

# Access to Safe Drinking Water, Good Sanitation, Occurrence of Under-Five Mortality and Standard of Living in Developing Countries: System GMM Approach

*Akses kepada Air Minuman yang Selamat, Sanitasi yang Baik, Kejadian Kematian Bawah Lima Tahun dan Taraf Hidup di Negara Membangun: Kaedah Sistem Dinamik Panel Momen*

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## ABSTRACT

*The present study aims to examine the impact of access to safe drinking water and good sanitation on under-five mortality in developing countries by using a panel data-set for 81 selected developing countries with data spanning from 2008 to 2016. System generalized method of moments (GMM) was applied to achieve the objectives of the study. The findings of the first objective reveal that access to safe drinking water is negative and significantly related to under-five mortality. Similarly, the result of the second objective shows that good sanitation is also negatively related with the prevalence of under-five mortality in developing countries. The results have implication on the availability of future workforce and the citizens' standard of living in developing countries. Thus, the study recommends that, by providing safe drinking water and good sanitation for all, could potentially reduce water-related diseases and death prevalence amongst children below the age of five, especially in developing countries where more than 80% of global under-five mortality exists.*

*Keywords: Developing countries; safe drinking water; sanitation; under-five mortality*

## ABSTRAK

*Kajian ini bertujuan untuk mengkaji kesan akses kepada air minuman yang selamat dan sanitasi yang baik ke atas kematian bawah lima tahun di negara membangun dengan menggunakan set data panel untuk 81 buah negara sedang membangun yang terpilih mencakupi tahun 2008 hingga 2016. Kaedah sistem dinamik panel momen digunakan untuk mencapai objektif kajian ini. Penemuan objektif pertama mendapati akses kepada air minuman yang selamat adalah negatif dan memainkan peranan penting ke atas kematian bawah lima tahun. Begitu juga objektif kedua menunjukkan sanitasi yang baik berkaitan negatif dengan prevalen kematian bawah lima tahun di negara membangun. Hasil kajian ini mempunyai implikasi terhadap ketersediaan tenaga kerja di masa hadapan dan taraf hidup rakyat di negara membangun. Oleh itu kajian ini menyarankan agar penyediaan air minuman yang selamat dan sanitasi yang baik untuk semua berpotensi untuk mengurangkan penyakit yang berkaitan dengan air dan prevalen kematian di kalangan kanak-kanak di bawah umur lima tahun, di mana terdapat lebih dari 80% kematian bawah lima tahun ini adalah di negara membangun.*

*Kata Kunci: Negara membangun; air selamat diminum, sanitasi; kematian bawah lima tahun*

## INTRODUCTION

Lack of access to safe drinking water and good sanitation is associated with unfavorable health condition, especially amongst children below the age of five. Due to its importance to human lives, safe drinking water has been formally declared as human right agenda by the United Nations (UN) general assembly in 2015

(United Nations 2015). However, about 58% of the global population are lacking of access to safe drinking water, which is equivalent to about 1.2 billion people using unimproved water for their household routine. Poor access to safe drinking water and good sanitation have an adverse effect on human health, which increase the prevalence of water-sanitation related diseases such as diarrhea, cholera, malaria and dengue. World Health



Organization (2018) reported that globally, about 1,000 children died every year from water-related diseases. More than 95% of these children are from the developing countries, and about 95% of them below the age of five. The World Health Organization (WHO) has categorized diseases associated to water as; water-borne, water-wash, water-based, and water-related to insect vectors. Diseases like diarrhea, malaria, dengue and other water related communicable diseases also lead to premature death, and they are associated with poverty especially in low income countries (Kaldewei 2010; Michael Marmot & Alpbach 2013; Romani & Anderson 2002). Almost 4% of the global death is attributed to diarrhea. Approximately, this can be translated to about 2.2 million people are affected annually, which comprises mostly children under the age of five in developing countries.

The consequences of lacking in the access to good drinking water and sanitation goes beyond the health implication, whereby the vulnerability of these children would have a long-run economic effect on the future working population. The persistent occurrence of death of under-five children implies a declining trend of a country’s workforce from medium to long term period. Subsequently, this affects the level of output and the living standard of citizens in the affected countries. At this point, we then pose the following questions: What is the impact of lack of access to safe drinking water and sanitation on the working population? How does the under-five mortality affect the standard of living of an economy?

Figure 1 below presents the global distribution of people access to safe drinking water and good sanitation and under-five mortality rate based on their income level. More than 95% of population in high income countries have access to safe drinking water and good sanitation. Conversely, lower-income countries are lagging behind

with only 47.8% and 23.6% of the population having access to safe drinking water and good sanitation. Similarly, the prevalence of under-five mortality rate in lower income countries is exhibits the double digit percentage (11.6%) as against a single digit (8.9%) in higher income countries. Figure 1 reveals a negative relationship between access to safe drinking water and sanitation with the prevalence of under-five mortality rate.

