DETERMINANTS OF LIFE EXPECTANCY IN KENYA: A TIME SERIES ANALYSIS (1961-2013)

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A research paper submitted in partial fulfillment of the award of Master of Arts, Economics degree at the University of Nairobi.

Declaration

This research paper is my original work and has not been presented to any other institution or university.

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This research paper has been submitted for examination with my approval as the university supervisor.

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Dedication

To my family, for their unwavering support and belief!

Table of Contents

List of tables

List of figures

Abbreviations

ADF   Augmented Dickey-Fuller

AIC   Akaike Information Criterion

AIDS   Acquired Immunodeficiency Syndrome

AGPO Access to Government Public Procurement Opportunities

ARDL Autoregressive Distributed Lag model

GDP   Gross domestic product

GNI   Gross National Income

ECM   Error correction model

HDI   Human Development Index

H.I.V   Human Immunodeficiency Virus

SSA   Sub Saharan Africa

LEB   Life expectancy at birth

OECD Organization for Economic Cooperation and Development

PPP   Purchasing power parity

PM   Particulate matter

UN   United Nations

VAR   Vector Autoregressive model

Abstract

Kenya's life expectancy has been improving from a low of 46.36 years in 1960 to 61.6 years in 2014. However this is still below the world life expectancy of 71.5 years. The country aims at achieving a life expectancy of 72 years by 2030. This study investigated determinants of life expectancy in Kenya for the period 1961-2013.

The study employed the VAR model to analyze the effect of per capita GDP, urbanization rate, food production index (a proxy for food availability) and pollution on life expectancy. Granger causality test was used to test the causality relationship between life expectancy and per capita GDP.

The study findings indicate that per capita income, pollution and food production index (proxy for food availability) were significant determinants of life expectancy in Kenya. Higher income improves life expectancy while an increase in pollution (proxied by carbon dioxide emission) and low food production index negatively affect life expectancy. The effect of urbanization on life expectancy was not significant.

To achieve high life expectancy, efforts should be made to explore innovative ways of increasing household/individual income, reducing pollution and enacting policies aimed at enhancing food security.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

In assessing the human development index (HDI) of a country, life expectancy is used as an indicator of human development. Governments therefore seek to improve the life expectancy of its citizens as part of their development agenda. Kenya is placed in the low human development category (UNDP, 2015). Kenya's HDI value increased from 0.453 to 0.548 between 1980 and 2014 [see **Figure 1**]. During this period, life expectancy at birth dropped to a low of 50.7 years in 2000 and later recovered to 61.6 year in 2014 possibly due to efforts in fighting the HIV/AIDS pandemic. Similarly, education and standard of living measured by Gross National Income (GNI) per capita are used to assess the human development index. The expected years of schooling increased from 9.3 years in 1980 to 11 years in 2014. This could be attributed to the free primary education policy that came into effect in 2003. Consequently, the average years of schooling increased from 2.5 years in 1980 to 6.3 years in 2014. In the same period, GNI per capita increased by approximately 24.9 percent due to growth of the economy witnessed over the years.

To achieve socio-economic progress, governments invest in social sectors like education and health. Several studies have indicated that increase health expenditure improves health outcomes (Novignon *et al.,* 2012; Makuta & O'Hare, 2015). Government investment in health infrastructure and human resource for health leads to better healthcare provision that ultimately improves the health status of its citizens. Education is positively associated with health seeking

behavior and improves knowledge on health risks that induces more utilization of health services (Behrman, 2015; Kitui *et al.,* 2013; Tarekegn *et al.,* 2014).

Figure 1: Trends in Kenya's HDI component indices, 1980-2014
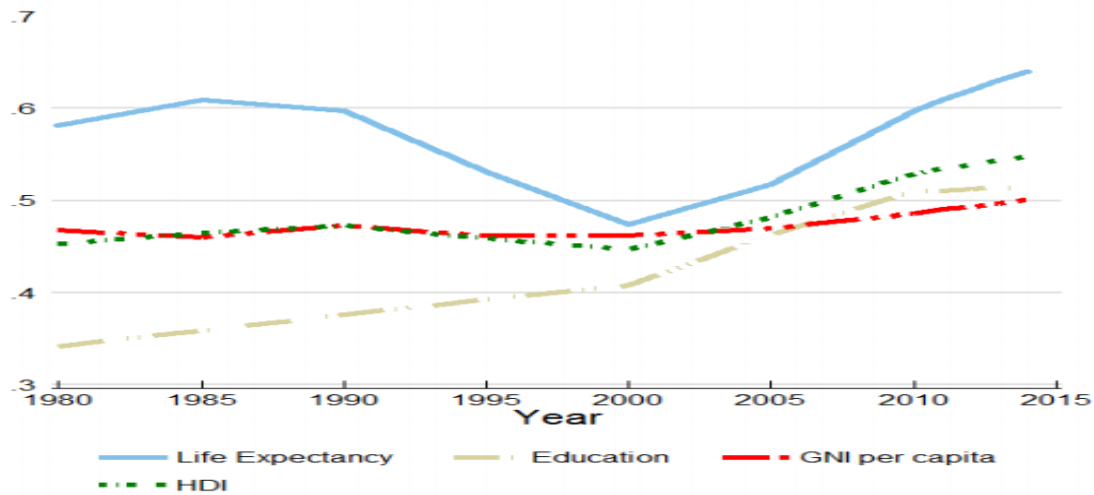
Source: UNDP (2015)

The world life expectancy increased from 70.2 years in 2009 to 71.5 years in 2014 (World Bank, 2016). However, disparities exist across income level and region. Comparing life expectancy based on country's economy, the life expectancy of lower middle income economies (which Kenya is categorized in) is 67.3 years while that of high income countries is 80.6 years (World Bank, 2016). OECD member countries had a high life expectancy of 80.2 while Sub-Saharan Africa (SSA) countries had a mean life expectancy of 58.6 years. This can be attributed to high income countries having a higher share of income spent on health that is associated with better health status (Poullier *et al.,* 2002). Compared with her neighbor's, Kenya has a life expectancy of 61.6 compared with Tanzania's 64.9 years, Rwanda's 64 years with Uganda having a lower life expectancy of 58.5 years (World Bank, 2016). Even though Kenya's life expectancy at birth has been on an upward trajectory from a low of 46.36 years in 1960 to 61.6 years in 2014, it is

below Mauritius which has the highest life expectancy of 74.2 years in Sub Saharan Africa, (World Bank, 2016).

Gains in life expectancy have been reversed by HIV/AIDS in SSA and Kenya in particular (see Figure 2), faced a declining life expectancy in the 90's due to HIV/AIDS pandemic that was on the rise and had a devastating effect on health in Kenya (Republic of Kenya, 2012). According to National Aids Control Council, (2016) the HIV prevalence in Kenya stands at 5.9% of the total population while deaths associated with AIDS related illnesses stood at 35,821 in 2015. Despite efforts to increase HIV treatment services, the treatment coverage is at 66% (National Aids Control Council, 2016). This means that 620,063 people are at risk of contracting AIDS related illnesses since they do not receive antiretroviral therapy.

