Mortality rate and life expectancy in Africa: the role of flood occurrence

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Abstract

Purpose – The purpose of this paper is to investigate the effect of flood occurrence on mortality rate and life expectancy amongst 53 African countries.
Design/methodology/approach – The study utilizes panel data from the period 2000–2018 on 53 African countries and system generalized method of moments (system GMM) for the analysis.
Findings – The result indicates that flood occurrence causes the destruction of health facilities and the spread of diseases which reduces life expectancy. In addition, flood occurrence increases mortality rate amongst 53 African countries.
Research limitations/implications –
Practical implications – The study recommends that governments amongst African countries should implement strategies being enshrined in Conference of Parties (COP, 2021) on climate change. This will help to reduce the level of climate change and flood occurrence.
Originality/value – Previous studies focussed on the adverse effect of flood occurrence without considering the issue of life expectancy amongst African countries. This study contributes to existing empirical studies by examining the effect of flood occurrence on mortality rate and life expectancy amongst African countries.
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Keywords Life expectancy, Mortality rate, Flood occurrence, Health facility, Income inequality, Gross domestic product (GDP)

Paper type Research paper

Introduction

Climate change has caused a lot of extreme weather events with respect to drought, heat waves, extreme precipitation, flooding, hurricanes, landslides and bush fires (Gordon and

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Data availability statement: The data that support the findings of this study are openly available in [figshare] at [https://datatopics.worldbank.org/world-developmentindicators/] [https://databank.worldbank.org/source/worldwide-governance-indicators/] [https://www.wider.unu.edu/project/wiid-%E2%80%93-world-income-inequality-database/]

In the interest of transparency, data sharing and reproducibility, the author(s) of this article have made the data underlying their research openly available. It can be accessed by following the link here: "DOI: 10.6084/m9.figshare.19603900."

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Kate, 2016; Haitham and Jayant, 2014; Hilary *et al.*, 2019). The excessive release of carbon dioxide emission leads to higher atmospheric temperatures. This increases water bodies' evaporation and cloud formation, this falls back to us in large quantities as rains and can lead to flooding. United Nations Environment Program (UNEP) estimates indicate that, the level of flooding has increased more than tenfold in Africa (UNEP, 2018).

According to Global Climate Risk Index (GCRI) report in 2019, amongst the top ten countries heavily affected by climate change are countries from Africa: Mozambique, Zimbabwe, Niger, South Sudan and Malawi were heavily affected by climate change (GCRI, 2019). This has led to frequent flooding in countries like Mozambique, Niger, Sudan, Zimbabwe and others. Flood occurrence deteriorates health facilities of affected countries. Aside the destruction of health facilities, it leads to the spread of both water borne diseases (example typhoid fever, cholera and others) and vector borne diseases for example malaria, dengue and others. In addition, geographical areas that experience perennial levels of flooding discourage health personnel from working in these affected regions (Hilary *et al.*, 2019; Katie *et al.*, 2018; Jouni, 2017). All these undesirable conditions adversely affect the health of people.

A research carried out by Health Consumer Powerhouse Institute (HCPI, a think tank based in Sweden) in 2018, indicated that in most part of Africa where there is persistent flooding health personnel normally refuse employment posting to these areas due to the health risk imposed by these flood occurrences (HCPI, 2018). This implies that countries in Africa that experience persistent flooding will face the problem of unequitable distribution of health personnel. This problem of unequitable distribution of health personnel results in the rendering of poor health services. This leads to health related problems like morbidity rate, mortality rate, reduced life expectancy, stunting and others (Johanna *et al.*, 2019; Hilary *et al.*, 2019; Gordon and Kate, 2016; Katie *et al.*, 2018).

Empirical studies carried out by Abbas and Routray (2014) and Collins *et al.* (2013) for countries in Latin America indicated that persistent flooding increases mortality rate by 8.5% and reduces life expectancy by 6.7%. With respect to African countries to what extent does flooding affects mortality rate and life expectancy has not yet been explored with a recent data set. There is the need to know the extent of the effect to help governments, foreign stakeholders and other policy makers put up the needed strategies in order to help tackle the adverse effect of climate change and flood occurrence in Africa. Hence, the study contributes to existing empirical studies by examining the effect of flood occurrence on mortality rate and life expectancy amongst African countries. Focussing on mortality rate and life expectancy is appropriate. This is because statistics from the World Health Organization (WHO) indicates that mortality rate amongst these countries has increased by 28% and life expectancy reduced by 24% over the past five years (WHO, 2019).