Tabulating the data based on regions, Figure 2 shows that, Sub-Saharan Africa and South Asia are regions with high prevalence of under-five mortality. Diseases such as diarrhea, malaria and dengue fever are claiming the lives of million children in these regions over a decade. Literature such as by Ribeiro, (2015) and Deribew, (2015) have suggested that, access to safe water, good sanitation and good hygiene reduce disease prevalence and mortality among children.

The objectives of this paper are to examine (i) the impact of access to safe drinking water on under-five mortality and; (ii) the effect of access to good sanitation on under-five mortality. The remaining sections of the paper is structured as follows. Section two deals with the literature review; section three focuses on the research methodology; section four presents the variable description, section five discusses on the results while section six concludes the paper highlighting the key findings of the study.

Based on the above scenario, it is obvious that access to safe drinking water and good sanitation are critical facilities to mankind. Globally, about 17% of the world population have no access to safe drinking water and 41% are lacking in good sanitation<sup>1</sup>. This situation has triggered the prevalence of under-five mortality rate caused by water-related diseases such as diarrhea, dengue and malaria, which otherwise could be

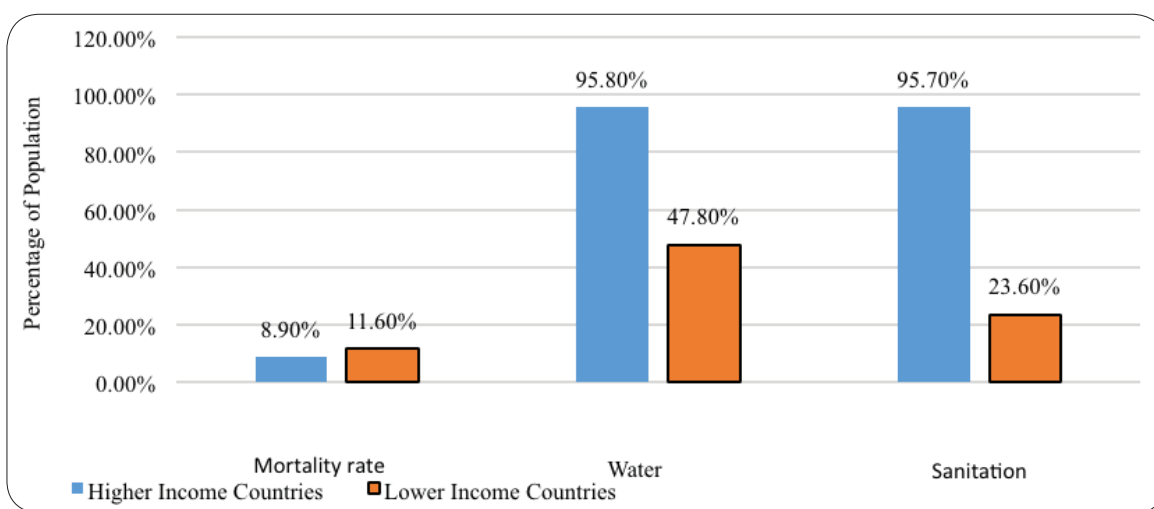


FIGURE 1. Global population access to improved water, sanitation and under-five mortality rate by region in high and low-income countries for 1995 and 2016.

Source: WDI (2018).