The United Nations projected that a HIV prevalence of 2.5% among adults reduces life expectancy by 4 years and an additional more than a year for every 1% point rise in HIV prevalence (UNAIDS, 2004). The 2004 projections by United Nations suggests that Sub-Saharan life expectancy dropped by 3 years since 1990 while countries most affected by HIV/AIDS faced a 20 year or more drop in life expectancy at birth (UNPD, 2005). Dorling *et al.*,(2006) indicated that life expectancy in Africa was 6.9 years lower due to AIDS in the period 2000-2005.

As part of its plan to control the population program in Kenya, the government of Kenya through Sessional Paper no.3 of 2012 developed the National Policy for Sustainable Development. Part of its demographic target is an improvement of life expectancy at birth from 57 years in 2009 to 64 years by 2030 (Republic of Kenya, 2012). These targets seem to be on course to being met earlier than projected time frame however they conflict with targets set in the Kenya Health Policy (2014-2030) that aims towards a life expectancy of 72 years by 2030.

Figure 2: Trend in life expectancy and HIV prevalence rate

Bar chart showing Life expectancy at birth, total (years) and Prevalence of HIV, total (% of population ages 15-49) for years 1990 to 2014. Y-axis from 0 to 70.

Legend: ■ Life expectancy at birth, total (years)   ■ Prevalence of HIV, total (% of population ages 15-49)
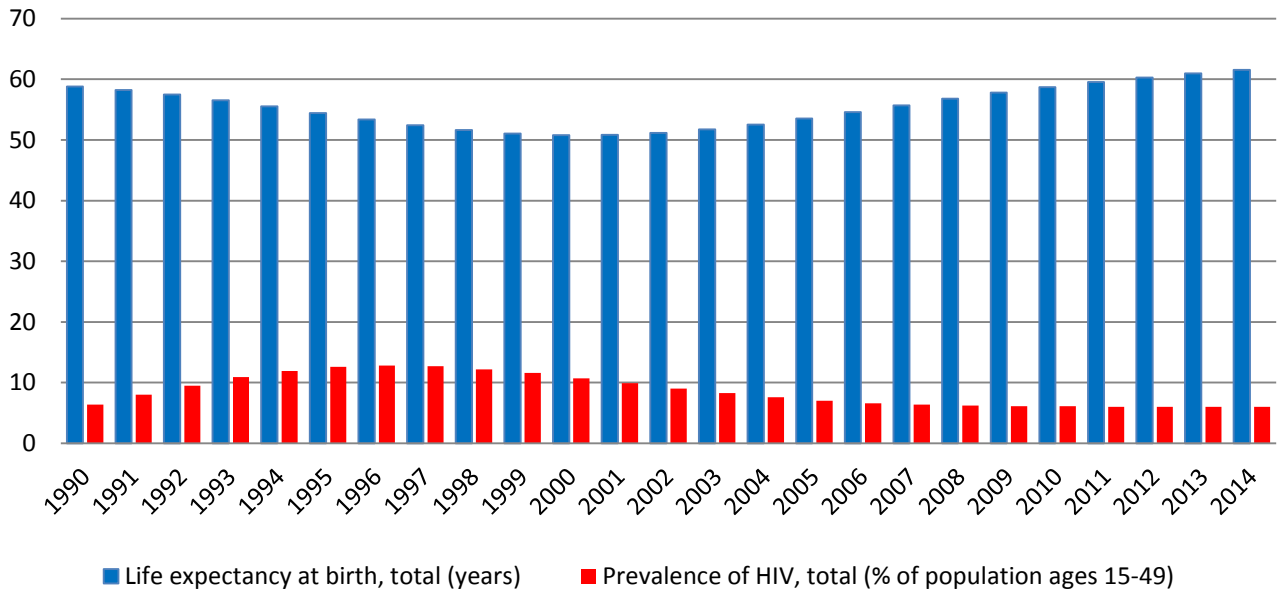
1.2 Statement of the problem

Various studies have examined the effect of income and urbanization on life expectancy and found mixed results, for instance the studies by Kabir, (2008); Sede and Ohemeng, (2015) found income had no significant effect on life expectancy while Lin et *al.,* (2012); Kim and Kim, (2014) found income to be a significant determinant of life expectancy. While Shahbaz *et al.,* (2015) found urbanization rate had a significant effect on life expectancy, Barlow *et al.,*(2011); Kabir, (2008) found urbanization rate having an insignificant effect on life expectancy. Thus the literature on impact of income and urbanization on life expectancy is yet to come to a consensus.

The Kenya Health Policy (2014-2030) whose goal is "to attain the highest possible standard of health in a responsive manner" sets a target for Kenya to achieve health status of a middle income economy. To achieve this health status, Kenya has set policy targets that it aims to reach by 2030. One of the policy targets is improving life expectancy of Kenyan citizens by 16% from 60 years in 2010 to 72 years by 2030 (Republic of Kenya, 2014). However, for the government

to achieve the life expectancy target, it is imperative to determine the factors affecting life expectancy in Kenya. Although several studies have examined the relationship between life expectancy and a set of factors (see for example Sede and Ohemeng, (2015); Ali and Ahmad, (2014) and Shahbaz *et al*., (2015), there are hardly studies done in Kenya that have examined the effect of food availability and pollution on life expectancy. The closest study to determinants of life expectancy in Kenya is by Ndisha, (2013) which examined the effect of gender, age of retirement and amount of pension received on longevity of retirees. No study is yet to examine country specific determinants of life expectancy in Kenya. To achieve the policy target, there is need to identify the factors that influence Kenya's life expectancy and their effect so that policy interventions can be made to speed up progress of attaining high life expectancy.

This study attempts to answer the question, what is the effect of income, urbanization, food availability and pollution on life expectancy in Kenya?

1.3 Aim and Objectives of the Study
The aim of this study is to investigate determinants of life expectancy in Kenya. The specific objectives are;

1) To identify the determinants of life expectancy in Kenya.

2) To estimate the effect of the identified determinants of life expectancy in Kenya.

3) To suggest policy recommendations on how to improve life expectancy in Kenya based on the study findings.

1.4 Justification of the study
Studies that have incorporated Kenya while investigating factors that determine life expectancy in a cross country analysis investigated different variables using different estimating models with the studies having conflicting results on the effect of these determinants on life expectancy (see

Kabir, (2008); Lin *et al.,* (2012); Novignon *et al.,* (2012). The studies used multiple regression, linear mixed model, and panel data regression models which fail to account for the lagged effect of the exogenous variables on life expectancy and endogeneity nature of life expectancy and per capita income. High life expectancy is a form of human capital that enables one to work longer and earn more income in absence of illness while the level of income affects ones consumption of basic necessities and expenditure on health that influences one's health status. Makuta & O'Hare, (2015) used the two stage least square regression which accounts for endogeneity problem but fails to capture the lagged effect of the regressors on life expectancy. This study employs the Vector Autoregressive (VAR) model to estimate the lagged effects of the explanatory variables on life expectancy in Kenya in oder to account for the endogeneity between life expectancy and per capita income.

Life expectancy is a key population health indicator of a country. For Kenya to attain a middle income economy health status it is important for policy makers to be privy of determinants of life expectancy and their effect. The country specific determinants of life expectancy in Kenya are yet to be explained. By providing this information, the study will assist planers and health policy makers in coming up with ways of improving life expectancy as envisioned in the Kenya Health Policy (2014-2030).

In addition, this study seeks to contribute to the existing debate on the effect of income on life expectancy and causal relationship between them. It also seeks to contribute new knowledge on the effect of pollution and food availabilty on life expectancy in Kenya.

1.5 Organization of the study

Chapter two presents a review of relevant literature while the third chapter discusses the research

methodology used in the study and estimation issues. Chapter four discusses the study findings

while chapter five gives a summary of the study findings, conclusions and policy

recommendations based on the study findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical literature review

2.1.1   Grossman model

According to Grossman (1972), good health is a commodity that is produced by individuals and households. Good health is produced based on the choices individuals and households make. The choices made are constrained by initial health endowment, finance, social and natural environment (Mullahy, 2010). A key assumption is that individuals are endowed with an initial stock of health that depreciates as they age and can be increased by investing in healthcare. Certain socioeconomic variables referred as 'environmental variables' e.g. education influences the health production function. The health status of a group can be predicted from the output of the health production function.

2.1.2 Preston Curve

Preston, (1975) observed that an increase in a country's GDP per capita improved the life expectancy of its population. This relationship held true in his analysis of the periods 1930 and 1960 and led to what is known as the Preston curve. GDP was used since it gives a good indication of living standards. In the Preston curve, income levels had diminishing returns to life expectancy in the 1960's. An increase in per capita income in high income countries resulted in a lower increase in life expectancy than in low income countries. This could be attributed to new health interventions that were exploited by underdeveloped countries e.g. TB vaccination and use of antibiotics to treat infectious diseases whose potential could be realized at relatively low expenditure. Secondly, more efforts have been focused on low income countries with greatest impact on mortality reduction by international health programs. Preston discovered an upward shift of the curve from the empirical analysis of the 1930 data and 1960 data. He suggested that

the upward shift of the curve could be attributed to non-income factors like education, nutrition and improvement in public health services e.g. antimalarial initiatives, reduction of deaths related to plague, smallpox and cholera. From his analysis, Preston found that the income level of a country attributed to between 10 to 25 percent growth in life expectancy.

Preston's work has not gone unchallenged. Despite the high correlation between income and health, the causality relationship may arise from improved health leading to a higher income and this calls for an empirical investigation of the reverse causality between income and life expectancy (Bloom and Canning, 2007). Moreover, an increase in resources due to an increase of revenue does not necessarily guarantee that extra funds will be used in health sector to improve health outcomes. Easterly, (1999) argued that there is a lag between period moments of economic growth and improvement in health of a population.

2.2 Empirical literature

Sede and Ohemeng, (2015) employed the VAR model in examining socioeconomic factors that affect life expectancy in Nigeria for the period 1980-2011. They found that secondary school enrolment rate; a proxy for literacy had a positive effect on life expectancy. This is consistent with findings by Lin *et al*., (2012); Makuta and O'Hare, (2015). A percentage increase in secondary school enrolment in the past increases life expectancy by 15 days. Literacy improves the productivity of labor which in turn raises income growth that ultimately influences health care services consumption. Literacy also improves health awareness of an individual. An increase in unemployment rate negatively affected life expectancy, a finding consistent with Buck & Maguire (2015). Unemployment reduces the chances of one affording to cater for medical bills where user fees are charged and also influences the choice of health care facility that one attends. Exchange rate of the Naira against the US dollar had a negative effect on life

expectancy. A depreciation of the local currency exchange rate indirectly influences the ability to afford health services since medical equipment are mostly imports that incur import charges. Government health expenditure and income per capita were insignificant. The insignificance of government health expenditure was attributed to a decline on capital expenditure on health compared to recurrent expenditure on health. Insignificant effect of income on life expectancy was attributed to the probability that the data on per capita income had implicitly taken into account the poverty level in Nigeria. The study found per capita income and life expectancy Granger cause each other.

Kabir, (2008) while investigating the factors influencing life expectancy in developing countries using multiple regression and probit model found that per capita income, access to safe drinking water, urbanization, expenditures on health and education to be statistically insignificant in determining life expectancy. This was attributed to methodological challenges of using cross-sectional study instead of panel data due to unavailability of long term data. However, increasing physicians' availability, reducing adult illiteracy and undernourishment would improve life expectancy.

Balan and Jaba, (2011) analyzed factors that influence life expectancy in Romania using a regression analysis. They found that wages, number of doctors, number of beds in hospital and readers subscribed to a library had a positive impact on life expectancy while illiteracy had a negative impact. A 10 percent increase in wages increased the life expectancy by approximately 131 days in Romania. A 10 percent increase in the ratio of illiterate population led to a decrease in life expectancy by approximately 0.16 percent.

Ali and Ahmad, (2014) using the Autoregressive Distributed Lag (ARDL) method in analyzing the effect of various socioeconomic factors on life expectancy in Oman in the period 1970-2012, found that school enrollment and food availability had positive and significant effect on life expectancy. Food provides the nutrition the body requires for a good health thus low food production makes people susceptible to malnutrition and starvation due to food insecurity. School enrolment is a proxy for literacy. Carbon dioxide emission had a negative effect on life expectancy. Environmental pollution causes illnesses and in severe cases leads to mortality.

Shahbaz *et al.*, (2015), while examining causes of life expectancy in Pakistan using Autoregressive Distributed Lag bounds testing model, found that economic misery (inflation and unemployment) and illiteracy had a negative impact on life expectancy. A rise in inflation lowers the purchasing power of a household thus reducing its consumption of essential goods and services worsening a household's welfare. Increased public health spending had a positive effect on life expectancy consistent with findings by Cremieux *et al.*, (2005); Novignon *et al.*, (2012). Life expectancy increased by 0.46 percent due to a percentage increase in public health expenditure while holding other factors constant. Increased urbanization improved life expectancy. This is consistent with findings by Arouri *et al.*, (2014). Population in urban areas have access to better health services and improved socioeconomic infrastructure that impact positively on health.

Gulis (2000) investigated the effect of some overall environmental indicators on life expectancy in 156 countries using a linear regression and found that an increase in per capita GDP, calories available as a percentage of needs, literacy and access to safe drinking water improved life expectancy. Health spending was statistically insignificant in affecting life expectancy. This was

attributed to multicollinearity between per capita public health expenditure and per capita GDP in the multivariate regression model.

Barlow *et al.*, (2011) in a cross sectional multivariate analysis of life expectancy in 77 countries found that better nutrition, literacy and increased population with access to safe water had a positive effect on life expectancy. A 10 percent increase in the adult literacy rate raises life expectancy by 1.3 years. Reduced fertility improved life expectancy because having fewer children encourages more investment in child health and nutrition. Urbanization was not significant in determining life expectancy. This was attributed to environmental influences on health in which the positive effect was offset by the negative influences like poor sanitation. Effect of per capita health expenditure was insignificant possibly because a large percentage of the expenditure is aimed at reducing morbidity rate as opposed to mortality rate. Secondly, there exists inefficiency in health facilities brought about by bureaucracy and inadequately trained health staff. Income had a positive effect on life expectancy consistent with the findings of Lin *et al*., (2012); Kim & Kim, (2014). A 10% increase in per capita income raises life expectancy by 0.14 years in their cross country analysis of determinants of life expectancy.

Chen *et al*., (2013) (Chen et al., 2013)investigated the effect of air pollution on life expectancy in China, posit that life expectancy in Northern China was 5.5 years lower than Southern China. The study further suggested that an additional exposure of 100 μg/m^3 of total suspended particulates was linked to a three year reduction of life expectancy. Ebenstein *et al.*, (2015) also found a negative relationship between air pollution exposure and life expectancy in China. Stevens *et al*., (2008), while studying impact of environment on mortality in Mexico suggested that reduction of urban PM pollution would lead to a gain of life expectancy by 2.4 months. Pope

III *et al.*, (2009) concluded that reducing pollution in the United States would result to a 15% increase in life expectancy.

2.2.3 Overview of empirical literature

Different methodologies have been used to estimate the effects of determinants of life expectancy (panel data regression, VAR, multiple regression, two stage least squares regression and ARDL). Panel data regression, multiple regression are however faulted for not accounting for the lagged effects of exogenous variables on life expectancy as well endogeneity between life expectancy and per capita income. Two stage least squares does not consider the lagged effects of exogenous variables on life expectancy and it may produce inconsistent estimates if the instrumental variable used to control for endogeneity is weakly correlated with per capita income.

A review of factors that affect life expectancy indicates that per capita income, urbanization rate, food availability, pollution, literacy, unemployment, exchange rate, nutritional status, inflation, health expenditure and access to safe drinking water are significant factors. However, due to data limitation, all of these variables cannot be included in the estimation model used in this study. This study employs the Vector Autoregressive estimation model and includes per capita GDP, urbanization rate, food production index (proxy for food availability) and pollution as the independent variables.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Conceptual framework

Figure 3: Conceptual framework of determinants of life expectancy

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                    ┌─────────────────┐
                    │  Health outcome │
                    │ (life expectancy)│
                    └─────────────────┘
                             ▲
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        │            │                │             │
┌──────────────┐ ┌──────────────┐ ┌──────────────┐ ┌──────────────┐
│   Income     │ │Socioeconomic │ │Food          │ │Environmental │
│(per capita   │ │status        │ │availability  │ │pollution     │
│GDP)          │ │(Urbanization)│ │(food         │ │(carbon       │
│              │ │              │ │production    │ │dioxide       │
│              │ │              │ │index)        │ │emission)     │
└──────────────┘ └──────────────┘ └──────────────┘ └──────────────┘
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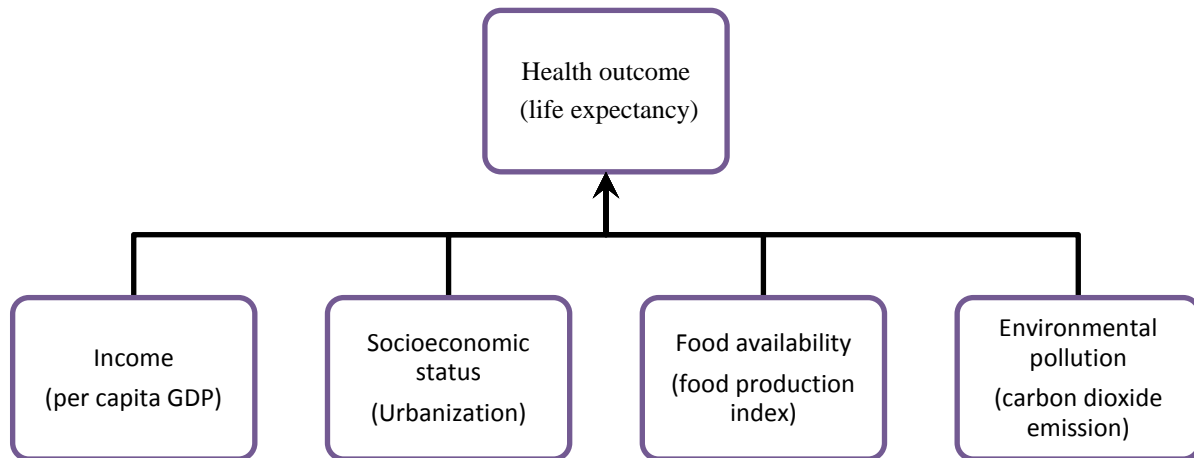
Health of individuals is determined by the social and economic conditions that they live in (Grossman, 1972). Income and socioeconomic development are health promoting factors. Income enables individuals to access medical care and pay for it which in turn improves their health and enables them to live longer (Kimani, 2014). Kabir (2008) posits that urban population has an advantage of improved infrastructure as well access to better health facilities that are better equipped with medical equipment and medical staff to treat illness. However, populations living in slums tend to exhibit poor health status relative to those in posh neighborhood. The disparity is due to poor drainage and deplorable housing condition in the slums, low income that

poses a challenge to access to health care. Pollution is an environmental health hazard that influences the risk of diseases and mortality which lowers an individual's life expectancy.

Food is a basic need required for one's survival. It provides the nutritional requirements for bodies to function as well as nutrients that help the body to fight off diseases which lowers an individual's health status. In severe cases, famine leads to malnutrition and death due to starvation. The National Food and Nutrition Security policy notes that per capita food availability has declined by over 10% in the past 30 years yet consumption has been rising by 3% per year thus making Kenya food insecure (Republic of Kenya, 2011). Food production index is used as a proxy for food availability because it compares food production of a certain year from the production of the base period. An index above 100 indicates that food production of that year was higher than that of the base period and hence more food was available.

3.2 Theoretical framework

The approach used in modeling determinants of life expectancy is adapted from Grossman (1972) and Preston (1975). The health status of a population can be derived from a health production function which involves different inputs and life expectancy as an output based on the Grossman model of health capital. According to Grossman (1972), individuals are endowed with an initial health which depreciates over time. To improve the stock of health, individuals invest in their health through utilizing health care that is constrained by income. Therefore health capital H can be expressed as a function for initial health stock H_0 and income Y as follows;

$$H = f(H_0, Y) \dots \dots \dots \dots (3.1)$$

Taking the health capital to be life expectancy LE, then life expectancy is a function of income as revealed by the Preston curve. Preston (2016), posit that income only accounted for between 10

to 25 % increase in life expectancy. Other covariates that affect life expectancy are represented by X. In particular, X includes urbanization rate, pollution, food availability and cost of living. Therefore the relationship between life expectancy and income including other covariates is expressed as follows;

$$LE = f(Y, X) \dots \dots \dots \dots (3.2)$$

However, the Preston curve indicate that the relationship between life expectancy and income is nonlinear, therefore taking the logarithm of equation (3.2) transforms it into a linear equation (3.3)

$$\ln LE = \ln Y + \ln X \dots \dots \dots \dots (3.3)$$

Following suggestion by Easterly (1999) that there exists a lag between economic growth and improvement of population health, lagged variables of both income and its covariates replace the exogenous variables in (3.3) transforming it into equation (3.4)

$$\ln LE = \ln \sum_{i=0}^{K} Y_i + \ln \sum_{i=0}^{K} X_i \dots \dots \dots \dots (3.4)$$

Where; K is the number of lags.

3.3 Estimation Model
Life expectancy is a human capital that determines the amount of time that an individual engages in an income earning activity assuming time lost due to sickness is minimal. A high longevity translates to more time that one spends earning wages. On the other hand, income influences life expectancy through expenditure on health care services, housing, education and food that influences the health of an individual. The reverse causality between life expectancy and income

brings about the problem of endogeneity where a regression of the two will give inconsistent estimates. Makuta and O'Hare (2015) used the instrumental variable approach to control for endogeneity between life expectancy and income. However, the instrumental variable approach suffers a problem of producing inconsistent estimates if an instrument is correlated with an error term or if it is weakly correlated with explanatory variable that is endogenous with the dependent variable.

To address the problem of endogeneity, this study used the Vector Autoregressive model based on the findings of Sede and Ohemeng (2015) that there exists a reverse causality between life expectancy and income. If reverse causality exists, then there is no distinction between independent and dependent variables in the model as suggested by Sims (1980). All of the variables are regressed against their own lagged values and lagged values of other variables in the model. This removes the need of using an instrumental variable that may give inconsistent estimates. Each dependent variable is regressed on its own past values and lagged values of all other independent variables in the model.

Lagged variables are added in the model because the impact of the explanatory variables on life expectancy is not instantaneous but take time to be felt. The lag in each variable in the model is one beyond which values of the exogenous variables don't affect the dependent variable. The lag length to be used in the model is based on the Akaike Information Criterion. The data was transformed to natural logarithm. The equations are as follows;

$$LLEXP_t = \propto_{1t} + \sum_{j=1}^{K} \beta_{1j} LLEXP_{t-j} + \sum_{j=1}^{K} \gamma_{1j} LPGDP_{t-j} + \sum_{j=1}^{K} \Omega_{1j} LURB_{t-j} + \sum_{j=1}^{K} \delta_{1j} LFPI_{t-j}$$
$$+ \sum_{j=1}^{K} \psi_{1j} LCO2_{t-j} + \mu_{1t} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots (3.5)$$

$$LPGDP_t = \alpha_{2t} + \sum_{j=1}^{K} \beta_{2j} LLEXP_{t-j} + \sum_{j=1}^{K} \gamma_{2j} LPGDP_{t-j} + \sum_{j=1}^{K} \Omega_{2j} LURB_{t-j} + \sum_{j=1}^{K} \delta_{2j} LFPI_{t-j}$$

$$+ \sum_{j=1}^{K} \psi_{2j} LCO2_{t-j} + \mu_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3.6)$$

$$LURB_t = \alpha_{3t} + \sum_{j=1}^{K} \beta_{3j} LLEXP_{t-j} + \sum_{j=1}^{K} \gamma_{3j} LPGDP_{t-j} + \sum_{j=1}^{K} \Omega_{3j} LURB_{t-j} + \sum_{j=1}^{K} \delta_{3j} LFPI_{t-j}$$

$$+ \sum_{j=1}^{K} \psi_{3j} LCO2_{t-j} + \mu_{3t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3.7)$$

$$LFPI_t = \alpha_{4t} + \sum_{j=1}^{K} \beta_{4j} LLEXP_{t-j} + \sum_{j=1}^{K} \gamma_{4j} LPGDP_{t-j} + \sum_{j=1}^{K} \Omega_{4j} LURB_{t-j} + \sum_{j=1}^{K} \delta_{4j} LFPI_{t-j}$$

$$+ \sum_{j=1}^{K} \psi_{4j} LCO2_{t-j} + \mu_{4t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3.8)$$

$$LCO2_t = \alpha_{5t} + \sum_{j=1}^{K} \beta_{5j} LLEXP_{t-j} + \sum_{j=1}^{K} \gamma_{5j} LPGDP_{t-j} + \sum_{j=1}^{K} \Omega_{5j} LURB_{t-j} + \sum_{j=1}^{K} \delta_{5j} LFPI_{t-j}$$

$$+ \sum_{j=1}^{K} \psi_{5j} LCO2_{t-j} + +\mu_{5t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (3.9)$$

Where;

$LLEXP_t$ = log of life expectancy at birth over time.

$LPGDP_t$ = log of per capita GDP over time.

$LURB_t$ = log of rate of urbanization over time.

$LFPI_t$ = log of food production index over time.

$LCO2_t$ = log of CO_2 emission in kilo tons over time.

J = 1, 2… 5

K= total number of lags.

$\sum$= summation of the lagged coefficients

β_{ij} = coefficients of life expectancy.

γ_{ij} = coefficients of per capita GDP.

Ω_{ij} = coefficients of rate of urbanization.

δ_{ij} = coefficients of food production index.

ψ_{ij} = coefficients of CO_2 emission in kilo tons.

μ_{it} = stochastic error term.

In equation (3.5) life expectancy is regressed against lagged values of itself, per capita GDP, rate of urbanization, food production index and pollution. In equation (3.6), (3.7), (3.8), (3.9), per capita GDP, urbanization rate, food production index and carbon dioxide emission are regressed on the lagged values of the regressors respectively. In this study, only estimates of equation (3.5) are be presented since the study only focused on determinants of life expectancy and their effects.

3.4 Estimation issue

3.4.1 Endogeneity

Endogeneity problem arises when an exogenous variable is correlated with the error term. The reverse causality between life expectancy and per capita income brings about the problem of endogeneity during estimation. Estimation of models without controlling for endogeneity produces inconsistent empirical results that cannot be used to make recommendations. The instrumental variable method solves the endogeneity problem by replacing the explanatory variable that is correlated with the error term with an instrument that is correlated with the endogenous explanatory variable but has no effect on the dependent variable. However, if the instrument is correlated with the error term or if its correlation with the endogenous explanatory variable is weak then the instrumental variable method will produce inconsistent estimates. To control for endogeneity the VAR model does not make a distinction between exogenous and endogenous variables. Furthermore, it takes into account the lagged effect of the variables. All

variables are treated as dependent variables and are regressed against lagged values of itself and other variables in the model.

3.5 Estimation tests

3.5.1 Unit root test

Economic time series data may exhibit a trend or unit roots over time. A time series is said to be stationary if the mean and variance do not vary systematically over time (Gujarati, 2004). A stationary stochastic process implies that the underlying stochastic process that generated the series is invariant with time. Non stationary time series produce spurious regression results where results may suggest significant statistical relationship when in reality no meaningful relationship exists between the variables.

In the presence of unit roots, one de-trends the series to remove the non-stationarity (deterministic trend) in it. Augmented Dickey-Fuller test investigates the existence of systematic and linear relationships between past and present values of variables. The ADF test adds lagged values of the endogenous variable in a random walk with a drift model with a deterministic trend to take care of the problem of correlation of the error term. The regression is run in the following form;

$$\Delta Y_t = \beta_1 + \beta_2 t + \delta Y_{t-1} + \sum_{i=1}^{m} \propto_i \Delta Y_{t-i} + \varepsilon_t \ldots \ldots \ldots (3.10)$$

Where t is the time trend variable and ε_t is the error term which is independently and identically distributed. When estimating, the null hypothesis is that $\delta = 0$, that is, there exists a unit root in Y_t. The acceptance of the null hypothesis confirms the presence of unit root.

3.5.2 Lag length selection

If the present value of a dependent variable is explained by the present value of an exogenous variable and past value of the exogenous variable, then lag selection is a necessity. VAR model estimation requires a lag length selection in the model. Akaike Information Criterion (A.I.C) which imposes a penalty for adding regressors to the model was used to select the maximum lag length.

3.5.3 Granger causality

Testing for Granger causality involves estimating the regression below while assuming the disturbance terms μ_{1t} and μ_{2t} are not correlated.

$$LLEXP_t = \sum_{i=1}^{n} \propto_i LPGDP_{t-j} + \sum_{j=1}^{n} \beta_j LLEXP_{t-j} + \mu_{1t} \qquad (3.11)$$

$$LPGDP_t = \sum_{i=1}^{n} \lambda_i LPGDP_{t-j} + \sum_{j=1}^{n} \delta_j LLEXP_{t-j} + \mu_{2t} \qquad (3.12)$$

There exists a one-way directional causality from $LPGDP_t$ to $LLEXP_t$ when the estimated lag coefficients on the lagged $LPGDP_t$ is statistically different from zero i.e., $\sum \propto_i \neq 0$ in equation (3.11) and the estimated coefficients on the lagged $LLEXP_t$ is not statistically significant from zero i.e. $\sum \delta_j = 0$ in equation (3.12). Conversely, there exists one way causality from $LLEXP_t$ to $LPGDP_t$ when the estimated lag coefficients on the lagged $LPGDP_t$ in equation (3.11) is not statistically different from zero i.e. $\sum \propto_i = 0$ and the lagged $LLEXP_t$ coefficients in equation (3.12) is statistically different from zero i.e. $\sum \delta_j \neq 0$.

In a case where both the sets of $LLEXP_t$ and $LPGDP_t$ coefficients are statistically different from zero in both regression, there exists a bi-directional causality whereas no causality exists between

the two variables if the sets of both $LLEXP_t$ and $LPGDP_t$ are not statistically significant in both regressions (Gujarati, 2004).

3.5.4 Tolerance and variance inflation factor.

If the explanatory variables are correlated, statistical inference will be a challenge. Estimated coefficients may be have the wrong/unexpected sign or rendered statistically insignificant despite regression having a high coefficient of determination Greene, (2003). In measuring the degree of multicollinearity, Gujarati (2004) posits that a variance inflation factor of more than 10 is high collinearity. A tolerance index close to zero indicates severe collinearity while a tolerance index closer to 1 suggests low collinearity. Variance Inflation Factor is the coefficient of determination in the regression of an explanatory variable on the remaining explanatory variables in the model less one i.e. $(1-R^2)$. Tolerance index is the inverse of Variance Inflation Factor.

3.5.5 Normality test

The error term in a regression model are required to have a normal distribution for a model to have unbiased estimates. The Cholesky test was employed by this study to examine the normality of the residual.

3.6 Data Source and Definition of variables

3.6.1 Data source

This study used data obtained from the world development indicators dataset for Kenya (World Bank, 2016). This is time series data that is collected yearly by the World Bank and other agencies of the United Nations. Kenya's life expectancy data was obtained from (1) United Nations Population Division, World Population Prospects. Food production index based on the 2004-2006 food production quantity was obtained from Food and Agriculture Organization. Carbon dioxide emission was obtained from Carbon Dioxide Information Analysis Center that estimated carbon dioxide emission from burning fossil fuel and manufacture of cement based on

(Marland and Rotty, 1984) methodology using Kenyan data collected by UN Statistical Office. Per Capita GDP was sourced from World Bank national accounts data. Data on Kenya's urban population growth rate was obtained from estimates based on United Nations Population Division, World Urbanization Prospects.

The time series data was converted into natural logarithm to take care of any nonlinear relationship among the variables and interpret the coefficients as elasticities.

3.6.2 Variable definition

Table 1: Variable description

Variable	Definition and measurement	Expected sign	Source
Life expectancy	It is the number of years a newborn infant would live if prevailing mortality patterns at the time of its birth were to stay the same throughout its life. This is the dependent variable.		World Development Indicator, 2016
Per capita GDP.	It is the total value of goods and services produced in a country in a year divided by the total population in mid-year. It's measured in Kenya shillings.	+	World Development Indicator, 2016
Urbanization rate.	It is the change in urban population growth per year.	+/-	World Development Indicator, 2016
Food production Index (2004-2006=100)	A proxy for food availability. It is the percentage ratio of food produced per year compared to the average food production quantity in 2004-2006.	-	World Development Indicator, 2016
Carbon dioxide emission.	A proxy for pollution. It is carbon dioxide emission from burning fossil fuels and cement manufacturing measured in Kilo tons.	-	World Development Indicator, 2016

CHAPTER FOUR

STUDY FINDINGS

4.1 Descriptive statistics

The mean life expectancy in Kenya in the period 1960-2013 was 54.86 years. Each Kenyan earned an average income of 20,568 Kenya shillings per year in the period 1960-2013. The mean level of urbanization rate was 5.47%. This means that urban population grew by 5.47% every year. The average carbon dioxide emission was 6,360.93 kilotons each year while the mean average food production was 61% of the average 2004-2006 food production in the country.

Table 2: Descriptive statistics

Variable	Mean	Standard Deviation	Range	
			Minimum	Maximum
Life expectancy	54.86146	3.793931	47.013	60.95378
Per Capita GDP	20568.03	27941.99	677.395	108609
Urbanization rate	5.468596	1.525059	4.073019	8.169952
Carbon dioxide emission	6360.93	3134.947	2401.885	13457.89
Food Production Index	61.52415	30.45784	23.9	124.04

Source: Author's computation

4.2 Econometric results

4.2.1 Unit root test

To avoid spurious regression that leads to biased and inconsistent estimates, the time series data for the variables were tested to determine their stationarity status. Augmented Dickey Fuller test was used and results presented in three dimensions; model with intercept only, model with trend and intercept and model with no trend, no intercept (see Table 8) in the appendix. Time series data for life expectancy is stationary in a model with trend and intercept at 10% level of significance. Per capita GDP data was non stationary at level in the trend and intercept model but

become stationary at 1 % level of significance after first differencing. Time series data on carbon dioxide emission was non stationary at level but stationary at 1 % level of significance after first differencing in a model with intercept only and one with trend and intercept. Food production index data had a non-stationary at level but is stationary at 5 % level of significance after first differencing in a model with an intercept only. Data for urbanization rate was non stationary at level but became stationary at first difference in a model with no trend and no intercept at 1 % level of significance.

4.2.2 Lag Length Selection

There is uniform results for lag selection with; AIC, LR, FPE, Schwarz Quinn information criteria and Hannan-Quinn information criteria being minimized at lag of 4 (see

Table 9) in the appendix. This study used lag 4.

4.2.3 Granger Causality test

Table 3: Granger Causality test result

Direction of causation	Chi2	Prob >chi2	Remark
LPGDP →LLEXP	32.55	0.000	Reject
LLEXP → LPGDP	9.5e +05	0.000	Reject
LURB → LLEXP	6.9886	0.136	Do not Reject
LLEXP → LURB	12790	0.000	Reject
LFPI → LLEXP	30.785	0.000	Reject
LLEXP → LFPI	3.3e+05	0.000	Reject
LCO2 → LLEXP	19.758	0.001	Reject
LLEXP → LC02	11986	0.000	Reject

Source: Author's computation

The null hypotheses that per capita GDP, food availability, urbanization and CO_2 emission do not granger-cause life expectancy were rejected. There is reverse causality relationship between life

and per capita GDP. This implies that increasing per capita GDP is necessary to improve life expectancy at the same time improving life expectancy is needed to increase per capita GDP. The same case applies for pollution and food availability. Increased carbon dioxide emission deteriorates life expectancy at the same time a higher life expectancy leads to an increase in carbon dioxide emission. There is a one way causality relationship between life expectancy and urbanization rate in favor of life expectancy. Urbanization and does not granger-cause life expectancy.

4.2.4 Tolerance and Variable Inflation Factor
Table 4: Variation Inflation Factor (VIF) & Tolerance Index Statistics

Variable	VIF	Tolerance index (1/VIF)
LPGDP	1.55	0.644215
LCO2	1.37	0.729287
LURB	1.06	0.943318
LFPI	1.15	0.867588

Source: Author's computation

The tolerance indices are closer to 1 than zero suggesting that the variables exhibit low collinearity among themselves same as the VIF which are below 10. Such mild collinearity is acceptable in estimation.

4.2.5 Normality tests
Table 5: VAR Normality test results

Test Criterion	Joint Chi-square	Prob > chi2
Jarque-Bera	489.231	0.000
Skewness	85.541	0.000
Kurtosis	403.691	0.000

Source: Author's computation

The Jarque-Bera statistics, Skewness and Kurtosis passed the Chi-square test at 1% level of significance. The normality test indicates that the residuals are normally distributed.

4.2.6 VAR results

From the VAR estimation, coefficient of determination of 0.99 indicates that the explanatory variables accounted for 99% change in life expectancy. The chi square statistic was significant at 1% level therefore the null hypothesis that the explanatory variables do not have any significant relationship with life expectancy was rejected.

Table 6: VAR estimated coefficients

Variable	Coefficient	Z ratio	Variable	Coefficient	Z ratio
Life expectancy (1)	3.618744	598.49*	Food production (1)	-0.0025513	-4.50*
(2)	-4.941318	-10.29	Index (2)	-0.0016523	-2.42**
(3)	3.022847	185.77*	(3)	-0.0026916	-3.84*
(4)	-0.7019025	-65.13*	(4)	-0.0024896	-3.77*
Per Capita GDP (1)	0.0000258	-0.06	Carbon dioxide (1)	-0.0002587	-1.00
(2)	0.0005522	1.34	Emission (2)	-1.6e-06	-0.01
(3)	0.0010498	2.52**	(3)	-0.00011	-0.05
(4)	0.0022075	4.81*	(4)	-0.000823	-4.05*
Urbanization rate(1)	0.0004623	1.44	Constant	0.0065157	2.30
(2)	0.0003331	1.05	$R^2 = 0.99$		
(3)	0.000487	1.59			
(4)	0.0001748	0.56	Chi2 = 2.91**		

Source: Author's computation. *1% level of significance, **5% level of significance

Note: † The coefficients are obtained as number of days by multiplying by 365. A year is taken to be 365 days.

The per capita GDP coefficients are 0.0000258, 0.0005522, 0.0010498, 0.0022075 for the immediate past, second, third and fourth year respectively. The effect of per capita GDP in the immediate past 2 years were insignificant in affecting life expectancy. This implies that the effect of income on life expectancy takes time to be felt and its impact starts to be felt from the third year. That is why it's lagged in the model. In the past third and fourth year, a percentage

increase in per capita GDP increased life expectancy by approximately 0.00105% and 0.0022% respectively. A ten percent increase in per capita GDP in the past third and fourth year raised life expectancy by approximately 4 and 8 days respectively[†]. The explanation for this finding is that income enables one to afford health care which improves the health of an individual.

The coefficients of the pollution variable are -0.0002587, -0.00011, -0.000823 for the immediate past, third and fourth year respectively while the coefficient for the second lag (-1.6e-06) is extremely small approaching to zero. However, the coefficients of the past three lags are insignificant. While the negative coefficients indicate a loss of life expectancy, their insignificance in the short run is possibly due to a mere reflection of mortality cases that would arise days later even without exposure to pollution. A percentage increase in carbon dioxide emission reduces life expectancy in the fourth year by 0.000823% at 5% level of significance. This means that an increase carbon dioxide emission by 100 kilo ton increase in the past fourth period reduces life expectancy by approximately 32 days[†]. Inhaling carbon dioxide emission results to increased cardiovascular and pulmonary diseases that may leads to poor health and deaths in extreme cases. The detrimental effect of pollution on life expectancy becomes significant when lagged for longer period because exposure to pollution does not lead to instantaneous mortality rather it increases mortality risk with time. Exposure to air pollution has a delayed effect on the deterioration of a person's health status therefore a time series study on effect of pollution on life expectancy requires a long observation window i.e. several years to reveal the magnitude of a loss in life expectancy due to pollution as explained by Rabl *et al*., (2011) on the methodological challenges of time series analysis on mortality. A few lags only reveal the lower bound loss of life expectancy.

The coefficients of food production index variable are -0.0025513, -0.0016523, -0.0026916 and -0.0024896 for the immediate past, second, third and fourth year respectively. A percentage decrease in food production reduced life expectancy in the immediate past, second, third and fourth year by approximately 0.0026%, 0.0017%, 0.0027% and 0.0025% respectively. A ten percent drop in food production from the production of base period 2004-2006 reduces life expectancy in the immediate past, second, third and fourth years by approximately 9.5, 6.2, 10 and 9.1 days respectively[†]. The total effect in deterioration of life expectancy due to a decrease in food production is about 35 days. Much of Kenya's land is arid and semi-arid with low agricultural potential, coupled with reliance on rain fed agriculture; it increases the risk of Kenya being food insecure. Low food production that occur during bouts of drought and famine brings about food insecurity that leads to severe malnutrition cases which lowers immunity to fight illnesses while starvation can lead to high mortality that decrease life expectancy.

The coefficients of urbanization rate are 0.0004623, 0.0003331, 0.000487 and 0.0001748 for the immediate past, second, third and fourth year respectively but are insignificant. This finding is consistent with Barlow *et al.,*(2011); Kabir, (2008) but contradict with Shahbaz *et al.,* (2015). This implies that urbanization has less influence on population health in Kenya. A possible explanation for this is that gains made on population health due to urbanization are offset with low access to quality health care among the low income earners in informal settlements, unplanned rapid urbanization and a high population density that puts pressure on public infrastructure resulting to poor sanitary condition that increases the risk of spreading disease.

4.2.7 Variance Decomposition

The variance decomposition indicates the magnitude of the impact of a variable to another in an auto regression model. Taking a simple linear model with two variables; Y- the dependent variable and X- the independent variable

$$Y = \alpha + \beta X + \mu \dots \dots \dots (4.1)$$

The variance of Y will be the expected variance with respect to X plus the variance of the expected variance of Y.

$$Var(Y) = E(Var[Y|X]) + Var(E[Y|X]) \dots \dots \dots (4.2)$$

The variation of Y comprises of two components; a variation explained by changes in X and variation due to chance. The ratio of the two components is compared to the F ratio and if found to be greater than the F ratio then effect of X in creating total variance is significant.

Variance decomposition measures the proportion of error variance in one variable explained by innovations from its self and other variable. It indicates the relative contribution of past period's life expectancy to its current values as well as the contribution made by other independent variables in the model to life expectancy. Urbanization was found to be insignificant in both causation and as a determinant of life expectancy from the Granger Causality test and VAR results. The magnitude of its impact can be exposed from variance decomposition of the VAR. The variable decomposition estimates for a period of 20 years are presented in Table 7. Apart from a share of 41.568 % on itself, pollution contributed to the largest share of a change in life expectancy by 14.15 % in a twenty year period. This was followed by changes in food production with 13.4377 % and per capita GDP at 9.2529%. Urbanization is the least contributor of change in life expectancy with 1.5881%.

