Analysis of the Determinants and Drivers Life Expectancy in North Africa

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ABSTRACT

This paper empirically investigated the drivers of life expectancy in North Africa using secondary data from World Development Indicators (WDI) for the period between 1985 and 2018. The study utilized a Panel Fixed Effect Least Square Dummy Variable Regression model. The result revealed that carbon (iv) oxide emissions per capita, total fertility rate, old-age dependency ratio, infant mortality rate significantly affect life expectancy in North Africa and real per capita gross national income is insignificant. The study recommended that the governments in this sub-region should adequately formulate and implement policy blueprints to improve health outcomes (life expectancy, infant and child mortality rates) and provide adequate social protection measures for the elderly so as to reduce the financial burden on the working population.

Keywords: Life Expectancy, health outcomes, infant and child mortality rates

JEL Classification: H51, I14, I15

1. INTRODUCTION

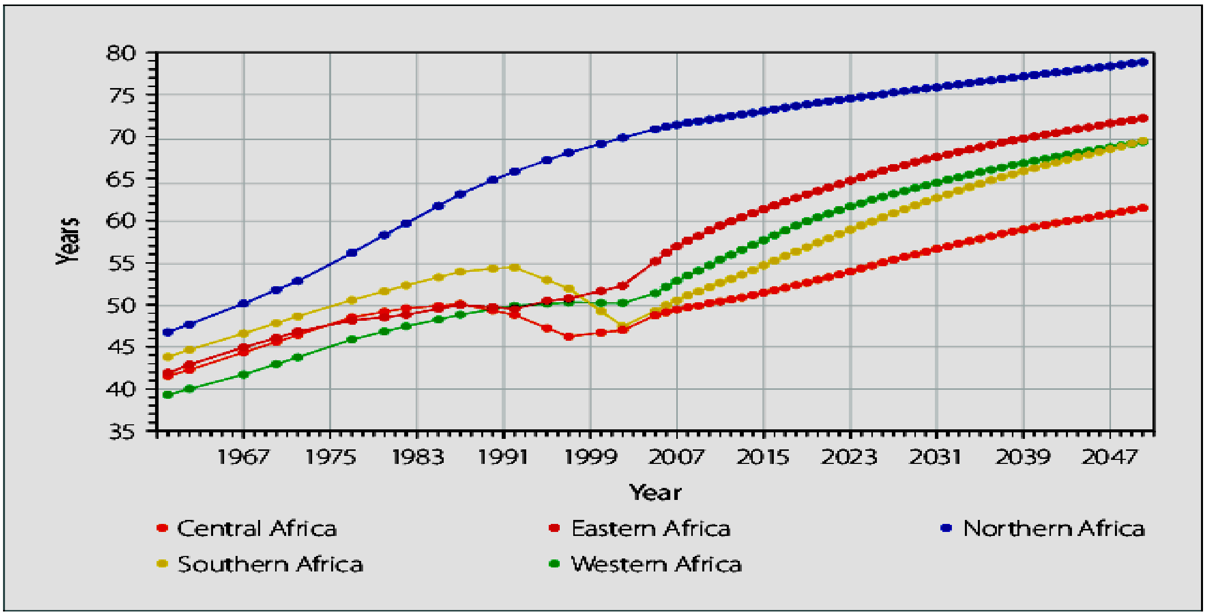
Africa is the second largest continent in the world in relation to population. However, the continent is riddled with dismal health outcomes such as high mortality rate, rising infant mortality rate (IMR), high under-five mortality rate (U5MR) and low life expectancy (Orji, Ogbuabor, Mba, and Anthony-Orji, 2021). Although the different regions of the continent have at various points, made giant strides aimed at economic growth and development so as to enhance the quality of life of its teeming populace. This study aims to investigate the drivers of life expectancy of specific countries in the North African region based on population size and they include: Egypt, Algeria Sudan, Morocco and Tunisia. It is noteworthy that Africa comprises five sub-regions which include North Africa, Central Africa, West Africa, East Africa and Southern Africa.

Arguably, North Africa has the most impressive estimates of life expectancy and other health outcomes as well as relatively high human development indices (HDI). Life expectancy measures the mean or average length of life of an individual given a prevalent age-specific death rate in a specific population for a given time period. Life expectancy can be interchangeably used with life expectancy at birth (LEB). Globally, life expectancy at birth- a statistical estimation of the number of years an infant would live if exposed to the same mortality trend over the course of its lifetime- averaged 73 years in 2019 (United Nations, Department of Economic and Social Affairs, Population Division, 2019). An improvement in life expectancy is an indication of socioeconomic progress made by a country but it is safe to say that significant variations exist among nations in different regions of the world for obvious reasons which may include, differences in level of development occasioned by institutional quality and government effectiveness. Comprehending the imperatives of life expectancy and its various drivers are both a necessary and sufficient conditions for policy formulation and implementation towards the attainment of sustainable development goals (SDG). "Global Health and Well-Being" as a component of SDGs encapsulates specific targets whose achievement can impact positively on life expectancy. In 2015, the average life expectancy at birth in Africa where approximately 16% of the global population is domiciled, was 61 years old while in other regions of the globe where the remaining 84% of the global population lived, ranged from 70years and 80years. North Africa had the highest life expectancy which averaged 71years; East Africa had a life expectancy of approximately 62 years, Southern Africa had 61years, Central Africa's life expectancy was 58years while Western Africa had the least average of 55years.