Hence, there is the need to find out the causes of the situation and the appropriate strategies to deal with that.

Literature review

This section focusses on both theoretical and empirical reviews to help enhance our understanding on the subject matter.

Theoretical review

The study reviews a theory on behavioural change to help explain key issues on the subject matter. Behavioural change theories explain how the behaviour of individuals changes over the period of time. Specifically, it states how the environmental and social factors and other character traits influence the behaviour of people. Amongst the numerous theories on behavioural change, the study focusses on the theory of reasoned action.

The theory of reasoned action was developed by Icek Ajzen in 1985. The theory assumes that individuals are rational in their endeavours in the sense that they consider the consequences of their actions before they act. According to the theory, individuals' intentions determine their behavioural change. The theory is relevant for the study because in most African countries, the issue of flooding is sometimes caused by people's irrational actions. Example throwing of plastic waste into gutters choke them leading to flooding. The construction of buildings in waterways is also a typical example. Hence, there is the need for behavioural change emanating from reasonable actions.

Empirical review

Empirical studies have been carried out on the subject matter; this section focusses on reviewing these studies.

Damasceno-Junior *et al.* (2004) examined the mortality rate at Rio Paraguai (Brazil) after extreme flooding. This region in Brazil experiences perennial flooding; hence, the study was interested to find out its effect on mortality rate. The study gathered data from the residents of Rio Paraguai based on severe flooding that occurred in 1995, for the analysis. Result of the study indicated that mortality rate has increased by 9.1% over the past five years, due to excessive flooding.

Collins *et al.* (2013) contribute to the study carried out by Damasceno-Junior *et al.* (2004) by examining the people of Sudan vulnerability to flood occurrence and its associated health risk. The study collected data from 589 households from communities in Aroma and Tendellei for the analysis. The result indicates that 41% of rural households and 25% semi-urban houses are highly vulnerable to flooding and its associated health risks like mental illness, hepatitis A and E, dengue, malaria and others.

Murillo and Tan (2017) fill the gap in existing studies carried out by Collins *et al.* (2013) and Damasceno-Junior *et al.* (2004), by examining the effect of flooding on life expectancy when you compare affected males and females in Southeast Asia. The study employed a regional data set from the period 1995 to 2011 for the analysis. The result indicated that these countries are highly vulnerable to the adverse effect of climate change. This reduces socioeconomic conditions of males higher than females, thereby affecting their life expectancy.

Vinet *et al.* (2019) contribute to existing empirical studies of Collins *et al.* (2013), Damasceno-Junior *et al.* (2004) and Murillo and Tan (2017). The study examined mortality rate caused by persistent flooding in the Mediterranean basin. The study employed 2011 pooling regional and national database on flood mortality from countries in the Mediterranean basin for the analysis. The result indicated that flood-related deaths for the south gradient of the Mediterranean basin are higher than that of the west–east gradient.

Ferdous *et al.* (2020) contribute to existing empirical studies by focussing on structural flood protection, population density and flood mortality in Jamuna River (Bangladesh). The study employed primary and secondary data from Jamuna River. The study found that there have been increasing levels of population density, flood-induced mortality and destruction of valuable assets due to perennial flooding in Jamuna River.

Liu *et al.* (2022) contribute to these empirical studies reviewed by examining the patterns of global flood occurrence effect on flood-induced mortality rate. The study employed data covering the period between 1985 and 2019 for countries in Africa, Europe, Asia, North America and South America for the analysis. The study found that flood-induced mortality tends to be high, with Asian countries highly affected.

Borujeni *et al.* (2022) fill the gap in existing empirical studies (Collins *et al.*, 2013; Damasceno-Junior *et al.*, 2004; Vinet *et al.*, 2019; Murillo and Tan, 2017; Ferdous *et al.*,

2020; Liu *et al.*, 2022). The study examined social consequences of flooding on the quality of life and life expectancy of flood victims of the Khuzestan province (Thailand). The study employed data from 600 victims from the Khuzestan province for the analysis. The study found that flood occurrence has adversely affected physical health, mental health, social relations and life expectancy of these victims.

These studies and others (Gorman *et al.*, 2003; Gelormino *et al.*, 2015; Geary *et al.*, 2021; Diderichsen *et al.*, 2019; Alvarenga *et al.*, 2019; Walsh *et al.*, 2020; Symonds *et al.*, 2019; Pujolar *et al.*, 2016; Pierce, 2012; Nutbeam, 2004; Neagu *et al.*, 2017) have not focussed on examining the effect of flood occurrence on mortality rate and life expectancy amongst countries in Africa with a recent data set. This study fills the yawning gap in existing studies by employing a data set from 53 African countries to examine the subject matter. It is relevant to undertake this study to help guide governments and other policy makers to enhance their strategies towards the fight against climate change in order to help deal with the perennial problem of flood occurrence.

Methodology

This section focusses on model specification, scope of the study, variables' measurement and expected outcome.

Model specification

There is a higher tendency that a country experiencing higher levels of mortality rate and reduced life expectancy in their previous year will have an effect on their current year's mortality rate and life expectancy. For example, assuming a country experiences a higher mortality rate in 2014. This will adversely affect labour productivity, gross domestic product (GDP) and tax revenue of the government, assuming majority of them are in the labour force. This implies that government's ability to raise enough revenue to improve the health system will adversely be affected, leading to a higher mortality rate in 2015. Reduced life expectancy will have the same effect.

Hence, the study employs a dynamic panel model for the analysis. A panel unit root test was taken to check for the existence of a unit root in order to decide whether to use generalized method of moments (GMM) or system GMM for the analysis. The result indicates existence of a unit root (as shown in Table 1). Hence, system GMM is used to correct for the unit root for robust results.

The general model for system GMM as specified by Hansen (1982) can be written as

$$Y_{it} = \beta_0 + \beta_1 Y_{it-1} + \beta_2 X_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (1)$$

Y_{it} = a dependent variable, Y_{it-1} = a lag of a dependent variable and X_{it} = independent variables

Table 1. The panel unit root test and Sargan test

Test statistics	Panel unit root test statistic	The panel unit root test p value	The Sargan test for validity of instruments
Inverse chi squared (p-value)	155.54	0.32	
Inverse normal (Z-value)	1.87	0.89	
Prob. > χ^2			0.27

Source(s): Authors' creation

U_i, U_t *and* ε_{it} represent country fixed effect, time fixed effect and idiosyncratic error term, respectively.

Based on (1), two equations are specified for the analysis;

$$Mortality_{it} = \beta_o + \beta_1 Mortality_{i,t-1} + \beta_2 Flood_{it} + \beta' X_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (2)$$

In this equation, the study is interested to find out how flood occurrence affects mortality rate. Flood occurrence leads to drowning and electrocuting people, wash away vehicles and others. This is expected to increase mortality rate amongst these African countries. X_{it} represents the vector of control variables that affect mortality rate. These include availability of health staff (Healstaf), health facility (Heafac), income inequality (Incomeinequal), government health expenditure (Healthexp), GDP, nutritional level (Nutri) and conflict occurrence (Conflict).

$$Expectancy_{it} = \delta_o + \delta_1 Expectancy_{i,t-1} + \delta_2 Flood_{it} + \delta_3 Flood_{it} * Heafac + \delta_3 Flood_{it} * Spdisease + \delta' X_{it} + \mu_i + \mu_t + \varepsilon_{it} \quad (3)$$

In this equation, the study is interested to find out how flood occurrence affects life expectancy through the destruction of health facilities and the spread of diseases. Flood occurrence is interacted with health facility and the spread of diseases. Flood occurrence by destroying health facilities will adversely affect health services rendered. Without proper measures put in place to fix these facilities, it is expected to reduce the life expectancy of the citizenry. Again, as already reiterated flood occurrence leads to the spread of diseases, without proper preventive measures, it is expected to reduce life expectancy. X_{it} represents the vector of control variables: health staff (Healstaf), health facility (Heafac), income inequality (Incomeinequal), government health expenditure (Healthexp), GDP, nutritional levels (Nutri), conflicts occurrence (Conflict) and spread of diseases (Diseases).

Variables' measurement, expected sign and source of data

This section presents variables for the study, their proxies and expected outcome. All the variables are collected from World Bank (World Development Indicators) with the exception of income inequality which is collected from Standardized World Income Inequality Database (SWIID) from UNU-WIDER.