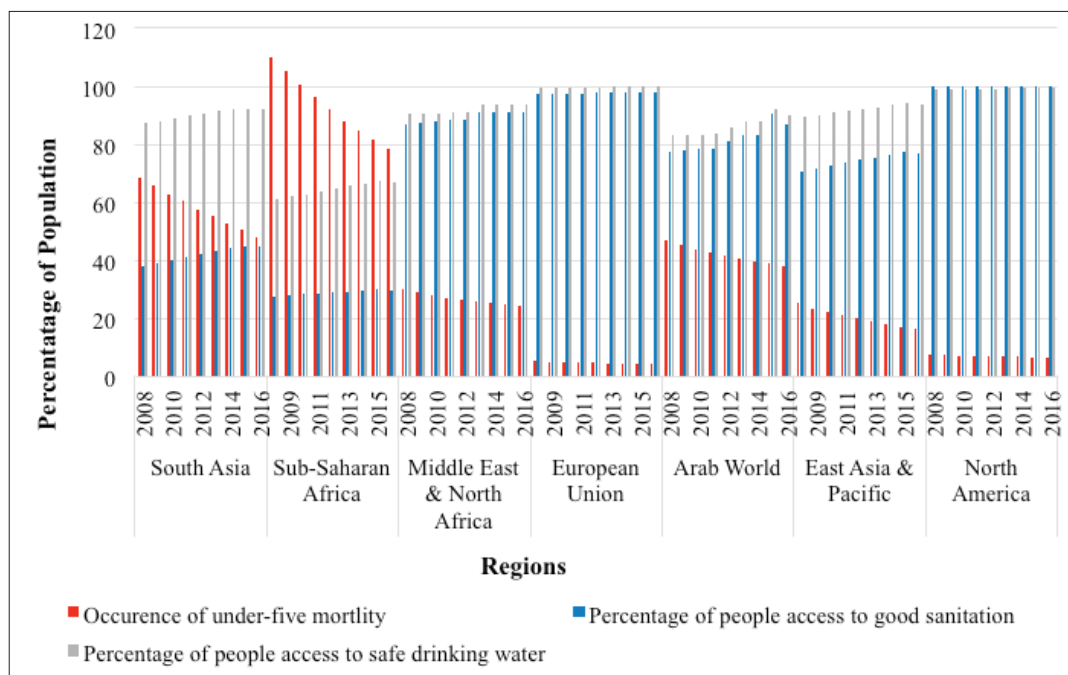


FIGURE 2. Percentage of Population Access to Good Sanitation, Safe Drinking Water and occurrence of Under-Five Mortality (per 1,000 live birth) amongst different Regions of the World.

Sources: Author’s computation from World development Indicators (2018).

avoided through providing access to safe drinking water and good sanitation. Water-sanitation related illnesses have been largely eliminated in developed countries (Sartorius & Sartorius 2014a). However, it remains a major environmental health-challenge in most developing countries, especially low- and lower-middle income countries. In, these countries, it makes up about 98.5% of the global under-five mortality, where the prevalence still remains very high<sup>2</sup>.

Asia and Africa are the most affected regions, with Asia having the largest share of under-five deaths of about 50%, followed by Africa 45%, Latin America and Oceania 3.3%, while Europe constitutes the remaining 1.7%. Therefore, conducting an empirical study on how under-five mortality rate is influenced by lack of access to safe drinking water and good sanitation in low- and lower-middle income countries is imperative.

### LITERATURE REVIEW

Studies on under-five mortality especially in developing world have been presented by numerous previous literature (Gupta & Mitra 2004; Masuy-stroobant 2001; Mincer & Polachek 1974; Mosley & Chen 1984; Scheffler et al. 2010; Tamura 2006). Based on the experience from developing countries, Mosley and Chen (1984) found that environmental contaminations such as indoor and outdoor pollution, fingers<sup>3</sup> and contact transmitted diseases were amongst the main reasons for high mortality in children below the age of five. Similarly, Bartram et al. (2005)

suggested that, lack of improved water and sanitation increased the prevalence of vector-borne diseases such as malaria, filariasis, onchocerciasis, dengue, and Japanese encephalitis, which spread between human beings through insects breeding in water environments. The rate of communicable diseases such as diarrhea incidences are mostly recorded in slum (informal) settlements, which are dominated and occupied by low-income earners. In contrast, the above situation is not the same in the higher-income earners that are residing in the formal settlements, their level of education and/or income is also relatively higher than the former (residents of slum). Studies by Qureshi and Mohyuddin, (2006); Costantini and Monni, (2007); Gangadharan and Valenzuela (2001); Adubofour at al. (2013); and Sulaiman at al. (2015) found a positive correlation between income, health and education.

The literature on sub-Saharan African countries, Sartorius and Sartorius (2014) disclosed factors such as inadequate safe drinking water, poor sanitation and lack of female education are among the factors attributed to the risk for mortality. Also, Munir (2015) examined the environmental sanitation and its health hazards in Ibadan Polytechnic Nigeria and revealed that, environmental health hazards such as prevalence of diseases like Ebola, Cholera and Malaria are linked with unhygienic environment. Ribeiro (2015) suggested that children of poor families with lack of access to improved drinking water and sanitation services may suffer most than children of higher income families in terms of morbidity and mortality from water-related diseases such as

diarrhea. While Nor et al. (2015) discovered that, shocks to human capital (diseases) have a large adverse effect on economic performance, particularly; Dengue, TB and HIV. Houweling et al. (2005) stated that, expenditure on health, delivery by skilled health worker and effective immunization packages reduce the under-five mortality in both rich and poor income countries. Based on the empirical literature reviewed above, other determinants of under-five mortality are presented. For example, Wang (2003); Schell et al. (2007); Sartorius and Sartorius (2014b); Bello and Joseph (2014); and Brown (2014) have identified the role played by health expenditure (both government and private), population growth and technology transfer, (see French 2014), can improve the health outcomes, especially towards the reduction of under-five mortality in developing countries. In the same vein, Bello and Joseph (2014) used child mortality as a proxy to health outcome in their study and the logistic regression method of cross-sectional study was applied on the data from 150 respondents. They found that malaria, poverty, lack of effective breastfeeding are the major determinants of child mortality in Atiga local Government Area of Oyo state Nigeria.

