



## **Group Project Report**

**Title:**

**Impact of access to basic water services in rural areas on under-five mortality rate in Sub-Saharan Africa**

**Subject: Software For Economist II (STATA)**

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### **Abstract**

The under-five child mortality rate has shown progress over time, decreasing its global value from 93 deaths per 1000 live births in 1990 to 38 deaths in the same scale in 2021, according to the World Health Organization. Still, the Sub-Saharan Africa region shows difficulties in addressing this problematic, as the same indicator takes a value of 73 deaths per 1000 live births in 2021 according to the UNICEF. In this context, the purpose of the present research is to measure the impact of the access to basic water services in rural Sub-Saharan areas on the under-five mortality rates of this region. After controlling for country specific effects and relevant time variant variables in the econometric framework of fixed effects modeling, it was found that a 1 percentage point increase on the population with access to basic water services in rural areas implies a decrease of 0,91 on the under-five mortality rate in the Sub-Saharan region. Finally, some conclusions and limitations of the model are presented.

## **1. Introduction and Literature Review**

The child mortality rate is a relevant indicator of a country's public health, due to the especially vulnerable characteristics of this demographic group and the fundamental role of the government in ensuring the necessary conditions for their well-being and development. According to the World Health Organization, the under 5 mortality rate has decreased, going from 93 deaths per 1000 live births in 1990 to 38 in 2021, showing a drop of 59%<sup>1</sup>, statistic that shows a considerable improvement, but also arises the doubt of which territories are still having trouble to counteract this phenomenon.

The issue of child mortality differs between high- and low-income countries, with the Sub-Saharan Africa territory as the one showing the most critical indicators; as children born in that region are 14 times more likely to die before 5 compared to children in Europe and North America, according to the WHO. The persistence of this problematic and its relevance in this territory motivate a region-specific analysis.

While, as said, the global average took a value of 38 deaths per 1000 births in 2021 according to the WHO, the average rate of sub-Saharan Africa was 73 deaths per 1000 births, according to the UNICEF. Given this reality, it is important to be aware of the main drivers of this difference but also which are the more impactful variables that can be improved to address this phenomenon from a public policy perspective.

In this context, the purpose of the present research is to measure the impact of the access to basic water services on the mortality rate of children under five years in Sub-Saharan Africa. This, given the fact that the access to clean water is a human right that in case of not being satisfied, can represent a cause of the child vulnerability shown in this region via illnesses derived from contaminated sources or the scarcity of this vital substance.

The average of population having access to water services, using data from the World Bank Development Indicators, have shown a significant increase through time, going from 55% of the people with access in the year 2000 to 69,3% of the population having it in 2021 for the 48 countries subject to this study. The aim of the study is to measure the impact that this improvement has had on the child mortality rate, and consequently, expose the potential relevance that this indicator can have in the counteraction of this problematic.

The variables that can affect the child mortality rate on a territory are diverse, going from economic factors such as the income level of a country to household specific characteristics such as the type of residence (rural/urban), for that reason, the approach chosen in this research, using data of the World Bank Development Indicators for 48 sub-Saharan Africa between the years 2000 and 2021, measures the impact of the access to water on under five mortality rate while controlling for other relevant variables and the several country specific characteristics that can also affect the behavior of this indicator.

## Literature Review

Over the past decades, there are numerous research studies that have investigated the complex relationship between the access to clean water and child mortality rates, particularly in Sub-Saharan Africa. This section reviews key findings on determinants of child mortality.

A study by Ezeh et al. (2014) examined the effect of water and sanitation on childhood mortality in Nigeria using panel data (2003-2013) from the DHS. They used child mortality (including neonatal, post-neonatal, and 12-59-month-old children) as the outcome variable in a multivariable analysis, with the water source and sanitation facility serving as important dependent variables. According to their findings, there was a significant rise in the risk of death by 24% for child mortality and 38% for post-neonatal mortality for every improvement in water and sanitation. (Ezeh OK, Agho KE, Dibley MJ, Hall J, Page AN, 2014).

