THE IMPACE OF WATER AND SANITATION ON CHILDHOOD MORTALITY IN SUB-SAHARAN AFRICA

By

KALBESSA, Chaltu Daniel

THESIS

Submitted to

KDI School of Public Policy and Management

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF DEVELOPMENT POLICY

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Committee in charge:

Professor Jaeun SHIN, Supervisor

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ABSTRACT

This study is conducted mainly to analyse the effect of water and sanitation on childhood mortality in Sub-Saharan Africa region. The empirical approach uses longitudinal data sourced from the World Development Indicators (World Bank) for the period 2000-2015. Infant and under-five mortality rates were used as indicators for childhood mortality. To diminish the possible confounding influence of water and sanitation in the child mortality regressions, we use an instrumental variable approach based on Dynamic Panel estimators or the General Method of Moment (GMM). The study finds that in Sub-Saharan Africa region, water and sanitation has a strong impact on reducing both infant and under-five mortality rates. Furthermore, the study finds that public health expenditure and aid all work together to reduce the possibility of infant and under-five deaths in Sub-Saharan Africa countries. These findings call for policymakers to pay a great deal of attention to increase investment in water and sanitation, improving official development assistance(ODA) along with increased public spending on health as these are all important factors that can help to decrease infant and under-five deaths in Sub-Saharan Africa.

Keywords: Water and Sanitation, Dynamic Panel Estimation; Childhood Mortality; Sub-Saharan Africa

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May God bless you all.

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LIST OF ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
FE	Fixed Effects
GDB	Global Disease Burden
GDP	Gross Domestic Product
GMM	Generalized Method of Moments
HIV	Human Immunodeficiency Virus
MDGs	Millennium Development Goals
ODA	Official Development Assistance
OLS	Ordinary Least Square
RE	Random Effects
SDGs	Sustainable Development Goals
SSA	Sub-Sahara Africa
UNICEF	United Nations Children's Fund
UN	United Nation
WHO	World Health Organization
WSH	Water Sanitation and Hygiene

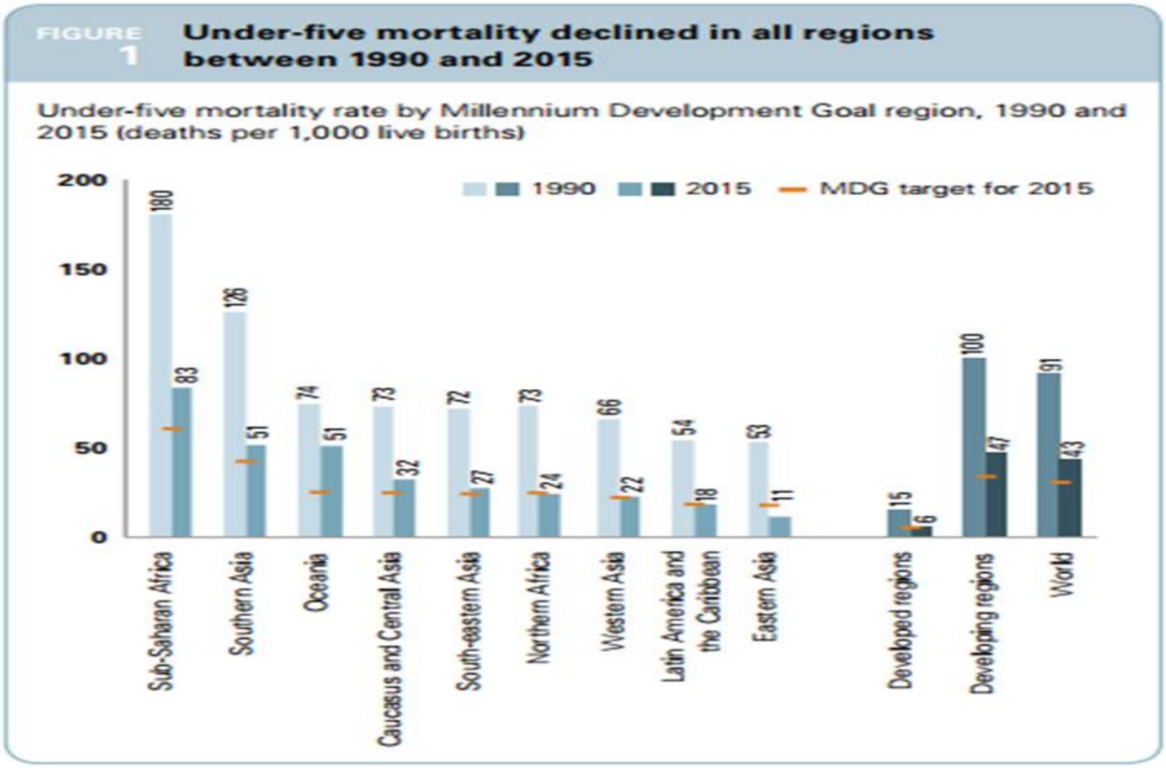
1 INTRODUCTION

1.1 Background of the Study and overview

Reducing child mortality has been the key priority of international development agenda at regional and global level. Hence, as one of the millennium Development Goal, child mortality was targeted to decrease by two third by 2015 (United Nations 2000) and it targeted to reduce to less than 2.5% by 2030 in post-2015 Sustainable Development Goals (United Nations 2015).

Globally, the child mortality rate has declined to 43/1000 in 2015 out of 91/1000 in 1990. Thus, show that the World has achieved remarkable improvement in lessening of child mortality in the last two decades. But there are regional variations in the progress across the regions. The situation is more severe in sub Saharan Africa(SSA). Although SSA region made some progress in reduction of child mortality from 3.8 million fatalities in 1990 to 2.9 million deaths in 2015, child mortality remains still higher in sub-Saharan Africa region parallel to other regions of world (UNICEF, WHO, WBG &UN, 2015). For instance, Child mortality in the WHO African Region which is 76.5/1000, around eight folds higher than that in the European Region which is 9.6/1000 live births (WTO, 2017).

Figure 1: Child Mortality (per 1000) by Region Between 1990 and 2015



Source: UNICEF (2015)

There are many socio-economic factors for this high childhood deaths in SSA region. In sub-Saharan Africa many child deaths are attributed to preventable infectious diseases. Together, unsafe water and poor sanitation are a principal cause of child mortality by attributing to different infectious diseases.

1.2 Statement of the Problem

Clean water and better sanitation are essential for the endurance, wellbeing and growth of children (WHO, 2017). Increasing the improved water supply and sanitation facility has been the issue of international development agenda by including them as one of the goals in Millennium

Development Goal and Sustainable Development Goal. But despite these efforts at the local and universal levels, access to safe water and improved sanitation remain insufficient in developing countries, particularly in Sub-Saharan Africa. According to UNICEF (2015), 663 million people globally lacking access to clean water supply and 2.4 billion people still do not have an improved sanitation facility. The situation is especially severe in Sub-Saharan region. Half of the global community using unimproved water sources and approximately 700 million people lacking access to improved sanitation dwell in Sub-Saharan Africa (UN, 2015).

Together, unimproved water supply and sanitation are a principal cause of child mortality. Diarrhea is the principal burden of unimproved sanitation and water, and is the second leading cause of child mortality. Daily around thousand (1,000) children below year 5 pass away from diarrhea and around 525,000 children die yearly WHO (2017). On average, children mortality under five in Sub-Saharan Africa is more than 14 times of developed regions (WHO, 2016).

Several studies have been conducted on the potential effect of water and sanitation on child mortality in different countries (Gunther & Fink, 2011; Checkley, Black, Epstein, Cabrera, Sterling & Moulton, 2004; Ezeh, Agho, Dibley, Hall & Page, 2014). These studies found that improved water and sanitation have significant effects on the reduction of child mortality. Within the context of the Sub-Saharan African region, only a few studies exist, however these studies only include a few countries of the region and they are also not recent one. Given that the Sub-Saharan African region, the region which face the greatest challenge of water and sanitation access in the world, this research will fill the gap in the research by examining the effect of water and sanitation on child mortality in this region by including all 46 countries in the region and also using updated data (2000-2015). Furthermore, this study will disaggregate childhood mortality components into infant and under-five mortality to cater for the possibility of measurement errors. Moreover, the paper will endow to the existing body of literature on the region.