Wang (2003) utilized demographic and health survey data from 60 sample of less developed countries (LDCs) for the period of 1990 to 1999 and reported that, public health expenditure was had significantly reduced child mortalities. In another study, Schell et al. (2007) used panel data of 152 lower, middle and high income countries and their findings suggested that, government health expenditure, gross national income per capita, Gini index, and young female illiteracy rate are the socioeconomic determinants of infant mortality. Their result suggested that, effective government health expenditure, which mean an increase in GDP per capita and improvement in female education would assist in reducing child mortality. The importance of government was also affirmed by Brown (2014), where he reported that with an additional \$10 health expenditure per capita reduced all-cause of mortality by 9.1 deaths per 100,000 in the case of California. Similarly, Tae and Shannon (2013) found a statistically significant result on the relationship between government health expenditure and two indicators of health; child mortality and life expectancy. Their finding suggested a negative relationship between government health expenditure and infant mortality rate, while on the other hand there is a positive relationship between government health expenditure with life expectancy rate. Similarly, the findings of Purohit (2015) revealed that, government expenditure (proxy to expenditure on water and sanitation facilities) on selected water-borne diseases in India, is positively related with water-borne diseases reduction, such as acute diarrhea, enteric fever and malaria.

As the world population continues to increase, the demand for industrial products also increases, which leads to industrialization. This industrialization

process did not go smooth without adverse effect on environmental quality (Chindo et al. 2014). The waste substances, which are mostly toxic and produced by industries are frequently discharged into water bodies such as rivers, canals, lakes, oceans etc. and these practices reduce water qualities. As a result of the unethical practices, the a global populations are exposed to environmental health related problems such as spread of infectious diseases like malaria, dengue fever, asthma and sometimes even death (Bartram et al. 2005a; Fogden 2009; Marcus 1986; Sherif 2010).

Researchers such as Wood (2003); Van Kraayenoord (2008); Fritzell et al. (2015) Russ and Howard (2016) and Landrigan, (2016) proved that, there is a positive relationship between natural resources explorations with poverty and ill-health in both low and high-income countries. Nevertheless, the issue is more pronounced in developing countries, in which ill-health is associated with natural resources explorations and poverty. For example, the prevalence of under-five mortality is associated with polluted water as a result of lead mining in Zamfara state northern Nigeria. According to Ortiz-correa, Resende, and Dinar (2016), it is reported by the Global Analysis and Assessment of Sanitation and Drinking Water (GLASS) in 2015 about 1.8 billion people are at risk of using water source that can be potentially contaminated. This situation may increase the spread of communicable diseases amongst the vulnerable communities.

While Also Gebretsadik and Gabreyohannes (2016) revealed that, factors like preceding birth interval, family size, birth type, breastfeeding status and income of mother determines the under-five mortality in Ethiopia. Another important determinant of under-five mortality is indoor pollution as suggested by Sulaiman et al. where, following the work of Gangadharan and Valenzuela (2001), they investigated the impact of wood fuel consumption on health outcomes in sub-Saharan Africa. The result indicated a significant and negative relationship between fuel wood consumption and under-five mortality.

Having reviewed the literature on the determinants of under-five mortality above, the present study focuses on the impact of access to safe drinking water and good sanitation on the occurrence of under-five mortality. However, this study differs from existing literature for the following reasons (i) Most of the previous studies which emphasized on the influence of environment on a child's health were limited to their first 28 days of life (neonatal period) and post-natal period between 28 days to 11 months. However, the child health is more influenced by the environmental factor within the age of 1 year to 5 years. (ii) We used an extended version model by augmenting for carbon dioxide, public expenditure on health, labour force, gross capital formation and gross domestic product per capita to serve as control variables without over parameterizing the model.



## METHODOLOGY

The theoretical foundation for this study is the human capital model developed by Grossman (1972). The human capital model is determined by education and health. Stock of human health can be depreciated through factors like age, diseases and time. It can also improve through investment on health such as exercise, taking balanced diet, avoiding alcoholic life etc. Environmental quality could also have negative or positive effect on health stock.

Later, the model was augmented by variables supported in subsequent literature. Therefore, the study adopted the original work of Mosley and Chen (1984) as one of the early empirical literature on child health taking into consideration economic factor and environmental factor like sanitation. Following some empirical studies of Gangadharan & Valenzuela (2001) and Bloom and Canning (2003) the under-five mortality model is specify as follows:

$$MORT = f(WAT, SAN, CO_2, PHE, LAB, GCF, GDP) \quad (1)$$

MORT is under-five mortality rate in developing countries, also as dependent variable of the model, while WAT stands for the percentage of population access to safe drinking water and SAN is the percentage of population access to good sanitation. WAT and SAN are the main hypothesis variables and determinants of under-five mortality. Whereas, CO<sub>2</sub>, PHE, LAB, GCF and GDP stand for carbon dioxide, public expenditure on health, labour force, gross capital formation and gross domestic product per capita served as control variables in the model respectively. These control variables were included in the model to avoid the problem of functional specification error in the model and to further contribute to knowledge by including relevant variables. Furthermore, an econometric model can be derived (1) by incorporating intercept ( $\alpha_0$ ) and disturbance variable ( $\eta$ ) in the model as:

$$MORT = \alpha_0 + \alpha_1 WAT + \alpha_2 SAN + \alpha_3 CO_2 + \alpha_4 PHE + \alpha_5 LAB + \alpha_6 GCF + \alpha_7 GDP + \eta \quad (2)$$