This finding aligns with the broader research by (Prüss-Ustün A, Wolf J, Bartram J, Clasen T, Cumming O, Freeman MC, Gordon B, Hunter PR, Medlicott K, Johnston R, 2019) that observed the correlation between infectious diseases and inadequate water. The research found that in 2016, diarrheal illnesses accounted for 60% of all that due to unsafe water, poor sanitation, and poor hygiene where children under five made up 5.3% of the fatalities. In this research, it was found that one of the biggest risk factors for infectious illnesses is using unsafe water and maintaining inadequate cleanliness, as many pathogens, such as bacteria, viruses, and parasites, may be found in contaminated water and can trigger different health problems like severe diarrhea, dehydration, and malnutrition, which can be fatal for small children.

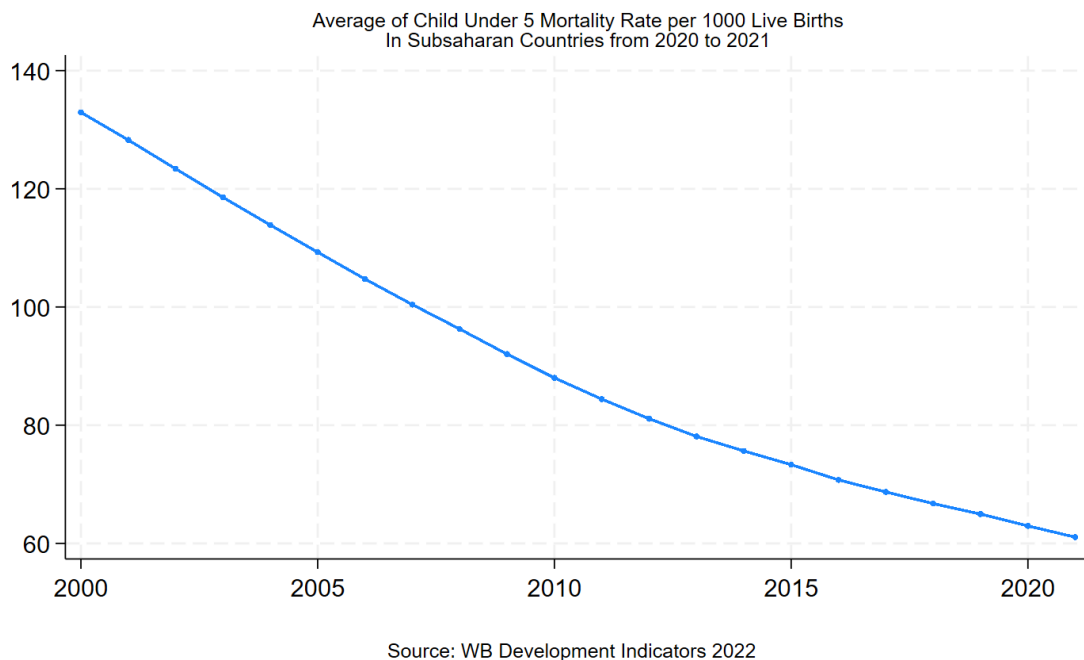
With a more socioeconomic approach, rather than a focus on basic services supply, a study by (Yaya S, Bishwajit G, Okonofua F, Uthman OA, 2018), had found a significant correlation between mother level of education and under-five mortality rates. This suggests that an increase in female education attending would be related to a lower death rate for children under five.

Another example comes from (Yaya S, Bishwajit G, Okonofua F, Uthman OA, 2018), which studied the effect of adolescent pregnancy on child mortality in low- and middle-income countries by using data on health and demography in 46 countries. According to their findings, the children mortality rate of births given by women at this age is higher in comparison to women in a more mature stage, showing the special risk represented by the pregnancies at this early stage of life.

Furthermore, a study by (Kazembe L, Clarke A, Kandala N-B, 2012) aimed to measure and estimate childhood mortality as well as the impact factors and its spatial correlations, by using the census data from three sub-Saharan African countries: Rwanda, Senegal, and Uganda. Their finding has shown that rural and urban areas do not have the same pattern of child mortality.