According to UNDESA (2019), in 2019, North Africa also had the highest life expectancy at birth of 72years; East Africa was 64years, Southern Africa's life expectancy at birth was 63years, Central Africa had an average of 59 years and West Africa also had the least which averaged 57 years, though the overall average life expectancy at birth in Africa was approximately 63 years representing an increase of 3%. These figures represent a considerable shortfall in life expectancy at birth in the continent in relation to other regions of the globe as well as the global average of 72years (UNDESA, 2019). Life expectancy at birth (LEB) just like other health outcomes is determined by socioeconomic factors like per capita GNI, government health expenditures, unemployment, gender, educational attainment, social status, lifestyle, quality of health care system and its affordability, access to safe drinking water, sanitation, out-of- pocket expenditure (OOP), mortality, global burden of disease (GBD).There exist a strong relationship between economic growth and life expectancy. This is evident in Organization for Economic Cooperation and Development (OECD) nations with robust economies and impressive health outcomes as well as human development indices. Since important health outcomes like life expectancy is a summary measure of population health (SMPH), comprehensive analyses and subsequent understanding of the determinants of health outcomes have shown that health outcomes are functions of investments both from within and beyond the health sector. Biological make-up and the availability of affordable and quality health care services are necessary but not sufficient to understand why health outcomes such as life expectancy differ among individuals. Empirical evidence have shown that an individual's health also hinges on determinants like life style preferences (Marmot and Wilkinson, 2006; WHO, 2008). These factors can be still be affected by health systems directly, though public health and measures adopted to prevent avoidable illnesses. Specifically, non-medical factors related to lifestyles preferences are necessities. These include primary risk factors such as smoking, alcohol consumption and unhealthy dietary plan as well health-seeking engagements/activities such as physical exercises. (Orji, Ogbuabor, Anthony-Orji, Okoro and Aniorji, 2020 and Nwanosike, Orji, Okafor, Umesiobi 2015).

But much broader social drivers of life expectancy in particular and health outcomes in general are also worthy of mention. These social drivers include income level, level of education, working and general living conditions. Having more than enough income enables people to purchase essential commodities such as nutritious foods and shelter needed for sustainable health, though higher incomes mean substituting more work for leisure thereby subjecting the body to stress (Fuchs, 2004). The more educated and most probably with better incomes may be better be in tune with health-seeking activities (Mackenbach et al.,2008).Unemployment and dismal working conditions negatively affect mental health and some professions or jobs are associated with greater hazards (Bassanini and Caroli,2014). Living in an environment with poor sanitary conditions, unsafe and polluted environment with low air quality also increases the risk of ailments or death. The social drivers of life expectancy are closely interrelated. Matter-of-fact the linkages make it difficult to empirically disaggregate the individual effects of the various factors that affect health outcomes (Fuchs, 2004) but what is known for a fact is that these factors will always reinforce each other. For instance, the better educated are most likely to get good jobs in the formal sector with high incomes, less likely to engage in health-harming behaviours and more likely to live in a decent environment. By extension, some researchers are of the opinion that large income differentials will not only lead to glaring health inequalities, but may also endanger the general population health (Pickett and Wilkinson, 2015)). Finally, health inequalities just like income and social inequalities are likely to continue over the life cycle inter temporally (intergenerational) with early life economic situations impacting either positively or negatively on future health and economic prospects. Also, across the different continents of the globe, there exist a wide gulf in life expectancy because of differences in social development especially when looking at the divide between the developed economies and the less develop economies. While the former has been able to achieve universal health coverage for its citizens to a significant extent, the latter has not been able to achieve same. Most times individuals from the most socially disadvantaged have poor access to quality health services because individuals may be oblivious of or unwilling to utilize the full range of health services at their disposal. Quality of health care may also be sub-optimal in socially deprived areas; co-payments and other direct payments by persons without effective exemption mechanisms will invariably and disproportionately affect the poor (OECD, 2014, 2015a). Studies using aggregated data pinpoint the significant contributions of socio-economic factors to life expectancy as some of the studies have utilized or fitted (estimated) "health production" function using aggregated data. Such empirical works have been used to evaluate the impacts of health spending, socio-economic and other factors on population health. In general, health expenditures, income level and level of educational attainment (Berger and Messer, 2002); with environmental pollution and lifestyles (especially smoking and alcohol consumption) impact negatively on health outcomes (Shaw, 2005; Blazquez-Fernanadez et al., 2013). It is noteworthy that very few studies have infused the variables of unemployment rate, occupation or income inequality and when included they have had mixed results (Or, 2000; Lin 2009).It is also worthy of mention that health expenditures and income level have typically had a much stronger impact with regard to causing a considerable reduction in mortality or infant mortality than on life expectancy (Heijink et al., 2013). Dynamic or changing factors like the business cycle especially recessionary periods are also important. For example, short-lived economic downturns have more mixed outcomes on health variables like mental health but also having the potential to drastically reduce mortality through a reduction in traffic fatalities and pollution reduction (Van Gool and Pearson, 2014). Basically, empirical analyses of the drivers of life expectancy in different countries explain variations in the impacts. More generally, gains in life expectancy over time show an increase in health expenditures, much healthier lifestyles and improved socioeconomic conditions hence the reason why the advanced or the OECD nations have higher life expectancy compared to the less developed nations because the former has enjoyed unprecedented gains in socio-economic development but this gain in health outcomes varies among the member countries of the OECD. The figure below shows life expectancy in different regions of the African continent.

Figure 1. Life expectancy in different regions of the African continent.



Source; WDI (2021)

North Africa was able to reach the global average life expectancy of 71 years for the first time in 2014 and it's expected to reach 75 in 2023 and above as shown by figure 1. This indicates a laudable trend in its quest for social and economic advancement as exemplified by the more advanced economies of Western Europe, Australia, North America, Japan, South Korea, Singapore and Hong Kong. Sustained increase in life expectancy promotes economic development but could increase the proportion of old-age population in a nation.

