recorded relatively low percent reduction in TFR.

The findings of the study revealed that the HIV/AIDS interventions were indeed effective at the county level. The study also found that while these interventions are effective, their effectiveness varied across the counties. Counties which are already saturated with HIV programs such asNairobi are expected to record the lowest decline in TFR attributable to HIV program interventions. This is because knowledge of HIV transmission and prevention is almost universal in these counties and much may not change by 2030. On the contrary, counties currently characterised by low uptake of HIV related programs such as Wajir are expected to record the highest percent reduction in TFR by 2030 as these programs become widespread due to devolvement of health function.

As far as mortality projections is concerned, the study concluded that HIV/AIDS would lead to decrease in life expectancy at birth in all counties except in Mandera county, Wajir, Kisumu, Migori and Siaya. The study further established that the effect of HIV/AIDS on life expectancy vary by county and gender. Among the females, life expectancy at birth is projected to be consistently high in no HIV/AIDS scenario than in HIV/AIDS scenario in all counties except in Wajir County. However, as far as males are concerned and contrary to expectations, HIV/AIDS is projected to lead to increase in e(0) in all counties in Luo Nyanza.

When interventions geared towards mitigating the effect of HIV/AIDS in Kenyan population are introduced in population projections at county level, the study established that, these program interventions would lead to increase in life expectancy at birth among males and females in all counties implying that the interventions are playing crucial role in population growth at county level. However, the effect of these interventions on life expectancy varies by counties. Lamu, Tana River and Samburu counties are projected to respond well in terms of the role of program interventions in affecting population growth at county level.

6.5 Contribution of the study

The existing county specific population projections in Kenya focus on projected estimates of county population size. Projections of fertility indicators like TFR and mortality indicators like life expectancy are not done. The effect of HIV/AIDS prevalence on population growth at county level remains undocumented in Kenya. Besides the effectiveness of HIV/AIDS programs in relation to population growth at county level remain undone. Based on these gaps the study contributes to the existing knowledge by including more demographic parameters in population projections. In particular variations in life expectancy and the total fertility rates across the counties were done. The national government needs this information to guide in allocation of funds to counties to spur economic development in an effort to realise vision 2030.

In the devolved system of governance in Kenya, this is the first study to evaluate the effectives of HIV/AIDS programs in relation to population growth at county level. The study modelled the effect of the following AIDS interventions on county population growth which is lacking in the existing literature: information and education campaigns, prevention of mother to child transmission probabilities, voluntary HIV counselling and testing and syndromic management of sexually transmitted infections. The purpose of this is to establish whether all government efforts to mitigate the effect of HIV/AIDS on Kenyan population are bearing fruit at the county level. This information is useful not only at the county level but also at the national level. At the county level, the findings generated should act as reference point in strengthening health care and up scaling uptake of HIV/AIDS interventions. At national level, the study forms basis for planning on provision of both primary and secondary education in addition to provision of security.

6.6 Study Limitations

In implementing this study, migration was not fully taken into account because the model used could not produce projections of net migrants at sub national level. Therefore, the relationship between migration and HIV and AIDS could not be established in this study although migration plays a key role in population growth at sub national level.For instance, people who are too sick living in other areas might opt to migrate to their home areas and therefore their deaths might not be fully accounted.

6.7 Recommendation for policy

Based on the findings of this study, it is recommended that population projections for future planning should take in to account the role of HIV and AIDS related programs since the study established that these programs are affect population growth.

The study further recommends that the health function which is already devolved to county level should to be strengthened by allocating more resources to the health function for the purpose of implementing strategies aimed at reducing the impact of HIV/AIDS in Kenyan population. This should involve strengthening of information and education campaigns as well as availing more Antiretroviral drugs. The free child delivery in government hospitals should be strengthened by employing more doctors at county level and opening up all counties through construction of roads to ensure that hospitals are accessible. The national health insurance scheme should be strengthened to cover more hospitals for outpatients as opposed to the current scenario where one has to choose one hospital. This will in effect facilitate easy access to government initiatives geared towards addressing the HIV/AIDS scourge.

6.8 Recommendations for further research

Although migration is a key component of population change at sub-national level, this study did not generate sub-national migration projections because of limited models for projecting migration flows. Future research should focus on developing models for projecting net migrants at sub national level.

The study did not take into account the effect of other proximate determinants in fertility projections such as use of contraception and changes in marriage patterns. Thus, the estimated future TFR did not take into account the dynamics in contraceptive use and marital dynamics which vary by regions in Kenya. Future research should incorporate changes marital dynamic and contraceptive use in fertility modelling.

ASSA2008 is structured based on South Africa experience where HIV prevalence is high. The applicability of the model should be tested in other regions with low HIV prevalence.

While there is evidence to show that fertility transition is taking place in Kenya, the results of this study showed huge variation in the pace of fertility decline at county level. Future research should endeavour to establish determinants of fertility transition at county level.

The study also established that, the HIV interventions are indeed affecting fertility and mortality across all counties. The study findings also revealed that the effect of HIV/AIDS interventions on fertility and mortality varied across the counties. However, the pathways through which these interventions affect population change at county level were not examined due to lack of adequate data. Future research should endeavour to unearth these pathways.

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