## 2. Descriptive Statistics

This section describes the data used in the empirical analysis and provides summary statistics of the variables. We have used macroeconomic data from World Development Indicators (WDI) which is the primary World Bank collection of development indicators, compiled from officially recognized international sources. Our database includes the 48 countries of sub-Saharan Africa over a period from 2000 to 2021. The World Bank Development Indicators define the variable of interest as "Basic drinking water services is defined as drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip. Improved water sources include piped water, boreholes or tubewells, protected dug wells, protected springs, and packaged or delivered water" (World Bank)



Graph1: Average mortality rate per Year

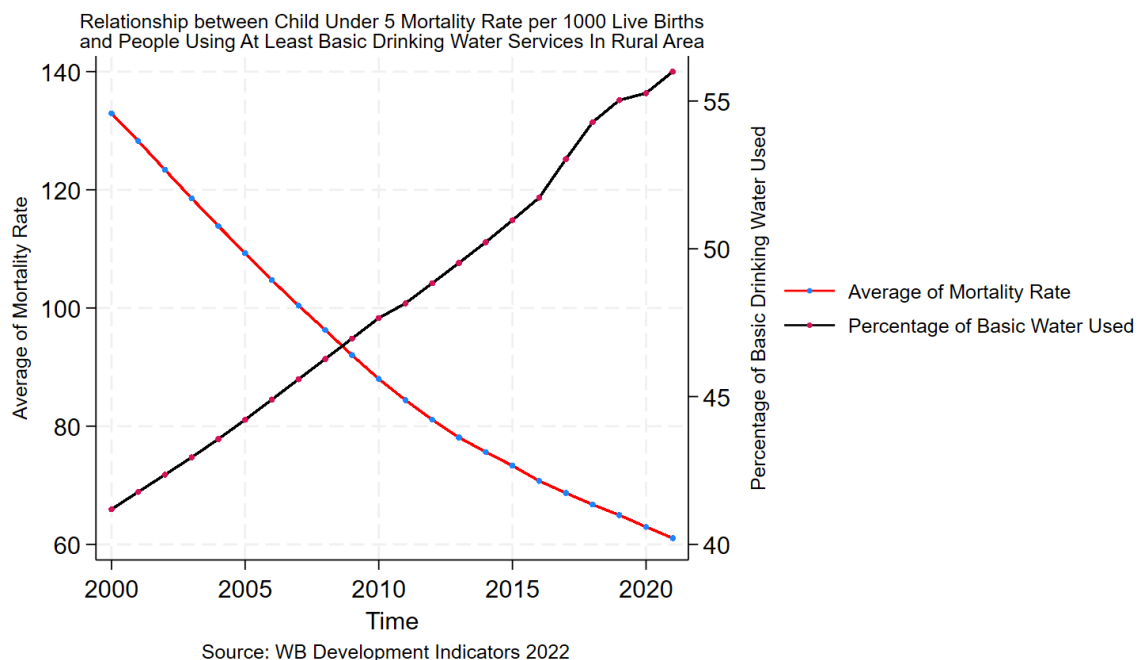
The graph1 shows a significant downward trend in the under-five mortality rate in sub-Saharan Africa over the period 2000 to 2021. This negative trend depicts remarkable progress in reducing deaths among children under five over the past two decades. This steady decline in the infant mortality rate from 137 deaths for 1000 births to 60 reflects sustained efforts in the region to improve access to maternal and child healthcare, strengthen health systems and implement effective public health interventions. At the start of the period under review, in 2000, the region was facing major child health challenges, with alarmingly high infant mortality rates. Over the years, however, tangible progress has been made, reflected in a gradual and steady decline in the infant mortality rate. This progress can be attributed to a combination of factors, including the expansion of access to primary healthcare services, improved quality of care, widespread vaccination, and initiatives to combat malnutrition and infectious diseases such as malaria.