1.3 Research Questions

The subsequent are research questions, which this study will aim to answer:

I. What is the effect of water and sanitation on infant(under-one) mortality in Sub-Saharan African countries?

II. What is the impact of water and sanitation on child(below-five) mortality in Sub-Saharan African countries?

1.4 Objectives of the Research

The broad objective of this paper is to investigate whether there exists a causal effect between water & sanitation and infant as well as below-five mortality rates for SSA region over the period of 2000 - 2015.

This broad objective is divided into two specific objectives:

I. To investigate whether there exists a causal effect between water & sanitation and infant as well as below-five mortality rates in SSA.

II. To determine the role of socio-economic variables that affect infant and under-five child mortality.

1.5 Hypothesis

The hypothesis this paper will test is that improved water & sanitation does affect infant and below-five deaths in SSA region.

1.6 Significance of the Study

Reducing childhood mortality, increasing access to clean water and better sanitation has been the key issues of international development agenda by including them as one of MDGs and SDGs. It's very important to know how and to what extent they are inter related. It's essential to examine the health benefit of improving water source and sanitation as well as its potential effect in reducing the child mortality. Given the SSA, a region which have a higher child mortality and greatest challenge in access of improving water and sanitation this study will investigate the effect of water and sanitation by analyzing its association with infant and below-five mortality rates in SSA region. Moreover, the study will be essential to the SSA strategist by helping them to determine appropriate policy interventions to ensure that access to clean water and sanitation is improved. Accordingly, this in future will potentially ensuring the achievement of SDG 3 goal (target 2) and SDG 6 goal of the United Nations post-2015 Sustainable Development Goals simultaneously. It could also serve as a reference for further studies in the area.

1.7 Organization of the Study

The study is divided in to five parts. Chapter one introduced the topic under study. The second chapter gives review of some theoretical and empirical literatures. The third chapter presents the methodology used in the paper. In chapter 4 and five study concludes with the study's major findings and policy recommendation respectively.

2 LITERATURE REVIEW

This literature review focuses on how sanitation and water effect childhood mortality in SSA region. Clean Water & improved sanitation are the fundamental needs for the survival and growth of children. The literatures show that the countries in sub-Sahara Africa face the greatest challenge in access to clean water and better sanitation facility. Half of the global population using unimproved water sources and approximately 700 million people lacking access to bettered sanitation reside in SSA (UN, 2015). Together, unsafe water source and unimproved sanitation are a principal cause of child mortality. This review of literature consists theoretical and empirical part.

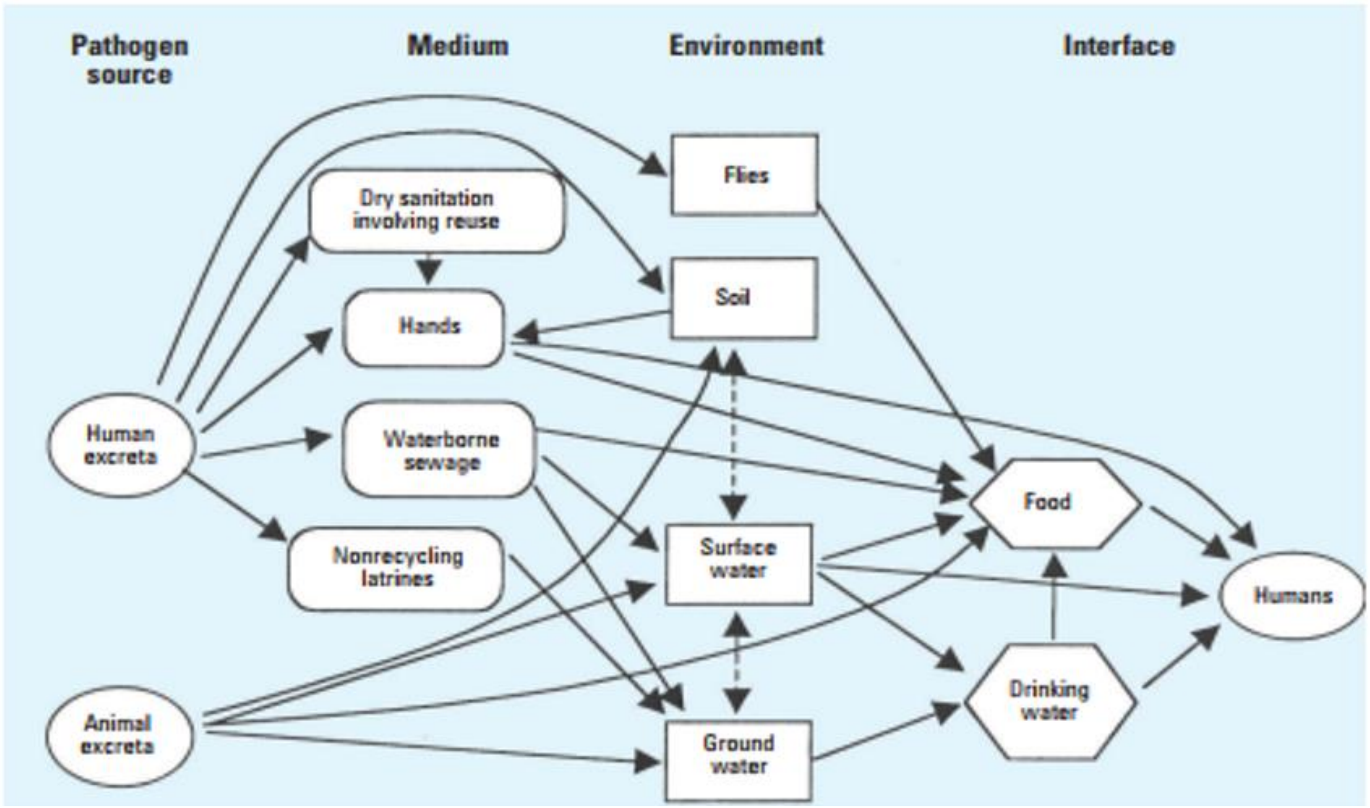
2.1 Theoretical Literature Review

Children are more vulnerable to hazardous environment (including poor water source and sanitation facilities as well as lack of hygiene) as they are continuously growing children need more air, food and water. Accordingly, they inhale more air, eat more food, and drink more water than elders do, in proportion to their weight (WHO, 2017). Moreover, children's digestive and respiratory systems as well as immune system are still growing and children play in areas where pollutants may gather (Fayehun, 2010).

The burden of infections from unsafe water, unimproved sanitation as well as hygiene is appraised at the universal level considering different disease results such as, diarrheal malaria, cholera, dysentery, hookworm, ascariasis, Schistosomiasis, typhoid, polio and other infectious disease(UNICEF,2003). The risk factor is including that intake of unsafe water (during drinking, and bathing), deficient hygiene and agricultural practices, the inadequacy of water connected to poor hygiene, and connection with unsafe water as well as insufficient water resources management. In the food production process, the function of water, and hence nutrition which is related with Malnutrition (stunting) is also important (Prüss, Kay, Fewtrell, & Bartram, 2002). Moreover, Pruss et al (2002) advocate that diseases resulting from unsafe water and poor sanitation system as well as deficient hygiene practices accounted for 5.7% of all disability and 4.0% of whole deaths at global level, considering diarrheal, ascariasis, schistosomiasis, trachoma, hookworm and trichuriasis disease.