30

Table 7: Variable decomposition estimate

STEP	LEXP	URB	PCGDP	LFPI	CO2
1	100	0.1818	3.6254	0.64369	20.0383
2	98.5556	0.5707	5.1663	12.2663	19.867
3	95.9575	0.608	5.0615	11.5334	16.1718
4	92.4508	0.5522	5.0408	11.4858	15.527
5	87.9032	0.5664	7.8527	9.9096	16.3733
6	82.7224	0.7298	7.723	13.2314	15.432
7	77.5062	0.742	7.5901	12.8739	14.6924
8	72.5732	1.0588	7.5747	12.7907	14.7598
9	68.0354	1.1966	7.4026	13.6367	14.0721
10	63.9307	1.2657	7.443	13.2062	14.4234
11	60.2335	1.2654	7.7969	13.1705	14.2658
12	56.8906	1.3789	8.0359	13.0612	14.1372
13	53.8682	1.4027	8.5177	13.1059	14.2677
14	51.16	1.403	8.9836	13.321	14.2349
15	48.7686	1.523	9.2562	13.2808	14.1919
16	46.6988	1.5607	9.3881	13.3438	14.1873
17	44.9529	1.5605	9.3955	13.4247	14.1519
18	43.5256	1.5807	9.3364	13.4267	14.1511
19	42.404	1.5789	9.2839	13.4522	14.102
20	41.568	1.5881	9.2529	13.4377	14.1544

Source: Author's computation

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary and Conclusion

This paper investigated the determinants of life expectancy in Kenya using the VAR model. The variables used in this study were per capita income, CO_2 emission (proxy for pollution), urbanization rate and food production index (proxy for food availability). The results indicate that income, pollution and food availability are significant in determining life expectancy while urbanization was not significant. Pollution and low food availability lower life expectancy. Income had a positive effect on life expectancy, a finding consistent with the Preston curve that reveals that a country's life expectancy can be improved through an increase in its income. A Granger causality test between per capita income and life expectancy shows that the two variables have a two way causality revealing that an improvement in life expectancy results to an increase in income and vice versa. The estimation issue of endogeneity between per capita income and life expectancy was overcome by the VAR model which makes no distinction between independent and dependent variable and regresses the variables against the lagged values of itself and other variables.

The variance decomposition of the VAR results further reveal that pollution and change in food production are the biggest contributor to change in life expectancy respectively. This was followed by income and finally urbanization.

Diagnostic tests were carried out to ascertain the robustness of the model. The tolerance and variable inflation factor indicate that there was low collinearity among the variables. The Jarque-Bera test reveals that the residuals are normally distributed.   .

5.2 Policy Recommendations

This study reveals to policy makers the importance of food availability. Food provides nutrients that boost the immune system to fight off diseases thus making it essential towards improving health status. Challenges facing food production in Kenya include declining soil fertility; over reliance of rain fed agriculture and use of obsolete technology among other things. Even though Kenya has a good agricultural research system; both physical and online agricultural extension services, adoption of new technologies by small scale farmers is minimal due to lack of awareness. Increased sensitization on the benefits of soil testing to determine the nutrient deficiency in the soil should be carried out to farmers and recommend appropriate fertilizer for specific crops rather than a blanket application of commercial fertilizer that may result to increase soil acidity which eventually lowers farm productivity. While more irrigation projects are being rolled out, the National Irrigation Board through its Expanded Irrigation Programme is yet to reach its target of having 1.7 million acres of land under irrigation possibly due to inadequate funds. An aggressive resource mobilization campaign can be initiated to source for more donor funds to assist in initiating more irrigation schemes.

The empirical results give a strong argument on reducing carbon foot print and environmental pollution in general to minimize Kenya's contribution to global climate change. Pollution has a negative effect on life expectancy. While Kenya is lowly ranked in the list of countries on carbon emission, it has pledged to reduce its carbon emission by 15% by 2030 through investment in renewable energy and reducing her dependence on fossil fuels. While large solar and wind projects are undertaken through public private partnerships by firms with huge capital, at a micro level adoption of these technologies are deemed to be expensive. The VAT tax exemption on solar products is an initiative that should get continued commitment in the coming years to encourage the adoption of solar energy and net metering among households. The government

should strive to establish a carbon trading platform that enables trading of emission permits among polluters as envisioned in the National Environment Policy of 2013 to induce polluters to reduce their carbon dioxide emission.

To improve the GDP per capita growth in Kenya the government has placed emphasis on job creation by issuing low interest loan through Uwezo and Women Enterprise funds to youths and women; reserving 30% of public tenders to youths, women and persons with disability under the Access to Government Public Procurement Opportunities (AGPO) initiative. However these initiatives have not had a full impact on employment creation due to challenges such as poor book keeping, financial over dependence and disintegration of investment groups that has led to collapse of small scale and medium enterprises. To counter these, further capacity building of entrepreneurial skills should be done to the funds beneficiaries as well as monitoring of their business and appropriate business support should be availed to them.

While the effect of urbanization on life expectancy is insignificant, uncontrolled urbanization can lead to pollution, proliferation of informal settlements and overcrowding which is a health hazard to population health. A draft National Urban Development policy of 2011 was developed with an aim of strengthening urban planning; governance; delivery of social and physical infrastructure in urban areas but has not been adopted. An adoption of this policy and its implementation will ensures that as rapid urbanization takes place the urban environment is habitable and socio-environmental needs are taken care of.

5.3 Areas for further research
From the empirical literature review economic factors like health expenditure, unemployment, foreign exchange rate and literacy do have an impact on life expectancy. These variables were not used in this study due to data limitations. In addition, the effect of HIV/AIDS on life

expectancy has not been controlled for in this study. This study recommends that future research incorporate the above factors when investigating the determinants of life expectancy in Kenya.

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APPENDIX

Table 8: Augmented Dickey-Fuller test result

Variable	Augmented Dickey-Fuller test					
	Intercept only		Trend and Intercept		No trend, No Intercept	
	Level	1st difference	Level	1st difference	Level	1st difference
LLEXP	-1.670	-0.621	-1.670*	—	—	—
LPGDP	—	—	-2.865	-5.454***	—	—
LCO2	-0.957	-4.278 ***	-3.048	-4.224***	—	—
LURB	-1.358	-2.871	-2.227	-2.829	-0.803	-2.827***
LFPI	-0.750	-3.111**	-3.186	-3.031	—	—

*** Null hypothesis rejected at 1%, **Null hypothesis rejected at 5%, *Null hypothesis rejected at 10%.

Table 9: Lag Length Selection results

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	304.863				2.6e-12	-12.4943	-12.4206	-12.2994
1	394.593	179.46	25	0.000	1.7e-13	-15.1914	-14.7494	-14.0219
2	511.01	232.83	25	0.000	4.0e-15	-19.0004	-18.1902	-16.8563
3	589.145	156.27	25	0.000	4.8e-16	-21.2144	-20.0358	-18.0957
4	671.575	164.86*	25	0.000	5.3e-17*	-23.6073*	-22.0604*	-19.514*