However, even if the overall level of infant mortality in African countries has improved, most countries still have very high rates, as shown in figure2(Annex). An initial observation reveals a significant variation in infant mortality rates between the different countries in the region. Countries with the lowest rates are often those that have made significant progress in maternal and child healthcare, as well as in access to quality health services, such as Cape Verde, Seychelles and Sao Tome and Principe. In contrast, countries with the highest infant mortality rates often face significant socio-economic challenges, such as fragile health systems, limited access to drinking water and sanitation, and high rates of poverty and malnutrition. The case of Niger, which reports a rate of around 120, describes this reality accordingly, as it is ranked 189th out of 191 countries in the 2022 United Nations Human Development Index (HDI).

### Comparative analysis of infant mortality rates and socio-economic indicators

The graphs present a comparative analysis between the infant mortality rate and several key socio-economic indicators, namely access to basic water services in rural areas, government spending on health, percentage of people with access to sanitation services and adolescent fertility rate. An initial observation reveals interesting trends suggesting a correlation between these variables and the infant mortality rate in sub-Saharan Africa.

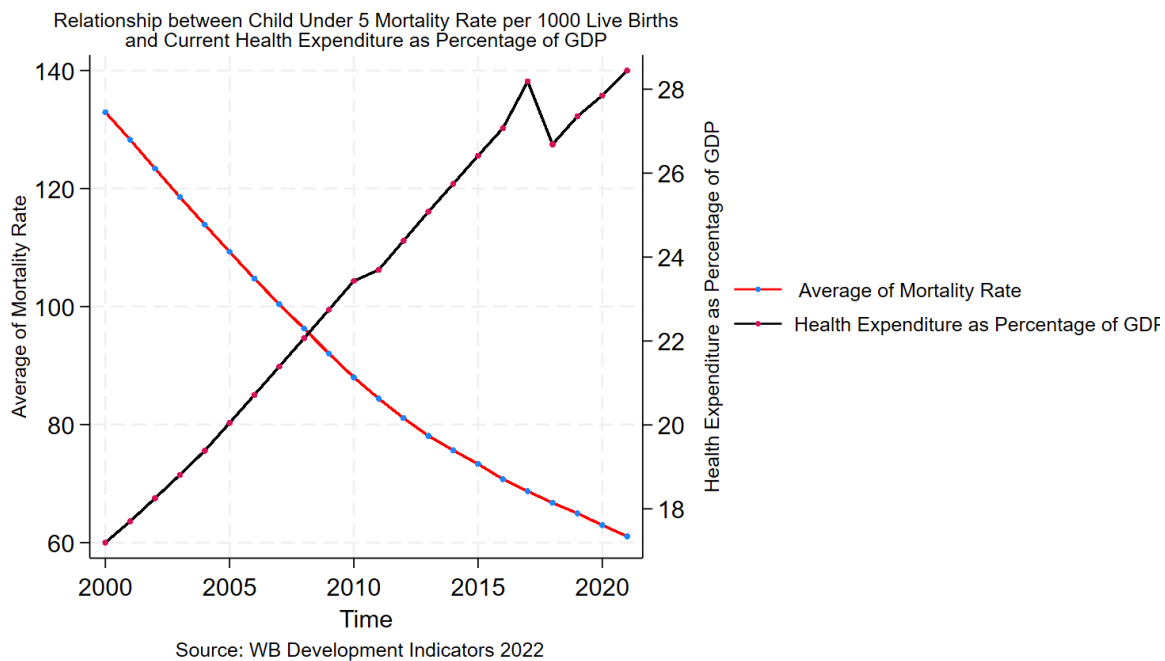
#### ▪ *Access to basic water services in rural area*



Graph3: Child mortality with percentage of people with access to water in rural area

The graph above below highlights the infant mortality rate and the percentage of the population using basic water services in rural areas. The percentage of the population with

access to water services in rural area has risen from 40% to 69% in two decades, showing a negative correlation (-0,55) with the under-five mortality rate. In fact, countries with higher infant mortality rates tend to have lower percentages of the population with access to drinking water in rural area and vice versa. The previous graph gives an idea of the direction in which these variables relate, relation that is going to be analyzed more in depth by the econometric model.