Against this background, this study investigates the determinants of life expectancy in the Northern Africa sub-region of the African continent. The study also determines the direction of causality between life expectancy and age-dependency in North Africa. The rest of the paper is structured as follows: section two reviews the literature, while section three provides the methodology. The results are presented and discussed in section four and section five concludes the paper.

2. LITERATURE REVIEW

Different studies such as Orji, Ogbuabor, Mba and Anthony-Orji (2021), Rayhan, Hasan and Akter (2019), Cervantes, López and Rambaud (2019), Orji, Okechukwu and Ogbuabor (2014), Orji and Okechukwu (2015) among others, have been conducted on health and health outcomes using different methodologies across different economies but this current study has a relatively different focus. For example, Rayhan, Hasan and Akter (2019) estimated the health production function which shows the functional association between health status and health care inputs for South Asian countries: Bangladesh, India, Sri-Lanka, Maldives, Bhutan, Pakistan and Nepal. Using life expectancy at birth as a proxy for population health status and economic (health spending per capita and food production index), social (education and ease of accessibility to safe water) and environmental factors (urbanization) as proxies for health care input, a balanced panel data from 1995-2015 obtained from World Development Indicators, Breusch-Pagan, Honda, Kung-Wu, Standardized Honda and Standardized King-Wu Lagrange Multiplier test are used to test the random effects on pooled OLS model. Hausman test was used to select the suitable model between fixed effect and random effect model. Breusch-Pagan LM, Pesaran LM and Baltagi, Kao and Feng bias corrected scaled test are performed to check the cross-sectional dependence of the residuals. Panel Corrected Standard Error (PCSE) model has been used to correct for autocorrelation. Empirical findings shows that health expenditure per capita, educational attainment, ease of accessibility to safe water facilities and urbanization have statistical significant positive effect on life expectancy while food production index has a statistical significant negative effect on life expectancy.

Cervantes, López and Rambaud (2019) examined factors which show causation with life expectancy. Their analysis utilized the Dumitrescu–Hurlin version of Granger causality test, panel data on life expectancy at birth and a select category of socio-economic variables on 17 Spanish regions from 2006-2016 as provided by Spanish Ministry of Health, Consumer Affairs and Social Welfare (MHCSW) and the National Institute of Statistics (NIS). The research results shows that Per capita income, the rate of availability of hospital beds, medical personnel and nurses Granger-cause the variable "life expectancy at birth", according to Dumitrescu–Hurlin's version of Granger causality test applied to panel data. They therefore reached the assertion that life expectancy at birth (LEB) is one of the primary measures of the level of development of a nation's health system.

Lin (2009) using data collated from eight Asia-Pacific countries of Japan, Hong-Kong, Singapore, South Korea, Taiwan, Indonesia, Malaysia and Thailand for the period 1976-2003 and a fixed effect regression model studied the impact of changes in economic fortunes on health outcomes. The result of the study indicated that unemployment rate had a statistically significant negative effect on total mortality, infant mortality and death from heart diseases and vehicular accidents suggesting that health outcomes may improve during economic decline which is in agreement with some research findings. Socioeconomic variables like age and gender also affected mortality rate.

In another study, Bai et al (2018) examined the impact of changes in life expectancy and its impact of economic progress on life expectancy (LE) of 65 countries in the Belt and Road Initiative (a Chinese government global development initiative that comprises 70 countries from Africa, Asia and Europe) using data collated from World Bank and World Health Organization from the period 2000-2014. The study used the linear quantile mixed regression model to estimate specific variables of economic progress such as inflation, growth rate of GDP, per capita GDP and unemployment rate. Results shown that GDP per capita was positively related to increase in longevity among B&R countries, unemployment rate was positively related to increase in life expectancy for countries in the top LE quantiles, GDP growth rate and inflation rate were found to be negatively related to life expectancy for countries in the bottom LE quantiles for men not for women and LE rose among B&R countries considerably in the period under consideration.

Ketenci and Murthy (2017) empirically investigated the impact of some primary factors that affect life expectancy in the United States of America from 1960-2012 using efficient methods of unit root testing and cointegration which allows for structural breaks such as Ng and Perron (2001), Maki (DE(2012) test as well data collated from Organization of Economic Cooperation and Development (*OECD Health Data 2013*), United States Bureau of Labour Statistics(2013) and the United States Census Bureau(2014). Findings showed that real per capita GNI and level of literacy had the most significant effect on life expectancy while other core variables like real per capita health expenditures and income inequality were found to be highly correlated with the level of per capita GNI.

In a different study, Muntele et al (2020) adopted a multi-scale approach in the investigation of the impact of economic development and quality of public health facilities on life expectancy in Romania from 1990-2018 using agglomerative hierarchical clustering, principal component analysis and multiple regression analysis with data obtained from the National Institute of Statistics (INS), Eurostat. The results of the study strongly suggest that there exists high degree of association between economic progress and quality of public health infrastructure which in turn impacts strongly on life expectancy

Zheng, Chang and Yip (2019) studied factors responsible for the general increase in life expectancy in Hong-Kong from 1986-2015 using the Arriaga decomposition technique was adopted to enable the independent evaluation of age composition and cause- specific mortality on life expectancy. Findings proved that the primary cause of the rise in life expectancy for the period under investigation was due to improvements in mortality rates among adults and older people for males and females alike.

Binase (2018) investigated socioeconomic factors that affect health outcomes such as public health expenditures, public education expenditures, GDP per capita, total fertility rate, urban population and accessibility of safe drinking water and malnourishment in post-apartheid South

Africa from 1994-2016. The study adopted vector error correction models (VECM), vector auto regressive (VAR) model, Granger causality and independent t-test as basic analytic tools. The author showed that socioeconomic variables exhibited both short and long-run associations with accessibility to safe drinking water, per capita GDP and public education spending having a significant positive effect on life expectancy. Life expectancy and malnourishment have bidirectional causality; life expectancy granger causes accessibility of safe water and not vice versa while total fertility rate granger causes life expectancy and not vice versa. Based on these results, the author concluded that females on the average had higher life expectancy than males.

Keita (2013) using a panel dataset on 45 countries in sub Saharan Africa from 1960-2011 scientifically assessed the socioeconomic factors that impact improvements in life expectancy with various econometric methods such as pooling, fixed-effect, long difference(LD) and system GMM (Generalized Method Moment). Findings showed that GDP per capita was statistically and positively related to life expectancy gains while variables like adult literacy rate, accessibility of potable drinking water and good sanitation were found to be positively related to improvements in life expectancy. In another study, Novignon, Olakojo and Nonvignon (2012) using a panel data from 1995-2010 across 44 countries in SSA and a fixed and random effects panel data regression estimation technique, investigated the impact of total health expenditures (public and private) on health outcomes (life expectancy at birth, infant mortality and death rate). The results showed that health care spending (public health care spending had a comparatively higher impact) improved health outcomes through a statistically and positively significant effect on life expectancy at birth and statistical significant negative effect on infant mortality and death rate. Anyanwu and Erhijakpor (2009) examined the relationship between per capita public health expenditure and total health expenditure (public and private) on infant mortality rate (IMR) and child mortality rate (CMR) using a panel data set of 47 African countries (Algeria, Egypt, Libya, Morocco and Tunisia inclusive) from 1999-2004 and panel data regression models-fixed effect estimator to correct for errors of measurements and serial correlation, robust ordinary least squares (ROLS), robust two stage least squares (R2SLS) to correct for endogeneity and reverse causality. Results show that total health care expenditure per capita has statistically significant negative effects on IMR and CMR. Also IMR and CMR had a strong and positively relationship with countries in SSA but the converse was observed for the North Africa region.

Furthermore, Sahnoun (2018) utilizing a Granger causality and vector error correction model (VECM), examined the impact of health care expenditure on economic growth in Tunisia between 1970 and 2014. Empirical evidence showed a positive relationship between health care spending and economic growth through improvement in health outcomes like life expectancy at birth, mortality rate, and morbidity rate and a health life expectancy (HALY). Nsereko (2018) analyzed the impact of total health care expenditure (public and private spending) and public health expenditure on selected health outcomes-infant mortality and under-five mortality which impacts strongly on life expectancy of 48 African nations using a panel data from 2003-2015 and a fixed effect model. The study showed that desirable health outcomes could be achieved if the total health care spending per capita increases for each country and that public health care expenditure contributed to a significant reduction in child or under-five mortality and infant mortality rate.

Abubakar, Nketiah-Amponsah and Owoo, (2019) in their study on drivers of life expectancy in 44 countries of Sub Saharan Africa (SSA) for the period between 2000 and 2015 did not include an important variable-old-age dependency ratio (OADR). The number of older persons(65+) per hundred persons of working age and its known to be high in developed countries but low in developing countries. Novignon, Olakojo and Nonvignon (2012) in their study for the period between 1995-2010 of 44 countries in Sub-Saharan Africa also did not examine the impact if any, of old-age dependency ratio (OADR) on life expectancy. Lastly, Amponsah (2019) in its study of 46 countries in SSA from 1996-2015 apparently overlooked the impact or otherwise of OADR on life expectancy other than the usual socio-economic determinants. Also, the latter two studies utilized the Random and Fixed effect models of panel data regression analysis. This study adopts the panel fixed effect least squares dummy variable regression (LSDV) and Driscoll and Kraay (1998) robust regression to obtain robust standard errors to correct for cross-sectional dependency, serial correlation and heteroskedasticity.

Summarily, although the studies reviewed above are very insightful, yet they did not particularly investigate the determinants and drivers of life expectancy in North Africa within the period under review.

3. METHODOLOGY

(3.1) Theoretical Framework

The study utilizes the Preston Curve Theory which shows the positive relationship between life expectancy and per capita GNI. In addition to the per capita GNI variable which is a core variable in the Preston Curve Framework, this study utilizes other variables that can significantly affect life expectancy at birth (LEB) and these include: old-age dependency ratio, $C0_2$ emissions (metric tons per capita), total fertility rate, food production index, GDP per capita growth (annual %), general government final consumption expenditure (% of GDP), infant mortality rate and under-five mortality rate. It is instructive to note that the Preston curve is an empirical cross-sectional association of life expectancy and real per capita income. It is named after Samuel H. Preston who first described it in 1975. Preston undertook a study of the relationship between life expectancy and real per capita income for 1900s, 1930s and 1960s and found out that for three decades, real per capita income was a major determinant of life expectancy at birth. The Preston curve shows that persons born in wealthy countries can expect to have a longer life span on the average than those persons born in less wealthy or poor countries. However, the link between income and life expectancy flattens out meaning that at very low levels of income, further increases in income correspond to a significant raise in life expectancy and at very high levels of real per capita income, there is little or no change in life expectancy at birth. If the relationship is causal, it can be stated in terms of the microeconomic concept of diminishing returns in production economics that there exists a diminishing returns to income with respect to life expectancy.

A further important finding of Preston study showed that the curve has shifted upwards during the 20th century. This means that life expectancy has increased in most countries regardless of changes in income level Preston attributed education, better technology, vaccinations, improved provision of public health services, oral re-hydration therapy and better nutrition with these exogenous improvements in health outcomes.

3.2 MODEL SPECIFICATION

Model specification is one of the key issues in empirical research that is treated with utmost sanctity so as to lend internal validity to the econometric model and provide a useful tool for prediction/forecasting. This study uses annual data from World Development Indicators (WDI) for the period between 1985 and 2018.

Model specification for Determination of drivers of life expectancy in North Africa

$$LE_{it} = \alpha+\alpha_1 OADR_{it} + \alpha_2 COE_{it} + \alpha_3 TFR_{it} + \alpha_4 FPI_{it} + \alpha_5 PCGNI_{it} + \alpha_6 GGFCE_{it} + \alpha_7 POPGR_{it} + \alpha_8 IMR_{it} + \alpha_9 U5MR_{it} + \beta_1 D_{1i} + \beta_2 D_{2i} + \beta_3 D_{3i} + \beta_4 D_{4i} + \mu_{it} \ldots\ldots.1$$

Where i=1,....,N denotes the country in the North African sub-region, t= 1,...,T denotes the time period and μ_{it} is assumed to be serially uncorrelated. And the dummies D_I , D_2 , D_3 and D_4 represent Algeria, Sudan, Morocco and Tunisia while α is the benchmark or base category which is Egypt.

Model specification of the Determination of the causal relationship between life expectancy and old age dependency ratio in North Africa

$$LE_{it} = \sum_{i=1}^{n} a_i LE_{i=1} + \sum_{i=1}^{n} \beta_i \mathrm{OADR}_{t-i} + U_{It} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..2$$

$$OADR_{it} = \sum_{i=1}^{n} \theta_i OADR_{t-i} + \sum_{i=1}^{n} \Pi_i \mathrm{OADR}_{t-i} + U_{2t} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..3$$

3.3 ESTIMATION TECHNIQUE

This study utilizes the fixed effect least squares dummy variable (LSDV) panel regression. This is because it provides consistent estimates for finite N and as T tends to infinity (Okeke and Okeke, 2016). In other words, fixed effect least squares dummy variable panel regression are suited to estimate panel data with T>N. This study utilizes 10 cross-sectional identities (N=10) and a total time period of 34(1985-2018) ie T=34. Additionally, it edummy or qualitative variables.

3.4 JUSTIFICATION OF VARIABLES

Old-age dependency ratio (OADR): Old-age dependency ratio is the proportion of persons of age 65+ that are dependent on the working population. This proportion is high in developed countries known to have high life expectancy while it is low in Africa countries known to have a low life expectancy. This study investigates the statistical significance of the ratio on life expectancy. **Carbon Emission Per capita (COE):** Carbon emission per capita (COE) is included in this study because it gives an indication of the level of environmental pollution (air pollution).The higher the emission, the poorer the air quality and the more susceptible the population are to respiratory diseases and other ailments. **Total Fertility Rate (TFR):** Total fertility rate (TFR) measures the average number of children that would be born of a woman during her reproductive life cycle given the prevailing maternal and infant mortality rate in the cohort population. **Food Production Index (FPI):** Food Production Index (FPI) is an indication of the availability of food needed for nutritional efficiency, good health and a strong body. The quality of food available contributes to food security. **Per Capita Gross National Income (PCGNI):** Per capita gross national income (PCGNI) is one of the core variables of human socio-economic development. It is a measure of the standard of living when evaluated from the standpoint of purchasing power parity (PPP). According to Preston (1976), life expectancy is largely dependent on consistent increase in per capita gross national income. **General Government Final Consumption Expenditure (GGFCE)** This variable is used to account for government expenditure on goods and services that include expenditures on health and education which are major components of human capital development. This variable helps to determine the quality of health care institutions. **Population Growth Rate (POPGR):** Population growth rate is a statistic that measures the rate of population increase (decrease) in relation to a country's total national output. If the increase in population growth rate is more than total output, then the population will have a poor standard of living. **Infant-Mortality Rate (IMR)**: Infant mortality rate (IMR) is a measure of death of newborns below 2years of age. A substantial reduction of this rate shows an improvement in life expectancy, other things held constant.

4. PRESENTATION OF RESULTS

4.1 DESCRIPTIVE STATISTICS FOR COUNTRIES IN NORTH AFRICA

TABLE 4.1

Variable	Observations	Mean	Std.Dev.	Min	Max
LEB	N =170	67.92941	5.853645	54.8	76.7
COEPC	N =170	1.871765	.9620751	0	3.9
TFR	N =170	3.662353	1.194809	2	6.5
FPI	N =170	70.41039	24.50548	23.7	117.3
GGFCE(% of GDP)	N =170	16.15235	2.808571	8.4	21.6
POPGR(annual %)	N =170	1.726471	.939756	0.7	11.4
IMR	N =170	33.98294	15.82559	14.6	83.8
CMR	N=170	42.06412	21.87721	16.9	118.6
LRPCGNI	N=170	3.3529	.2080218	2.86788	3.680435
OADR	N =170	8.024118	1.647719	5.7	12.3

4.2 PRE-ESTIMATION TEST RESULTS

4.2.1 STATIONARITY TEST/ UNIT ROOT TEST RESULT FOR COUNTRIES IN NORTH AFRICA

The test for stationarity is implemented using the Levin-Lin-Chu (2002) because the data generating process gives rise to a balanced panel data set and it is appropriate for a data set with few panels and many time periods. It also includes fixed effects and time trends in the model of the data generating process. The null hypothesis is that the series contains a unit root or is non-stationary while the alternate hypothesis is that there is no unit root or that the series is stationary. The null hypothesis is rejected if the Levin-Lin-Chu bias-adjusted t-statistic has a p-value that is less than 0.05 at the chosen level of significance which in this study is 5% otherwise we do not reject.

VARIABLES	ADJUSTED t* STATISTIC	P-VALUE @ 5%	ORDER OF INTEGRATION	DECISION
LEB	-2.4733	0.0067	I(0)	Stationary
COEPC	-3.5471	0.0002	I(1)	Stationary
TFR	-4.2776	0.0000	I(0)	Stationary
FPI	-7.2374	0.0000	I(1)	Stationary

GGFCEofGDP	-2.1181	0.0171	I(1)	Stationary
POPGRannual	-2.1861	0.0144	I(0)	Stationary
IMR	-3.5362	0.0002	I(2)	Stationary
CMR	-2.1612	0.0153	I(1)	Stationary
LRPCGNI	-3.6066	0.0002	I(1)	Stationary
OADR	-4.9745	0.0000	I(2)	Stationary

Source: Authors' Computation from Stata 15

4.2.2 COINTEGRATION TEST RESULTS OF VARIABLES IN NORTH AFRICA.

The cointegration test this study employs is the Kao (1999) test for panel data cointegration combines statistics computed for each individual in the panel thereby producing a test with higher power. Furthermore, the limiting distribution of the combined test converges to a standard normal distribution after appropriate standardization, whereas test for cointegration based on a single time series have non-standardized distributions. The test also account for serial correlation of the error term and it report five statistics which are the Modified Dickey Fuller, Dickey Fuller, Augmented Dickey Fuller , un-adjusted Modified Dickey Fuller and un-adjusted Dickey Fuller test statistics. If the p-values of the associated t-statistics of the abovementioned statistics are all simultaneously less than 0.05 (chosen level of significance), then the null hypothesis of no co-integration is rejected otherwise we fail to reject.

	t-STATISTIC	**P-VALUE**
Modified Dickey-Fuller t	-1.3591	0.0871
Dickey-Fuller t	-1.2753	0.1011
Augmented Dickey-Fuller t	-0.4961	0.3099
Unadjusted Modified Dickey Fuller t	-0.8671	0.1930
Unadjusted Dickey-Fuller t	-1.0538	0.1460

Source: Authors' Computation from Stata 15

From the p-values of the t-statistics associated with the various test statistics, it can be be deduced that no cointegration exists among the variables because all the p-values are greater than 0.05, hence the null hypothesis of no cointegration holds.

4.2.3 GRANGER CAUSALITY TEST.

This study utilizes the Dumitrescu and Hurlin (2012) Granger non-causality test for panel datasets which uses the p-values associated with test statistics of Z-bar and Z-bar tilde to either reject or fail to reject the null hypothesis of no causal relation between two variables.

TABLE 4.2.3

NULL HYPOTHESIS	Z-BAR	P-VALUE	Z-BAR TILDE	P-VALUE
OADR does not Granger-cause LEB	18.9132	0.0000	16.6146	0.0000
LEB does not Granger-cause OADR.	3.8132	0.0001	3.2701	0.0011

Source: Authors' Computation from Stata 15

From the table above, the p-values associated with both Z-bar and Z-tilde are less than 0.05 in each null hypotheses. Hence there is bi-directionally causal relationships between LEB and OADR.

4.3 PRESENTATION OF RESULTS FOR PANEL FIXED EFFECT DUMMY VARIABLE REGRESSION

TABLE 4.3

Dependent variable: LEB

VARIABLES	COEFFICIENTS	STD. ERRORS	T-STATISTICS	P-VALUE
COEPC	0.7997725	.2213572	3.61	0.000
TFR	-1.109007	.1208805	-9.17	0.000
FPI	0.0128544	.0044711	2.88	0.005
GGFCEofGDP	-0.0154097	.0339075	-0.45	0.650
POPGRannual	0.0885357	.0507223	1.75	0.083
IMR	-0.8180305	.0746028	-10.97	0.000
CMR	0.5028839	.0479461	10.49	0.000
LRPCGNI	1.243941	1.512895	0.82	0.412
OADR	0.5697768	.0763264	7.46	0.000
d1	1.953092	2467906	7.91	0.000
d2	-.9560962	.3268354	-2.93	0.004
d3	-6.337903	.6208784	-10.21	0.000
d4	1.043416	.2368655	4.41	0.000

R^2 = 0.9930		F-stat=1692.50		Prob.(F-stat)=0.0000
Adjusted R^2 = 0.9924		Wooldridge test=0.0173		

Source: Authors' Computation from Stata 15

4.3.1 PRESENTATION OF ROBUST STANDARD FIXED EFFECT REGRESSION RESULTS TO CORRECT FOR AUTOCORRELATION, HETEROSCEDASTICITY AND CROSS-SECTIONAL DEPENDENCY:DRISCOLL-KRAY STANDARD ERRORS

TABLE 4.3.1

Dependent Variable:LEB

VARIABLES	COEFFICIENTS	STD.ERRORS	T-STATISTIC	P-VALUE
CONSTANT	67.58791	4.599615	14.69	0.000
COEPC	0.7997725	.1378224	5.80	0.004
TFR	-1.109007	.1353435	-8.19	0.001
FPI	0.0128544	.0046321	2.78	0.050
GGFCEofGDP	-0.0154097 -	.0285705	0.54	0.618
POPGRannual	0.0885357	.0850166	1.04	0.356
IMR	-0.8180305	.1187071	-6.89	0.002
CMR	0.5028839	.0826498	6.08	0.004
LRPCGNI	1.243941	1.186603	1.05	0.354
OADR	0.5697768	.0944273	6.03	0.004
Within R-squared= 0.9818		F-stat= 3265.89	Prob.(F-stat)=0.0000	

Source: Authors' Computation from Stata 15

4.4 DISCUSSION OF RESULTS: DRISCOLL-KRAY ROBUST STANDARD ERRORS:

LEB_{it}=67.58791+.7997725$COEPC_{it}$-1.109007TFR_{it}+.0128544FPI_{it}-.015409$GGFCEofGDP_{it}$ +.0885357 $POPGRannual_{it}$ -.8180305 IMR_{it} + .5028839CMR_{it} + .5028839 $LRPCGNI_{it}$+ .5697768$OADR_{it}$.

From the regression results above, each coefficient represent the expected effect of each individual independent variable on the dependent variable (LEB) ceteris paribus.

The value of the intercept is 67.58791.This implies that the mean value of LEB will be equal to zero when all other independent variables are simultaneously equal to zero.

The coefficient of COEPC is 0.7997725 implying that if carbon (iv) oxide emission increases by one ton, LEB will increase by approximately ten months (9.5988 months, where one year equals 12 months).This is in stark contrast to empirical findings that have found carbon (iv) oxide emissions and other air pollutants to reduce health outcomes in places where they are prevalent especially in populated and industrially urban areas. The positive relationship between LEB and carbon (iv) oxide emission per capita can only be attributed to factors like the presence of quality health institutions to cater for illnesses arising from the pollutants, preventive measures by individuals to prevent direct inhalation through the use of nose masks and air purifiers in their homes and the existence of a market mechanism like the carbon emission trading where firms can trade carbon(iv)oxide emissions generated from industrial activities.

For the variable TFR, the coefficient is -1.109007, meaning that if total fertility rate increases by one child, LEB decreases by approximately thirteen months (13.2 months, where use is made of the fact that one year equals 12 months) .This also conforms to empirical proofs as seen in developed countries with low total fertility rate with high life expectancy.

The coefficient of FPI is 0.0128544, meaning that if food production index increases by one unit, LEB will equally rise by approximately five days (4.69 days, where use is made of the fact that one year equals 365 days).This conforms to the findings of Ferda (2010). For the variable GGFCEofGDP, the coefficient is -0.0154097, which means that if general government final consumption expenditure increases by one dollar, LEB will fall by roughly five days (5.48 days, where use is made of the fact that one year equals 365 days)y which conforms to the findings of Schoder and Zweifel (2011) but in stark contrast to the findings of Abubakar, Nketiah-Amponsah and Owoo (2019) .

The variable POPGRannual has a coefficient of .0885357, this means that if population growth increases by one percent then LEB will rise by roughly eleven months (10.56 months, where use is made of the fact that one year equals 12 months). For the variable IMR, its coefficient is -0.8180305, meaning that if infant mortality rate increases by one infant death, LEB decreases by roughly ten months (9.72 months, where use is made of the fact that one year equals 12 months), which is evident in empirical findings.

The coefficient of the variable CMR is 0.5028839, meaning that if child mortality rate increases by one child death, LEB roughly six months higher. This is in stark contrast to empirical research findings.

For the variable LRPCGNI whose coefficient is 1.243941, a percentage increase in real per capita gross national income leads to an approximately increase in LEB by approximately five days (4.52 days where use is made of the fact that one year equals 365 days).This conforms to the findings of Binase (2018) and Bai et al (2018). The coefficient of the variable OADR is 0.5697768, meaning that an increase in old-age dependency ratio by one percent leads to an increase in LEB by roughly seven months (6.83 months, where use is made of the fat that one year equals 12 months)

Within R-squared (Within Coefficient of Determination): The value of the within-R^2 in the model is approximately 98.18%.This means about 98.18% of the total variations in LEB within each country are explained by COEPC, TFR, FPI, GGFCEofGDP, POPGRannual, IMR, CMR, LRPCGNI and OADR. This implies that about 98.18% of the total variations in life expectancy are explained by changes in carbon (iv) oxide emission, total fertility rate, food production index, general government final consumption expenditure as a percent of GDP, population growth rate (annual %), infant mortality rate, child mortality rate, real per capita gross national income and old-age dependency ratio.

4.4.1 AUTOCORRELATION TEST

For this purpose, the Wooldridge autocorrelation test in panel data is used for this purpose.

H_0: the residuals are not Autocorrelated

H_1: the residuals are Autocorrelated

Decision Rule: reject H_0 if the P-value of the observed f-test is less than or equal to 0.05 at 5% level of significance and conclude that there is no first order autocorrelation in the residuals or fail to reject if otherwise.

4.4.2 WOOLDRIDGE TEST RESULT

F-TEST	17.731
Prob.(F-TEST)	0.0136

Source: Authors' Computation from Stata 15

Since the P-value of the observed chi-square 0.0173<0.05, we reject the null hypothesis at 5% level of significance and conclude that the residuals are Autocorrelated. This model can be innovated for the existence of first order autocorrelation when the Driscoll-Kraay robust stanadard errors are used.

4.4.3 CROSS-SECTIONAL DEPENDENCY TEST

The Breusch-Pagan LM test of cross-sectional independence is used to test for cross-sectional dependency among the individual specific effects (unobserved variables) in 99.the panel .The problem of cross-sectional dependency is evident in the estimation of parameters that are biased and lead to misleading statistical inference. The problem can be rectified using the Driscroll-Kraay robust standard errors.The hypothesis testing is stated below:

H_0:There is no cross-sectional dependency

H_1 :There is cross-sectional dependency

Reject the null hypothesis if the p-value of the of the chi-square statistic of the Breusch-Pagan LM test is less than 0.05 otherwise we fail to reject.

	_e1	_e2	_e3	_e4	_e5
_e1	1.0000				
_e2	-0.7956	1.0000			
_e3	0.6687	-0.5678	1.0000		
_e4	0.4614	-0.1976	0.3636	1.0000	
_e5	-0.5641	0.4431	0.0263	-0.3692	1.0000

Breusch-Pagan LM test of independence: chi-squared(10)= 82.903, Pr=0.000

Source: Authors' Computation from Stata 15

From the table above, the p-value is 0.000<0.05.Hence it is safe to reject the null hpothesis and conclude that there is indeed cross-sectional dependency.

ROBUST STANDARD FIXED EFFECT REGRESSION RESULTS TO CORRECT FOR AUTOCORRELATION, HETEROSCEDASTICITY AND CROSS-SECTIONAL DEPENDENCY: DRISCOLL-KRAAY STANDARD ERRORS

TABLE 4.5

Dependent Variable:LEB

VARIABLES	COEFFICIENTS	STD.ERRORS	T-STATISTIC	P-VALUE
CONSTANT	67.58791	4.599615	14.69	0.000
COEPC	0.7997725	.1378224	5.80	0.004
TFR	-1.109007	.1353435	-8.19	0.001
FPI	0.0128544	.0046321	2.78	0.050
GGFCEofGDP	-0.0154097 -	.0285705	0.54	0.618
POPGRannual	0.0885357	.0850166	1.04	0.356
IMR	-0.8180305	.1187071	-6.89	0.002
CMR	0.5028839	.0826498	6.08	0.004
LRPCGNI	1.243941	1.186603	1.05	0.354
OADR	0.5697768	.0944273	6.03	0.004
Within R-squared= 0.9818		F-stat= 3265.89	Prob.(F-stat)=0.0000	

Source: Authors' Computation from Stata 15

4.5.1 EVALUATION OF THE GRANGER CAUSALITY TEST.

This study utilizes the Dumitrescu and Hurlin (2012) Granger non-causality test for panel datasets which uses the p-values associated with test statistics of Z-bar and Z-bar tilde to either reject or fail to reject the null hypothesis of no causal relation between two variables.

TABLE 4.5.1

NULL HYPOTHESIS	Z-BAR	P-VALUE	Z-BAR TILDE	P-VALUE
OADR does not Granger-cause LEB	18.9132	0.0000	16.6146	0.0000
LEB does not Granger-cause OADR.	3.8132	0.0001	3.2701	0.0011

Source: Authors' Computation from Stata 15

From the table above, the p-values associated with both Z-bar and Z-tilde are less than 0.05 in each null hypothesis .Hence there is bi-directionally causal relationships between LEB and OADR.

5. CONCLUSION AND POLICY RECOMMENDATIONS

5.1 CONCLUSION

The major aim of this research is to determine the drivers or determinants of life expectancy at birth in North Africa using selected countries based on population size. The countries of interest for the North Africa sub-region include Algeria, Egypt, Sudan, Morocco and Tunisia in decreasing order of population size .The number of observations used is between the period 1985-2018 using a panel fixed effect least squared dummy variable regression analysis and the Driscoll-Kraay robust standard errors. Using the latter to correct for cross-sectional dependency, autocorrelation and heteroskedasticity, carbon (iv) oxide emission per capita, total fertility rate, infant mortality rate, child mortality rate and old-age dependency ratio significantly affect life expectancy at birth in North Africa. The adoption of the aforementioned model is in line with some theoretical relationships based on specific theories in economics. The result also shows that for North Africa, there is a bi-directional causality between old-age dependency ratio and life expectancy at birth.

5.2 POLICY RECOMMENDATIONS

Empirical studies have shown that pollutants like carbon (iv) oxide and other gaseous pollutants like sulphur (iv) oxide and chloro-fluoro carbons (CFC) have negative impacts on the environment and the general health status of the population. Thus, efforts should be made by governments of the North African countries included in this study to formulate policies that would curtail the indiscriminate emissions of carbon (iv) oxide and other forms of gas flaring to reduce to the barest minimum or mitigates its effects on human health. This could be achieved through command and control measures whereby emissions standards are legally defined to regulate the quantity of a permissible amount of gaseous pollutants into the atmosphere over a specified period beyond which legal defined sanctions are imposed on the defaulting entities. Also the use of a market-based control measures such as tradable permits in relation to the carbon markets can equally adopted. Also, total fertility rates and child mortality rates are significant drivers of life expectancy in the selected countries in North Africa. Government of these countries should ensure that this rates are reduced significantly in addition to maternal mortality through investments in educational and health infrastructures which are the key components of human capital development. Also the education of the girl-child/ women should be a matter of urgent policy consideration so as to empower economically and reduce dependence. Furthermore, old-age dependency ratio has a bi-directional causality with life expectancy and it is significantly related to life expectancy in North Africa. The establishments of old peoples as part of government's social protection measures for the most vulnerable citizens including the elderly should be encouraged as this would reduce dependency on the working population. Though the reduction of old-age dependency ratio has a tendency of raising government's recurrent expenditures, policy makers should prioritize economic growth and development goals /objectives for a robust and sustainable welfare programmes.

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