Dependent variable

Life expectancy measures the average number of years a person is expected to live. The variable is measured in years. Mortality rate measures the number of deaths as per 100,000 populations which is attributed to household and ambient air pollution.

Independent variables

Flood occurrence is proxied by the level of water stress. It measures water level going beyond excessive level after a place has experienced flooding. Flood occurrence causes the destruction of health facilities and spread of diseases; this adversely affects the health of people, as stated in the study of Abbas and Routray (2014). Hence, it is expected to reduce life expectancy and increase mortality rate. The study wanted to include other variables: droughts, heat waves, cold waves and landslides. But data were not available for majority of these countries.

Control variables

Health facility is proxied by hospital beds. Hospital beds measure inpatient beds which are available in public, private, general and specialized hospitals per 1,000 people. It is measured

in per 1,000 people. Governments' ability to provide the needed health facilities contributes towards reducing mortality rate and improving life expectancy as stated in the study of Pujolar *et al.* (2016).

Availability of health staff is proxied by community health workers. Community health workers are defined as the number of community health workers per 1,000 people. It is measured in per 1,000 people. Making health staff available to render the needed health services will lead to reducing mortality rate and improving life expectancy, as stated in the study of Gorman *et al.* (2003).

Government health expenditure measures public expenditure incurred on health as a share of GDP and government ability to spend on the health sector, when it comes to provision of hospitals, training of health personnel and others.

These help to improve health services' delivery to reduce mortality rate and improve life expectancy as stated in the study of Neagu *et al.* (2017). The variable is measured in percentage.

GDP per capita increasing overtime means that the standard of living of the citizenry has improved. Thus the citizens are able to afford better health services and well-balanced diet to reduce mortality rate and improve life expectancy. The variable is measured in dollars.

Nutritional level is proxied by consumption of iodized salt as used in the study by Johanna *et al.* (2019). Consumption of iodized salt measures the percentage of households that use iodized salt for cooking. Improvement in the nutritional level of the citizenry helps to build a good health system to withstand against diseases. Hence, it is expected to reduce mortality rate and improve life expectancy. The variable is measured in the percentage.

Income inequality measures the extent of distribution of income within a country. It ranges from 0 to 100, where 0 represents perfect equality and 100 represents perfect inequality. Government's inability to ensure equitable distribution of income will increase mortality rate and reduce life expectancy. The reason is because individuals who receive less income cannot afford better health services; this will adversely affect their health, as stated in the study by Geary *et al.* (2021).

Conflict occurrence is proxied by the number of people displaced by conflict and violence, as used in the study by Clare *et al.* (2009). This variable measures the number of people forced to flee their homes due to armed conflict or violence. Conflict occurrence destroys health facilities and produces harmful chemicals that pollute the environment. This leads to an increasing mortality rate and reducing life expectancy. The variable is measured in the number of people affected by conflict.

Spread of diseases is proxied by incidence of malaria cases. Incidence of malaria cases is the number of new cases of malaria in a year per 1,000 people. Stagnant flooded water breeds mosquitoes which lead to the prevalence rate of malaria. This increases mortality rate and reduces life expectancy. The variable is measured in per 1,000 population. The study wanted to include these diseases (typhoid fever, cholera and dengue) and the coverage rate of immunization in the analysis. But the data that were available were for under five years; hence they were not included.

Scope of the study

The study employs panel data covering the period 2000–2018 amongst 53 African countries for the analysis. These 53 African countries have been listed in Table 2. This period is selected because during these periods, these countries have experienced perennial levels of flooding as stated by UNEP (2018). Hence, the study is interested to find out the effect of flooding on mortality rate and life expectancy amongst these countries and prescribes the best policy direction.

Algeria	Cote divoire	Kenya	Nigeria	Togo
Angola	Central African Rep	Lesotho	Niger	Tanzania
Benin	Djibouti	Liberia	Rwanda	Uganda
Burkina Faso	Egypt	Libya	Sao Tomeo	Zambia
Botswana	Equatorial Guinea	Madagascar	Senegal	Zimbabwe
Burundi	Eritrea	Malawi	Seychelles	
Cameroun	Ethiopia	Mali	Sierra Leone	
Cape Verde	Gabon	Mauritania	Somalia	
Chad	The Gambia	Mauritius	South Africa	
Comoros	Ghana	Morocco	Sudan	
Congo, Dem.	Guinea	Mozambique	South Sudan	
Congo, Rep.	Guinea Bissau	Namibia	Tunisia	

Source(s): Authors' creation

Table 2.
List of countries used for the study

Empirical results and discussion

This section discusses results from descriptive statistics, a panel unit root, the Sagan test and system GMM.

Estimates from descriptive statistics, the panel unit root and the Sagan test

Estimates from flood occurrence show a mean value of 30.27, minimum value of 25.99 and maximum value of 34.26 as shown in Table 3. The result does not show a wide difference in flood occurrence amongst these countries. Life expectancy results indicate a mean value of 59.03, minimum value of 39.44 and maximum value of 76.69. The result does not show a wide difference in the life expectancy amongst these countries.

Estimates from mortality rate indicate a mean value of 65.03, minimum value of 56.55 and maximum value of 159.86. This indicates a wide difference in the mortality rate amongst these countries. The decision to use either GMM or system GMM depends on the panel unit root test as shown in Table 1. Estimate from the Fisher-type unit root test indicates p value of 0.32 which means that there exists a unit root in the data; hence the use of system GMM. The Sagan test for validity of instruments as shown in Table 1 indicates that the instruments are valid.

Results from system generalized method of moments (system GMM)

This section that presents results from the system GMM analyses the effect of flood occurrence on mortality rate and life expectancy.

Variable	Observation	Mean	Standard deviation	Minimum	Maximum
Gross Domestic Product	956	2,197.27	3,179.11	111.93	5,942.61
Health facility	1,007	1.61	0.36	0.58	2.45
Health Staff	1,007	0.37	0.19	0.05	0.75
Spread of diseases	872	229.25	166.25	0.005	589.33
Gov't health expenditure	954	1.73	1.11	0.062	6.049
Life expectancy	1,007	59.028	7.92	39.44	76.69
Nutritional level	1,007	71.22	7.88	54.48	84.8
Income inequality	967	54.29	7.71	31.88	74.23
Conflict occurrence	1,007	666,313.9	119,883.4	396,988.9	865,425
Mortality rate	1,007	65.03	22.49	56.55	159.86
Flood occurrence	1,007	30.27	2.66	25.99	34.26

Source(s): Authors' creation

Table 3.
Descriptive statistics

Effect of flood occurrence on mortality rate

Estimate from Table 4 indicates that the previous mortality rate (the lag mortality rate) has negative effect on the current mortality rate with a value of 0.16. Put differently, the result implies that the previous mortality rate reduces the current mortality rate. The result is consistent with our expectation.

The study identified that these governments based on the information on their previous mortality rate take proper measures to reduce their mortality rate. This accounted for the results obtained.

Flood occurrence result indicates positive effect on mortality rate with a value of 0.021 when you control for health staff, GDP, health facility, government health expenditure, nutritional levels, income inequality and conflict occurrence. Put differently, the result implies that flood occurrence increases mortality rate amongst these countries. The result is consistent with our expectation and results of these empirical studies (Babul *et al.*, 2020; Maji *et al.*, 2021). Flood occurrence causes drowning and electrocuting people, submerging of cars and other undesirable situations; these increase mortality rate amongst these countries. Flood occurrence amongst these countries can be attributed to building on waterways, poor drainage systems and choking gutters with plastic wastes and others.

Estimates from health facility and health staff indicate positive effect on mortality rate with values of 0.39 and 0.417, respectively. Put differently, the results imply that services rendered by health staff with these health facilities contribute towards increasing mortality rate. The results are not consistent with our expectation and results from these empirical

Table 4.
Effect of flood occurrence on mortality rate and life expectancy

Mortality/ Life expectancy	(System GMM) Mortality rate	(GMM) Mortality rate	(System GMM) Life expectancy	(GMM) Life expectancy
Lag of Mortality	−0.160***	−0.222***		
	(0.020)	(0.027)		
Flood occurrence	0.021***	0.022***	−0.167***	0.133**
	(0.003)	(0.004)	(0.035)	(0.048)
Health facility	0.390***	0.349***	−0.109***	0.020
	(0.013)	(0.016)	(0.016)	(0.022)
Health staff	0.417***	0.454***	−0.577***	−0.582***
	(0.032)	(0.040)	(0.018)	(0.025)
Gov't health expenditure	0.026	−0.004	−0.014	0.092***
	(0.024)	(0.023)	(0.010)	(0.011)
Income inequality	0.078***	−0.001	−0.018***	−0.010**
	(0.002)	(0.007)	(0.001)	(0.003)
GDP	0.005	0.014	0.008	0.006
	(0.011)	(0.011)	(0.007)	(0.008)
Nutrition levels	−0.013***	−0.017***	0.002	−0.002***
	(0.001)	(0.008)	(0.004)	(0.005)
Conflict occurrence	0.089***	0.069***	−0.125***	−0.046**
	(0.011)	(0.014)	(0.011)	(0.015)
Lag of life expectancy			1.003***	0.960***
			(0.001)	(0.002)
Flood*health facility			−0.442***	−0.406***
			(0.089)	(0.119)
Flood*spread of disease			−0.001***	−0.009***
			(0.009)	(0.001)
Spread of disease			−0.003***	−0.004***
			(0.003)	(0.004)
N	816	767	694	650

Source(s): *Authors' creation;* standard errors are in parentheses: $^{*}p < 0.05$, $^{**}p < 0.01$ and $^{***}p < 0.001$

studies (Alvarenga *et al.*, 2019; Diderichsen *et al.*, 2019). Health services rendered by health personnel have been identified as substandard due to poor maintenance and management of health facilities; this accounted for the result obtained. A research was conducted by Health Consumer Powerhouse Institute (HCPI, a think tank based in Sweden) in 2018. The study rated services rendered by health personnel and maintenance of health facilities in Africa as 34.5 and 19.8%, respectively (HCPI, 2018). The study urges governments in Africa to work towards improving these undesirable conditions.

Nutritional level estimate indicates negative effect on mortality rate with a value of −0.013. Put differently, the result implies that improvement in the nutrition of citizens helps to reduce mortality rate. The result is consistent with our expectation and results of these empirical studies (Juan and Silvia, 2019; Cutler *et al.*, 2006; Marielle *et al.*, 2011; Collins *et al.*, 2013) ensuring proper nutritional practices, cutting down on excessive sugar intake, frequent consumption of vegetables, fruits and herbs, consumption of smoked meats and fishes, iodized salts' usage and others. These protect the citizenry from high blood pressure, high cholesterol, heart diseases, stroke, diabetes and others to reduce mortality rate.

Income inequality estimate indicates positive effect on mortality rate with a value of 0.078. Put differently, these governments' inability to ensure equitable distribution of income leads to the increase in mortality rate.

The result is consistent with our expectation and results of these empirical studies (Abbas and Routray, 2014; Johanna *et al.*, 2019). Income inequality in Africa adversely affects lower income earners, their ability to afford better health services and a well-balanced diet; this increases mortality rate. Africa Development Bank (AfDB) indicated in 2018 that income inequality is widening at an increasing rate. Hence, governments especially in West Africa, Southern Africa and Central Africa should work towards reducing it.

Conflict occurrence estimate indicates positive effect on mortality rate with a value of 0.089. Put differently, the result indicates that occurrence of conflicts leads to an increasing mortality rate amongst these countries. The result is consistent with our expectation and results of these empirical studies (Symonds *et al.*, 2019; Gurmesa *et al.*, 2013; Katie *et al.*, 2018). Destructive activities that occur during conflicts contaminating water bodies with chemicals, release of harmful chemicals into the atmosphere, shooting of people, food shortages and others, increase mortality rate.

Effect of flood occurrence on life expectancy

From Table 4, previous year's life expectancy estimate indicates positive effect on current year's life expectancy with a value of 1.003. This means that previous year's life expectancy contributes positively to improving life expectancy in the current year. Governments based on the information on their previous year's life expectancy take the necessary health measures to improve their life expectancy; this accounted for the result.

Flood occurrence has negative effect on life expectancy with a value of −0.167. This implies that flood occurrence directly reduces life expectancy. This is consistent with our expectation and results of these empirical studies (Gurmesa *et al.*, 2013; Haitham and Jayant, 2014; Maji *et al.*, 2021). Flood occurrence directly destroys economic activities of affected individuals. This adversely affects their standard of living which reduces their life expectancy. The result for flood occurrence interaction with health facility indicates negative effect on life expectancy with a value of −0.442. The result implies that flood occurrence causes the destruction of health facilities to reduce life expectancy. The result is consistent with our expectation and results of these empirical studies (Symonds *et al.*, 2019; Reanos, 2021; Babul *et al.*, 2020).

Flood occurrence leads to the destruction of properties like health facilities. This implies that health personnel cannot render quality health service; this reduces life expectancy.

Statistics from Africa Union (AU) indicates that since 2000 flood occurrence has accounted for 66% of disasters recorded in Africa (AU, 2018). Especially in countries like South Sudan, Sudan, Somalia, Ethiopia and Kenya. This has destroyed a lot of properties including health facilities which has adversely affected health services delivery and life expectancy.

The spread of diseases indicates negative effect on life expectancy with a value of −0.003. This implies that the spread of diseases directly reduces life expectancy. The result is consistent with our expectation and the study result of Pujolar *et al.* (2016). The spread of diseases, if not prevented, deteriorates people's health system which reduces their life expectancy. The result for flood occurrence interaction with the spread of diseases indicates negative effect on life expectancy with a value of −0.001. Put differently, the result implies that flood occurrence leads to the spread of diseases which reduces life expectancy of the citizenry. This is consistent with our expectation. Stagnant flooded waters and the washing away of dirty materials into water bodies lead to the spread of diseases like malaria, typhoid fever, cholera, dengue and others. This reduces life expectancy if not prevented.

Estimates from health facility and health staff indicate negative effect on life expectancy with values of −0.109 and −0.577. This implies that services rendered by health staff with these health facilities reduce life expectancy. The result is not consistent with our expectation and results of these empirical studies (Dialechti *et al.*, 2011; Diderichsen *et al.*, 2019). Health staff inability to render quality services due to poor maintenance and management of health facilities adversely affects the health of the citizenry. This reduces their life expectancy.

Income inequality estimate indicates negative effect on life expectancy with a value of −0.018. Put differently, the result implies that the inability of governments to ensure equitable distribution of income reduces life expectancy of the citizenry. The result is consistent with our expectation and results of these empirical studies (Gelormino *et al.*, 2015; Nutbeam, 2004; Reanos, 2021). Income inequality adversely affects the standard of living of low income earners. Leading to their inability to afford better health services and good balance diet reduces life expectancy.

Conflict occurrence indicates negative effect on life expectancy with a value of −0.125. This means that conflict occurrence reduces life expectancy of the citizenry. The result is consistent with our expectation and the results of these empirical studies (Dialechti *et al.*, 2011; Adedeji *et al.*, 2012).

Destructive activities of conflict that border on polluting water and air with chemicals from guns, shortage of food, slowing down economic activities and others adversely affect the health of the citizenry which reduces their life expectancy.

Conclusion, policy implication and limitation

The issue of climate change has become a perennial problem in the world, of which Africa is no exception. Excessive release of greenhouse gas emissions like carbon dioxide emission, methane emission and others cause extreme weather events like flooding. Flood occurrence and its destruction has been witnessed overall the world. In Africa, statistics from AU indicates that since 2000s, flood occurrence has accounted for 66% of disasters in the continent.

Hence, this study contributes to existing empirical studies by examining the effect of flood occurrence on mortality rate and life expectancy amongst 53 African countries. These countries desire to improve their mortality rate and life expectancy requires that issues of flood occurrence and measures to prevent it should be taken seriously. Hence, this makes this study relevant for policy makers. The result indicates that flood occurrence causes the destruction of health facilities and the spread of diseases to reduce life expectancy. Result from mortality rate indicates that flood occurrence through drowning and electrocuting people, submerging of cars and other undesirable situations increase mortality rate.

In order to deal with climate change and its adverse effect of flood occurrence the study recommends that governments amongst African countries should implement strategies being enshrined in Conference of Parties (COP, 2021) on climate change. Countries should ban the use of plastics for packaging and adopt the usage of soil-decomposable packaging material. Proportion of annual budget should be allocated towards the construction of drainage systems countrywide. Town and country planners should employ the use of trackers, drones to monitor and prevent the construction of buildings on waterways. Future empirical studies should focus on examining proper measures that needs to be operationalized in order to develop sustainable and smart cities in Africa to deal with climate change and flood occurrence.

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