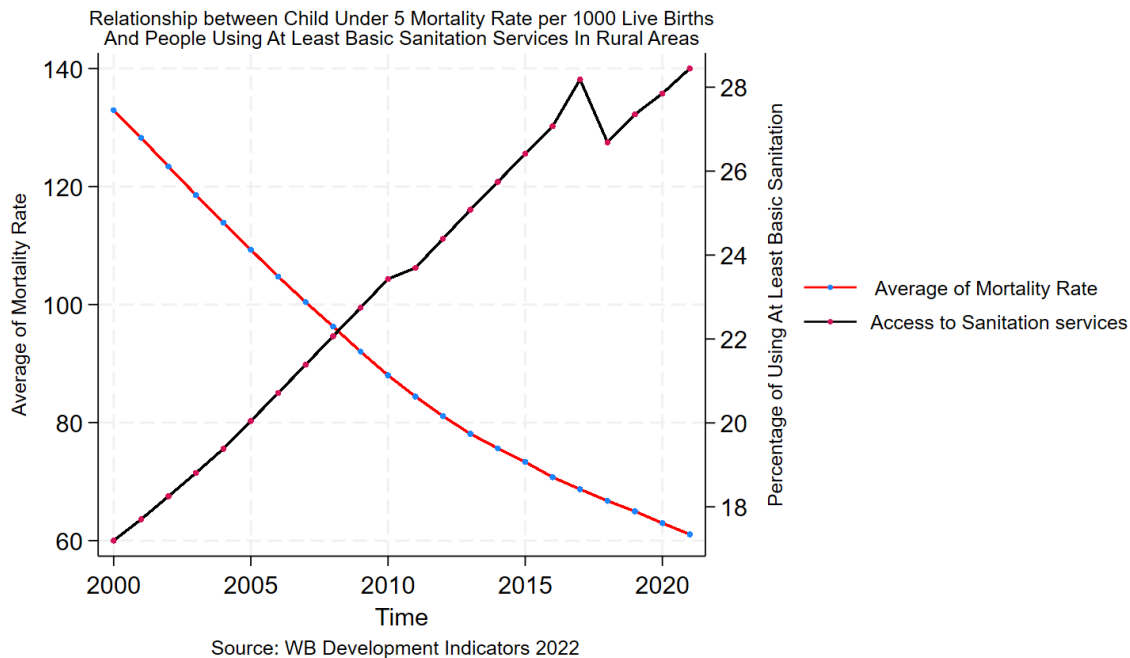
Graph4: Child mortality rate with Current Health Expenditure of %GDP

Analysis of the graph 4 reveals some interesting conclusions about the challenges of improving child health outcomes in sub-Saharan Africa. One notable observation is that, although the percentage of GDP invested in health rises from 4.6% in 2020 to 5.4% while the average infant mortality rate falls from 140 deaths per 1000 live births to 60 in 2021, it is clear that this relationship is not linear. A plausible explanation for this non-linearity lies in the political instabilities that are often observed in the region. Political fluctuations and changes in government priorities can lead to variations in levels of investment in the healthcare sector from one year to the next. Consequently, while some countries may record temporary improvements in their percentage of GDP invested in healthcare, others may experience periods of stagnation or regression due to political and economic instabilities. The expenditure in health can represent a logic way to improve the medical services offered to the population, this in order to protect the most vulnerable demographic groups.

#### ▪ *Use of sanitation services in rural areas*

The graph below shows the infant mortality rate and the percentage of the population using basic sanitation services in rural areas, it can be seen a negative relation between the two variables (Corr -0,48). Even though it is noticeable a significant increase in relative terms