In the same vein, a fixed panel data model can be derived from the econometric model above as follows:

$$MORT_{it} = \alpha_0 + \alpha_1 WAT_{it} + \alpha_2 SAN_{it} + \alpha_3 CO_{2it} + \alpha_4 PHE_{it} + \alpha_5 LAB_{it} + \alpha_6 GCF_{it} + \alpha_7 GDP_{it} + \vartheta_t + \chi_i + \eta_{it} \quad (3)$$

Where ( $i$ ) stands for the number of developing countries used in this study, and ( $t$ ) is time express in number of years used. Due to the weakness of fixed panel OLS model in handling heterogeneity problems such as time-invariant differences in the sample countries, we employed Generalized method of moment (GMM) model introduced by Arellano and Bond (1991) and Arellano and Bover (1995). The model is dynamic and can help in addressing the problem associated with fixed panel

model. Therefore, the GMM model specification is given as follows:

$$MORT_{it} = \alpha_0 + \ell MORT_{it} + \alpha_1 WAT_{it} + \alpha_2 SAN_{it} + \alpha_3 CO_{2it} + \alpha_4 PHE_{it} + \alpha_5 LAB_{it} + \alpha_6 GCF_{it} + \alpha_7 GDP_{it} + \vartheta_t + \chi_i + \eta_{it} \quad (4)$$

The dependent variable of the model is represented by  $MORT_{it}$  which is under-five mortality rate in developing countries. While  $MORT_{it-1}$  is the lagged dependent variable, and it takes care of the dynamic behavior of the panel GMM model. Then  $\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5, \alpha_6$  and  $\alpha_7$  are the coefficient of all the log form-independent variables in model equation 5. While  $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$  and  $\beta_7$  for model 6. We expect the coefficient of the hypothesized variables, access to safe drinking water  $\alpha_1$  and the coefficient of good sanitation  $\beta_1$  to be negatively related to under-five mortality. The variables included are water (WAT), sanitation (SAN), CO<sub>2</sub> emission (CO<sub>2</sub>), public health expenditure (PHE), labour-force (LAB), gross capital formation (GCF) and GDP per capita respectively. They also serve as elasticities in measuring the degree of variation or changes in under-five mortality rate in developing countries as a result of variation in the independent variables respectively. Then  $\vartheta_t$  is the time invariant country unobserved specific effect, which take care of differences in the panel countries, then,  $\chi_i$  is the time variant country specific effect. While  $\eta_{it}$  is a time variant error term that represents all other factors that can affect under-five mortality rate in developing countries, but not included in the model.

Estimating WAT and SAN in the same model as specified in equation (4) may lead us to have a mis-specified model due to possible endogeneity between water and sanitation variables, hence we specify them in separate models as:

$$MORT_{it} = \alpha_0 + \ell MORT_{it-1} + \alpha_1 WAT_{it} + \alpha_2 CO_{2it} + \alpha_3 PHE_{it} + \alpha_4 LAB_{it} + \alpha_5 GCF_{it} + \alpha_6 GDP_{it} + \vartheta_t + \chi_i + \eta_{it} \quad (5)$$

$$MORT_{it} = \alpha_0 + \ell MORT_{it-1} + \beta_1 SAN_{it} + \beta_2 CO_{2it} + \alpha_3 PHE_{it} + \alpha_4 LAB_{it} + \alpha_5 GCF_{it} + \alpha_6 GDP_{it} + \vartheta_t + \chi_i + \eta_{it} \quad (6)$$

The panel sample of 81 developing countries<sup>4</sup> were taken, based on WDI income classification of low- and lower-middle income countries. Also, the selection of time period (T) of 9 years<sup>5</sup> for the balance panel covering from 2008-2016 is based on the availability of data.

## VARIABLES DESCRIPTION

All the variables used in this study were collected from World Bank's World Development Indicators (WDI). Under-five mortality rate (MORT) is defined by the World Bank as the probability of death in children below the age five. It is mostly calculated as the number of deaths per 1,000 live birth. It is expected to have a negative

relationship with the proportion of population access to safe drinking and good sanitation. While good sanitation is measured as the percentage of people access to safe sanitation facilities, such as good toilets (flush to septic tank, or good ventilated pit) that safeguard hygienic separation of human excreta from contact. Then GDP stand for gross domestic product per capita.

Others include CO<sub>2</sub> which is the carbon dioxide emission and is measured in metric tons per capita. While public health expenditure measures the current and recurrent spending by government on health sector. The public health expenditure covers the provision of health services, family planning activities, nutrition activities, and emergency aid designated for health, but, excludes provision of water and sanitation services to the population. We expect a negative relationship between public health expenditure with the under-five mortality rate in low- and lower-middle income countries. Then labour-force productivity measures the output per head, which is calculated by dividing the total output of labour by the number of labour-force. GDP per capita is used as proxy to total number of labour output, whereas total sum of labour force employed from the age of 18 to 64 years old were used respectively. Finally, gross capita formation is measured in terms of additional fixed assets possessed by a given country, which include; plant, machinery, and equipment purchases and the construction of road networks, active railway lines, and other physical structures.

## RESULTS AND DISCUSSION

The summary statistics of the variables used in the study are presented in Table 1 below.

The overall mean of the annual under-five mortality is 63.42, which indicates that, on average, 63% of the children in the low- and lower-middle income countries dies before reaching five years. The proportion of population access to safe drinking water in the region constituted about 67%, while the proportion of population

access to good sanitation facilities is only 39%. The labor force productivity is measured by the number of working populations aged from 15 to 64 years, which is on average 66%. Then carbon dioxide emission in metric tons is 0.94% per capita when shared across the total population of the samples (81 low- and lower-middle income countries). The gross capital formation proxy to capital, on average is 21% in the region and government health expenditure indicated at about 92%.

In order to determine the degree of relationship, and to avoid high correlation amongst the independent variables, the correlation matrix test is performed and presented in Table 2. The variables were not highly correlated in the sense that, their degree of correlation is less than 0.8. Variables with highest correlation are SAN and WAT with 0.67, while those with lowest correlation are GCF and WAT with 0.05. The rule of thumb suggests that, the degree of correlation should not be greater than 0.8 (see Prodan 2013; Sulaiman et al. 2017).

Table 3 presents the result for the impact of access to safe drinking water on under-five mortality. System GMM was employed and the coefficient of lagged dependent variable found to be significant at 1% and positive as well, which entailed the dynamic nature of the model. The model has passed the diagnostic check, such as the Hansen J-test test for over identifying restrictions (which fails to reject the over-identifying restrictions) and difference in Hansen test for additional instruments also fails to reject the null hypothesis. The elasticity of the main hypothesized variable (access to safe drinking water) is -0.138 meaning that, as the proportion of the population having access to safe drinking water increases by 1%, then under-five mortality rate reduces by around 0.14%. This reveals a negative relationship between access to safe drinking water and under-five mortality in developing countries. Thus, access to safe drinking water improves labour force and subsequently the standard of living in developing countries. Therefore, as long as people are using safe drinking water for their domestic activities, the probability of occurrence of water-related diseases such as diarrhea, cholera, and dengue and other

TABLE 1. Summary Statistics

Variables	Mean	Std. Dev.	Min.	Max.	Observation
<i>MORT<sub>it</sub></i>	63.42	37.03	9	208.80	780
<i>WAT<sub>it</sub></i>	67.63	20.33	14.12	100	780
<i>SAN<sub>it</sub></i>	39.24	28.99	27.58	100	780
<i>PHE<sub>it</sub></i>	91.65	79.13	15.3	431.97	780
<i>CO<sub>2it</sub></i>	.938	1.72	.036	23.22	780
<i>LAB<sub>it</sub></i>	66.12	18.08	12.7	90.80	780
<i>GCF<sub>it</sub></i>	21.11	11.79	-1.32	68.02	780
<i>GDP<sub>it</sub></i>	1564.80	1104.41	191.11	4329.25	780

Note that *MORT<sub>it</sub>* is the occurrence of under-five mortality, *WAT* represents access to safe drinking water, *SAN* stands for access to good sanitation. *GHE<sub>it</sub>* is the total government health expenditure, *CO<sub>2it</sub>* stands for carbon dioxide emission in metric tons per capita, then *LAB<sub>it</sub>* stands for labour-force aged from 15 to 65 years. *GDP* per capita and *GCF* is are the gross capital formation.

