Longevity in Retrospect, Does Conflict Matter? A Panel Data Analysis of Different Countries' Experiences

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Abstract

We investigate the predictors of longevity and how they differ between emerging and OECD countries. Five facetsof longevity are examined: infant mortality, life expectancy for males at birth, life expectancy for females at birth, life expectancy for males at age 65, and life expectancy for females at age 65. Using a country-level panel data set covering the period 1990 through 2014, a series of multivariate regression models are estimated to isolate the effects of health expenditures and other non-health inputs such as the presence of conflicts, environmental factors, lifestyle choices, demographic factors, and economic factors in determining population longevity. Among the 35 OECD countries in the sample, we find a strong negative effect of the presence of conflict on longevity, regardless of how longevity is measured. Other important determinants of longevity include health expenditures and immunizations, pharmaceutical expenditures, number of hospital beds, fertility levels, education, the level of greenhouse gases, sanitation, and the percentage of the population living in poverty. Among the 25 emerging countries in the sample, many of these same variables are important, although their marginal effects differ. We also find that the number of hospital beds significantly correlates with longevity among only emerging countries whereas education, tobacco consumption, and pharmaceutical expenditures strongly correlate with longevity in OECD countries. Conflict, total health expenditures, greenhouse gas, immunization, fertility, sanitation, alcohol consumption and poverty significantly correlate with longevity in the two groups of countries.

Keywords: Longevity, OECD countries, Emerging countries, Conflict, Healthcare expenditures, Environmental factors, Demographic factors, Economic factors, health outcomes.

Introduction

One of the greatest social achievements of the last few decades has been an improvement in life expectancy and infant mortality. People are now living longer than in the past (Crimmins, 2015). This pattern is evident across most developed and developing countries. Over the decades, adverse events in most countries have waned and life expectancy continues to increase. Data from the Organization for Economic Co-operation and Development (OECD) reveal that average life expectancy in the 1940s was about 40 years among OECD member nations (OECD, 2000). This increased to 65.43years in the 1990s (OECD, 2000). Among European countries average life expectancy for females rose from 72.5 to 80 years between 1960 and 1995, and that of men rose from 67.6 to73.6 years over the same period. In the United States, life expectancy in 1960 for females was 73.1 years, whereas for males, it was 66.6 years. By 1980, these figures had risen to 77.4 and 70.0 years respectively. By 2000, they had climbed to 79.7 and 74.3 years, and by 2010, they had increased to 81.1 and 76.2 years respectively (Infoplease, 2000-2017). Thus, between 1960 and 1980, longevity increased by 8.76% for males and 10.81% for females. Currently in Africa, the average life expectancy for males is 61years and for females, 64years. In Asia, the average life expectancy is 75 for males and 79 for females.

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Worldwide, according to the World Health Organization (WHO), between 2010 and 2015 life expectancy at birth for an individual was about 70.5 years, for males it was 68.4 years and for females it was 72.8 years (WHO, 2015). This improvement is attributable to advancements in technology, medicine, education, urbanization, nutrition and other factors (WHO, 2015).

According to the WHO, infant mortality, which is another facet of longevity, has been falling worldwide. The infant mortality rate, defined as the number of deaths under one year of age that occur per 1000 live births in a given year, declined from 18.2% in 1960 to 4.3% in 2015 worldwide (WHO, 2016). Infant mortality was highest in the African region where 55 deaths occurred per 1000 live births in 2015. This was five times higher than in the European region where 10 deaths occurred per 1000 live births. Universally, the infant mortality rate has declined from 63 deaths per 1000 live births in 1990 to about 32 deaths per 1000 live births as of 2015 (WHO, 2016).

This study seeks to empirically examine how increasing health expenditures lead to increased longevity, and whether any other variable influence longevity more than health expenditures. More specifically, this paper differs from prior studies by considering how factors such as conflict, the state of the environment, and the state of a country's economy, affect longevity, and it examines whether and how the health production function of longevity differs between OECD countries and emerging countries.

Conflict kills, results in physical disabilities, creates fear and mental health problems, and damages infrastructure, including hospitals and clinics, and over the years, terrorist groups have become more daring, sophisticated and damaging. These effects may shorten lives and limit the ability to treat medical problems. But no one has looked at longevity effects. This paper does, and it is the first to introduce conflict into the health production function. The effects of conflict on longevity cannot be underestimated. Wars and conflicts not only lead to death and casualties among soldiers and military officers, but among civilians as well. According to the World Bank (2000) report, more than 4 million people lost their lives from violent conflicts between 1989 and 2000, whereas over 37 million people became displaced and refugees. The World Bank also reports that conflict remains a challenge to achieving the sustainable development goals as well as the World Bank group goal of ending poverty by the year 2030 (World Bank, 2017).

Background

A few authors have studied the relationship between some aspects of conflict and mortality. Li and Wen (2005) examined the immediate and lingering effects of armed conflict on adult mortality by employing a pooled time-series cross-sectional design. They examined the effects of different kinds of conflict across 84 countries from 1961 to 1998 on the age-standardized and gender-specific mortality rates of the working age population, ages 15 to 64. They modelled mortality rates as a function of the five indicators of conflict. To test the immediate effect of conflict, they created five different dummy variables. One of their conflict indicators was coded 1 if a country was engaged in any type of conflict that year, 0 otherwise. Two other indicators measured the presence or absence of interstate and intrastate conflict, respectively. Each was coded 1 if the country was involved in that type of conflict that year, 0 otherwise. They also created indicators for whether minor or severe conflict occurred in a country. Minor conflict was defined as the occurrence of 1,000 conflicts or less, whereas severe conflict was defined as the occurrence of more than 1,000 conflict in a country. They lagged the conflict dummy variables one year behind the dependent variable to control for possible reverse causality. To test the lingering effects of conflict on mortality, they created five continuous variables where they used the percentage of years a country has been in a conflict type from 1946 to year (t-2). Using a Heckman-type selection model, they found that armed conflict had both lingering and immediate effects on adult mortality with lingering effect being robust than immediate effect. They also found that the immediate effect for intrastate conflict was very large and the reverse applied to the lingering effect. The lingering effect for interstate conflict however was very robust but the immediate effect was not too strong. In addition, both the immediate and lingering effects of severe conflict were much stronger than the effects of minor conflicts. In terms of intrastate conflicts, the immediate effects on men were more pronounced than the effects on women, although women experience much mortality in the long run owing to the lingering effects.

Studies have also been conducted at the individual level. Grimard and Laszlo (2014) studied the long-term effects of civil war on women's health outcomes in Peru. They analyzed the long-term health effects of early life exposure to civil conflict using data from the Demographic and Health Survey (DHS) of Peru and district-level conflict data for that country. Following the conceptual framework used by Grimard et al. (2010) (inspired by Grossman (1972) and; Maccini and Yang(2009)), the authors used the ordinary least square (OLS) and the district fixed effect methods.

They found that district exposure to conflict deaths and disappearances in the year prior to birth had a negative effect on women's stature. Thus, there is a long-lasting impact on women's height. Specifically, they found that the effects of the shock at birth are long-lived, especially for height even when adult socioeconomic conditions such as education and wealth are controlled.

As some researchers find positive relationship between conflict and mortality, Lawrence et al. (2015) have also conducted a study on the relationship between happiness and longevity. In their study that examined the relationship between happiness and longevity among a nationally representative sample of adults in the United States, data from 1978-2002 was obtained from the General Social Survey-National Death Index (GSS-NDI). Using a sample size of 32,830 individuals of which 9,271 died over the follow-up period, the authors estimated cox proportional hazards models to determine how happiness relates to longevity. They found that happy people live longer and further explained that happiness may be related to other risk factors such as social relations, census division, socioeconomic status, as well as religious attendance, and its effect on life expectancy may operate partially through stronger social relationship and increased socioeconomic status. A corollary may be that in countries where there is conflict, happiness is short-lived and therefore longevity is reduced.

Shaw et al. (2005) analyzed the determinants of longevity in OECD countries, Cremieux et al. (1999) studied longevity among residents of Canada, and Case and Deaton (2015) studied longevity in the United States. Some researchers have also undertaken the study of longevity by considering both developed and developing countries (Jaba et al. 2014; Kabir, 2008). This current study, however, will consider whether and how the determinants of longevity differ between OECD countries and emerging countries.

Jaba et al. (2014) used panel data to analyze the relationship between life expectancy at birth and health expenditures from 1995 to 2010. According to the authors, some causes of increasing health expenditures include population aging, medical technology and improvement in living standards. Data were collected from World Bank Indicators for 175 countries, and the countries were grouped according to geographical regions and income groups. That is, the countries were grouped into low income, lower middle income, upper middle income and high-income categories. Fixed-effects models were estimated separately for each group of countries. Their results suggest that, for developed countries, health expenditure per capita increase significantly along with an increase in longevity, and the European countries enjoy the highest longevity. They also found that variation in health expenditures per capita is more relevant in the developed and developing or less developed countries with the difference growing in time.

Kabir (2008) examined the socio-economic determinants of life expectancy for 91 developing countries using data from the United Nations Development Program (UNDP, 2004, 1994), the United Nations Conference on Trade and Development (UNCTAD, 2004) and World Bank (2003). Multiple regression and probit frameworks were used in drawing conclusions about significance of the variables he incorporated in the analysis. Disaggregated probitregression was applied for three groups of countries with low, medium and high life expectancy. Most of explanatory variables turned out to be statistically insignificant, which implied that relevant socio-economic factors like per capita income, education, health expenditure, access to safe water, and urbanization cannot always be influential in determining life expectancy in developing countries. Based on the analysis it was suggested that the countries should formulate and implement appropriate social sector policies and programs to increase physicians' availability and reduce adult illiteracy and undernourishment to improve their life expectancies.

Shaw et al. (2005) conducted a panel data analysis of the determinants of life expectancy for 19 developed countries using data from the OECD Health 2000 database from 1960 to 1999. Life Expectancy at ages 40, 60 and 65 for men and women in 1997 were used as their dependent variables. Their explanatory variables included the gender distribution, gross domestic product (GDP), the age distribution, pharmaceutical consumption, health expenditures, health behaviors of the population such as overall tobacco use, and butter and vegetable consumption. They found that pharmaceutical consumption has a positive effect on life expectancy at middle and advanced ages. They also found that doubling annual pharmaceutical expenditures adds about one year of life expectancy for males at age 40 and slightly less than a year of life expectancy for females at age 65. According to the authors, decreasing tobacco consumption by about two cigarettes per day, or increasing fruit and vegetable consumption by 30%, increases life expectancy by about one year for 40-year-old females. Per capita GDP is also a relevant predictor of life expectancy at ages 60 and 65. Studies of longevity have also been undertaken at the individual level.

Thus, linking data on medical care expenditures to estimates of life expectancy for persons 70 years of age in various health states, Lubitz et al (2003) assessed the relations among health, longevity and the expected health care spending. Their data were obtained from the 1992-1998 Medicare Current Beneficiary Survey. They classified each person's health according to functional status, whether they were institutionalized or not, and self-rated health. They then used multistate life-table methods and micro simulation to estimate life expectancy for persons in various states of health. Annual health care expenditures were then linked with transitions between health states. Their results revealed that persons in good health at age 70 can expect to live longer than those in poor health at the same age. But their total expected medical care expenses appear to be no greater than those for less healthy persons even though healthier persons live longer.

The paper is organized as follows. The following section discusses the data sources used for the present study, variables in the analysis, and the specification of the health production function. Following this, we report the estimation results and then discuss them. The paper concludes with a summary of the major findings.

Methods

Data Sources and Variable Measurement

The main sources of data for the 35 OECD and 25 emerging countries from 1990 to 2014 are the OECD health database, the World Development Indicators data set from the World Bank, the Uppsala Conflict Data Program and the Global Health Expenditure Database of the WHO. The period selected for this study is limited by the availability of data.

To test what makes for longevity, the five facets of longevity; infant mortality (infmort), male life expectancy at birth (lebm), female life expectancy at birth (lebf), male life expectancy at age 65 (le65m), and female life expectancy at age 65 (le65f) are modeled as functions of conflict, economic factors, healthcare consumption, environmental factors, demographic factors and lifestyle choices. Health production functions for each of these aspects of longevity are estimated for the panel data set. The dataset includes various measures of healthcare consumption such as total health expenditure, immunization, pharmaceutical expenditures and the number of hospital beds; environmental factors which constitute sanitation and the level of greenhouse gas; the level of poverty which is used as proxy for economic factors; demographic factors which include fertility and education; and lifestyle choices which include tobacco and alcohol consumption.

Measures of longevity and healthcare consumption may be influenced by the population age structure which is measured in previous years or simultaneously. Therefore, to account for this effect and to guarantee the reliability of our regression results, we use both life expectancies at birth and at age 65 or older, (Shaw et al. 2005). Since we are using data on both OECD and emerging countries, inferences drawn from this study are valid for both developed and emerging countries. We concentrated on these two categories of countries because of data availability and reliability.
The empirical analysis for males and females is separated for women and men as women tend to have higher longevity than men and this is also a standard practice in the public health literature. In addition, in terms of physiological dynamics and gender roles, men and women are different, (Li and Wen, 2005). Since we are studying the determinants of longevity over time across countries, we need data covering enough years to make a valid generalization and to also know what is currently happening in the countries in terms of longevity studies, hence the selection of the period from 1990 to 2014.

Description of Variables

Summary statistics and variable definitions for OECD and emerging countries are presented in Tables 1a and 1b, respectively. There are five outcome variables, each measured at the country level: life expectancy for males at birth, life expectancy for females at birth, life expectancy for males at 65 years, life expectancy for females at age 65, and the infant mortality rate.

Table 1a: Variable Definitions, Means, and Standard Deviations for OECD Countries from 1990-2014

Code	Variable	Definition	Source	Mean	Standard deviation
conflict	conflict	Involves government and/or territory, armed and unarmed that result in 25 deaths and above.	Uppsala Conflict Data Program	0.130	0.337
thexp	Total health expenditure	It measures the final consumption of health care goods and services. It sums both private and public consumption.	OECD data	2161.7	1534.631
immuz	Immunization	% of children that receive the respective vaccination in the recommended timeframe. This indicator is presented for Diphtheria, Tetanus and Pertussis.	OECD data	93.177	6.521
pharm	Pharmaceutical expenditure	This covers expenditure on prescription medicines and self-medication	OECD data	296.925	223.066
ledu	Lower education	Education below post-secondary. That is high school and below	World Development Indicators of the World Bank (WDI)	23.517	21.336
tedu	Tertiary education	All post-secondary education including private and public universities, technical and vocational institutes and colleges	WDI	19.363	14.367
fer	Fertility	Number of children that will be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates.	OECD	1.713	0.414
san	Sanitation	% of the population using safely managed sanitation facilities and % of rural population with access	WDI	91.080	20.693
ghg	Greenhouse gas	Greenhouse gases which include the total emission of CO_2, methane, nitrous oxide, hydrofluorocarbon, perfluorocarbon, Sulphur hexafluoride and nitrogen trifluoride in tonnes	WDI	12.199	5.608
alcho	Alcohol	Sales of pure alcohol in litres per person aged 15 years and older	OECD	9.462	2.954
tobcons	Tobacco consumption	Population aged 15 years and above who consume tobacco everyday	Global Health Expenditure	1155.744	1053.502
poverty	Poverty	The poverty rate is defined as the percentage of a country's population working at $1.90 a day or less (measured in 2011 PPP)	WDI	12.199	5.608
infmort	Infant mortality	Number of death of children under one year per 1000 live births	OECD	6.331	4.881
lebf	Female life expectancy at birth	The number of years a female newborn is expected to live on average if current death rates do not change	OECD	80.676	2.829
lebm	Male life expectancy at birth	The number of years a male newborn is expected to live on average if current death rates do not change	OECD	74.516	3.808
le65f	Female life expectancy at age 65	Average number of years that a female at age 65 is expected to live if mortality remains constant	OECD	19.487	1.821
le65m	Male life expectancy at age 65	Average number of years that a male at age 65 is expected to live if mortality remains constant	OECD	15.940	1.846

Variables measured annually

Table 1b: Variable Definitions, Means, and Standard Deviations for Emerging Countries from 1990-2014

Code	Variable	Definition	Source	Mean	Standard deviation
conflict	Conflict	Involves government and /or territory, armed and unarmed that result in 25 deaths and above.	Uppsala Conflict Data Program	0.532	0.499
thexp	Total health expenditure	It measures the final consumption of health care goods and services. It sums both private and public consumption.	World Development Indicators of the World Bank (WDI)	236.045	340.814
immuz	Immunization	Percentage of children aged 12-23 months. This indicator is presented for Diphtheria, Tetanus and Pertussis.	WDI	85.215	14.703
fer	Fertility	Total birth per woman	WDI	2.999	1.274
alcoh	Alcohol	Sales of pure alcohol in litres per person aged 15 years and older	WDI	3.608	3.683
san	Sanitation	% of the population using safely managed sanitation facilities and % of rural population with access	WDI	58.710	27.698
ghg		Greenhouse gases which include the total emission of CO2, methane, nitrous oxide, hydrofluorocarbon, perfluorocarbon, Sulphur hexafluoride and nitrogen trifluoride in tonnes	WDI	2.720	6.798
poverty	Poverty	% of a country's population working at $1.90 a day or less (measured in 2011 PPP)	WDI	5.014	11.695
hbeds	Number of hospital beds	The number of hospital beds per 1000 people	WDI		
infmort	Infant mortality	Number of death of children under one year per 1000 live births	Global Health Expenditure	34.826	26.944
lebf	Female life expectancy	The number of years a female newborn is expected to live on average if current death rates do not change	WDI	70.045	8.075
lebm	Male life expectancy	The number of years a male newborn is expected to live on average if current death rates do not change	WDI	65.088	7.539

Variables measured annually

Each outcome is modeled as a function of healthcare consumption, the presence of conflict in the country, environmental factors, economic activity, demographics of its population, lifestyle habits, and country-specific fixed effects. Regarding healthcare consumption, a country interested in the healthy life of its citizens spends more on their health, hence the importance of healthcare consumption in determining longevity. Mack (2016) mentions that some of the causes of high healthcare expenditure include wasteful spending, prescription drugs, advances in medical technology, unhealthy lifestyle, ageing workforce, high administrative costs and service provider consolidation.

Total health expenditures (measured in PPP 2011 US dollars) is used as one of the explanatory variables in this study (OECD 2017; World Development Indicators (WDI) 2014). Immunizations against infectious diseases, pharmaceutical expenditures, and hospital beds per capita are other facets of healthcare consumption included in the models. In communities where most children are vaccinated against infectious diseases, both those who are vaccinated and those who are not benefit. Immunizations reduce the number of deaths and disabilities from diseases such as whopping cough. We expect a positive relationship between longevity and immunization.

Pharmaceutical expenditures include not only the cost incurred in purchasing drugs but also the cost of developing new and effective drugs. Pharmaceutical spending across OECD countries reached around USD 800 billion in 2013, accounting for about 20% of total health spending on average when pharmaceutical consumption in hospitals is added to the purchase of pharmaceutical drugs in the retail sector.

Retail pharmaceutical spending growth has slowed down in most OECD countries in the last decade, while spending on pharmaceuticals used in hospital has increased in most countries. Current market developments, such as the multiplication of high-cost medicines targeting small populations and/or complex conditions, have prompted new debates on the sustainability and efficiency of pharmaceutical spending (Health at a Glance, 2015, OECD).It is expected that if a country spends more on needed pharmaceuticals, longevity would be increased. It is expected that if the number of hospital beds per capita increases, more people can be admitted when sick. People are better taken care of when on admission than at home depending on the type of sickness, and they will live longer. We expect a positive relationship between number of hospital beds per capita and longevity.

Another variable of interest is conflict. Most economic studies on longevity have not included conflict in the production function to know its correlation with longevity. It is believed that understanding the effects of conflict on longevity has some important policy implications. Conflict theorists Marx and Weber understood that any social order involved the regulation of opposing interests, and because of that, conflict among groups and between individuals was a vital part of every society. Conflict, irrespective of the type, is common in most countries worldwide and its effect on society cannot be underestimated. Not only does conflict exploit humans, it can also have effects on social and economic development and can erode the social capital of communities and countries. In the presence of conflict, resources meant for other sectors in the economy to improve lives may be diverted to the military. This may lead to economic insecurity and hardship and that can lead to suicide, starvation and other death-threatening diseases. In Africa and Latin America, armed conflict is the 9th and 7th leading cause of death, respectively (Peden, McGee and Krug, 2002; WHO, 2008b). In times of conflicts, thousands of people are injured whereas some suffer permanent disabilities, and this can have a lingering effect on them throughout their lives. Examining the association between conflict and longevity may help illuminate the real costs of war and conflicts, and thereby help in promoting peace. To test the effect of conflict on longevity, we created a dummy variable. Conflict dummy is coded 1 if a country is engaged in any type of conflict in a year and 0 otherwise, and it was regressed on longevity.

Environmental factors may also affect longevity. The level of greenhouse gases is used to measure the health of the country's environment. As more countries become industrialized, there is increased employment, increased GDP and improved livelihood of people. Although industries emit these gases into the atmosphere, the good aspect of this allows people to take care of themselves well and enables countries to put measures in place that will reduce the harmful effect of these emissions. This translates to increased longevity since people can now take care of themselves well and live longer. We expect a positive correlation between longevity and the level of greenhouse gas.

Will a nation advance if its main resource, the people, are so diminished from the beginning of their lives – diminished by preventable diseases like diarrhea and cholera? Sanitation is therefore another important environmental factor that affects longevity. In this 21st century, half of the world's population are enduring a medieval level of sanitation. Most people in developing countries do not have access to decent toilet as many queue-up to pay for the use of filthy latrine. In some developing countries, the plagues of the earlier times are revisiting. The recent cholera epidemic in Peru and the outbreaks of bubonic and pneumonic plagues in India are examples of this. Sanitation's influence on longevity is therefore assessed in this study (Khan, 2018). We expect a positive correlation between sanitation and longevity.

The economic characteristics of a country is another potential predictor of longevity in this study, and differences across countries may significantly influence longevity. According to the United Kingdom Prime Minister Theresa May, "If you were born poor, you will die on average nine years earlier than others" (Milne, 2016). The poverty rate measures the percentage of families living with an income below a given percentage. This is a good economic indicator of the relative size of the poorest segment of the population. It is expected that poor people are not able to afford certain necessities of life such as food and better health care. As a result, they tend to have lower levels of longevity. We expect a negative correlation between poverty and longevity.

Lifestyle variables included in the models are tobacco consumption, and alcohol intake. Alcohol intake and or smoking by an expectant mother or even the father can have a negative impact on an unborn child. Smoking and alcohol intake can also affect the liver of the smoker and can lead to cancer as well as other liver-related sicknesses, which can affect longevity. It is suggested that moderate drinking is not cardio protective and that higher mortality among abstainers results from people who no longer drink due to poor health (Shaw et al., 2005).

Demographically, fertility and education may also impact longevity. Joshua Mittledorf (2010) found that women who give birth to a lot of children tend to have shorter lives, compared to those who do not give birth. Fertility worldwide has been decreasing over the years and with the continuous decline in fertility, this study expects to find a negative association with longevity.

Lastly, education is another potential determinant of longevity. People of higher education generally take better care of themselves. People who attain higher education are mindful of their eating habits, exercising, avoid certain behaviors like drinking and smoking excessively. Furthermore, they can change their risky health behaviors quicker in response to new evidence. As a result, they tend to live longer. Research from Harvard Medical School indicates that individuals with more than 12 years of education live longer than those who never went beyond high school (Harvard Medical School, 2008). In this study, we expect a positive relationship between higher education and longevity and a negative relationship between low levels of education and longevity.

A relevant econometric problem encountered during this study however, was the issue of missing data. This problem was resolved by using the modified zero-order regression method. With this method, the missing values were filled with zeros, and a dummy variable was created to take the values of one for the missing values and zero for the complete ones.

Model Specification and Estimation

We estimate the determinants of longevity using a random-effects model. There are several reasons for this. First, with this model, it is assumed that the unique errors u_i are not correlated with the regressors. Second, within a country, the variables change little among themselves but there is great level of variability across countries and it is the relationship among various countries which are being explored making random effect a better model to use.
In our framework,Y_{it} measures population longevity for country i at time t and it depends on a vector of inputs, X. Therefore, the random-effects health production function is given as:

- $Y_{it} = \beta X_{it} + \alpha + u_i + \varepsilon_{it}$

where the vector, X, includes measures for conflict, total health expenditures, immunizations, pharmaceutical expenditures, the number of hospital beds, education, fertility, sanitation, greenhouse gas, poverty, tobacco use, and alcohol consumption. Our interest centers on β, the vector of coefficients on the explanatory variables. Country-specific random effects are captured by u, and ε reflects an error term, assumed to be independently and identically distributed across time and countries, and which is independent from u. We explicitly test for the possibility that the underlying function for longevity may vary between OECD and emerging countries, in other words the vector,β,varies between these two sets of countries. We use a Chow test to formally test for this (Wooldridge, 2009), and if there is evidence of differential functions, we proceed with estimating separate functions for each set of countries. All statistical analyses are performed using Stata 14.1® (Stata Corporation, College Station, Texas).

Results

We begin with our assessment of whether or not the health production functions for longevity differ between OECD and emerging countries. We use the Chow test to determine whether the estimated coefficients are different for the two sets of countries. If they are not, we should estimate one set of models for all countries, whereas if they are, we should estimate separate models for each set of countries. Three Chow tests are conducted, one for each of the three outcome measures common to both sets. For life expectancy at birth for females, the corresponding F-statistic for the Chow test is $F(9, 1451) = 27.03$, which is significant (p-value < 0.001). For life expectancy at birth for males, $F(9, 1451) = 25.90$ (p-value < 0.001), and for the infant mortality rate, $F(9, 1451) = 57.06$ (p-value < 0.001).

Thus, for all three outcome measures, we reject the null that the coefficients of the production functions are the same between OECD and emerging countries. Therefore, separate models are estimated for each group of countries. The estimation results for OECD countries are reported in Table 2. Depending on the outcome measure, the estimated models explain between 42% and 49% of the variation observed across OECD countries. Specifically, the R-squares were 48% for female life expectancy at birth, 42% for male life expectancy at birth, 47% for female life expectancy at age 65 years, 49% for male life expectancy at age 65, and 44% for the infant mortality rate. The estimated models for emerging countries are reported in Table 3. They explain 67% to 80% of the variation in longevity across countries, again, depending on the outcome measure. The R-squares were 67% for female life expectancy at birth, 69% for male life expectancy at birth, and 80% for the infant mortality rate.

Table 2: Estimated Health Production Functions for Five Facets of Population Longevity in OECD Countries, 1990-2014

variables	LEBF Coefficient (se)	LEBM Coefficient (se)	LE65F Coefficient (se)	LE65M Coefficient (se)	Infant Mortality Coefficient (se)
Intercept	76.806	70.662	16.921	13.715	17.645
	(0.910)	(1.105)	(0.597)	(0.524)	(2.796)
conflict	-0.509***	-0.509***	-0.283***	-0.287***	0.740*
	(0.123)	(0.146)	(0.082)	(0.071)	(0.431)
thexp	0.066***	0.109***	0.037***	0.069***	-0.034*
	(0.006)	(0.007)	(0.004)	(0.004)	(0.020)
immuz	0.039***	0.032***	0.018***	0.011***	-0.048**
	(0.006)	(0.007)	(0.004)	(0.003)	(0.021)
pharm	0.076***	0.091***	0.075***	0.002	-0.343***
	(0.030)	(0.035)	(0.020)	(0.017)	(0.102)
ledu	-0.016***	-0.015***	-0.013***	-0.011***	-0.006
	(0.002)	(0.003)	(0.002)	(0.001)	(0.008)
tedu	0.055***	0.062***	0.044***	0.037***	-0.036**
	(0.004)	(0.005)	(0.003)	(0.002)	(0.015)
fer	-1.941***	-2.042***	-0.481***	-0.259**	1.611***
	(0.190)	(0.226)	(0.126)	(0.109)	(0.597)
san	0.006**	0.001	0.004**	0.000	-0.053***
	(0.003)	(0.39)	(0.002)	(0.002)	(0.009)
ghg	0.113***	0.151***	0.048***	0.048***	-0.082*
	(0.021)	(0.025)	(0.139)	(0.012)	(0.057)
alcoh	-0.075***	-0.102***	-0.081***	-0. 081***	-0.152*
	(0.030)	(0.036)	(0.020)	(0.018)	(0.921)
tobcons	-0.009	-0.018**	-0.005	-0.019***	0.016
	(1.47)	(0.008)	(0.004)	(0.004)	(0.021)
Poverty	1.930***	1.721***	1.449***	1.088***	-2.208*
	(0.390)	(0.463)	(0.259)	(0.224)	(1.366)
R^2 overall	0.480	0.415	0.471	0.486	0.439
R^2 within	0.792	0.826	0.796	0.872	0.279
R^2 between	0.326	0.233	0.295	0.246	0.541
Observations	847	847	847	847	847
Wald chi^2	3065.33***	3767.60***	3132.25***	5385.26***	346.16***

1% = *** 5% = ** 10% = *

Table 3: Estimated Health Production Functions for Five Facets of Population Longevity in Emerging Countries, 1990-2014

variable	Lebf Coefficient(se)	Lebm Coefficient(se)	Infant mortality Coefficient(se)
Intercept	63.203	58.641	62.181
	(1.965)	(1.869)	(6.462)
conflict	-0.409*	0.259	1.522*
	(0.259)	(0.242)	(0.893)
thexp	0.053	0.10***	0.212*
	(0.039)	(0.036)	(0.132)
immuz	0.064***	0.059***	-0.360***
	(0.014)	(0.013)	(0.049)
fer	-1.54***	-1.383***	8.787***
	(0.239)	(0.225)	(0.800)
alcoh	-0.261***	-0.288***	0.390*
	(0.064)	(0.060)	(0.214)
san	0.118***	0.112***	-0.440***
	(0.015)	(0.014)	(0.048)
ghg	0.031*	0.026	-0.068
	(0.020)	(0.018)	(0.068)
poverty	-0.019***	-0.017**	0.066***
	(0.008)	(0.007)	(0.026)
hbeds	-0.275***	-0.291***	0.244
	(0.082)	(0.077)	(0.277)
R^2 overall	0.67	0.686	0.797
R^2 within	0.486	0.502	0.621
R^2 between	0.693	0.706	0.828
Observations	609	609	609
Wald chi^2	600.06***	635.06***	1059.40***

1% = ***   5% = **   10% = *

Effects of Environmental Factors on Longevity

In all instances where we find a significant effect of environmental measures, the coefficients have the expected sign. Among OECD countries, a unit increase in greenhouse gas produced an increase in female life expectancy at birth (lebf) and at age 65 (le65f) of 0.113 years and 0.048 years, respectively. Likewise, it raised male life expectancy at birth (lebm) and at age 65 (le65m) of 0.151 years and 0.479 years, respectively. Among emerging countries, a unit increase in greenhouse gas significantly raised lebf by 0.031 years. This is obviously because most of the emerging countries were not industrialized. The effects of sanitation on longevity are more pronounced in emerging countries, as one might expect, since access to safe sanitation is generally not an issue in developed OECD countries. Among OECD countries, sanitation is a significant predictor of female life expectancies at birth and at age 65, and infant mortality. A unit increase in sanitation raised female life expectancies at birth and at 65 years by 0.006 and 0.004 years, respectively. It also lowered infant mortality in these countries by 0.053 years.

In emerging countries, a unit increase in sanitation raised female life expectancy by 0.118 years, male life expectancy by 0.112 years, and lowered the infant mortality rate by 0.440 years. Notice these effects are far larger than in OECD countries. Sanitation's effect on longevity is also much greater than the effect of health expenditures on longevity. This suggests that the fundamental access to improved sanitation is enormously valuable as far as longevity is concerned. During late pregnancies and delivery times, a lack of convenient sanitary facilities has a negative impact on mothers and their babies. The positive impact of improved sanitation on longevity is consistent with the works of Hertz et al. (1994), who found that sanitation plays an important role in reducing the infections of early childhood and facilitating good hygiene before, during, and after childbirth.

Effects of Conflict on Longevity

Among all countries, the presence of conflict shortens lives dramatically. Among OECD countries it reduced life expectancy at birth among females by 0.509 years, life expectancy at birth among males by 0.509 years, life expectancy at age 65 among females by 0.283 years, life expectancy at age 65 among males by 0.287 years and increases the infant mortality rate by 0.740. Among emerging countries, conflict's effects are most pronounced among females and infants. The presence of conflict reduces life expectancy at birth among females by 0.409 years and raises the infant mortality rate by 1.522.

In both OECD and emerging countries, the correlation between conflict on longevity are highest for the infant mortality rate. Conflict is costly, and its effects can be very damaging to the national economy. When a country is faced with constant conflicts, be it armed or unarmed, a lot of private and public properties are destroyed. Conflict discourages investors from investing in the country, which may also contribute to a slowdown in economic growth, unemployment and low GDP. A slowdown in growth, in turn, weakens public services such as health and education.

Low GDP creates a poverty trap whereby the poor people in the country become vulnerable to diseases. Unemployment causes psychological, emotional and physical stress and may lead to increased rates of alcoholism, smoking and suicide. In addition, many people become homeless because of wars and conflicts whereas others are forced to migrate.

Effects of Economic Measures on Longevity

Poverty remains one of the greatest challenges of most developing countries. In the developing world, poverty means not having enough to eat, not having a place to sleep, and not having access to good medical care, among other things. Hence, any increase in the poverty rate tends to raise mortality rates. The situation in OECD countries, on the other hand, is different in the sense that poverty is not equated to starvation and absolute deprivation.

Poverty significantly correlates with longevity among the two groups of countries. In OECD countries, a unit increase in poverty level predicts an increase in life expectancy at birth among females by 1.93 years, life expectancy at birth among males by 1.721 years, life expectancy at age 65 among females by 1.449 years and life expectancy at age 65 among males by 1.088 years and predicts a decrease in the infant mortality rate by 2.208 years. This is consistent with the works of Bezruchka (2009) and; Gerdthamand and Ruhm (2006). Gerdthamand and Ruhm (2006) found that mortality increases during good times or economic booms and reduces during economic downturns among OECD countries. In other words, longevity increases during economic downturns. They attributed this to the wide range of social insurance systems as well as strong safety nets. According to Bezruchka (2009), mortality declines faster during recessions in rich countries than periods of economic growth. Among emerging countries on the other hand, a unit increase in the poverty level predicts a reduction in life expectancy at birth among females and males by 0.019 years and 0.017 years, respectively, and predicts an increase in the infant mortality rate of 0.066.

Pressures from poverty such as financial struggles, poor and unsafe living conditions, lack of good and effective social support, bad neighborhood, among others create the kind of environment that bring stress not only to adults but also to children. Poverty in general increases stress which affects the happiness of people by creating despair and hopelessness. People who are poor are not able to pay their bills, not able to eat healthy foods, not able to go to hospitals when they are sick, and all these reduce longevity in emerging countries. Poverty affects not only the physical health of people but also their mental health. Countries like India and China have instituted some economic growth-oriented policies aimed at reducing poverty, although it has come with environmental costs, such as increased air pollution. In a nut shell, for poor and emerging countries, improved economic growth appears to improve health by providing the means to meet essential needs such as food, shelter and clean water, as well as assess to good health care. This leads to long life. Lack of these basic things due to poverty reduces longevity.

Effects of Healthcare Consumption on Longevity

We find the effect of total health expenditures on longevity is direct for OECD countries and this is consistent with what Jaba et al (2014) found. A hundred units increase in total health expenditures predict an increase in life expectancy at birth among females by 0.066 years, life expectancy at birth among males by 0.109 years, life expectancy at age 65 among females by 0.037 years, and life expectancy at age 65 among males by 0.069 years and predicts a reduction in the infant mortality rate of 0.034 years.

Among emerging countries, a hundred units increase in total health expenditure predicts an increase in life expectancy at birth among males by 0.099 years and an increase in the infant mortality rate of 0.212 years. Notice that the effect of health expenditure on infant mortality among emerging countries is positive, unlike in OECD countries. In most OECD countries, health expenditures are heavily subsidized by the government. Hence, more can be spent in the health sector to improve life thereby expanding lifespan. Most emerging countries which in this dataset are basically developing countries do not experience infrastructural development in the health sector. Health expenses are usually borne by individuals of which most of the people are poor, making healthcare unaffordable to the vulnerable. This explains the negative relationship. Kabir (2008) did not find any significant relationship between health expenditure and life expectancy among developing countries. The effects of immunization on longevity cannot be underestimated. Immunization is associated with a decreased infant mortality and increased life expectancies for both OECD and emerging countries with significant effects.

Among OECD countries, a unit increase in immunizations raises life expectancy at birth among females by 0.039 years, life expectancy at birth among males by 0.032 years, life expectancy at age 65 among females by 0.175 years, life expectancy at age 65 among males by 0.011 years and decreases the infant mortality rate by 0.048. Among emerging countries on the other hand, a unit increase in immunization raises life expectancy at birth among females by 0.064 years, life expectancy at birth among males by 0.595, and lowers the infant mortality rate by 0.36. Thus, in both groups of countries, immunizations reduce infant mortality and raise life expectancy. Interestingly, the effect of immunizations on longevity was stronger than the effect of total health expenditures.

Increased pharmaceutical expenditures raise life expectancy and lower the infant mortality rate. A hundred unit increase in pharmaceutical expenditure predicts an increase in life expectancy at birth among females by 0.076 years, life expectancy at birth among males by 0.914 years, life expectancy at age 65 among females by 0.075 years, and a decrease in the infant mortality rate by 0.343 years. Individuals who spend more on drugs tend to live longer. Patients who are not able to afford medications get sicker and when such occurrences happen it is the family, the government and the insurance companies that suffer more. To avoid this instance, insurance companies, government and individuals spend on drugs irrespective of the cost to prevent additional cost when the sicknesses escalates. This is consistent with the works of Shaw et al. (2005). In addition, more financial resources are spent in developing new and effective drugs which prolongs life. However, government must ensure pharmaceutical expenses are not too high so that patients will be able to afford prescription drugs.

The number of hospital beds per capita also affects longevity among emerging countries. A unit increase in the number of hospital beds per capita lowers female and male life expectancy at birth by 0.275 and 0.291 years, respectively. This is contrary to what was expected. One explanation is that hospital beds per capita are likely correlated with the level of illness in the population, and thus the negative effect of beds per capita is likely picking up the effects of the level of illness in the population.

Effects of Population Demographics on Longevity

Different researchers have found negative (Penn and Smith, 2007), positive (Le Bourg, 2007) and no relationship (Helle et al. 2004) between fertility and longevity. On average, the number of children born to each woman has declined over the years in both OECD and emerging countries. This may be due to several factors such as financial, contraceptive use, education, population control, and even social. For instance, highly educated women mostly end up becoming career women. Most of the women who have high education postpone marriage and hence childbirth. They also tend to have fewer children since they tend to focus on their career. Financially, couples who earn more usually have fewer children because most of such couples, place quality above quantity. They focus on their careers to earn more rather than parenting. Unlike some decades ago when most women did not work but stayed home to care for their children, women today are often career oriented, so there are competing demands between a woman's career development and raising children. Moreover, the increased availability of effective contraceptives has given couples the flexibility to decide on the number of children they would like to have and when. In terms of policies, the one child policy in China also limits the number of children born per woman.

Evolutionary theories suggest that, an inverse relationship exist between longevity and fertility and the results of this study confirm it. In OECD countries, a unit increased in fertility predicts a decrease in life expectancy at birth among females by 1.941 years, in life expectancy at birth among males by 2.042 years, in life expectancy at age 65 among females by 0.481 years, in life expectancy at age 65 among males by 0.259 years, and an increase in the infant mortality rate by 1.611 years.

In emerging countries, a unit increase in fertility predicts a decrease in female life expectancy by 1.54 years, male life expectancy by 1.383 years, and an increase in the infant mortality rate by 8.787 years. In both set of countries, fertility strongly correlates with longevity. Not surprisingly, the impact of fertility is smaller for life expectancies at age 65, since that is usually a menopausal age and very few people give birth around such age. This suggests that bearing and raising many children is physically taxing and depleting on a woman's health and hence reduces her expected longevity.

Longevity on average, differs across educational groups. This study considered people with tertiary education and people with high school education and less. Among OECD countries, people with high level of education tend to have higher longevity. A unit increase in high education predicts an increase in life expectancy at birth among females by 0.055 years, life expectancy at birth among males by 0.062 years, life expectancy at age 65 among females by 0.044 years, life expectancy at age 65 among males by 0.037 years and lowers the infant mortality rate by 0.036 years. In contrast, a unit increase in lower level of education predicts a reduction in life expectancy at birth among females by 0.016 years, life expectancy at birth among males by 0.015 years, life expectancy at age 65 among females by 0.013 years, and life expectancy at age 65 among males by 0.011 years. It had no impact on the infant mortality rate.

Individuals who come from impoverished families are more likely to have poor physical health early in life. Such individuals usually have negative peer influence and most of them end up with low levels of education. These individuals tend to have higher risk of mortality than their counterparts who do not face such hardships. Hence the factors pertaining to early life hardships might cause differences in education which affect longevity. Education often increases awareness, which helps people make more informed decisions that ultimately improve their health. Higher education often leads to a better occupational status as it enhances labor market productivity which in turn can lead to increased income. With higher income, better educated individuals can afford better housing in safer neighborhoods and increased access to quality foods. They are also able to purchase more comprehensive health insurance if there is the need for it. This too increases longevity. Women who are well educated can make decisions that affect their family's health positively. Those with low levels of education usually involve themselves in certain lifestyles that reduce their longevity. Such include smoking which lead to all kinds of cancer and heart diseases and eating unhealthy foods that leads to obesity.

In a nutshell, healthy behaviors such as the use of home safety devices like the fire alarm, exercising, nutrition, preventive healthcare, among others are all related to educational attainment and may account for the decreased longevity among those with low levels of education. In addition, highly educated people tend to marry highly educated spouses, and make friends who are also highly educated. In times of need, these people will be there to help. For instance, a physician friend can give free medical advice when there is the need for it. Differences in educational attainment bring about the differences in social ties and that leads to differences in terms of longevity between those with high educational attainment and those with low educational attainment.

Effects of Lifestyle on Longevity

Aspects of lifestyle such as alcohol consumption and tobacco smoking are generally known to be some of the factors that affect lifespan. Increased smoking leads not only to cancer but also to cardiovascular and lung diseases. Similar to the findings of Shaw et al. (2005), tobacco consumption significantly correlates with male life expectancy at birth and at age 65 in OECD countries. A hundred unit increase in smoking predicts a decrease in life expectancy at birth among males and life expectancy at age 65 among males by 0.018 years and 0.019 years, respectively. Alcohol consumption also affect life expectancy in both OECD and emerging countries. The results for the infant mortality rate in OECD countries, however, are not as expected. For OECD countries, a unit increase in alcohol consumption lowers life expectancy at birth among females by 0.747 years, life expectancy at birth among males by 0.102 years, life expectancy at age 65 among females by 0.081 years, and life expectancy at age 65 among males by 0.081 years. However, it lowers the infant mortality rate by 0.152 years. For emerging countries, a unit increase in alcohol consumption predicts a decrease in life expectancy at birth among females by 0.261 years, life expectancy at birth among males by 0.288 years, and predicts an increase in the infant mortality rate of 0.39 years.

Discussion and Summary

From this analysis of the determinants of longevity in OECD and emerging countries, we draw several conclusions.

First, influential predictors of longevity in both OECD and emerging countries include conflict, the economy, health care consumption, immunizations, fertility rates, alcohol consumption, sanitation, levels of greenhouse gas, and rates of poverty.

Second, there are some variables that affect longevity only in OECD countries or only in emerging countries. For example, factors such as education, tobacco consumption, and pharmaceutical expenditures strongly correlate with longevity only in OECD countries, whereas the number of hospital beds correlates with longevity only in emerging countries.

Third, even when variables are important in both sets of countries, their effects often differed between them. Access to safely managed sanitation facilities, for example, was found to have a major effect on longevity in emerging countries, but only a small effect in OECD countries.

Fourth, this paper demonstrates the importance of acknowledging conflict as an important determinant of longevity. We found strong evidence that conflicts shorten lives in both OECD and emerging countries, regardless of how longevity is measured. Conflict, whether armed or unarmed, causes tension in the social fabric, leading to unhappiness, thereby reducing lifespan. Health facilities and infrastructure can be destroyed during conflicts. For instance, bombings destroy not only hospitals but kill doctors and nurses. Roads and highways are often damaged, making it difficult for the sick and wounded as well as hospital equipment to be transported to the hospitals. Coupled with a weakened healthcare sector, mortality increases. Considering the detrimental effects of conflict, the onus is on government to institute measures that facilitate peace in and among nations.

Fifth, to measure environmental factors, most previous studies have used carbon dioxide levels and sanitation, among others. We, however, included greenhouse gas as a determinant of longevity, and found that its effects were more pronounced in OECD countries. One might argue that the emission of gasses should be detrimental to health and as a result, its effect on longevity should be negative rather than positive. The positive relationship we found, however, is in the right direction as it represents an economy where the historical economic growth is driven by unsustainable utilization of energy. In general, industrialization thrives on the availability of energy. As an economy expands and depends on energy intensive sectors, Gross Domestic Product (GDP) increases as emission increases. An increase in a country's GDP confirms the well-established relationship between a country's overall wealth and its citizens' average lifespan.

This is called high GDP emission intensity measured as GDP/Total Emission. Mostly, developed and industrialized countries depend on energy from industrialization where both GDP and emission are high. Although this leads to increased longevity, it is not desirable. Perhaps a more desirable measure would be to pursue a decarbonized economic development pathway where GDP grows and emissions declines. This would lead to a more efficient economy. Some of the policies that lead to growth in GDP and decline in emissions are green policies or investment in technologies like renewable energy such as solar power and removing subsidies on fossil fuels. In addition, one of the problems leading to poor sanitation especially among emerging countries is lack of proper urban planning. As more people migrate to the urban areas, there should be proper city planning at the regional and municipal levels. Instead of people living in slums as they migrate to the cities, government can build affordable houses for such migrants with at least one toilet facility per ten people. Again, most cities and villages also lack toilet facilities and investors can be encouraged to invest in it in addition to what the government can build, and ensure it is maintained effectively. There should also be increased awareness of diseases associated with poor sanitation in order to facilitate better hygiene practices.

With regards to alcohol and tobacco consumption, the government can increase taxes on alcohol and tobacco production causing the prices to increase to discourage people from buying. Tariffs on their importations can also be increased. Furthermore, the government can enforce laws such as increasing the alcohol and tobacco consumption legal age to 25 years, banning public smoking and instituting measures that ensure no sale of alcohol during weekends.

Finally, we find that although increasing health expenditure impact positively on longevity, the coefficients are smaller, and the effects of conflict, poverty, immunization and low fertility rates outweigh health expenditure's impact on longevity. Education is very key in explaining longevity among OECD countries.

Finally, our results are broadly in line with other studies that have contributed to this area of research. Further research can, however, be conducted on the impact of extraordinary events such as oil shocks, Asian currency crisis, and the 2008 financial crisis, etc. Future research in this area of study can also be conducted on the impact of different kinds of conflicts on longevity.

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