Fecal–oral diseases attribute an important part of above mentioned disease burden. Human excreta able to hold above 50 known pathogens and virus. The most of excreta-associated diseases are acquired over ingestion, less often via inhalation. Excreta-associated disease passes by a variety of ways from one host to the subsequent. Thus, by direct as well as indirect way which included through infected body parts like hands, via pollution of water, nutrition, soil, tools, and insects (Brown, Cairncross & Ensink,2013).

Figure 2: Ways of Fecal-Oral Infections



Source:Pruss et al(2002)

For children below age five, water- and sanitation-associated infectious is one of the primary reasons of childhood deaths. As Children's respiratory, digestive and immune systems are still growing they are more exposed to the health risks arise from unsafe water source & poor sanitation facilities. Daily, above 800 children die from avoidable infectious caused by unsafe water, and unimproved sanitation facilities as well as poor hygiene practices (UNCEF 2015).

Health costs related with diseases burden from unsafe water such as diarrhea, malaria, and worm infections are incurred more within developing world, for instance in sub-Saharan Africa countries it portrays more than one third of the income of poor families (WHO,2017).

2.1 Empirical Literature Review

Subsequently, recognizing the significance of water and sanitation in reducing childhood mortality, several researchers have recently attempted to investigate the linkage between access to improved water supply and improved sanitation facility and health outcomes, particularly it's impacts on children mortality.

Esrey, Potash, Roberts, &Shiff (1991) investigated the potential impacts of improved water source and sanitation facility on diarrhoea, ascariasis, hookworm disease, dracunculiasis, trachoma, and schistosomiasis. They used total 144 studies for analysed these relationship by applying disease-specific median reduction for all studies. They found that improved water supplies and sanitation can lead the median reduction in morbidity for diarrhoea by 26%, trachoma by 27%, and for ascariasis by 29% as well as for schistosomiasis and dracunculiasis by 77% and 78%, respectively which is higher. They also found strong correlation between improved water supply and sanitation and children health, that reduction in child mortality by 55 %.

Gundry, Wright & Conroy (2004), similarly point out that in their research of a systematic study of the health effects (generally diarrhea and cholera) associated to family's access to clean water in a less developed countries found that intervention in water investment did significantly reduce cholera and diarrhea prevalence in an underdeveloped region. Fewtrell et al. (2005) used systematic study and meta-review to investigate the functionality of water, sanitation and hygiene intervention on health outcome by using diarrhea morbidity specifically as health outcome in less developed countries. They found that all the intervention has significant impact on reduction of the risk of diarrhea disease but water quality interventions (single interventions) appear to be better effectual than many measures (including of joined sanitation and water as well as hygiene interventions).

Wolf et al. (2014) systematic study and meta-analysis studies which is within middle and low income setting also consistent with the previous studies. The results of the studies found that there are enormous possible declines in diarrheal illness by developments to both water and sanitation. Moreover, they found that there is difference in the effect of water interventions and sanitation interventions at household level and community level with different interventions method. Likewise, Clasen et al. (2014) assessing the effect of unimproved WSH on the global burden of disease (GBD) with evolving and alternative methods. They conclude that the significant studies of GBD and the necessity for policy intervention on water and sanitation as its still top risk factor.

Gunther and Fink (2010) analyzed the effect of water and sanitation on childhood health (morbidity and mortality) in 70 developing countries by using household level survey data. By applying OLS and Logit regression method, the study concluded that there is strong correlation between child health (morbidity & mortality) and access to technologies of sanitation and water. The result of this research indicate that rely on the technology degree and sub-region selected the investment in water and sanitation reduces the chance of diarrhea infection by 7-17% and decreases the risk of child mortality by around 5-20%. Moreover, the study found that largest effect for sanitation technologies and lowest significant for water supply. Furthermore, Fink, Gunther and Hill (2011) stated that access to clean water and advance sanitation was related with less mortality risk and diarrhea infection as well as a lower risk of stunting. And the effect of sanitation was found greater.

Similarly, Ezehet al. (2014) investigated the risk of children lacking access to improved water supply and sanitation facilities in Nigeria; by means of cross-sectional for the period 2003-2013 and Cox regression analyses were used. The authors' findings confirm that the chance of neonatal, post-neonatal and child mortality is higher for children lacking access of improved water and sanitation than children with access to clean water supply and advance sanitation facilities. The risk of mortality from both unsafe water and sanitation for new born, post neonatal and child fatalities was higher by 6%, 38%& 24% individually. Checkley et al. (2004) in Peru and Cheng et al. (2012) in 193 countries as well as Pickering et al. (2015) in Mali similarly point out there is strong correlation among access to improved water supply & sanitation facilities and child health.

Generally, both theoretical and empirical literature trend indicates that water and sanitation are the important foundation of child health. Moreover, literatures demonstrating that, Water and sanitation are very interrelated variables and both of them significantly effect child health. But the magnitude of the significance is different in some studies; for instance, Gunther and Fink (2010) found that largest effect for sanitation compare to water, while Fewtrell et al. (2005) found water is more significant than sanitation in child health. Given these trends, this study sheds more light using a case of Sub-Saharan Africa region with high child mortality rate and most severe water and sanitation challenges.

3 METHODOLOGY OF THE STUDY

3.1 Methodology

Given the characteristic and nature of the problem under examination in this study, it is vital to empirically test the hypothesis stated in chapter 1. To do that we will use panel data with both panel model which is dynamic and static. Longitudinal data or panel data is the special case of pooled time series and cross-sectional data, where all cross-section units such as households, countries, firms, companies, cities, states etc. is observed overtime. In this study, the cross-section in this paper involves a sample of all Sub-Saharan Africa countries, where variables observations were annually for which annual observations of a number of variables were gathered.

Using longitudinal data have both benefits and limitations. The benefits are that adjusting for individual heterogeneity, gives better informative data, variability, among variables it enables less collinearity, better degrees of freedom and efficiency. Moreover, its ideal in the study of dynamics, enables the study testing complicated behavioral models, can better detect and measure effects, longitudinal unit root tests that have more power and have standard asymptotic distributions and Minimizes the bias in using broad aggregates. Generally, panel data enriches empirical analysis that may be impossible to do using cross sectional or time series data. Regarding limitation, it includes that Design and data collection problems, Short time-series dimension, Attrition and the possibility of cross section dependence (Baltagi, 2005).

Having acknowledged the benefit and limitation of using panel data, this study considers three various econometric approaches to confirm permanence of the conclusions over distinct methods. Ordinary least squares (OLS) with the pooled data will be the first estimation technique. The flaw of the pooled OLS estimator is that it is probable to create highly biased coefficients as a result of disregard country specific effects as well as potential endogeneity of independent variables or predictor variables.

The second method consists of applying either Fixed Effects (FE) or Random Effects (RE) technique of estimation depending on Hausman specification test. The null hypothesis of the Hausman test says no systematic difference between the FE and RE estimations, Failure to reject the null means that both FE and RE are both consistent. Hence, the random effects estimator is more efficient (Hausman, 1978). Both of RE and FE techniques can handle the systematic tendency of individual effects and time effects as well as they adjust for heteroscedasticity. Although FE and RE estimators are seem to be better than to the pooled OLS, they need to meet strict exogeneity assumption.

The major empirical challenge in establishing causal relationship is the possibility that our key variable might correlate with the error term. This might be due to:

- Measurement error: In most developing country, the likelihood of recording data with error is high as there is poor data set. The measurement error in observed data lead to key variable to be associated with disturbance term. If this is the case the OLS result will be biased towards zero, called attenuation bias, in our paper we tried to show the robustness of the result by using FE and GMM where the latter takes in to account the dynamic nature of the data set and creates internal instrument to handle endogeneity problem.
- Reverse Causality: this means that our key variable might be affected by our outcome variable. This might not be a case in our paper. That is, it is less likely to think that child mortality can directly affect water sanitation. Hence, the endogeneity problem that arises due to reverse causality is not a big worry in this paper.

- Omitted variable bias. This arises when there is a variable we did not control that affects both the key variable and outcome. OLS estimator under the presence of Omitted variable bias are biased and inconsistence. If the unobservable variables are time invariant, the FE effect estimation can give us unbiased and consistent result. Hence, in our Paper, considering the heterogeneous nature of the countries under our sample, we use the panel fixed effect estimations. But if the unobservable are time variant, neither FE nor RE can give inconsistent result. Hence, considering the dynamic nature of the data set and possibility of time variant unobservable confounding factors, we used GMM to see the robustness of our result.

Generally, Improved water and sanitation could be endogenous in in infant and under-five mortality regressions if there are omitted variables and reverse causality. For instance, climate/geography, population shocks, economic adjustment and political shocks are probable to be omitted variables in our study. Estimation under these challenges can generate inconsistent and biased estimates. Therefore, to tackle these problems such as possible endogeneity, unobserved heterogeneity as well as country fixed effects issues, this study employs the instrumental variable method based on linear Dynamic Panel estimators or the Generalized Method of Moments (GMM) first presented by Arellano and Bond (1991). The GMM is the key estimation approach for this paper. The GMM (Generalized Method of Moments) estimation method uses internal instrument to manage for endogeneity, in which the lagged independent variables and lagged differenced variables as instruments. The benefit of linear dynamic panel is the assumption of strict exogeneity and stationarity restrictions and its capability to draw robust results when dynamic instruments are used.

3.2 Model Specification

To measure the impact of water and sanitation on childhood mortality two models are specified. The baseline model measures the correlation between water & sanitation and childhood mortality is specified with control variables. The model is written as follows.

$Mortality_{it} = \alpha_i + \beta_1 IwatS + \beta_2 ISanF + \varphi X_{it} + \varepsilon_{it}$………………………………………. (1)

For country i=1, …. N and Year t= 1, …. T, Where $Mortality_{it}$ is the dependent variable defined by infant and under-five mortality rate, $\beta_1 IwatS$ is improved water source, $\beta_2 ISanF$ is improved sanitation facilities. X_{it} is a vector of socioeconomic control variables assumed to affect child mortality. The control variables are including public health spending, of GDP per capita HIV/AIDS prevalence, immunization, and aid. Φ is a vector of coefficient measures of the control variables and α_i the country fixed effects and ε is random error term.

Moreover, to deal with the potential endogeneity of water and sanitation as well as all independent variables, the paper introduce the dynamic panel model (GMM) instrumental variable which applies instruments for the first-differenced equation that is lags of the dependent variable and first differences of the exogenous variable by generating moment conditions. The equation is as follows:

$Mortality_{it} = \alpha i + \delta_1 Mortality_{it-1} + \delta_2 IwatS + \delta_3 \beta_2 ISanF + \varphi X_{it} + \varepsilon_{it}$……………………… (2)

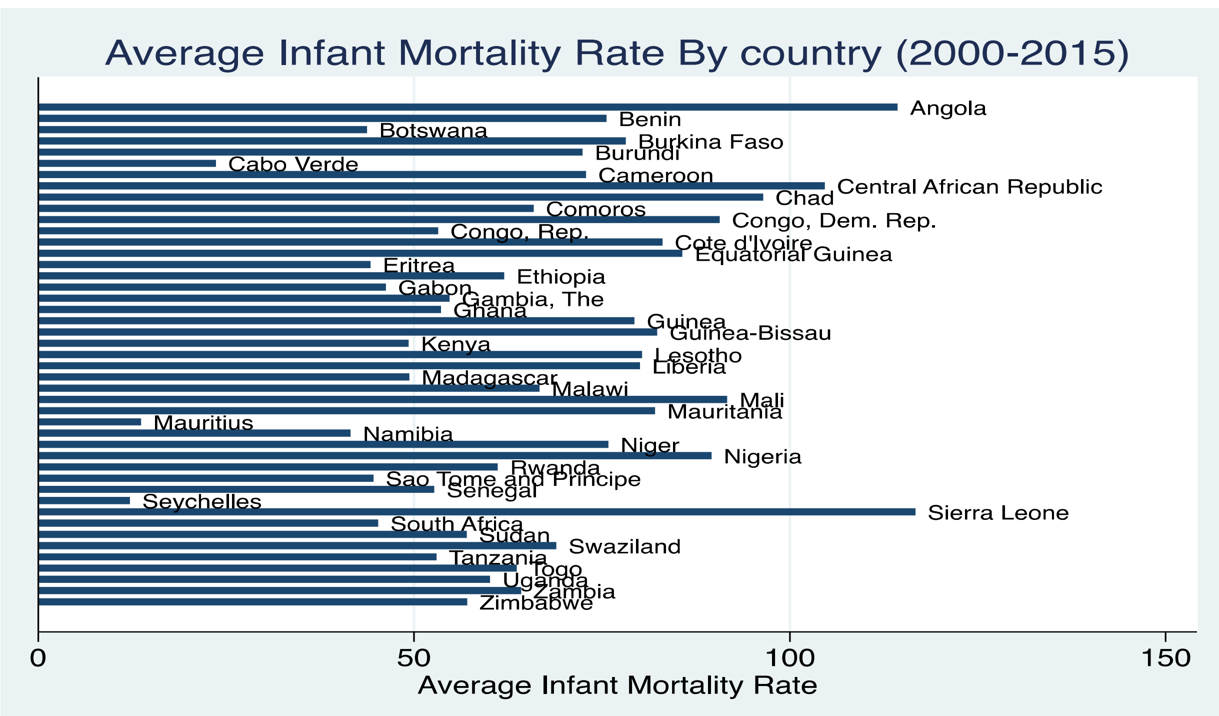
Where $Mortality_{it}$is lagged childhood mortality to account for robustness the dynamics of adjustment for childhood mortality.

3.3 Definition of Variables

As mentioned before, the dependent variable is childhood mortality, which is divided into two equations for infant and under-five mortality. The main independent variables improved water source and improved sanitation facilities as percentage of population with access. The control variables are, Real GDP per capita, public health expenditure, HIV/AIDS prevalence, immunization, and aid from UNICEF.

Infant mortality rate this is the dependent variable defined as the death of infant under one year old per one thousand live births in a given year. According to UNICEF 2017, in SSA it declined from 94 in 2000 to 54 in 2016. The following graph shows the average infant mortality rate for sub-Saharan Africa countries.

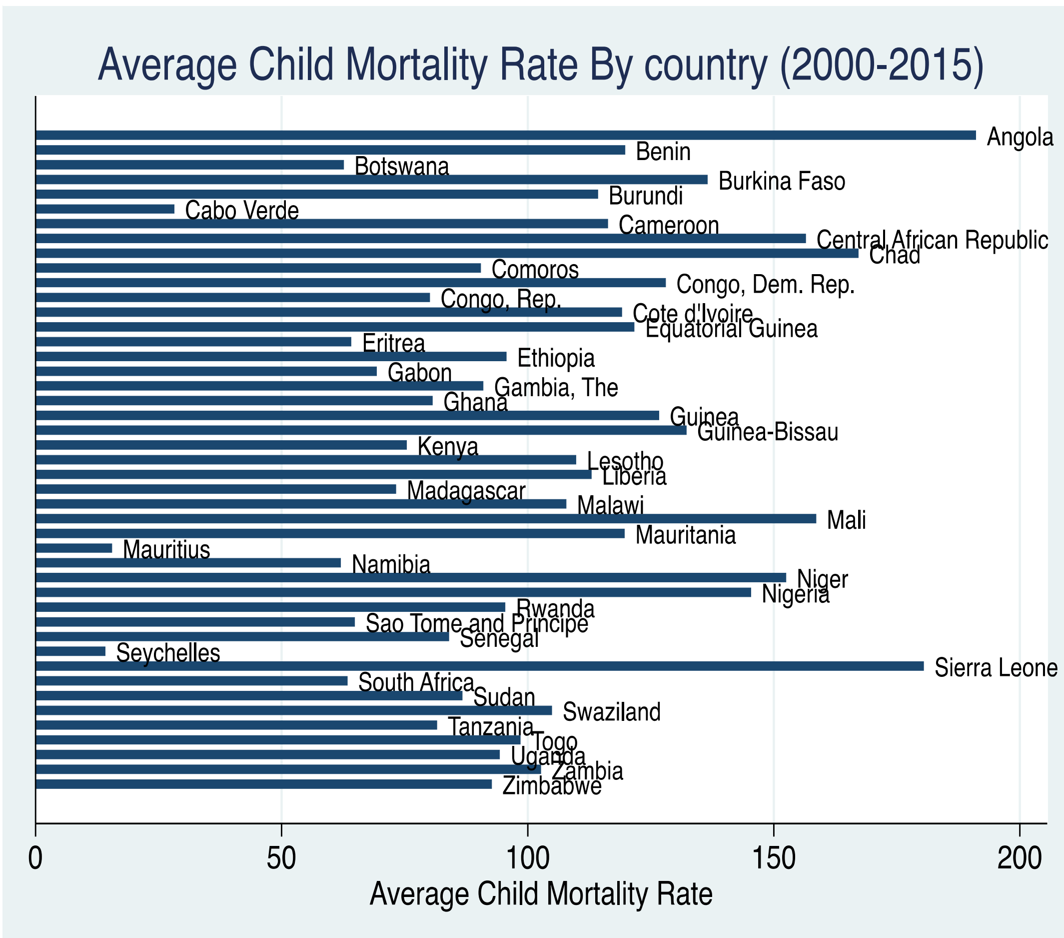
Figure 3: Average Infant Mortality Rate by Country (2000-2015)



Source: Author's computation based on World Bank (2017)

Under-five mortality rate this is also a dependent variable and defined as the probability per 1000 live births that a child born dying before aged 5 in a given year. In the SSA region, this mortality averaged 156 in 2000 and declined to 80 in 2016(UNICEF 2017). The following graph shows the average under-five mortality rate for sub-Saharan Africa countries.

Figure 4: Average Under-Five Mortality Rate by Country (2000-2015)



Source: Author's computation based on World Bank (2017)

Improved water source indicates to the percentage of the total population utilizing an improved drinking water source. The improved source of water contains piped water on dwellings as well as other improved sources such as public taps, boreholes, shielded (wells and springs), and accumulation of rainwater. Access to improved source of water in Sub-Saharan African region improved during the period 1990-2015 as over 40% of the population gained the access during these periods (WHO&UNICEF 2017). But still the region is lags behind other developing regions and didn't meet the millennium development goal target.

Improved sanitation facilities refer to the percentage of the total population utilizing advanced sanitation facilities. Improved facilities of sanitation are probable to make certain hygienic split of feces from contact. It comprises flush and latrine, as well as toilet composting system. Despite some progress on sanitation, majority of the global people use unimproved sanitation facilities still live in sub Saharan Africa region. According to UNICEF & WHO 2017, between 1990 and 2015, sub Saharan Africa has supplied access to less than 20 percent of the population.

GDP per capita demonstrates the income level of a country as well as it is proxy for standard of living of a country. In literature, it is claimed that income level of a country is a significant element of infant and children health outcomes. Economic theory's and empirical studies shows that Country's income level can affect its health care expenditure, education, nutrition and other important factor of child health as well as the overall population.

Public health expenditure includes government budgets that's comprises both recurrent and capital expenditure, outside borrowings and grants as well as insurance of social health. In this study, it is measured by public health spending as a percentage of total GDP.

HIV/AIDS prevalence donates to the percentage of people ages from 15 to 49 that are diseased with HIV. According to WHO, sub-Saharan Africa region remains the most harshly effected region, with accounting for around 2/3 of the people infected with HIV globally. The most vulnerable group are women and children which make it more severe and attribute for child mortality.

Immunization estimates the percentage of children ages from 12 to 23 months who were vaccinated before 12 months. It is believed child is effectively immunized against once acquired one dose of vaccine.

Aid in this study is the net official aid flow from UNICEF (United Nations children's fund). Theoretically, Aid policy is targeting at improving the potential of economic growth and human development of developing countries. Particularly, the ODA from UNICEF is targeting to improving the health and development of child health which in turn expected to affect children's health outcome including child mortality.

Table1: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Infant Mortality Rate	720	65.73986	25.67497	11.7	143.3
Under-Five Mortality Rate	720	101.9453	45.00967	13.5	235.8
Improved Water Source	719	69.18261	16.0179	28.9	99.9
Improved Sanitation Source	719	32.91669	21.82859	6.6	98.4
GDP Per Capita	716	2166.684	3226.154	193.87	20333.94
Health Expenditure	675	2.599985	1.309933	.04	9.09
Prevalence Of HIV	672	6.085417	7.096305	.1	30
Immunization Measles	720	73.61528	17.47259	16	99
Aid	692	7738483	1.02e+07	270000	6.06e+07

3.4 Expected Results

Given the models stated in equations 1 and 2 mentioned before, expected results of the variables' coefficient are as follows:

Table 2: Expected Results

Variable	Expected sign
Improved water source (% of population with access)	Negative
Improved sanitation facilities (% of population with access)	Negative
GDP per capita (current US$)	Negative
Health expenditure, public (% of GDP)	Negative
Prevalence of HIV, total (% of population ages 15-49)	Positive
Immunization, measles (% of children ages 12-23 months)	Negative
Official Aid (UNICEF)	Negative

3.5 The Data and Sources

The study used balanced longitudinal data set from a sample of 45 sub-Saharan African countries from years 2000 to 2015, sourced from the World Development Indicators (World Bank).

4 RESULTS AND DISCUSSION

This chapter will provide a complete account of the findings acquired from employing pooled OLS, FE and GMM estimators from equations 3&4. Table 3 and 4, show general empirical results from regression based on a sample of 45 sub- Saharan Africa countries.

Table 3: Results of Infant Mortality- Sub Saharan Africa

REGRESSION RESULT FOR INFANT MORTALITY RATE			
Dependent Variable Infant Mortality Rate	(1)	(2)	(3)
	Pooled OLS	**FE**	**IVGMM**
Improved Water Source	-0.40*** (0.06)	-1.28*** (0.08)	-0.13*** (0.02)
Improved Sanitation Facilities	0.11** (0.05)	-0.14 (0.11)	-0.08*** (0.02)
Log of RGDP Per Capita	-6.64*** (0.97)	-17.19*** (1.94)	-0.59 (0.52)
Public Health Expenditure	-0.17 (0.67)	-1.36*** (0.31)	-0.59*** (0.06)
Prevalence Of HIV	0.43*** (0.13)	1.12*** (0.30)	0.10 (0.06)
Immunization for Measles	-0.57*** (0.05)	-0.14*** (0.03)	-0.03*** (0.01)
Log of aid	-0.34 (0.79)	-4.96*** (0.67)	-0.76*** (0.10)
Infant mortality$_{t-1}$			0.85*** (0.008)
Constant	191.63*** (16.59)	359.69*** (13.48)	37.52 *** (4.29)
Year dummy	YES		
Observations	627	627	543
R-squared	0.50	0.79	
Number of country		42	42

Note: Standard errors in Parenthesis.

**Significant at 10 percent*
***Significant at 5 percent*
****Significant at 1 percent*

Fixed effects method is preferred for the estimation of the infant mortality equation based on Hausman test (Prob> Chi$_2$= 0.000).

Overall, the findings are consistent with the empirical evidence noted in the literature. As expected access to improved water source is significant at 1% level in all of the 3 regressions that in the pooled OLS, FE and in GMM. The coefficient of this variable is -0.40, -1.28 and -0.13 implying that a 1% increase in access to improved water source will reduce infant mortality by 0.40%, 1.28% and 0.13% in SSA countries. Access to improved sanitation facilities is significant at 5% in the pooled OLS and at 1% in GMM. In the GMM, it has a coefficient of -0.08 indicating that a 1% rise in access to improved sanitation facilities will result in 0.08% decline in infant mortality in SSA countries. The variable has a positive sign in pooled OLS demonstrating the likelihood of results inconsistency of the method due to endogeneity and unobserved country-specific heterogeneity that may influence childhood mortality.

In the case of control variables GDP per capita is significant at 1% level in both pooled OLS and FE. Public health spending is significant at 1% level in both FE and GMM, with the coefficient of -1.36 and -0.59 respectively. HIV prevalence is only significant in in FE and pooled OLS both at 1%. As expected immunization is significant at 1% in all three regressions, in pooled OLS, in FE and GMM. The coefficient of this variable is -0.57, -0.14 and - 0.03. Aid is highly significant at 1% in two regression that, in FE with coefficient -4.96 and in GMM with coefficient -0.76. The lagged dependent variable is statistically significant for infant mortality in GMM estimator, indicating significant past effect on the current infant mortality rate.

Table 4: Result for Under-five mortality rate- Sub Saharan Africa

REGRESSION RESULT FOR UNDER-FIVE MORTALITY RATE			
Dependent Variable Child Mortality Rate	(1)	(2)	(3)
	Pooled OLS	**FE**	**IVGMM**
Improved Water Source	-0.67*** (0.10)	-2.65*** (0.15)	-0.24*** (0.03)
Improved Sanitation Facilities	0.16** (0.09)	-0.14 (0.21)	-0.11*** (0.03)
Log of RGDP Per capita	-10.48*** (1.64)	-26.00*** (3.48)	-1.93*** (0.74)
Public Health Expenditure	1.11 (1.14)	-1.87*** (0.55)	-1.08*** (0.09)
Prevalence Of HIV	0.40* (0.22)	1.47** (0.54)	0.35*** (0.1)
Immunization for Measles	-0.99*** (0.09)	-0.40*** (0.06)	-0.05*** (0.01)
Log of Aid	1.66 (1.34)	-10.18*** (1.20)	-1.00*** (0.15)
Under-five mortalityt-1			0.86*** (0.006)
constant	281.42*** (28.13)	649.163*** (24.23)	64.73*** (6.22)
Year Dummy	YES		
Observations	626	626	543
R-squared	0.55	0.82	
Number of Country		42	42

Note: Standard errors in Parenthesis.

**Significant at 10 percent*
***Significant at 5 percent*
****Significant at 1 percent*

Access to Improved water source is significant at 1% level in all 3 methods, that in pooled OLS, in FE and GMM. The estimated coefficient of this variable is -0.67, -2.65 and -0.24 donating that a 1% increase in access to improved water source will reduce under-five Mortality by 0.67%, 2.65% and 0.24% in sub Saharan Africa countries. Furthermore, access to improved sanitation facilities is significant at 5% level in pooled OLS and 1% level in GMM. In the GMM, it has a coefficient of -0.11 indicating that a 1% increase in access to improved sanitation facilities will reduce below-five mortality by 0.11% in sub-Saharan Africa countries. The positive sign of the variable in pooled OLS denoting the possibility of results inconsistency of the method due to endogeneity and unobserved country-specific heterogeneity that may influence childhood mortality.

In the case of control variables GDP per capita is highly significant at 1% level in all of the three methods. Public spending is significant at 1% level in both FE and GMM with coefficient of -1.87 and -1.08 respectively. Moreover, prevalence of HIV is significant in all three methods, at 10% level in pooled OLS, 5% level in FE and 1% level in GMM. The estimated coefficient of this variable is range from 0.35 to 1.47. Immunization is significant at 1% level in pooled OLS, FE and GMM with the range of estimated coefficient between -0.05 to -0.99. Aid is highly significant in two regressions, at 1% level in both FE and GMM method. The lagged dependent variable is statistically significant for under-five mortality in GMM estimator, indicating an important past effect on the current under-five mortality rate.

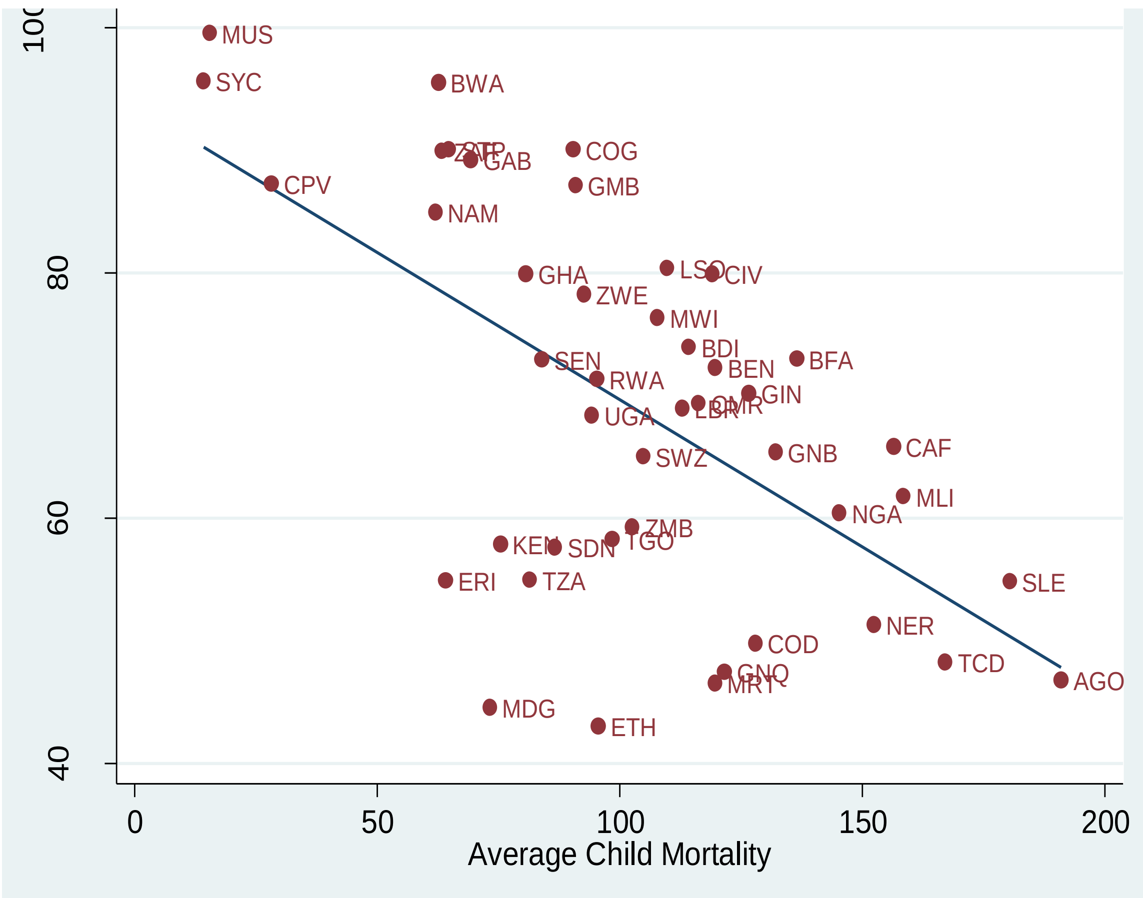
Moreover, in this study we found that the effect of unimproved water and sanitation is more substantial on under five child mortalities compared to that infant mortality. A possible explanation of our findings is that infants are less probable to be vulnerable to germs in contaminated water compared to under five children; Exclusive breastfeeding has crucial protective impacts on infant's survival, strengths immunity, as well as reduces the risk of acute respiratory infection and diarrhea. Thus, optimal breastfeeding has greatest potential impact on decreasing the risk of infant mortality (UNICEF, 2015). For children aged from 1 to 4 years old they are more vulnerable to environmental hazardous including contaminated water as they starting to learn to crawl, walking and play in areas where pollutants may gather. In addition, during this period children also start consume more food, and drink more water.

Findings from this study also demonstrating that although both improved water source and sanitation facility have significant impact on reducing childhood mortality (infant mortality and under-five mortality) in SSA countries, improved water source is more effective compared to improved sanitation facility. This more effectiveness in water is possible partly due to the better investment in water supply in the last two decades in sub-Saharan Africa compare to the sanitation facility. As stated in the report on progress on sanitation and drinking water (UNICEF &WHO, 2015), Sub-Saharan Africa countries has provided improved water source access to more than 40 % the population between 1990 and 2015. On the other hand, SSA region has supplied improved sanitation facility access to less than 20 % of the population with in the same period that is between 1990 and 2015.

Graph Description

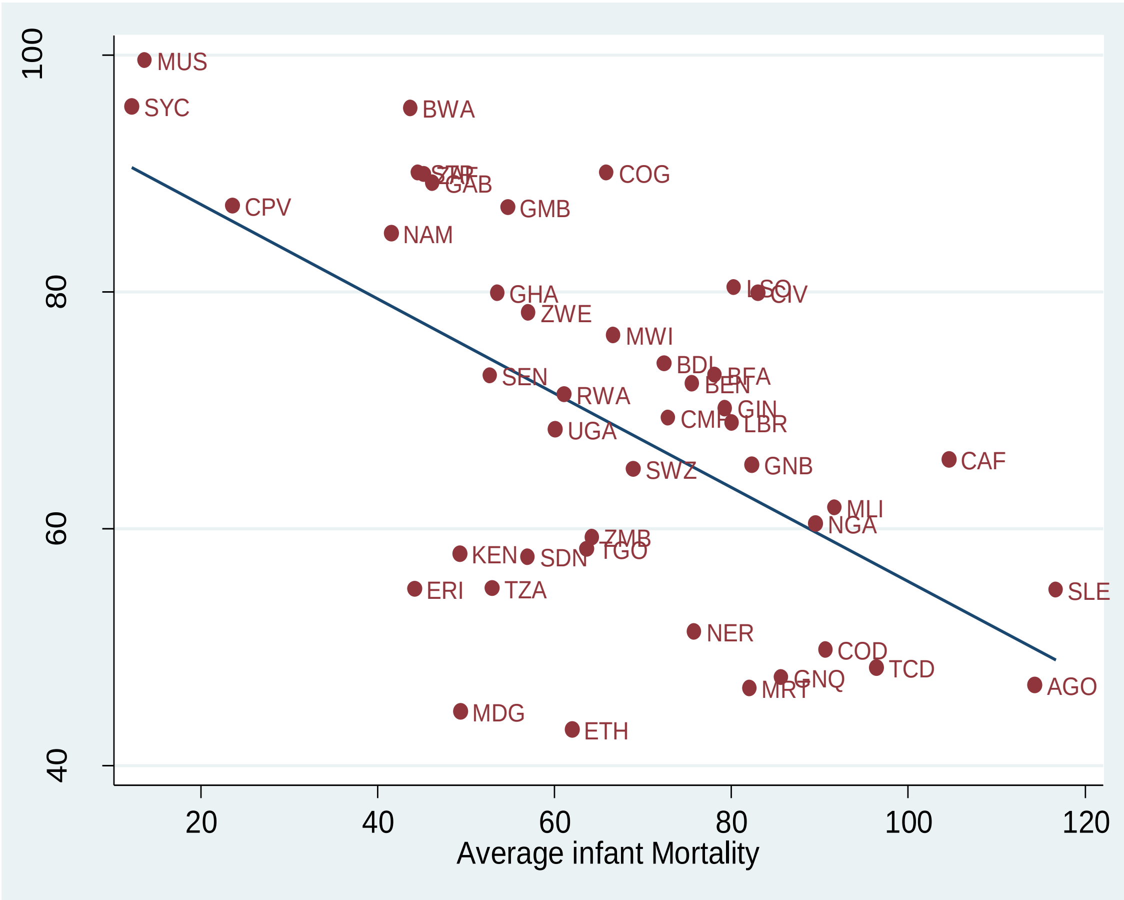
The following graphs also show that on average there is negative correlation between improved water source and childhood mortality that is measured with infant mortality and under-five mortality in Sub-Saharan Africa countries. This indicates that when access to improved water source increases, childhood mortality will decrease.

Figure 5: Correlation (Improved Water Source and under-five /child mortality)



Source: Author's computation based on World Bank (2017)

***Figure 6*: Correlation (Improved water source and infant mortality)**



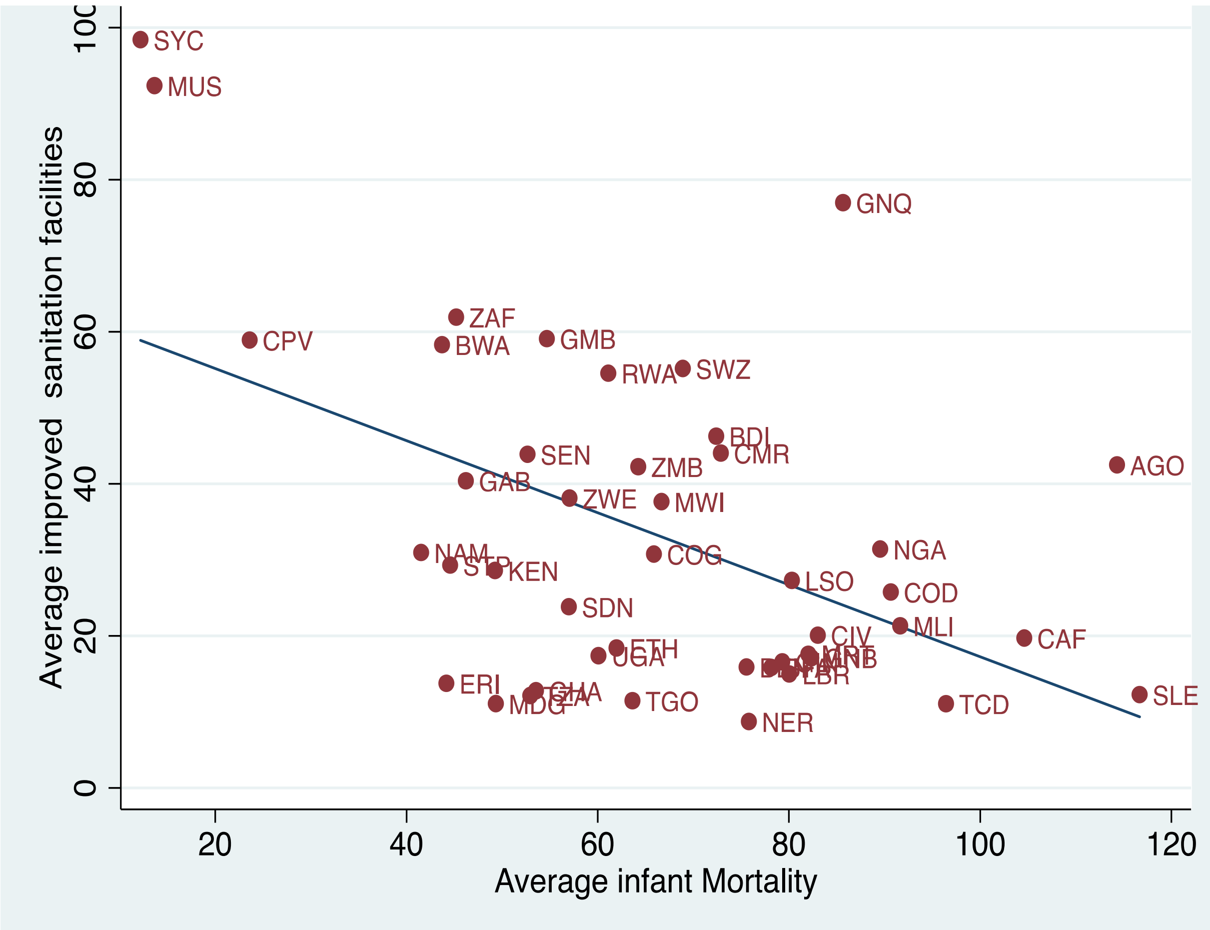
Source: Author's computation based on World Bank (2017)

Moreover, the following graphs also indicate that on average there is negative correlation between improved sanitation facilities and childhood mortality (infant mortality and under-five mortality) in SSA region. On average, increased access to improved sanitation facilities decreases childhood mortality.

Figure 7: Correlation (Improved Sanitation facility and under-five mortality)

Source: Author's computation based on World Bank (2017)

Figure 8: Correlation (Improved sanitation facilities and infant mortality)



Source: Author's computation based on World Bank (2017)

5 CONCLUSION

5.1 Summary of the Study

The study met its overall objective investigating the effect of access to improved water source and sanitation facility on childhood health (infant mortality and under-five mortality) in sub-Saharan Africa Region while controlling for the effect of GDP per capita, Public Health expenditure, the prevalence of HIV, immunization and aid.

In our empirical investigation, we solve the potential of endogeneity, simultaneity bias and unobserved heterogeneity of water and sanitation facility on childhood health (infant mortality and under-five mortality) by applying an instrumental variable method founded on Dynamic Panel estimators or the General Method of Moment (GMM). Our estimation results find that in Sub-Saharan Africa region, access to improved water source and sanitation facility has a strong impact on reducing both infant as well as under-five mortality rates. We also find that public health expenditure and aid is linked with lower infant and under-five mortality rates.

5.2 Policy Recommendations

The findings suggest that improved water and sanitation facility, public health spending and aid have caused significantly to the reduction in infant and under-five mortalities achieved between 2000 and 2015 in sub-Saharan Africa region. The findings have some implications for policymakers.

Improved water source and sanitation are one of the targets for international development agendas (MDG and SDG), as well as potentially assisting to attainment of other target of these agendas such as reducing childhood mortality. However, sub Saharan Africa region didn’t meet both the water and sanitation target of the MDGs, where 319 million people lacking access to safe drinking water source, and 700 million people lack improved sanitation facility (UNICEF&WHO, 2015). This show there are much to do for current SDG-6(Improved water source and sanitation) as well as for the achievement of SDG-3 target 2. Hence, it suggests that sub-Saharan Africa countries have to increase the investment and reallocate the resource in such projects (water and sanitation) an urgent priority as it's the potential instrument in reducing childhood mortality.

Aside from improved water supply and sanitation facility, sub-Sahara Africa countries should pay attention to public health spending and aid since have been found to reduce infant and under-five mortality. Hence, it implied that other policy consists of centering on improving other economic elements. According to WHO, the total health expenditure as a percentage of GDP is less than 5 % for most of SSA countries in 2014 and they did not achieve vital health financing goals like the Abuja Declaration target of earmarking 15% of the state budget to health. Honoring this Abuja declaration and increase their allocation to the health sector to attain the declaration is the right direction regarding improving the public health spending. For example, increased public health spending will enable expand access to as well as utilization of primary health care services, principally for children. Moreover, policies should gear towards improving the ODA, by strengthens the partnerships for health along with coordination and harmonization as well as alignment of resources and activities.

Reference

Arellano, M. and Bond S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations, Review of Economic Studies 58(2): 277-297.

Baltagi, B. H. (2005). Econometric Analysis of Panel Data, 4e. John Wiley & Sons Ltd.

Brown, J., Cairncross, S., &Ensink, J. H. J. (2013). Water, sanitation, hygiene and enteric infections in children. *Archives of Disease in Childhood*, *98*(8), 629–634. http://doi.org/10.1136/archdischild-2011-301528

Checkley, W., Gilman, R. H., Black, R E., Epstein, L. D., Cabrera, L., Sterling,C. R. & Moulton, L. H. (2004). Effect of water and sanitation on childhood health in a poor Peruvian peri-urban community. *Lancet*, 363, 112–18

Chengr, Corinne J Schuster-Wallace, Watt S., Newbold B K. and Mente A.(2012).An ecological quantification of the relationships between water, sanitation and infant, child, and maternal mortality. Environmental Health, 11:4

Clasen T, Prüss-Ustün A, Mathers C, Cumming O, Cairncross S. Colford JM., Jr (2014).Estimating the impact of unsafe water, sanitation and hygiene on the global burden of disease: evolving and alternative methods. Tropical Medicine & International Health.

Esrey SA, Potash JB, Roberts L, Shiff C. (1991). Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. Bull World Health Organ, 69(5):609-21.

Ezeh,O. K., Agho, K. E.,Dibley,M. J., Hall,J.,& Page,A. N. (2014). The impact of water and Sanitation on childhood mortality in Nigeria: Evidence from demographic and health surveys, 2003–2013. International Journal of Environmental Research and Public Health, 11, 9256-9272.

Fayehun, O.A (2010). Household Environmental Health Hazards and Child Survival in Sub Saharan Africa. DHS Working papers, Demographic and Health Research, No. 74.

Fewtrell L, Kaufmann RB, Kay D, Enanoria W, Haller L, Colford JM., Jr (2005).Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta- analysis. Lancet Infect Dis.; 5:42–52.

Fink, G.; Gunther, I. (2011).The Impact and Cost of Water and Sanitation Infrastructure; Development Economics Prospects Group, World Bank: Zurich, Switzerland.

Gundry S, Wright J, Conroy R.(2004). A systematic review of the health outcomes related to household water quality in developing countries. J Water Health,(2),1–13.

Gunther, Isabel; Fink, Gunther. 2010. Water, sanitation and children's health: evidence from 172 DHS surveys. Policy Research working paper; no. WPS 5275; Paper is funded by the Knowledge for Change Program (KCP). Washington, DC: World Bank.

Hausman, J. A. (1978). "Specification tests in econometrics". Econometrica 46 (6): 1251–1271.

Pickering A J., Djebbari H, Lopez C., Coulibaly M, Alzua M L.(2015). Effect of a community- led sanitation intervention on child diarrhoea and child growth in rural Mali: a cluster-randomised controlled trial**.** The Lancet Global Health, Volume 3 , Issue 11 , e701 - e711

Prüss-Üstün A, Kay D, Fewtrell L, Bartram J (2002).Estimating the Burden of Disease from Water, Sanitation, and Hygiene at a Global Level. Environmental Health Perspectives, 110 (5): 537-542

United Nations (2000). Millennium Development Goals. http://www.un.org/millenniumgoals/

United Nations (2015). Sustainable Development Knowledge Platform.

https://sustainabledevelopment.un.org/sdg3

United Nations (2015). UNICEF urges swift action, 'robust financing' to close water and sanitation gaps in Sub-Saharan Africa. http://www.un.org/sustainabledevelopment/blog/2015/12/unicef-urges-swift-action-robust-financing-to-close-water-and-sanitation-gaps-in-sub-saharan-africa

UNICEF (2003). Common water and sanitation-related diseases. https://www.unicef.org/wash/index_wes_related.html

UNICEF, WHO, WB & UN (2015). Levels and Trends in Child Mortality. https://www.unicef.org/publications/files/Child_Mortality_Report_2015_Web_8_Sept_15.pdf

UNICEF (2015). Water, Sanitation and Hygiene. https://www.unicef.org/wash/

World Health Organization. (2017). Global Health Observatory (GHO) Data.

http://www.who.int/gho/child_health/mortality/mortality_under_five_text/en/

World Health Organization (2017). Unsafe drinking-water, sanitation and waste management. http://www.who.int/sustainable-development/cities/health-risks/water-sanitation/en/

WHO & UNICEF (2017). Progress on Drinking Water, Sanitation and Hygiene.

Wolf J, Prüss-Ustün A, Cumming O, et al.(2014) Review of the evidence relating

drinking-water and sanitation to diarrhoea: a meta-regression. Tropical Medicine and International Health,19(8):928-42