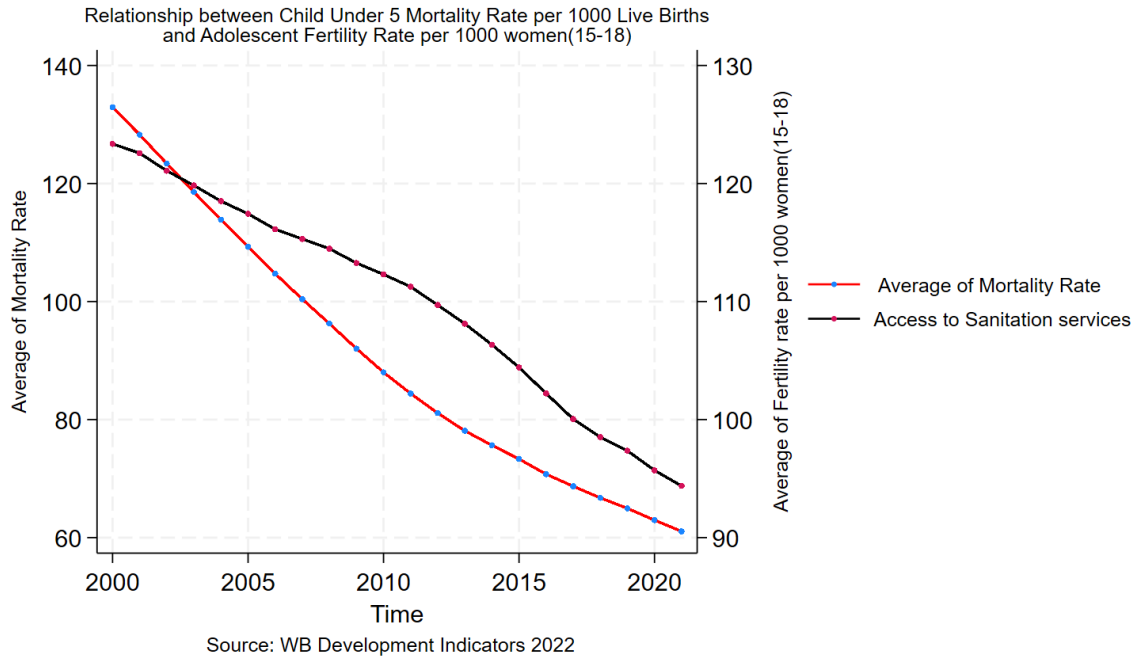
in the use of sanitation services, going from 17% in 2021 to 30% in 2021, this percentage still falls short in the absolute quantity of people with access to this basic service, with a remaining 70% of people without this need satisfied.



Graph5: Child mortality rate and use of sanitary services

#### ▪ *Teenage fertility rate*

Analysis of the graph representing the average number of births given per 1000 women aged 15 to 19 reveals crucial information about the reproductive health of young women. Firstly, it is essential to note that this number decreased from 120 births per 1000 women aged 15 to 19 in 2020 to 90 in 2021, while the infant mortality rate also falls over the same period. Variations in the average number of births among adolescent girls may reflect differences in access to sexual and reproductive health services, as well as in education and awareness of family planning issues.



Graph6: Child mortality rate and Adolescent fertility rate

### 3. Methodology

The chosen econometric approach for estimating the effect of water access on under five mortality rate in this panel data, is a fixed effects model, that includes the variable of interest (Under-Five Child Mortality) as the dependent variable on the left hand side of the equation. On the right side as independent variables: the percentage of population with access to basic water services (rural areas), controls ( $X_{it}$ ) such as logarithm of the GDP per capita for all countries in the dataset (IGDP), the health expenditure as percentage of the GDP, percentage of people using basic sanitation services (rural areas) and the adolescent fertility rate per 1000 women between 14 and 19 years old. The choice of these control variables is motivated by its impact on child mortality according to the literature. Finally, the equation includes the country specific fixed effects ( $\alpha_i$ ) that consider the unobservable time invariant differences between the units of the study and the error term.

$$Child\ Mortality\ Rate = \beta_0 + \beta_1 BasicWater_{it} + \theta X_{it} + \alpha_i + e_{it}$$

A potential bias can occur because of the presence of an omitted variable. Given the complex nature of the mortality rate, that can be affected by several economic, social and even political factors, to address this phenomenon, the country fixed effects were included, catching all of the specific characteristics for each country that don't vary over the period of time chosen



and can also affect the outcome variable. These fixed effects inclusion counteracts endogeneity issues.

