

The Effects of Antiretroviral Therapy (ART) on Life Expectancy in Sub Saharan Africa

by  
Jeanette Stevens

A thesis presented to the Honors College of Middle Tennessee State University in partial fulfillment of the requirements for graduation from the University Honors College.

Fall 2017

The Effects of Antiretroviral Therapy (ART) on Life Expectancy in Sub Saharan Africa

by  
Jeanette Stevens

APPROVED:

---

Dr. Stephen Morris  
Department of Political Science  
& International Relations

---

Dr. Michael Federici  
Chair of the Department of Political  
Science & International Relations

---

Dr. James Chaney  
Department of Global Studies &  
Human Geography

---

Dr. John Vile  
Dean, University Honors College

## Dedications

For my professors, who have sparked in me a life-long love of learning and travel.

For my sister, whose strength was an inspiration to my perseverance.

For my parents, whose love and support set the foundation for my achievements.

And for the friends I have made along this amazing journey, and for the Honors College and Buchanan Fellowship that brought us together.

## Abstract

This study seeks to discover the impact of the HIV/AIDS treatment antiretroviral therapy (ART) on life expectancy in Sub Saharan Africa (SSA). Six predictor variables (gross domestic product, foreign direct investment, political stability, literacy rate, the prevalence of HIV/AIDS, and health expenditure) found to be significant in the literature were used to control for extraneous relationships. A hierarchical multiple regression was performed to measure the effects of ART on life expectancy. It was found that when controlling for certain predictor variables, the percentage of the population with HIV/AIDS receiving ART was a significant predictor of the change in life expectancy from 2000-2015. This suggests that to continue the increase in life expectancy in SSA, policymakers should focus on making ART more easily accessible to those who need it most.

*Keywords:* life expectancy, Africa, HIV, AIDS

## Table of Contents

Abstract .....	iii
List of Tables .....	v
Introduction.....	1
Antiretroviral Therapy (ART).....	2
Literature Review.....	4
Life Expectancy .....	4
HIV/AIDS Treatment.....	5
Methodology .....	7
Variables .....	8
Dependent Variable .....	8
Independent Variable .....	8
Control Variables .....	9
Results.....	11
Regression 1: LE as Dependent Variable .....	14
Regression 2: LELONG as Dependent Variable .....	15
Discussion.....	16
Policy Implications .....	17
Limitations .....	17
Conclusions & Future Study.....	18
References.....	19
Appendix A.....	26

## Tables

Table 1. Variables with Operationalizations and Sources .....	10-11
Table 2. Correlations Between 2 Independent and 2 Dependent Variables .....	12
Table 3. Descriptive Statistics and Correlations for All Continuous Variables .....	13
Table 4. Hierarchical Regression Model of Life Expectancy .....	14
Table 5. Hierarchical Regression Model of Life Expectancy Over Time .....	15

According to the World Health Organization (WHO), life expectancy in Africa decreased in the 1990s while the global average increased. Yet for the period of 2000-2015, the African region enjoyed the largest increase in life expectancy: an increase of 9.4 years to an average life expectancy of 60. Though life expectancy has been increasing over the past 10 years, Sub Saharan Africa (SSA) today remains the region with the lowest life expectancy (WHO, 2016a). Austin and Mckinney (2012) blamed the HIV/AIDS boom in SSA in the late 20<sup>th</sup> century for the decrease in life expectancy, as 70% of the world's HIV/AIDS cases are in SSA. Cotton (2011) finds this to be especially important, as young adults are affected the most by the epidemic. This has negative implications for the population distribution, as well as the possibility of shrinking the future generation in the fight against AIDS. Austin and McKinney (2012) also found that the region faces many problems that have been eradicated or minimized in developed countries, such as war, poverty, and hunger. These factors not only decrease life expectancy, but can also create obstacles to deliver the treatment needed to combat HIV/AIDS.

It must be noted, however, that recent efforts by IGOs, such as the Joint United Nations Programme on HIV/AIDS (“UNAIDS Report,” 2012), have resulted in a dramatic effect on the prevalence of HIV/AIDS. From 2001-2011, 23 SSA countries have seen a decrease in HIV/AIDS cases by 26-50%, while another 8 have remained stable.<sup>1</sup> With treatments becoming more advanced and readily available, the population with HIV/AIDS is expected to continue decreasing.

---

<sup>1</sup> UNAIDS defines stable as countries with incidence rates that have not increased or decreased by more than 25%.

Life expectancy is accepted as an indicator of health and is used by international agencies, such as the UN, for indicating national development. It also has important policy implications; for example, if it is found that literacy rates positively correlate with life expectancy, nations with low literacy rates could look to this to create policy to increase literacy (Barlow & Vissandjee, 1999).

For recent life expectancy increases in SSA to continue, research must be done on which actions and policies have been the most significant contributors to the turnaround. Because the scale of HIV/AIDS is much higher in SSA than any other world regions, looking at recent developments in prevention and treatment options will provide a solid foundation on which to begin finding the determinants of increasing life expectancy.

### **Antiretroviral Therapy (ART)**

Because the decline of life expectancy in SSA in the 1990s is traced to the HIV/AIDS epidemic, recent research has been on the effects of antiretroviral therapy (ART) on those infected (Thiers, 2008; Ford, 2011; Mills et al., 2011; Kharsany & Karim, 2016). ART is a combination of anti-HIV drugs which WHO has found to reduce mortality rates of those infected with HIV, as well as raise quality of life (“Antiretroviral,” 2017). UNAIDS has found multiple benefits of the use of ART in HIV treatment: lowering mortality rates, preventing new infections, preventing the risk of tuberculosis in HIV infected patients, contributing to economic development, and increasing labor productivity by allowing patients to return to work earlier (“UNAIDS Report,” 2012).



We now know that ART is incredibly effective in lengthening life spans, but after its creation in 1996, there was international debate on whether the cost was worth the benefits in developing nations. It was argued that ART was too expensive to risk using in countries with subpar health infrastructures. Ford and Mills (2011) found that this changed in 2001 when an Indian generics manufacturer was able to drop the price of ART from \$10,000 USD per patient/year to only \$50 USD.

Most countries in SSA have scaled-up their use in the past decade, but variability across the continent remains. In Botswana, Namibia, and Rwanda, for example, over 80% of eligible patients are covered, while less than one quarter have access in Nigeria and the Central African Republic (Kharsany & Karim, 2016).

Kharsany and Karim (2016) list four factors that may prevent the effectiveness of ART. (1) Most individuals with HIV are never tested, (2) which is often due to a lack of access to facilities. (3) Less than half of those who began ART continue treatment, causing them the struggle to maintain viral suppression. (4) Prevention and treatment services are not being prioritized in the most heavily affected areas.<sup>2</sup>

My goal is to determine if ART had an influence on changes in life expectancy in the SSA region while controlling for other factors. The amount of literature focusing specifically on life expectancy in SSA is smaller than studies with large-Ns or in developing countries. As found in the literature review below, SSA is an anomaly in the field of life expectancy research, as many variables that account for variance in other developing nations do not hold true to SSA. This research seeks to fill this gap by

---

<sup>2</sup> The 2016 UNAIDS update also provides methods to expand prevention and coverage in areas with high concentrations of people living with HIV.

providing a comprehensive analysis on the effects of ART on Sub Saharan life expectancy.

## **Literature Review**

### **Life Expectancy**

Ample research has explored the determinants of life expectancy. Much of this research is performed using a cross-country analysis with a large N. These studies use 70+ countries without differentiating between development statuses. I will first review general life-expectancy studies, followed by those focused on lesser-developed countries, and finally case studies in life expectancy research in SSA.

Some prominent variables shown to have positive effects on life expectancy found in the literature include: per-capita income (Barlow & Vissandjee, 1999; Yavari & Mehrnoosh, 2006; Monsef & Mehrjardi, 2015), literacy rate (Barlow & Vissandjee, 1999; Yavari & Mehrnoosh, 2006), access to clean water (Barlow & Vissandjee, 1999), urbanization (Barlow & Vissandjee, 1999; Monsef & Mehrjardi, 2015), and availability of physicians per 100,000 (Kabir, 2008). Such results show higher life expectancy among more developed countries with greater literacy rates, access to clean water, and levels of urbanization.

When specifically looking at lesser-developed countries (LDCs), however, different patterns emerge. While some research finds these traditionally agreed-upon

variables to be significant with LDCs, others do not. For example, Keita's (2013) research on life expectancy in LDCs found per-capita income to have a significant positive impact, while others found that income showed no significant effect in LDCs (Kabir, 2008; Sede & Ohemeng, 2015; Hauck, Martin, & Smith, 2016), unlike studies observing all countries.

Certain political variables were found to be significant in LDCs. Performing a longitudinal study using 35 years of data from 119 LDCs, Lin et al. (2012) analyzed the effects of four socioeconomic indicators, (GDP per capita, educational attainment, nutrition, and political regime/democracy), on life expectancy. All factors increased life expectancy over time, though democracy did not begin to increase life expectancy until three years into the data. This tells us that though democracy may not have an immediate effect on life expectancy, it will have a positive influence over time. Lin et al. (2012) believe that this is because a democratic regime is more likely to listen to the voices of its citizens and enact policy changes based on the socioeconomic needs of the population. This has important implications for countries with nondemocratic regimes, which are prevalent in SSA. Hauck et al. (2016) also found that increased political stability leads to an increase in life expectancy in LDCs.

### **HIV/AIDS Treatment**

Perhaps the most common variable found to have an impact on life expectancy in LDCs is health expenditure and infrastructure. Heimer (2007) stressed the importance of health expenditure when speaking of the factors that make it so much harder to combat

infectious disease in SSA. To successfully create policy around HIV/AIDS, money and treatment, including ART, are necessary. Austin and McKinney (2012) found that funds from international agencies, such as UNAIDS, account for up to two-thirds of spending on HIV/AIDS in poor countries. They also found that governmental health expenditures were low, correlating with lower GDPs in general. Though some money and treatment may be coming in through foreign aid, the lack of domestic health expenditure leads to a weak medical infrastructure and inexperienced doctors, as reiterated by Sede (2005). In addition, Kabir (2008) found that the availability of physicians per 100,000 people had a positive impact on life expectancy. This shows the need for adequate policy to be formed to build and self-sustain an infrastructure that can handle the epidemic, while also increasing foreign direct investment (FDI).

The literature has confirmed that ART not only lengthens lives, but can also decrease mortality rates altogether. Thiers (2008), along with the Antiretroviral Therapy Cohort Collaboration, performed a study with 43,355 HIV-positive patients from 14 high-income countries. The patients began taking ART for the study and were periodically monitored for one year. The Collaboration found that mortality rates declined at the period of initiation and follow-up periods. This study helped verify that ART can greatly lowered the risk of mortality associated with HIV/AIDS, but only with continued treatment.

The Collaboration confirmed that ART has dramatically increased life expectancy for those with HIV in the US and northern Europe, but it did not address LDCs. Mills et al. (2011) build off the Collaboration's work on the effects of ART in high-income countries by focusing on LDCs. They performed a cohort study on 22,315 HIV patients

in Uganda who started ART during the study. It was found that patients on ART had a comparable life expectancy in comparison to the national average, though there was variation between genders and severity of the disease. This study further exemplifies the need to provide more access to ART, especially in the most vulnerable areas. Mills et al. (2011) find that these benefits will only come to fruition if the international donor community steps up its funding for ART.

### **Methodology**

A contentious issue in African regional studies is which countries should be included in the SSA category. The United Nations Development Programme (UNDP) lists 46 of the 54 African countries as Sub Saharan, excluding Algeria, Djibouti, Egypt, Libya, Morocco, Somalia, Sudan, and Tunisia (“About Sub-Saharan Africa,” 2017). This is not geographically accurate, as some countries included lie on the Sahara, while Djibouti, below the Sahara, is not. The World Bank includes Somalia and Sudan. The states of Mauritania, Mali, Niger, Chad, and Sudan have mixed Arab-African ancestries and include regions in and below the Sahara (“World Bank Country Groups”). For the sake of inclusion, I will use the 48 countries defined by the World Bank, as well as adding Djibouti, bringing the total number of countries in my study to 49 (see Appendix A for full list). To measure the effects of ART on life expectancy while controlling for the effects of extraneous variables, I will perform a multiple regression using IBM’s SPSS package.

To assess only the impact of ART on life expectancy in SSA, the model can be refined by controlling for other variables found to impact life expectancy. Income per capita (Bayati, Akbarian, & Kavosi, 2013; Keita, 2013), health expenditure (Heimer, 2007; Austin & McKinney, 2012), FDI (Heimer, 2007; Austin & McKinney, 2012), political regime (Lin, et al., 2012), level of education/ literacy (Bayati, et al., 2013; Keita, 2013; Hauck, et al., 2016), as well as the prevalence of HIV will be used to control for extraneous relationships.

## **Variables**

### Dependent variables

Two dependent variables will be used for this project, both of which are based on basic measures of life expectancy which summarize mortality risks and trends against the entire population. The first is life expectancy at birth for 2015 (coded as LE). The second is change in life expectancy from 2000 to 2015 (coded as LELONG), which is calculated by the difference of the 2000 and 2015 figures. Data for both variables are taken from WHO (2000, 2015). This indicator is also popular due to its ease of use, availability of data, and international usage.<sup>3</sup>

---

<sup>3</sup> One drawback is that it does not address the effects of disabilities or communicable disease. I will use this variable as other measures of life expectancy, such as healthy life expectancy (HLE) carry more problems. HLE has no single metric for measurement, and because it relies on survey data, (with no international consensus on the questionnaire), there are issues with providing an accurate comparison (“An Overarching Health Indicator,” 2014). For these reasons, I will use the World Bank’s indicator of life expectancy at birth.

### Independent variables

Similar to the dependent variable, I will use two variables to measure the use of ART. I will first use the percentage of the population with HIV/AIDS who are currently receiving ART, (coded as ART). Data is for 2014 and from WHO (“WHO,” 2014). I will then run the same regression, but with the percentage of the population who are on ART and who have been on it for over 12 months. The literature above has shown that ART only reaches peak effectiveness after continued use (Kharsany & Karim, 2016), and I seek to find out if the second variable, (coded as ART12), is a better measure of ART’s effects on life expectancy. Data are for 2011<sup>4</sup> and are from UNAIDS (“UNAIDS Report,” 2012).

### Control Variables

To isolate the impact of ART, this study controls for the influence of a number of variables that have been shown to impact life expectancy. FDI is operationalized as the net inflow of money from investors as a percentage of GDP (“World Bank,” 2015).<sup>5</sup> Given the influence of established democracy in prior studies (Lin et al., 2012), I am using the World Bank’s Worldwide Governance Indicator “Political Stability and Absence of Violence.” I believe the aggregate indicator of political stability, (measured as the likelihood of government failure, coups, and terrorism on a scale from -5 to 5), will most accurately measure a country’s political climate (“World Bank,” 2016a).

---

<sup>4</sup> Data for Zambia are from 2014.

<sup>5</sup> Djibouti FDI data are from 2011.

I chose to include the prevalence of HIV, operationalized as the percentage of the adult population (ages 15-49) with HIV, to account for some cases in the ART data. Countries with low-levels of infection may mean a lower likelihood of being tested and treated. Including the prevalence of HIV, (coded as HIV%), will counter any statistical uncertainty regarding countries with less people infected with HIV (“WHO,” 2016c).

GDP is measured using the World Bank’s indicator of GDP per capita, adjusted for purchasing power parity (PPP). The country’s GDP is converted to constant 2011 international dollars (“World Bank,” 2016).<sup>6</sup> UNICEF measures literacy rate as the percentage of the population over 15 years old who can read and write their local language. Data range from the year 2007 to 2014 (“UNICEF,” 2008-2012). Health expenditure is measured as the sum of public and private health expenditure as a percentage of a country’s GDP (“World Bank,” 2014). A summary of variables with their operationalizations and sources are found below in Table 1.

Table 1. Variables with Operationalizations and Sources

<b>Variables</b>	<b>Operationalization</b>	<b>Sources</b>
Life Expectancy (LE)	The number of years a newborn would live if prevailing patterns of mortality at the time of its birth continued throughout its lifetime	WHO
Change in Life Expectancy, 2000-2015 (LELONG)	The difference between life expectancy in Sub Saharan African nations from 2000-2015	WHO
% Receiving ART (ART %)	Percentage of people living with HIV currently receiving ART	WHO

<sup>6</sup> Data for Eritrea are from 2011, and data for South Sudan and Djibouti are from 2015.



---

% Receiving ART/ 12 months (ART12)	Percentage of adults and children with HIV known to be on treatment 12 months after initiation of antiretroviral therapy.	UNAIDS
Foreign Direct Investment (FDI)	Net inflows in the reporting economy from foreign investors divided by GDP.	World Bank
Political Stability (PS)	An aggregate variable capturing perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism	World Bank WGI
HIV Prevalence (HIV %)	The estimated percentage of adults aged 15-49 years with HIV infection.	WHO
Literacy Rate (LIT) 2007-2015	Percentage of the population over the age of 15 that can read and write	UNICEF
Health Expenditure (HEALTH)	The sum of public and private health expenditure as percentage of GDP	World Bank
GDP/PPP per Capita (GDP) (Control)	PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates.	World Bank

---

## Results

To find the best fitting operationalization of my independent and dependent variables, I performed a correlation with four combinations of the two dependent and two independent variables: life expectancy in years (LE), the change in life expectancy from 2000-2015 (LELONG), the percentage of the HIV/AIDS population on ART (ART), and the percentage of the population on ART who have been on it for over 12 months (ART12). I expected to see the strongest relationship between LELONG and ART12, as consistently taking ART better lowers mortality, which in turn should lead to higher life

expectancy over time. The correlation matrix for the four variables is listed in Table 2 below.

Table 2. Correlation Matrix of Dependent and Independent Variables

	LE	LELONG	ART	ART12
Life Expectancy Sig. (2-Tailed)				
LELONG Sig. (2-Tailed)	-.070 .634			
ART Sig. (2-Tailed)	.314* .034	.465** .001		
ART12 Sig. (2-Tailed)	.453** .005	-.006 .972	.331* .036	

Note. Statistical Significance: \* $p < .05$ ; \*\* $p < .01$

As seen in Table 2, I was surprised to find that ART12 was not a good predictor of life expectancy over time. Because this relationship is not statistically significant, I am unable to continue performing a regression using a combination of these two variables. It is also interesting to note the lack of relationship between the two measures of life expectancy.

The strongest relationship found was using the percentage of the HIV/AIDS population on ART as a predictor for the change in life expectancy from 2000-2015. ART accounted for 46.5% of variance in LELONG, with a less than .1% chance that this relationship is spurious. To continue, I will perform two hierarchical multiple

regressions: one using LE as the dependent variable and one using LELONG as the dependent variable, with the independent variable (ART) the same in both.

Hierarchical multiple regression was performed to investigate the effects of ART on life expectancy over-time in SSA, while controlling for GDP, FDI, prevalence of HIV, political stability, and literacy rate. Preliminary analyses were performed to ensure no violation of the assumptions of normality and linearity. Additionally, the correlations among the variables included in the study were examined and are presented in Table 3 below.

Table 3. Descriptive Statistics and Correlations for All Continuous Variables

Variables	1	2	3	4	5	6	7	8	9
1. LELONG									
2. LE	-.07								
3. ART	.47**	.31							
4. FDI	.13	.00	-.19						
5. PS	.06	.51**	.45***	.13					
6. HIV	.24	.05	.55**	-.02	.37*				
7. LIT	-.06	.41**	.45	-.11	.46**	.49**			
8. HEALTH	.12	-.12	.17	.29*	.12	.41**	.07		
9. GDP	-.16	.43**	.23	-.09	.50**	.38**	.61	-.21	
<i>Means</i>	8.54	61.22	44.61	5.46	-.61	5.00	62.55	6.00	4726.15
<i>Stan. Devs</i>	4.15	5.32	20.41	6.53	.87	6.79	20.03	2.34	6019.81

Note. Statistical Significance: \*  $p < .05$ ; \*\*  $p < .01$

### Regression 1: LE as Dependent Variable

In the first step of the regression, seen below in Table 4, 6 predictor variables were entered. This model explained 20.7% of variance in LE, as seen by the adjusted  $R^2$  value, and was significant at the .05 level ( $F(6, 35) = 2.778; p = .026$ ). After adding ART in Step 2, the total variance explained by the model was 33.0% ( $F(7,34) = 3.888; p = .003$ ). As seen by the p-value, the second model is highly significant. The introduction of ART explained an additional 12.3% of the variance in life expectancy, after controlling for the 6 predictor variables. In the final adjusted model, only ART ( $\beta = .449, p = .01$ ) was a significant contributor to the model.

Table 4. Hierarchical Regression Model of Life Expectancy

Variable	Model 1			Model 2		
	<i>B</i>	<i>SE B</i>	$\beta$	<i>B</i>	<i>SE B</i>	$\beta$
FDI	-.004	.107	.006	.063	.102	.090
PS	2.971	1.004	.494**	2.385	.947	.397*
HIV	-.143	.130	-.214	-.247	.125	-.368
HEALTH	-.431	.383	-.211	-.522	.354	-.255
GDP	.000	.000	-.158	.000	.000	-.105
LIT	.079	.044	.333	.056	.041	.233
ART				.109	.040	.449**
$R^2$		.323			.445	
Adjusted $R^2$		.207			.330	
<i>F</i> for change in $R^2$		2.78*			7.47**	

Note. Statistical Significance: \*  $p < .05$ ; \*\*  $p < .01$

## Regression 2: LELONG as Dependent Variable

This regression uses the same controls and dependent variable, while measuring the *change* in life expectancy from 2000-2015. In the first step of the regression, (see Table 5 below), the control variables were tested. These variables were not predictors of LELONG; the adjusted  $R^2$  equaled -.049, indicating a lack of relationship ( $F(6, 35) = .680$ ;  $p = .666$ ). After adding ART in Step 2, the total variance explained by the model increased to 17.1%. This change in F value is significant at the .01 level, showing a fair amount of significance to the model ( $F(7,34) = 2.205$ ;  $p = .058$ ).

Table 5. Hierarchical Regression Model of Life Expectancy Over Time

Variable	Model 1			Model 2		
	<i>B</i>	<i>SE B</i>	$\beta$	<i>B</i>	<i>SE B</i>	$\beta$
FDI	.036	.108	.059	.113	.099	.185
PS	.515	1.009	.098	-.154	.922	-.029
HIV	.161	.131	.274	.042	.122	.072
HEALTH	.055	.385	.031	-.049	.344	-.027
GDP	.000	.000	-.211	.000	.000	-.142
LIT	-.009	.044	-.043	-.036	.040	-.174
ART				.124	.039	.586**
$R^2$		.104			.312	
Adjusted $R^2$		-.049			.171	
<i>F</i> for change in $R^2$		.680			10.273**	

Note. Statistical Significance: \* $p < .05$ ; \*\* $p < .01$

## Discussion

The results of the initial correlations to choose how to operationalize ART and life expectancy were surprising. I expected all four models to have significant positive correlations, with ART12 and LELONG having the strongest relationship. However, this relationship was not only weak, but highly insignificant ( $p = .972$ ). This could be because ART12 had the most missing data and a relationship could not be properly measured.

While this result was surprising, the strongest relationship (ART% and LELONG) does make sense logically. The more people receiving treatment contributes to increased life expectancy over time in the SSA region. It is possible that the percentage of those with HIV/AIDS on ART is a more important factor to increasing life expectancy than how long they have been on it. This has interesting implications, as it may be more important to focus time and funds on getting the drug to the most people as possible, with less emphasis on follow-ups.

I was further surprised to see that the regression model with LELONG did not have a strong significance ( $p = .06$ ). None of the control variables showed any significance to the model, and even though ART showed a strong correlation ( $\beta = .586$ ,  $p = .003$ ), we cannot be sure that the correlation with the model was not by chance. The first regression model was significant, however, and it can be said with 99.997% certainty that ART does effect life expectancy in SSA when controlling for the 6 independent variables.

## **Policy Implications**

These results add to the growing pool of life expectancy research focused on SSA. This information can be applied in many ways to produce measurable effects on life expectancy. With the confirmation that ART can be a significant force on life expectancy, the focus now needs to be on: (1) Building a healthcare infrastructure that can support a large population of patients. This is easier said than done; FDI and international donors may play a substantial role in obtaining this goal. (2) Promoting the medical sciences, beginning at an early age. For any treatment to be administered, there must be a trained medical professional to provide it. A larger and more highly skilled network of doctors can administer ART to more people, more effectively. (3) Getting the treatment to the people. Having clinics full of doctors ready to provide treatment in the city does not aid those in rural areas who may be limited by transportation or money. I suggest a regional, strategic plan that would place clinics a reasonable distance from patients, with mobile teams to routinely visit the most rural and impoverished of areas.

## **Limitations**

There is no flawless research method, and there are limitations to my research, as well. Because many states in Africa have recently been in volatile situations, some cases were missing in my data. Countries recently formed, such as South Sudan, also lacked data. Additionally, one must always be aware of the chance of collinearity and cannot assume that correlation equals causation.

## Conclusions and Future Study

Africa's life expectancy has shown dramatic improvement since the start of the 21<sup>st</sup> century. I found that ART does have a significant impact on life expectancy, though not necessarily the change in life expectancy overtime. Research must continue to enhance knowledge of the key factors in raising life expectancy.

This research could be improved by controlling for different predictor variables, as those in my model showed limited significance. Also, if the data is available, it may be more beneficial to look at the relationship between the *change* in the population taking ART overtime with the change in life expectancy. Turning this simple multiple regression analysis into a longitudinal analysis may tell us in more detail how and why life expectancy began to increase in the early 2000s, and ART's role in that increase.

Even though the cases of HIV/AIDS continue to decrease, the epidemic still causes thousands of unnecessary deaths each year, (over 1 million in 2016, with 720,000 of those in Africa alone) ("WHO," 2016b). With the expansion of ART programs and continuing research on how to more effectively use this treatment, this generation may soon see the eradication of HIV/AIDS altogether.



## References

About Sub-Saharan Africa. (2017). Retrieved from

<http://www.africa.undp.org/content/rba/en/home/regioninfo.html>

An overarching health indicator for the Post-2015 Development Agenda. (2014).

Retrieved from

[http://www.who.int/healthinfo/indicators/hsi\\_indicators\\_SDG\\_TechnicalMeeting  
\\_December2015\\_BackgroundPaper.pdf?ua=1](http://www.who.int/healthinfo/indicators/hsi_indicators_SDG_TechnicalMeeting_December2015_BackgroundPaper.pdf?ua=1)

Antiretroviral Therapy. (2017). Retrieved from

[http://www.who.int/topics/antiretroviral\\_therapy/en/](http://www.who.int/topics/antiretroviral_therapy/en/)

Austin, K. F., & McKinney, L. A. (2012). Disease, War, Hunger, and Deprivation: A Cross-National Investigation of the Determinants of Life Expectancy in Less-Developed and Sub-Saharan African Nations. *Sociological Perspectives*, 55(3), 421-47. <https://doi.org/10.1525/sop.2012.55.3.421>

Barlow, R., & Vissandjee, B. (1999). Determinants of National Life

Expectancy. *Canadian Journal of Development Studies*, 20(1), 9-29. doi:  
10.1080/02255189.1999.9668787

Bayati, M., Akbarian, R., & Kavosi, Z. (2013). Determinants of Life Expectancy in Eastern Mediterranean Region: A Health Production Function. *International Journal of Health Policy and Management*, 1(1), 57-61.

<https://doi.org/10.15171/ijhpm.2013.09>

- Cotton, D. (2011). Life expectancy in Africa: back to the future? *Annals of Internal Medicine*, 155(4), 265-6. <https://doi.org/10.7326/0003-4819-155-4-201108160-00359>
- Ford, N., Calmy A., & Mills, E. J. (2011). The First Decade of Antiretroviral Therapy in Africa. *Globalization and Health*, 7(1), 33. <https://doi.org/10.1186/1744-8603-7-33>
- Global Aids Update. (2016). Retrieved from [http://www.unaids.org/sites/default/files/media\\_asset/global-AIDS-update-2016\\_en.pdf](http://www.unaids.org/sites/default/files/media_asset/global-AIDS-update-2016_en.pdf)
- Hauck, K., Martin S., & Smith, P.C. (2016). Priorities for Action on the Social Determinants of Health: Empirical Evidence on the Strongest Associations with Life Expectancy in 54 Low-income Countries, 1990-2012. *Social Science & Medicine*, 167, 88-98. <https://doi.org/10.1016/j.socscimed.2016.08.035>
- Heimer, C. A. (2007). Old Inequalities, New Disease: HIV/AIDS in Sub-Saharan Africa. *Annual Review of Sociology*, 33(1), 551-77. <https://doi.org/10.1146/annurev.soc.31.041304.122203>
- Kabir, M. (2008). Determinants of Life Expectancy in Developing Countries. *The Journal of Developing Areas*, 41(2), 185-204. <https://doi.org/10.1353/jda.2008.0013>
- Keita, M. (2013). Standards of Living and Health Status: The Socioeconomic Determinants of Life Expectancy Gain in Sub-Saharan Africa. *Diss. Centre*

*D'Etudes Et De Recherches Sur Le Développement International*. Retrieved from  
<https://mpira.ub.uni-muenchen.de/id/eprint/57553>

- Kharsany, A. B. M., & Karim Q. A. (2016). HIV Infection and AIDS in Sub-Saharan Africa: Current Status, Challenges and Opportunities. *The Open AIDS Journal*, 10(1), 34-48. <https://doi.org/10.2174/1874613601610010034>
- Lin, R., Chen Y., Chien, L., & Chan, C. (2012). Political and Social Determinants of Life Expectancy in Less Developed Countries: A Longitudinal Study. *BMC Public Health*, 12(1). <https://doi.org/10.1186/1471-2458-12-85>
- Mills, E. J., Bakanda, C., Birungi, J., Chan, K., Ford, N., Cooper, C. L., ... Hogg, R. S. (2011). Life Expectancy of Persons Receiving Combination Antiretroviral Therapy in Low-Income Countries: A Cohort Analysis From Uganda. *Annals of Internal Medicine*, 155(4), 209-18. <https://doi.org/10.7326/0003-4819-155-4-201108160-00358>
- Mondal, N. I., & Shitan, M. (2013). Impact of Socio-Health Factors on Life Expectancy in the Low and Lower Middle Income Countries. *Iranian Journal of Public Health*, 42(12), 1354-362. <https://doi.org/10.2188/jea.je20130059>
- Monsef, A., & Mehrjardi, A. S. (2015). Determinants of Life Expectancy: A Panel Data Approach. *Asian Economic and Financial Review*, 5(11), 1251-257. <https://doi.org/10.18488/journal.aefr/2015.5.11/102.11.1251.1257>
- Sede, P. I., & Ohemeng, W. (2015). Socio-economic Determinants of Life Expectancy in Nigeria (1980 - 2011). *Health Economics Review*, 5(1).

<https://doi.org/10.1186/s13561-014-0037-z>

Social determinants of health. (2017). Retrieved from

[http://www.who.int/social\\_determinants/en/](http://www.who.int/social_determinants/en/)

Thiers, B. H. (2008). Life Expectancy of Individuals on Combination Antiretroviral

Therapy in High-income Countries: A Collaborative Analysis of 14 Cohort

Studies. *Lancet*, 372(9635), 293-99. <https://doi.org/10.1016/s0140->

[6736\(08\)61113-7](https://doi.org/10.1016/s0140-6736(08)61113-7)

The World Bank Country and Lending Groups. (2017). Retrieved from

<https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>

The World Bank, World Development Indicators (2015). *Foreign direct investment, net*

*inflows (% of GDP)*. [Data file]. Retrieved from

<https://data.worldbank.org/indicator/BX.KLT.DINV.WD.GD.ZS>

The World Bank, World Development Indicators (2014). *Health expenditure, total (% of*

*GDP)*. [Data file]. Retrieved from

<https://data.worldbank.org/indicator/SH.XPD.TOTL.ZS>

The World Bank, World Development Indicators (2016). *GDP per capita, PPP (constant*

*20111 international \$)*. [Data file]. Retrieved from

<https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.KD>

The World Bank, Worldwide Governance Indicators. (2017). Retrieved from

<http://info.worldbank.org/governance/wgi/index.aspx#reports>

The World Bank, Worldwide Governance Indicators (2016a). *Political Stability and Absence of Violence*. [Data file]. Retrieved from <http://info.worldbank.org/governance/wgi/#reports>

The World Bank in Africa. (2017). Retrieved from <http://www.worldbank.org/en/region/afr>

The World Health Organization, Global Health Observatory data repository (2014). *Estimated antiretroviral therapy coverage among people living with HIV (%)*. [Data file]. Retrieved from <http://apps.who.int/gho/data/node.main.626?lang=en>

The World Health Organization, Global Health Observatory data repository (2000, 2015, 2016a). *Life expectancy*. [Data file]. Retrieved from <http://apps.who.int/gho/data/node.main.688>.

The World Health Organization, Global Health Observatory data repository (2016b). *Number of deaths due to HIV/AIDS, Estimates by WHO region*. [Data file]. Retrieved from <http://apps.who.int/gho/data/view.main.22600REG?lang=en>

The World Health Organization, Global Health Observatory data repository (2016c). *Prevalence of HIV among adults aged 15 to 49*. [Data file]. Retrieved from <http://apps.who.int/gho/data/node.main.622?lang=en>

World Population Aging, Annex II: Classification of Regions. (2015). Retrieved from [http://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA\\_2015\\_Report.pdf](http://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA_2015_Report.pdf)

UNAIDS Report on the global AIDS epidemic. (2012). Retrieved from  
[http://www.unaids.org/sites/default/files/media\\_asset/20121120\\_UNAIDS\\_Global\\_Report\\_2012\\_with\\_annexes\\_en\\_1.pdf](http://www.unaids.org/sites/default/files/media_asset/20121120_UNAIDS_Global_Report_2012_with_annexes_en_1.pdf)

UNICEF, Statistics by Country. Total Adult Literacy Rate (%) 2008-2012. [Data file].  
Retrieved from <https://unicef.org/infobycountry>

Yavari, K., & Mehrnoosh, M. (2006). Determinants of Life Expectancy: A Cross -  
Country Analysis. *Iranian Economic Review*, 11(15), 131-42.  
<https://EconPapers.repec.org/RePEc:eut:journl:v:11:y:2006:i:1:p:131>



## Appendix A

### List of Countries Used in Analysis

Angola	Madagascar
Benin	Malawi
Botswana	Mali
Burkina Faso	Mauritania
Burundi	Mauritius
Cabo Verde	Mozambique
Cameroon	Namibia
Central African Republic	Niger
Chad	Nigeria
Comoros	Rwanda
Congo	Sao Tome and Principe
Cote d'Ivoire	Senegal
Democratic Republic of the Congo	Seychelles
Djibouti	Sierra Leone
Equatorial Guinea	Somalia
Eritrea	South Africa
Ethiopia	South Sudan
Gabon	Sudan
Gambia	Swaziland
Ghana	Togo
Guinea	Uganda
Guinea-Bissau	United Republic of Tanzania
Kenya	Zambia
Lesotho	Zimbabwe
Liberia	