TABLE 2. Correlation Matrix

	$MORT_{it}$	$WAT_{it}$	$SAN_{it}$	$GHE_{it}$	$CO2_{it}$	$LAB_{it}$	$GCF_{it}$	$GDP_{it}$
$MORT_{it}$	1							
$WAT_{it}$	-0.589	1						
$SAN_{it}$	-0.678	0.670	1					
$GHE_{it}$	-0.514	0.434	0.416	1				
$CO2_{it}$	-0.358	0.200	0.309	0.394	1			
$LAB_{it}$	0.196	-0.166	-0.231	-0.489	-0.144	1		
$GCF_{it}$	-0.073	-0.05	-0.061	-0.118	0.062	0.218	1	
$GDP_{it}$	0.021	-0.09	-0.056	-0.210	0.152	-0.049	0.159	1

Note that  $MORT_{it}$  is the occurrence of under-five mortality,  $WAT$  represents access to safe drinking water,  $SAN_{it}$  stands for access to good sanitation.  $GHE_{it}$  is the total government health expenditure,  $lnCO_{2it}$  stands for carbon dioxide emission in metric tons per capita, then  $LAB_{it}$  stands for labour-force productivity,  $GDP$  per capita and  $GCF$  is the gross capital formation.

related diseases would be less. Hence, the prevalence of death related to environmental health exposure especially amongst the most vulnerable group (children below the age of five) would also be minimized. This result authenticates the findings of Fotso at al. (2007) and Sulaiman at al. (2017) as in the case of sub-Saharan African countries.

Interestingly, all the control variables used in the model, such as  $CO_2$ ,  $PHE$ ,  $GDP$ ,  $LAB$ , and  $GCF$  have produced results that are statistically significant and negatively related to under-five mortality in the regions, hence, consistent with the theoretical provision.

The second main hypothesized variable is the access to good sanitation. As stated earlier in the methodology part, estimating the two variables (access to safe drinking water and good sanitation) in one model may produce

spurious result. Hence, in order to avoid endogeneity in the model and multicollinearity amongst them, each variable is estimated in a separate model respectively. Therefore, Table 4 presents the estimated coefficient of access to good sanitation. The estimated coefficient of access to good sanitation for the system GMM model is also negative and statistically correlated to under-five mortality  $-0.065$  and subsequently, improves standard of living. Meaning that when access to good sanitation improves by 1% in lower income countries, this will correspondingly reduce under-five mortality by almost 0.065%. The results confirmed the findings of Adubofour and Quansah (2013) which suggested that, improvement in access to sanitation facilities would improve the standard of living, and would reduce the environmental health-related diseases such as diarrhea and cholera

TABLE 3. Impact of Access to Safe Drinking Water on Occurrence of Under-Five Mortality: System GMM

Variables	System GMM
	Coefficient
$lnU5M_{it-1}$	.816 (.002)***
$lnWAT_{it}$	-.138(.017)***
$lnPHE_{it}$	-.0345(.003)***
$lnGDP_{it}$	-.031(.006)***
$lnLAB_{it}$	-.097(.038)**
$lnGCF_{it}$	-.027(.007)***
$lnCO_{2it}$	-.014(.816)***
AR(2)	0.312
Hansen test of ORR	0.000
Difference-in-Hansen	0.129
Number of observation	607
Number of groups	69
Number of instruments	51

Note that, Values in the parenthesis () represents standard error, while \* \*\* \*\*\* represent significance level at 1%, 5% and 10%, respectively.

TABLE 4. Impact of Access to Good Sanitation on Occurrence of Under-Five Mortality: System GMM Model

Variables	System GMM
	Coefficient
$U5M_{it-1}$	.800(.002)***
$lnSAN_{it}$	-.065(.017)***
$lnPHE_{it}$	-.0345(.002)***
$GDP_{it}$	-.031(.006)***
$lnLAB_{it}$	-.119(.028)***
$lnGCF_{it}$	-.034(.007)***
$lnCO_{2it}$	-.007(.003)***
AR(2)	0.317
Hansen test of ORR	0.049
Difference-in-Hansen	0.129
Number of observation	607
Number of Groups	69
Number of Instruments	51

Note that, Figures in the parenthesis () represents standard error, then \*\* indicates significant at 5% and \*\*\* indicates significant at 1%. While values in the brackets are the standard errors.

within the two communities of Asawase constituency in Kumasi Ghana.

Other control variables include; government health expenditure which is significant at 1% and negatively related with under-five mortality. Its elasticity of  $-0.035$ , indicated that, an increase of government health expenditure in the low and lower-middle income countries by 1%, will correspondingly reduce under-five mortality rate by roughly 0.04%. Therefore, this is confirmed that public health expenditure is also an important instrument for curbing under-five mortality in lower income countries. Government expenditure if effectively utilized toward providing effective health services in health centers, the children would be fully immunized free of charge or at an affordable cost, and hence, the untimely under-five mortalities would be minimized.

However, the CO<sub>2</sub> emission produces negative coefficient which contradicts to the theoretical provision. This may likely happen as a result of low-global share of CO<sub>2</sub> emission in metric tons per capita from both the low- and lower-middle income countries due to less industrialization and urbanization in developing countries as compared with developed countries. Therefore, these factors are amongst the reasons why developed countries are producing higher amount of CO<sub>2</sub> emission in metric tons per capita when compared to the developing countries. Masters et al. (2010) reported that, since the beginning of industrial revolution, the trend of CO<sub>2</sub> has been increasing globally, and in 2010 about 6.5 billion metric tons of CO<sub>2</sub> was emitted globally and mostly from burning of fossil fuels. Hence, higher-income and developed countries constituted the largest share of CO<sub>2</sub> emissions comparing with developing countries especially low- and lower-middle income.

## CONCLUSION

Objectively, the study has investigated the relationship between under-five mortality with the two proxies of environmental health (access to safe drinking water and good sanitation) in low- and lower-middle income countries. The study employed the techniques of system Generalized Method of Moments (GMM) in modeling the stipulated relationship.

The estimated coefficients of the independent variables have produced results that are consistent with theory and our earlier expectation. Access to safe drinking water and good sanitation found to be negatively correlated with dependent variable (under-five mortality). Empirically, this study has proven that by providing people with clean and portable drinking water would reduce the possibility of water-related diseases such as diarrhea, malaria etc. Apart from reducing the occurrence of related diseases, this also improves their hygienic environment and would eventually reduce the rate of

mortality especially amongst the vulnerable children under the age of five.

From the estimated coefficients of the two models, access to safe drinking is more significant compare to access to good sanitation in terms of reducing under-five mortality per 1000 in low-and lower-middle income countries. For example, there is a reduction of about 138 per 1000 under-five mortality as a result of improvement in the access to safe drinking water in the sample countries. While access to good sanitation only reduces about 65 per 1000 under-five mortality. Therefore, impliedly the result suggests that, access to safe drinking water is a more effective tool in reducing under-five mortality in low- and lower-middle income countries.

Other control variables such as public health expenditure is found to be negatively and statistically significant in reducing under-five mortality amongst the low- and middle-income countries within the reported period. Finally, the finding confirms that, access to safe drinking water, good sanitation, public health expenditure are essential factors that aids towards reducing the prevalence of under-five in low- and lower- middle income countries.

## POLICY IMPLICATION

Based on the findings, the study recommends the need for government in low- and lower-middle income countries to seriously commits in the provision of safe drinking water for all. Based on the estimated coefficient of SAN<sub>it</sub>, it is recommended that enforcement of environmental sanitation laws should be maintained. Secondly, community-based efforts towards provision and management of safe drinking water facilities such as the construction of vigorous protected tube well, boreholes, rainfall harvesting etc. should be adopted in all the affected countries to ensure 100% of the global population have accessed to safe drinking water, especially in the low- and lower-middle income countries. Finally, in order to improve the quality of a country's workforce and the general standard of living, the policymaker should pay more attention in providing access to safe drinking water in developing countries and works towards improving the sanitation system.

## NOTES

- 1 Source: USEPA (2015) on the Global distribution of people access to safe drinking water and Sanitation in percentage (%)
- 2 Global Under-Five Death Related to Environmental Pollution WHO News release 6 March 2017)
- 3 Diseases such diarrhea is transmitted through liken finger as a result of failure to wash hand before and or after eating food. While children are frequently sucking their fingers in their neonatal, infant and under-five ages, such doings can assist in transmitting intestine transmitted disease.



<sup>4</sup> The list of 81 low- and lower-middle income countries utilised by the study is presented in appendix.

<sup>5</sup> Data used by the study covers the period of 9 years without averaging the period, since the data is available from WDI data base.

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APPENDIX  
List of 81 Countries used in the study

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Afghanistan	Honduras	Rwanda
Armenia	India	Samoa
Bangladesh	Indonesia	Senegal
Benin	Kenya	Sierra Leone
Bhutan	Kiribati	Solomon Islands
Bolivia	Korea, Dem. People's Rep.	Sri Lanka
Burkina Faso	Kosovo	Sudan
Burundi	Kyrgyz Republic	Swaziland
Cabo Verde	Lao PDR	Syrian Arab Republic
Cambodia	Lesotho	Tajikistan
Cameroon	Liberia	Tanzania
Central African Republic	Madagascar	Timor-Leste
Chad	Malawi	Togo
Comoros	Mali	Tonga
Congo, Dem. Rep.	Mauritania	Tunisia
Congo, Rep.	Micronesia, Fed. Sts.	Tunisia
Cote d'Ivoire	Moldova	Uganda
Djibouti	Mongolia	Ukraine
Egypt, Arab Rep.	Morocco	Uzbekistan
El Salvador	Mozambique	Vanuatu
Eritrea	Myanmar	Vietnam
Ethiopia	Nepal	West Bank and Gaza
Gambia, The	Nicaragua	Yemen, Rep.
Ghana	Niger	Zambia
Guatemala	Nigeria	Zimbabwe
Guinea	Pakistan	
Guinea-Bissau	Papua New Guinea	
Haiti	Philippines	

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Sources: Authors computation from WDI (2018)