On the other hand, a strong correlation between the GDP per capita and the access to water can arise some problems of multicollinearity, cause normally it is expected that in a richer country there will be more facilities to give access to water to the population. In fact, the correlation between the percentage of population with basic water services and the LGDP is strong, reaching a value of 0,68. To address this phenomenon, and in harmony with the findings in the literature that type of residence, rural or urban, has an impact on under 5 mortality, the present approach uses the access to basic water services specifically in rural areas, where it can be more difficult to provide the service. The correlation between the percentage of people using basic water services in rural areas and LGDP takes a value of 0,44, which represents a moderate relationship between these variables and giving a notion of the more challenging context experienced in these zones of the Sub-Saharan countries, that not necessarily see an improvement in the fulfilment of this necessity because of the macroeconomic performance of the country.

#### **4. Results**

The present fixed effects model aims to quantify the impact of the access to basic water services in rural areas on the under-five mortality rate, controlling by the specific time-invariant characteristics that can impact this indicator and other time varying variables such as LGDP, access to sanitation, adolescent fertility rate and health expenditure that can also have an impact on the phenomenon of interest.

VARIABLES	(1) Child_mort	(2) Child_mort
basic_water_rural	-1.267*** (0.183)	-0.919** (0.410)
lgdp_const		-35.66** (13.80)
Health_Expenditure		-3.022** (1.243)
FertilityRate_Adolescent		0.897*** (0.190)
Sanitation_Access		-0.513 (0.450)
Constant	153.2*** (10.87)	368.5*** (76.98)
Observations	1,012	918
Country Fixed Effects	No	Yes
R-squared	0.311	0.897

The results show that, increasing the percentage of people with access to basic water services in rural areas by 1 percentage point causes a decrease in the child mortality rate in 0,91 per 1000 live births, with a level of significance of 5%. This negative relation between both variables is coherent with the idea that children with less access to water services are more vulnerable.

On the other hand, lgdp, health expenditure and percentage of population with sanitation services, as expected, have a negative relation with the under-five mortality rate, while the adolescent fertility rate per 1000 women aged between 14-19 shows a positive relation with the interest variable. Based on the coefficients, a 1 percentage point increase in the gdp per capita would imply a reduction of under-five mortality rate of 0,35 per 1000 live births, while an increase in health expenditure as percentage of gdp in 1 percentage point would be related with a 3,02 decrease in this rate yearly, both variables statistically significant at a 5% level of significance. As for the adolescent fertility rate, the positive relation is significant at the 1% level of significance.

The R squared value of the model is at 89,71%, meaning that the variation of the independent variables explains that percentage of the variation of the under-five mortality rate. The number of observations for the regression is 918. Finally, the errors are clustered by country.

## **5. Conclusion & Discussion**

The objective of the present research was to measure the impact of the access to basic water services on the under-five mortality rate in Sub-Saharan Africa countries. After constructing a fixed effects model that controlled time for time invariant characteristics of each country and including time variant relevant variables according to the literature, as well as GDP, health expenditure, access to sanitation and adolescent fertility rate, it was found with a 95% of confidence that an increase in 1% of rural population having access to basic water services implies a reduction of 0,91 in the under-five mortality rate per 1000 live births.

The finding represents an argument for the public institutions in these countries to accelerate the already improving supply of basic water services in rural areas, that has seen an increase from 55% of the population in these territories with this necessity fulfilled in 2000 to 69% in 2021, showing a remaining 31 percentage points possible improvement that could represent an important action to counteract the relatively high under-five mortality rate seen in Sub-Saharan Africa.

With respect to the limitations of the model, it is important to state that the units of observation of the information define importantly the reach of the investigation. As seen in extensive literature, other ways to address the under-five mortality problem use household level data, in which tools like surveys it can give much more detailed information about the characteristics of the household of victims of this problematic, for example the level of education of the mother, the time the members of the family have to spend to get water from an improved source or the challenges they face in transportation to different health facilities.

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## Appendix

Graph2:

