Econometrics 1 Project

Sharif University of Technology

Department of Management and Economics

Government expenditure and income level impact on reducing child mortality

Author:
Fatemeh Abbasian-Abyaneh

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Abstract

In this project, I aim to identify the impact of income and public expenditure on health in reducing mortality of children under 5 years of old. In particular, this relationship is examined for the developing world using a sample of 36 countries over a time horizon of 10 years from 2010 to 2019 right before Covid-19 pandemic which was one of the most prominent public health challenges. First, I conducted an pooled OLS model then adopted instrumental variable approach is used to address endogeneity problem in income and government expenditure and establish a closer causal impact(not merely associative)of income and public health expenditure towards health care services as well as enhanced focus on ways to boost income per capita in general, in an effort towards enhancing child health outcomes.

Contents

1 Introduction

1.1 Objectives

As defined by the United Nations, child mortality (also known as Under five mortality) is "the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates" (United Nations, n.d.). As Mosley and Chen (1984) suggest, death being a measurable and easily aggregated variable, child mortality is an expedient measure of child health. Child mortality constitutes the fourth of the Millennium Development Goals of the United Nations and as 2015, the target year for achieving these goals draws near, it would be useful to analyse the most important factors influencing child mortality so that the last ditch efforts could be channelled in the correct direction. Given that evidence suggests that the highest incidence of child mortality is in the low and middle income nations, it would not be unreasonable to assume that child mortality declines as incomes rise. Moreover, governments around the developing world are spending enormous sums of money to improve child health outcomes through vaccination and awareness programmes, providing subsidised or free treatment for specific diseases etc. Consequently, increased public expenditure on health may be assumed to be correlated with reduced child mortality. However, there is no consensus in the literature as to the precise determinants of child mortality and different studies suggest varying degrees of impact of these factors.

1.2 Contributions

Nowadays, development economics and related fields have a huge focus on government expenditure, and how to distribute resources to to targeted groups. It's not surprising in interested countries where development economist are working on are low income countries and limited resources. Child mortality and the role of governmental resources are still significant issues in such countries and attract particular attention from economist. For example in their 2019 studies, Carine Van Malderen, et al. argues in sub-Saharan Africa, socioeconomic factors such as place of residence, mother's educational level, or household wealth, are strongly associated with risk factors of under-five mortality (U5M) such as health behaviour or exposure to diseases and injuries. In another studies by Bernadette O'Hare, they quantify the relationship between national income and infant and under-five mortality in developing countries. The role of government expenditure is more complicated and it's discovered widely by Filmer 1999.

2 Data and Methodology

Primarily, the data used in this study has been obtained from the World Development Indicators and World Governance Indicators databases of the World Bank.Using the World Bank classification of countries, the Sub-Saharan African region comprises of 48 countries. However, for my purpose of reducing fixed effect of countries, I chose to narrow my study to a subset of 36 countries, in which I dropped high income countries like Gabon and South Africa. Moreover, since for some countries, data was not available on all of the variables included in the model, not all countries comprising these regions could be considered and as a result, 10 more countries were put aside from the study. The map of selected countries is shown in figure 1. The benefit of such choice of countries is similarity in public health challenges like prevalence of HIV, Malaria, etc. This countries are somewhat homogeneous in institutions and demographic background. This benefits our study in pooled OLS and cross sectional analysis, I elaborate later. Independent variables are gathered in table 1. I collected data on each variable from 2010 to 2019, right before Covid-19 pandemic, that affected each country differently, and including the years ahead would involve heterogeneity, we are not interested in. Comparing to the original studies, I have not conducted fixed effect estimation, therefore, I included more control variables that seem to be the source of heterogeneity in child mortality across these countries. For example, mother literacy that I used compulsory education to proxy for it, since female school enrolment is not available for all the selected countries. incidence of HIV and Malaria are also included. In appendix A, I attached Malaria and HIV prevalence map and their shares of death of children under five years old, based on which I keep Malaria since it has a substantial share in child mortality, and it varies cross countries. HIV seems to have a small share of child mortality in comparison to Malaria. And fortunately, countries with somehow highest child infection like South Africa and lowest incidents like Gabon and Namibia has been put aside form the study. I do not emphasize on including it in my analysis, since it could increase standard errors and reduce precision.
In the first part of my project, I would assume data as an OLS model, and neglect its panel data nature[the fixed effect version of it could be added later]. This could be a source of inconsistency of our estimates: According to Wooldridge, chapter 14, pooled OLS estimates are consistent and inefficient(due to serial correlation), when we have no correlation between time variable factors and individual effect(countries). With all this in mind, it would be naive to consider we have no such kind of correlation, but I assume, I have controlled it enough for the purpose of this project through my data and variables selection. In the next steps, I offer two non-nested structural model and use David Mckinnon test to choose the proper specification, which is log form for of all variables. Then, I test variables for stationary and correct non-stationary ones with first order differentiation(to diminish trend effect), and repeat OLS regression estimation with the corrected form of variables. I check perfect collinearity for time series variable using Variance Inflation Factor; I also conduct Breush-Godfrey for serial correlation. In the following, it is important to test whether we have omitted variables, which I do using RESET, which is useful to detect omitted variables as a result of model misspecification(it's not informative if we have omitted variables with linear expectations).Then, I test for hetroskedasticity with Breusch Pagan test, and re-estimate robust OLS coefficients. In the next stage, I run an OLS regression model with absorbed trend to control for year effect to have more accurate perception of expandability of the model and from now on I work with absorbed year model. then, I test for joint significance of the coefficients. For the sake of readability, I gathered test results in Table 9 of Diagnostic Tests Results Section(OLS). In the end part, I proceed to check whether our model suffer from endogenous explanatory variables or not. GDP per capita and public health expenditure are prone to be endogenous, due to reverse causality and confounding variables, since countries with serious problem of child mortality are inclined to increase their public health spending. Besides, in countries, where have serious problem of child mortality and low income level, there could be a problem of confound variables like quality of institutions and internal conflicts, and other development related issues, we have not controlled in our model. As a result of such concern, I introduce gross capital formation and external balance of goods and services as instrumental variables for GDP per capita and public health spending, and conduct 2SLS regression and uss Durbin Wu Hausman to check whether OLS and 2SLS are close enough. The result of test for Durbin Wu Hausman and over-identification test are gathered in table 11 of Diagnostic test results(IV).

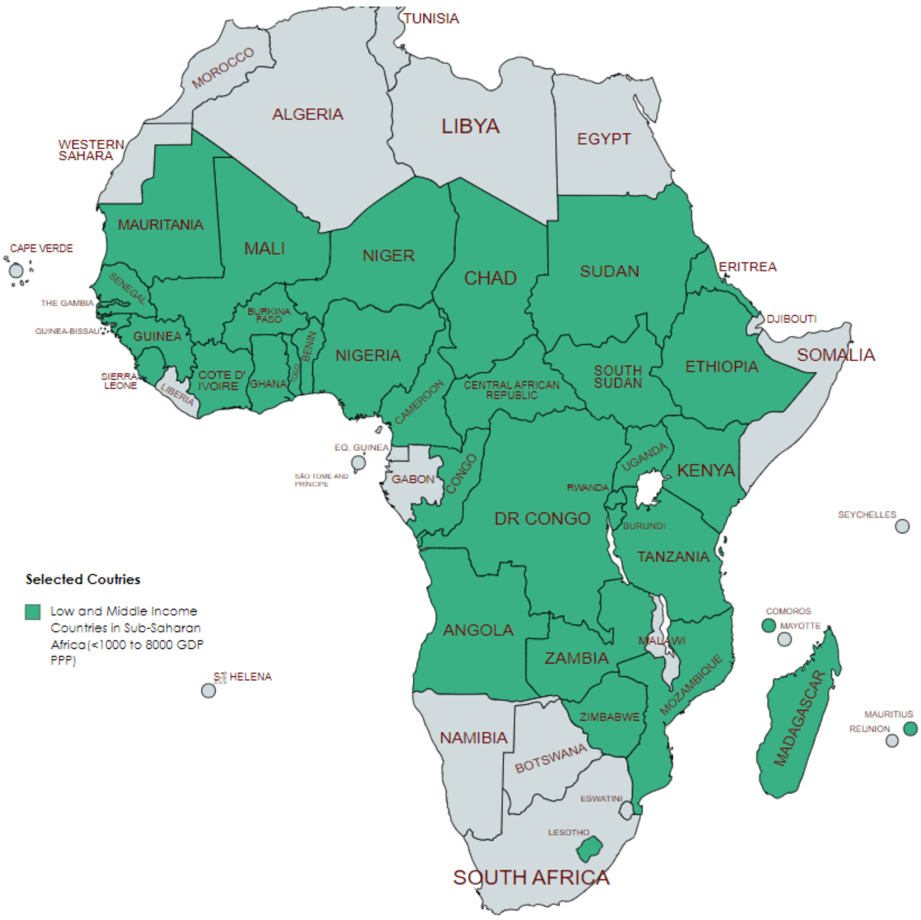


Figure 1: Selected Sub-Saharan countries

Table 1: Independent Variables Definition

Variable Label	Variable Name	Sign Expected
GDP per capita(in constant 2015 US$)	GDP	Negative
Public Expenditure on Health(current % of GDP)	PHE	Negative
Fertility Rate(births per woman)	FERT	Positive
Compulsory Education(duration, years)	CEDU	Negative
Access to basic drinking water(% of population)	ABD	Negative
Access to basic sanitation services(% of population)	ABS	Negative
Severe or moderate food insecurity(% of population suffering)	FINS	Positive
Prevalence of HIV cases(per 100,000 population)	HIV	Positive
Prevalence of Malaria cases(per 100,000 population)	IMal	Positive

3 Data Visualization and Summary Statistics

3.1 Data Visualization

In the table 1, I assumed expected sign of each independent variable based on mechanisms supported by empirical research and intuition. In this section, I show scatter plot of each explanatory variable and child mortality, and also scatter matrix of explanatory variables in figure 2 and figure 3. Figure 2 corroborate expected sign in table 1. To more elaborate on mechanisms behind the expected signs; GDP: we expect Higher income countries would allow access to better standard of living (including access to food, health facilities); PHE: Higher Public Health Expenditure on health care facilities would improve the quality and quantity of these services available; ABS: Improved Sanitation would reduce the prevalence of diseases and improve child health outcomes; ABD: Access to improved water source would reduce child mortality from diarrheal illnesses; CEDU: more educated parents, specially mothers, increase parenting quality and proper care for children; FERT: More children per woman would lower the resources available for each child (including care); FINS: Food deprivation would increase the probability of mortality through malnutrition causing lower immunity to diseases among children; IMAL: malaria in children under 5 years, specially ones with malnutrition is severely fatal; in fact, in Africa, it's in three top causes of death in children. Please check Appendix B for more graphs of of variables over time and their scatter plots. From this graphs it can be inferred that there are mild negative trend in child mortality and positive time trend in access to basic drinking water, which can be source of non-stationary issue. We test for them in the following.

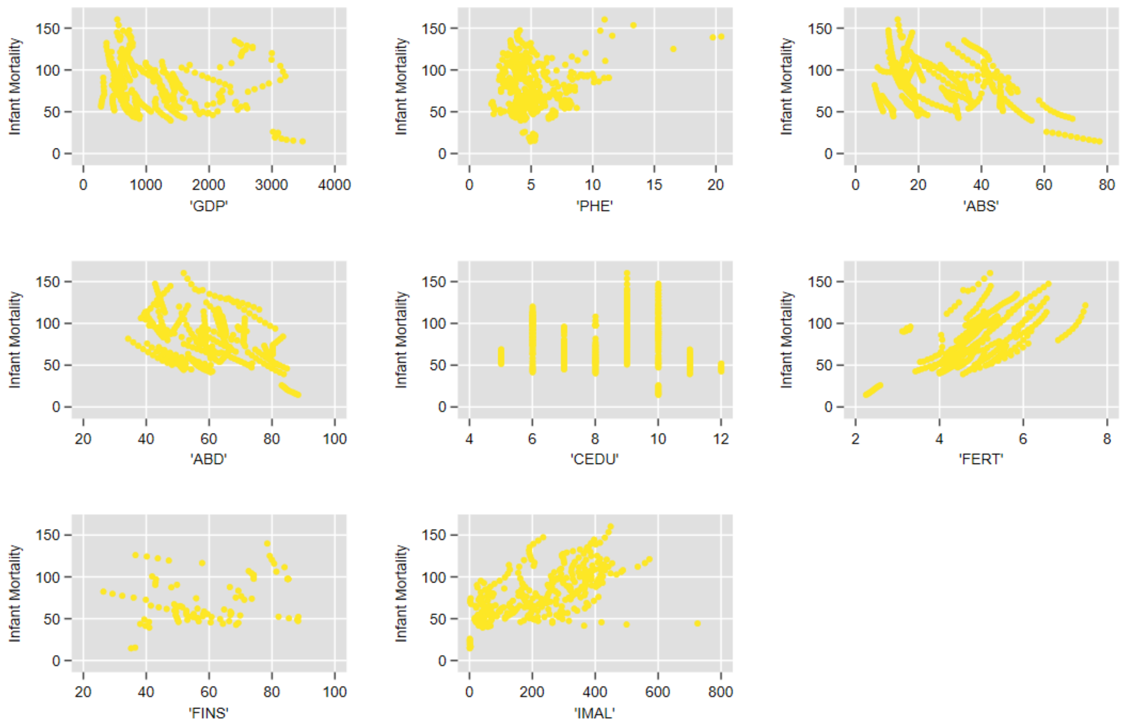


Figure 2:

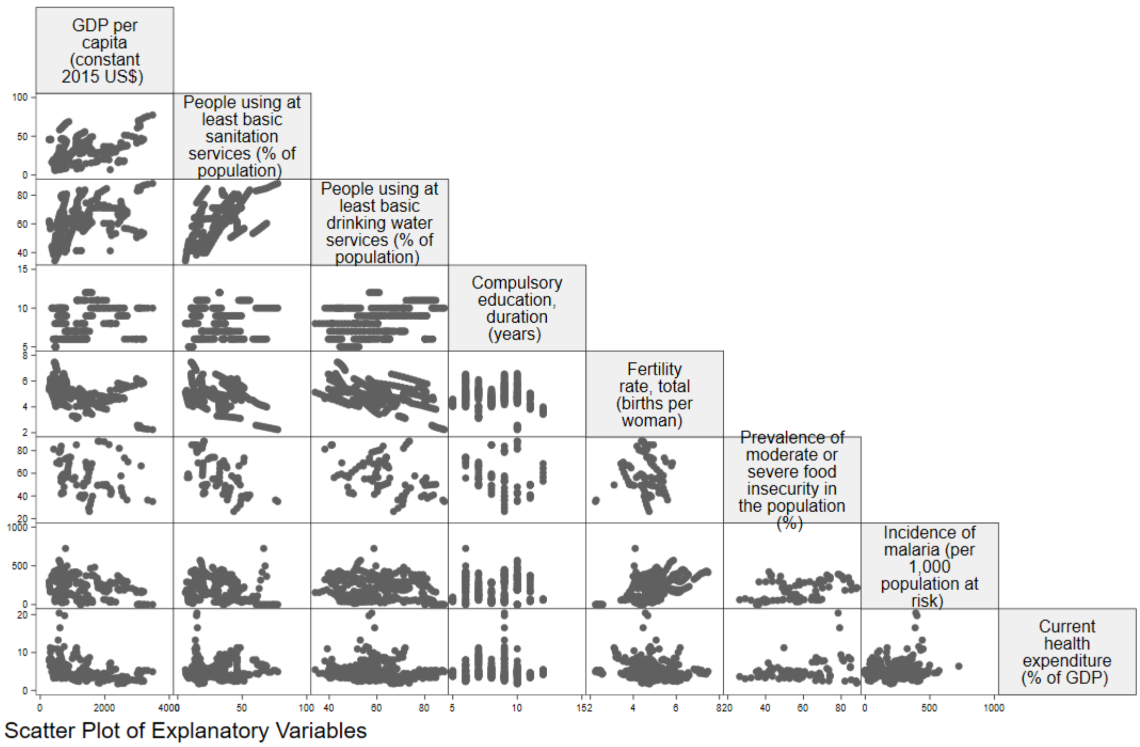


Figure 3:

3.2 Summary Statistics : Table*

	Sum	Mean	SD	Min	Max	N
Child Mortality	29,323	81.45	27.98	15	161	360
GDP per capita	418,575	1,162.71	729.34	278	3,482	360
Public health spending	1,924	5.35	2.82	2	22	360
Access to basic sanitation	10,298	28.61	15.70	6	77	360
Access to basic drinking water	21,607	60.02	12.53	34	88	360
Compulsory education	2,908	8.08	1.76	5	12	360
Fertility rate	1,760	4.89	0.90	2	7	360
Food insecuity	17,239	47.89	19.82	9	88	360
Incidence of Malaria	77,452	215.14	145.42	0	725	360

3.3 Correlation Matrix : Table**

					(1)				
	Child Mortality	GDP per capita	Public health spending	Access to basic sanitation	Access to basic drinking water	Compulsory education	Fertility rate	Food insecuity	Incidence of Malaria
Child Mortality	1								
GDP per capita	-0.249***	1							
Public health spending	0.181***	-0.215***	1						
Access to basic sanitation	-0.383***	0.453***	-0.0655	1					
Access to basic drinking water	-0.337***	0.465***	-0.184***	0.602***	1				
Compulsory education	-0.0161	0.220***	-0.0564	-0.0271	0.278***	1			
Fertility rate	0.573***	-0.338***	-0.152**	-0.322***	-0.444***	-0.175***	1		
Food insecuity	0.129*	0.0237	0.245***	-0.136**	-0.139**	-0.0822	-0.0863	1	
Incidence of Malaria	0.566***	-0.300***	0.0259	-0.299***	-0.254***	-0.0117	0.551***	0.0590	1

4 Pooled OlS

4.1 Model Selection and David Mckinnon test

I can specify two models as below. I ran regression for two models: Table 2 and Table 3, in both of which income and public health spending are significant at least on 5% level. In the following I used David Mckinnon test to choose between them. According to the test in table 6, the log for of model B would be more proper to choose.

$$modelA : MU5 = \beta_0 + \beta_1 \, GDP + \beta_2 \, PHE + \beta_3 \, ABS + +\beta_4 \, ABD + \beta_5 \, FINS + \beta_6 \, CEDU + \beta_7 \, IMAL$$

$$modelB : \log MU5 = \beta_0 + \beta_1 \log GDP + \beta_2 \log PHE + \beta_3 \log ABS + +\beta_4 \log ABD + \beta_5 \log FERT + \beta_6 \log CEDU + \beta_7 \log IMAL$$

Table 2: OLS (normal form)

	1	2	3	4	5
GDP per capita	-0.010***	-0.008***	-0.001	0.003	0.004*
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Public health spending		1.329*	1.313**	2.727***	2.458***
		(0.516)	(0.492)	(0.432)	(0.413)
Access to basic sanitation			-0.505***	-0.469***	-0.361***
			(0.111)	(0.091)	(0.092)
Access to basic drinking water			-0.283*	0.277*	0.136
			(0.141)	(0.123)	(0.122)
Fertility rate				19.381***	14.460***
				(1.460)	(1.614)
Food insecuity				0.134*	0.104
				(0.059)	(0.056)
Incidence of Malaria					0.055***
					(0.009)
Compulsory education					0.700
					(0.657)
Constant	92.554***	84.164***	107.314***	-41.072**	-27.096*
	(2.695)	(4.216)	(7.847)	(12.974)	(13.448)
Observations	360	360	360	360	360

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: OLS (log fom)

	1	2	3	4	5
GDP per capita (log)	-0.211***	-0.214***	-0.107**	0.075*	0.085**
	(0.033)	(0.035)	(0.040)	(0.032)	(0.032)
Public health spending (log)		-0.010	0.002	0.271***	0.263***
		(0.050)	(0.049)	(0.040)	(0.040)
Access to basic sanitation services (log)			-0.105*	-0.161***	-0.139***
			(0.044)	(0.033)	(0.034)
Access to basic drinking water (log)			-0.312*	0.261*	0.223*
			(0.126)	(0.102)	(0.103)
Fertility rate (log)				1.507***	1.204***
				(0.091)	(0.121)
Food Insecurity (log)				0.037	0.020
				(0.028)	(0.028)
Incidence of Malaria (log)					0.045***
					(0.013)
Compulsory education (log)					-0.028
					(0.070)
Constant	5.786***	5.818***	6.671***	0.334	0.746
	(0.230)	(0.280)	(0.449)	(0.526)	(0.529)
Observations	360	360	360	360	359

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

According to Davidson Mckinnon in table 4, the coefficient of log form predictor is significant. As a result, proper to proceed with the log form.

Table 4: Davidson Mackinnon

	B to A's predictor	A to B's predictor
GDP per capita (log)	0.033	
	(0.034)	
Public health spending (log)	0.110*	
	(0.052)	
Access to basic sanitation services (log)	-0.047	
	(0.040)	
Access to basic drinking water (log)	0.117	
	(0.104)	
Fertility rate (log)	0.541**	
	(0.192)	
Food Insecurity (log)	-0.024	
	(0.029)	
Incidence of Malaria (log)	0.020	
	(0.014)	
Compulsory education (log)	-0.102	
	(0.070)	
Linear prediction	0.009***	
	(0.002)	
GDP per capita		0.004*
		(0.002)
Public health spending		3.081***
		(0.615)
Access to basic sanitation		-0.457***
		(0.118)
Access to basic drinking water		0.192
		(0.130)
Fertility rate		19.309***
		(3.965)
Food insecuity		0.115*
		(0.057)
Incidence of Malaria		0.059***
		(0.009)
Compulsory education		0.656
		(0.658)
Linear prediction		-19.194
		(14.064)
Constant	2.267***	27.089
	(0.622)	(41.676)
Observations	359	359

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Levin–Lin–Chu unit-root test

Varable Name	Unadjusted t	Adjusted t*	P value
Ln_MU5	-1.9621	-1.6033	0.0544
Ln_GDP	-33.2027	-33.9984	0.000
Ln_PHE	-8.3138	-5.5260	0.000
Ln_ABS	-13.5451	-11.8046	0.000
Ln_ABD	4.1278	6.5760	1.000
Ln_FINS	-46.8087	-48.7668	0.000
Ln_FERT	-6.5489	-6.6408	0.000

4.2 OLS model with first-order-differentiation correction

According to Table 5, we can't reject the null hypothesis of unit root for $Log_A BD$ or access to drinking water(with severe non stationary problem). The simplest way to correct for it, could be first order differentiating transformation.

Now it's proper to repeat OLS estimation with stationery corrected variables(access to drinking water):

Table 6: OLS model with first order diffrentiated variables

	1	2	3	4	5
GDP per capita (log)	-0.211***	-0.214***	-0.141***	0.108**	0.115***
	(0.033)	(0.035)	(0.041)	(0.033)	(0.034)
Public health spending (log)		-0.010	0.001	0.262***	0.256***
		(0.050)	(0.053)	(0.042)	(0.041)
Access to basic sanitation services (log)			-0.165***	-0.123***	-0.106***
			(0.039)	(0.028)	(0.029)
Access to basic dringking water(Diff. log)			-3.575*	-5.400***	-5.381***
			(1.403)	(1.026)	(1.009)
Fertility rate (log)				1.501***	1.196***
				(0.089)	(0.118)
Food Insecurity (log)				0.030	0.014
				(0.029)	(0.029)
Incidence of Malaria (log)					0.046***
					(0.013)
Compulsory education (log)					-0.033
					(0.069)
Constant	5.786***	5.818***	5.852***	1.158**	1.443***
	(0.230)	(0.280)	(0.292)	(0.359)	(0.381)
Observations	360	360	324	324	323

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 4:

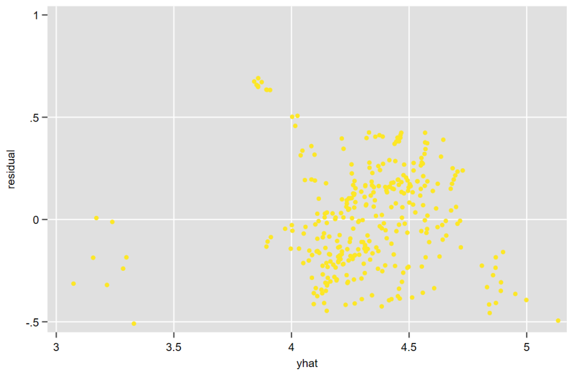
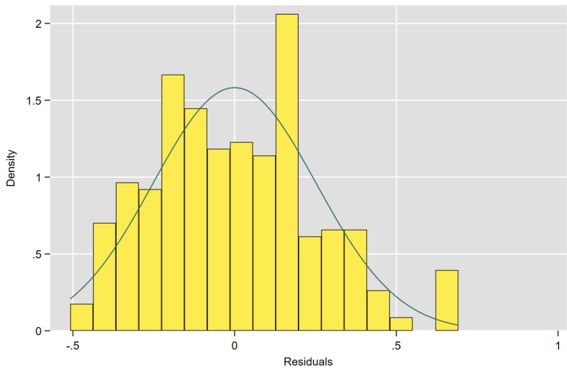


Figure 5:



4.3 Robust Regression Model

In this section, I intend to study the residuals to correct for hetroskedasticity. For this matter, before conducting Breusch Pagan test, from figure 4 and figure 5 that the assumption of normally distributed residuals is troubled, which is corroborated by Breusch Pagan test(see Diagnostic tests table)

4.3.1 Robust estimation

I repeated OLS estimation with robust standard errors.

Table 7: Robust estimations

	1	2	3	4	5
GDP per capita (log)	-0.211***	-0.214***	-0.141**	0.108**	0.115**
	(0.045)	(0.049)	(0.045)	(0.037)	(0.036)
Public health spending (log)		-0.010	0.001	0.262***	0.256***
		(0.052)	(0.048)	(0.051)	(0.050)
Access to basic sanitation services (log)			-0.165***	-0.123***	-0.106***
			(0.038)	(0.029)	(0.030)
Access to basic dringking water(Diff. log)			-3.575**	-5.400***	-5.381***
			(1.099)	(0.948)	(0.927)
Fertility rate (log)				1.501***	1.196***
				(0.109)	(0.122)
Food Insecurity (log)				0.030	0.014
				(0.026)	(0.025)
Incidence of Malaria (log)					0.046***
					(0.013)
Compulsory education (log)					-0.033
					(0.058)
Constant	5.786***	5.818***	5.852***	1.158**	1.443***
	(0.305)	(0.375)	(0.370)	(0.377)	(0.387)
Observations	360	360	324	324	323

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.4 OLS regression model with absorbed year effect

It would be helpful to grasp a better vision of explainability of the model, I proposed so far, by controlling for year effects and de-trending variables, which can be seen in table 8. The detrended OLS model has about 50% explainability, which is noticeable. Joint significance tests are showed in table 9 and are performed on absorbed model.

Table 8: OLS with controlled year effect

	1	2	3	4	5
GDP per capita (log)	-0.203***	-0.207***	-0.145***	0.098**	0.103**
	(0.033)	(0.035)	(0.040)	(0.034)	(0.034)
Public health spending (log)		-0.017	-0.010	0.249***	0.238***
		(0.049)	(0.052)	(0.042)	(0.041)
Access to basic sanitation services (log)			-0.147***	-0.116***	-0.094**
			(0.038)	(0.029)	(0.029)
Access to basic dringking water(Diff. log)			-4.144**	-5.571***	-5.600***
			(1.388)	(1.033)	(1.008)
Fertility rate (log)				1.457***	1.084***
				(0.091)	(0.123)
Food Insecurity (log)				0.037	0.021
				(0.029)	(0.029)
Incidence of Malaria (log)					0.055***
					(0.013)
Compulsory education (log)					-0.033
					(0.069)
Constant	5.728***	5.781***	5.851***	1.267***	1.623***
	(0.225)	(0.274)	(0.288)	(0.364)	(0.384)
Adjusted R-squared	0.142	0.140	0.182	0.550	0.553

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Diagnostic tests table for OLS model

Test Name	Value of Test Statistics	Inference Drawn
Inflation Variance Factor (perfect collinearity)	Ln_FERT (VIF) = 2.56 Ln_IMAL (VIF) = 2.28 Ln_GDP (VIF) = 1.89 Ln_PHE (VIF) = 1.39 Ln_ABS (VIF) = 1.34 Ln_CEDU (VIF) = 1.15 Ln_FINS(VIF) = 1.07 Ln_ABD1D(VIF) = 1.04	Non of variables has severe multicollinearity
Breush-Godfrey (Serial correlation)	F(1, 35) = 249.408	No incidence of serial correlation
RESET (omitted variables)	F(3, 311) = 17.19	No incidence of omitted variables due to functional form
Breusch Pagan	chi2(1) = 24.37	Residuals have heteroskedasticity
T test (β_1)	F(1, 306) = 9.39	income level is significant
T test (β_2)	F(1, 306) = 33.56	Health spending is significant
T test(β_1, β_2)	F(2, 306) = 16.83	Income and health spending spending are significant jointly
F test (joint significance)	F(8, 306) = 47.03	Coefficients are jointly significant

4.5 Diagnostic Tests Results(OLS)

4.6 Instrumental Variables Approach

As I mentioned earlier, endogeneity for GDP and public health spending could be of serious problem in my analysis. So far, in all models I estimated through table 2,3,6 ,7, and 8, the effect of income level and public health spending deemed to be positive, which is contrary to economic intuition, and previous empirical works. Mechanism behind such result could be the fact that countries with acute child mortality are more eligible for international credits and loans, which would result in higher public health spending. The endogeneity of income could be more complicated and is beyond the scope of this project, and is related to institutional effect and county effect. For example, some upper-middle income countries like Nigeria have high child mortality due to internal conflict. The heterogeneous risk exposure of these countries to climate fluctuations could be another explanation. For example, poor countries like Eritrea, have a huge fluctuations in their economic output, because of their high vulnerability to drought.
With all that been said, in this section, I intend to address this issue by instrumental variable. I use gross capital formation, external balance on goods and services, to be instrument for GDP and public health spending in my analysis. Table 10 would show the IV result with two stage least squares:

Table 10: IV estimation using 2SLS (absorbed year effect)

	1	2	3	4	5
GDP per capita (log)	0.0959	-0.169	-0.458*	-0.406*	-0.403**
	(0.39)	(-0.54)	(-2.33)	(-2.37)	(-2.59)
Public health spending (log)	0.451	0.185	-0.0539	-0.0166	-0.0118
	(1.79)	(0.59)	(-0.24)	(-0.08)	(-0.07)
Access to basic sanitation services (log)	-0.234*	-0.129	0.0634	0.0505	0.0801
	(-2.22)	(-0.95)	(0.95)	(0.84)	(1.36)
Access to basic dringking water(Diff. log)		-3.361	-5.365***	-5.382***	-5.094***
		(-1.92)	(-3.75)	(-3.94)	(-3.86)
Fertility rate (log)			0.772*	0.850**	0.581*
			(2.48)	(3.11)	(2.20)
Food Insecurity (log)				0.0629	0.0658
				(1.53)	(1.58)
Incidence of Malaria (log)					0.0486**
					(2.78)
Compulsory education (log)					0.221*
					(2.04)
Constant	3.851*	5.515*	6.112**	5.377**	4.969***
	(2.17)	(2.50)	(3.13)	(3.25)	(3.70)
Observations	357	322	322	322	321

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.6.1 IV result interpretation

Table 10 shows that IV estimation has been quite successful in addressing the endogeneity problem. Both coefficients are negative now. However, just income level is significant on 1% level. Nonetheless, results are satisfying compared to the previous OLS models.

Table 11: Instrumental variable post-estimation tests

Test Name	Test Value	Inference Drawn
Durbin–Wu–Hausman test for GDP OLS-IV estimators	F(1, 303) = 37.68	IV estimation is significantly different from OLS estimation
Durbin–Wu–Hausman test for PHE OLS-IV estimators	F(1, 303) = 69.73	IV estimation is significantly different from OLS estimation

4.7 Diagnostic Tests Results(IV)

Since there are no extra instrumental variables compared to endogenous ones, I can not test for over-identification, but I use Hausman test to check for significant difference between OLS and IV estimators(whether the instruments were effective or not): table 11.

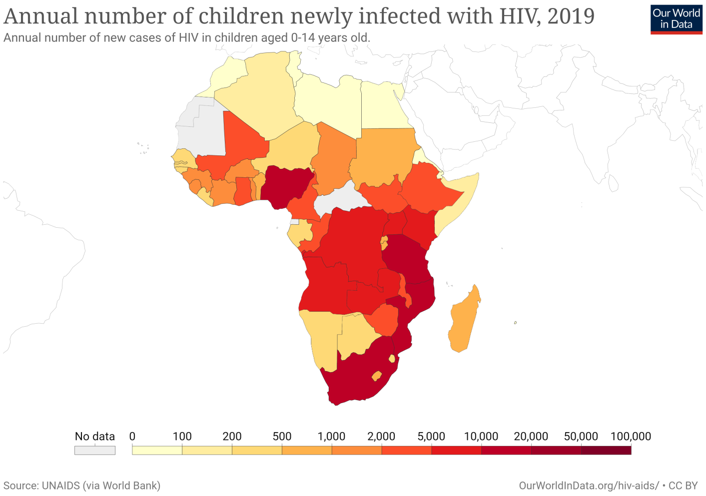
5 Conclusion

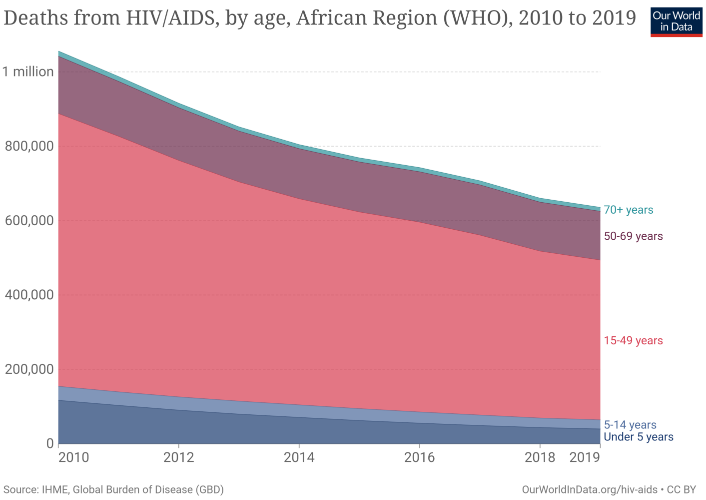
This study after proposing IV estimation for the structural model, so far shows that there might be an impact about 0.01% reduction in child mortality with 1% increase in public health expenditure by governments, however the results are not significant. There is also a significant negative effect(on 1% level) of about 0.4% in child mortality by income level. Higher incomes may also influence child health via better affordability of health care services and improved living standards in general. Higher government spending on health could affect child health outcomes, possibly through increased provision of maternal and child care, vaccination coverage and access to superior quality treatment. These results are in line with earlier studies. For example, Pritchett & Summers (1996) examined 88 countries during 1960-80 and estimated an income elasticity between 0.43 and 0.75 according to the instrument used, which was statistically significant. Filmer & Pritchett (1997) and Wang (2002) also find a statistically significant impact of income. The extent of impact of public spending on health on child mortality is more disputed in the literature.

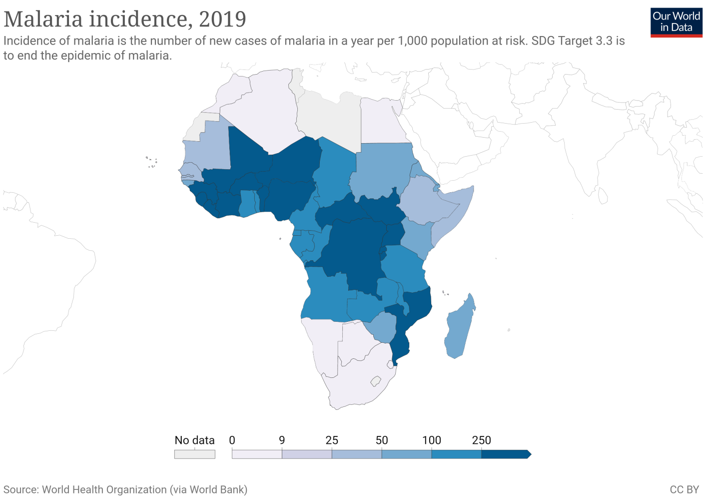
Wang (2002) uses an instrumental variables estimation technique for 60 low income countries observed between 1990-1999 to find a statistically significant effect of public health expenditure. Other researchers (Anand & Ravallion, 1993 cited in Filmer & Pritchett, 1997; Bidani & Ravallion, 1997 cited in Filmer & Pritchett, 1997) have also reached similar conclusions. On the other hand, Filmer & Pritchett (1997) claim the contrary. However, they conduct a cross-sectional analysis ignoring the time dimension of the impact which may account for the differences in their results.

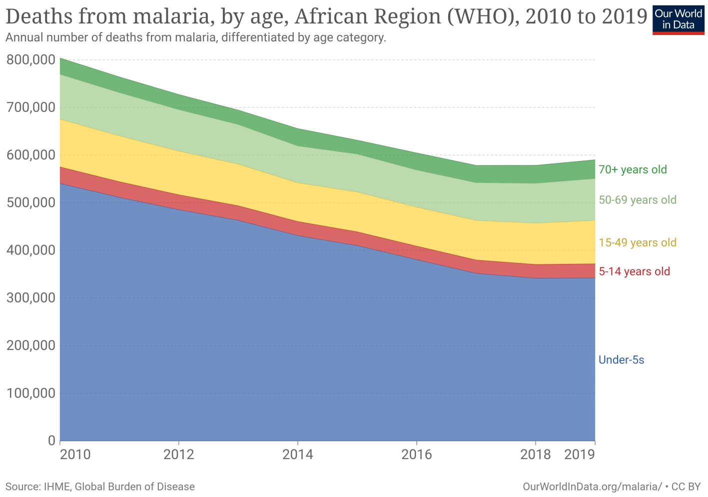
The analysis conducted in this project also points to a significant impact of improved access to sanitation in improving child health outcomes, moreover to the fact that the magnitude of the coefficients is also large: 1% increase in access to sanitation services even its basics can reduce child mortality by 5%. This possibly supports the fact that a large proportion of deaths of under-5 children in developing nations are due to diarrheal and respiratory illnesses as well as other infectious diseases rather than due to under nutrition, which can be inferred from non-significant result for food insecurity in our result. While Charmarbagwala et al (2004) claim that access to clean drinking water and sanitation facilities lower child mortality, Filmer & Pritchett (1997) hold the opposite view as far as access to safe water is concerned. However, as above, the robustness of this deduction may be questioned. Contradictorily, Wang (2002) argues for a statistically significant impact of access to sanitation facilities.Surprisingly, fertility rates lose their statistical significance in explaining child mortality in the final IV analysis. This may, however, be explained by the fact that it may be conditional on the level of income, so that higher incomes may be associated with lower fertility rates. Incidence of Malaria can confirm the fact that it is still a top cause of death in African countries. Depth of food deficit continues to be statistically insignificant in the instrumental variables estimation and can be explained by the fact that it might affect child mortality by targeting the most seek and poor ones. Compulsory education contrary to the finding of Duflo & Breierova finding of the importance of mothers' educational attainment for children survival, comes to be insignificant. That could be a result of choosing a week proxy for mother's educations level in my analysis due to the lack of data on female educational attainment in most of the countries I selected for this project.

6 Appendix A

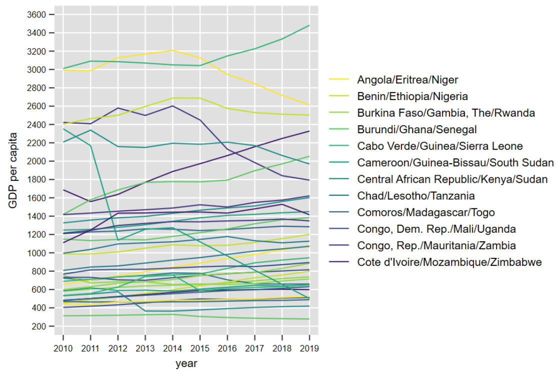

Annual number of children newly infected with HIV, 2019
Annual number of new cases of HIV in children aged 0-14 years old.
Our World in Data
No data
0
100
200
500
1,000
2,000
5,000
10,000
20,000
50,000
100,000
Source: UNAIDS (via World Bank)
OurWorldInData.org/hiv-aids/ • CC BY


Deaths from HIV/AIDS, by age, African Region (WHO), 2010 to 2019
Our World in Data
1 million
800,000
600,000
400,000
200,000
0
2010
2012
2014
2016
2018
2019
70+ years
50-69 years
15-49 years
5-14 years
Under 5 years
Source: IHME, Global Burden of Disease (GBD)
OurWorldInData.org/hiv-aids • CC BY

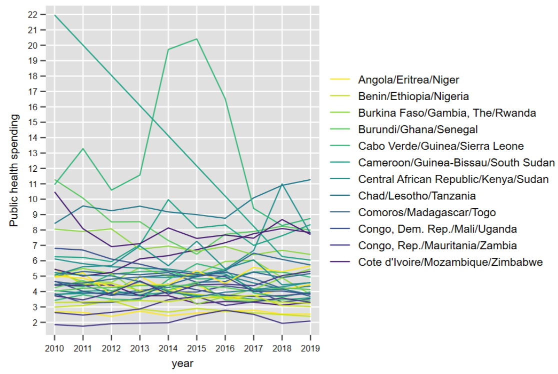

Malaria incidence, 2019
Incidence of malaria is the number of new cases of malaria in a year per 1,000 population at risk. SDG Target 3.3 is to end the epidemic of malaria.
Our World in Data
No data
0
9
25
50
100
250
Source: World Health Organization (via World Bank)
CC BY


Deaths from malaria, by age, African Region (WHO), 2010 to 2019
Our World in Data
Annual number of deaths from malaria, differentiated by age category.
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
2010
2012
2014
2016
2018
2019
70+ years old
50-69 years old
15-49 years old
5-14 years old
Under-5s
Source: IHME, Global Burden of Disease
OurWorldInData.org/malaria/ • CC BY

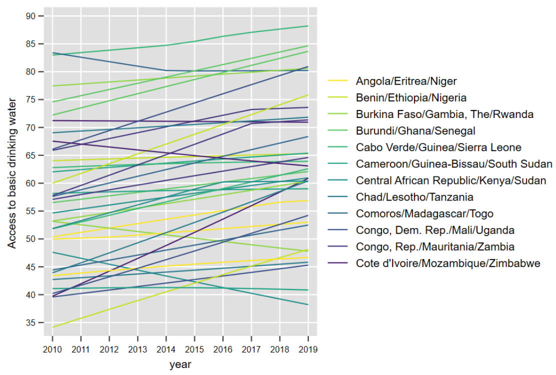
7 Appendix B



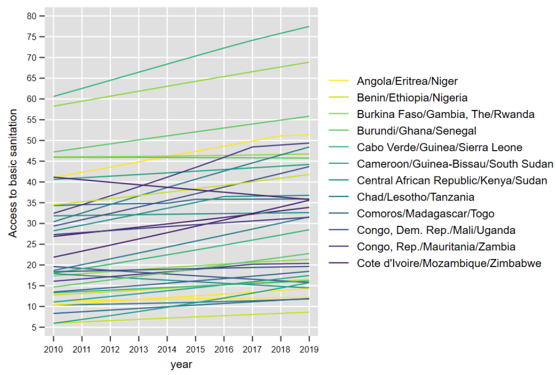
GDP per capita
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
Comoros/Madagascar/Togo
Congo, Dem. Rep./Mali/Uganda
Congo, Rep./Mauritania/Zambia
Cote d'Ivoire/Mozambique/Zimbabwe



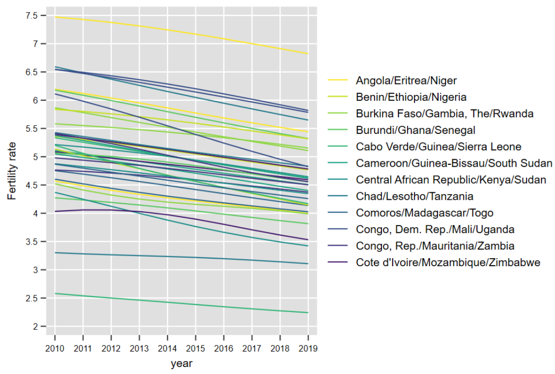
Public health spending
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
Comoros/Madagascar/Togo
Congo, Dem. Rep./Mali/Uganda
Congo, Rep./Mauritania/Zambia
Cote d'Ivoire/Mozambique/Zimbabwe

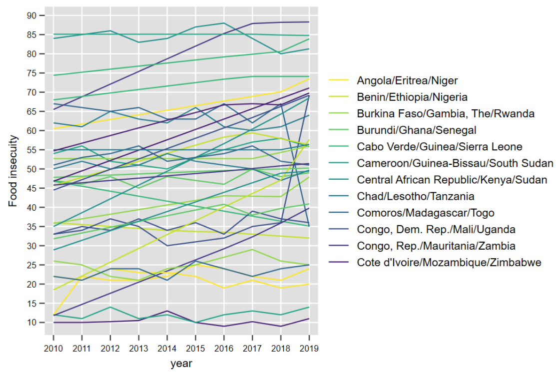


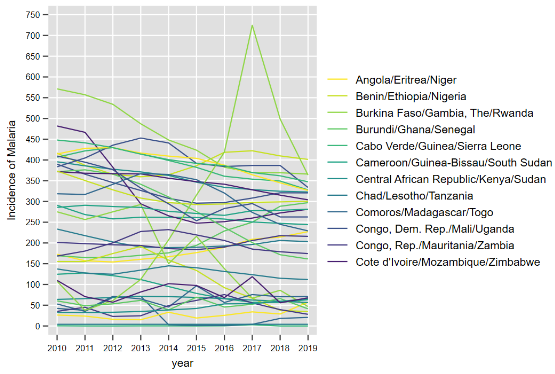
Access to basic drinking water
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
Comoros/Madagascar/Togo
Congo, Dem. Rep./Mali/Uganda
Congo, Rep./Mauritania/Zambia
Cote d'Ivoire/Mozambique/Zimbabwe



Access to basic sanitation
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
Comoros/Madagascar/Togo
Congo, Dem. Rep./Mali/Uganda
Congo, Rep./Mauritania/Zambia
Cote d'Ivoire/Mozambique/Zimbabwe


Fertility rate
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
Comoros/Madagascar/Togo
Congo, Dem. Rep./Mali/Uganda
Congo, Rep./Mauritania/Zambia
Cote d'Ivoire/Mozambique/Zimbabwe


Food insecuity
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
Comoros/Madagascar/Togo
Congo, Dem. Rep./Mali/Uganda
Congo, Rep./Mauritania/Zambia
Cote d'Ivoire/Mozambique/Zimbabwe


Incidence of Malaria
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
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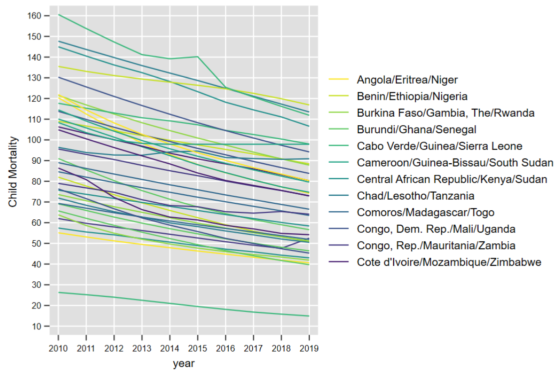
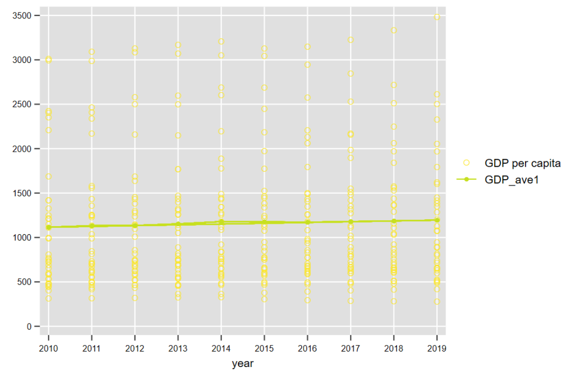
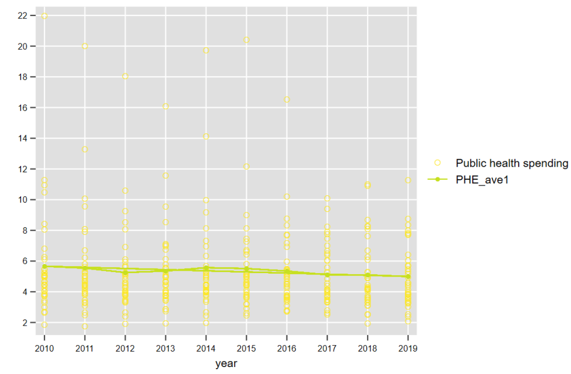
Cote d'Ivoire/Mozambique/Zimbabwe

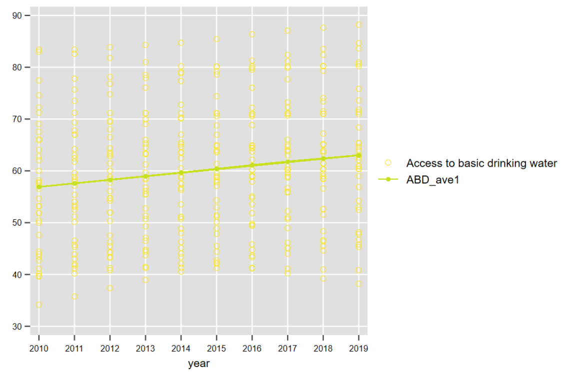

Child Mortality
year
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019
Angola/Eritrea/Niger
Benin/Ethiopia/Nigeria
Burkina Faso/Gambia, The/Rwanda
Burundi/Ghana/Senegal
Cabo Verde/Guinea/Sierra Leone
Cameroon/Guinea-Bissau/South Sudan
Central African Republic/Kenya/Sudan
Chad/Lesotho/Tanzania
Comoros/Madagascar/Togo
Congo, Dem. Rep./Mali/Uganda
Congo, Rep./Mauritania/Zambia
Cote d'Ivoire/Mozambique/Zimbabwe



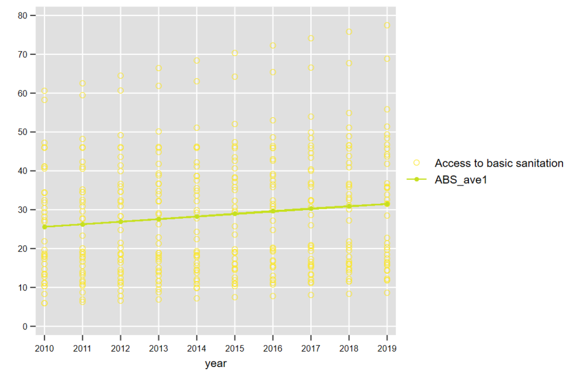
GDP per capita
GDP_ave1
year



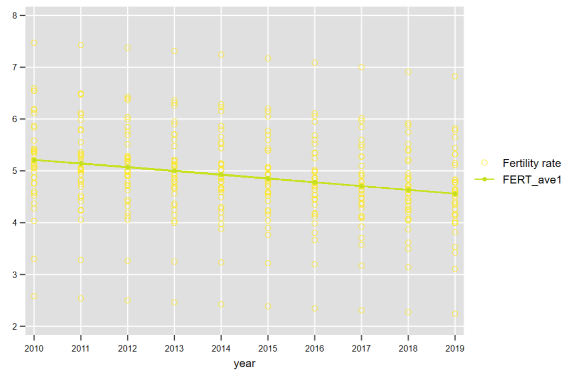
Public health spending
PHE_ave1
year



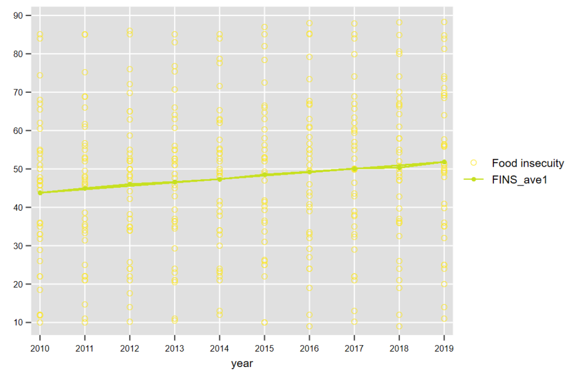
Access to basic drinking water
ABD_ave1
year



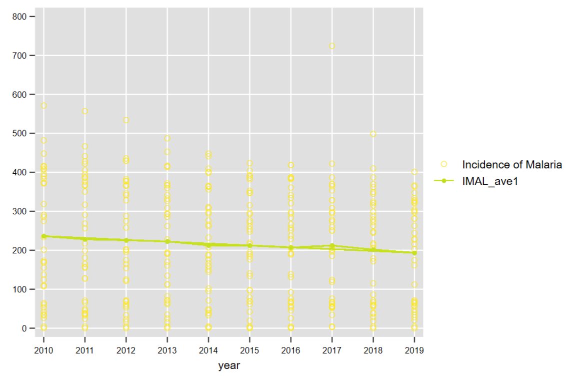
Access to basic sanitation
ABS_ave1
year



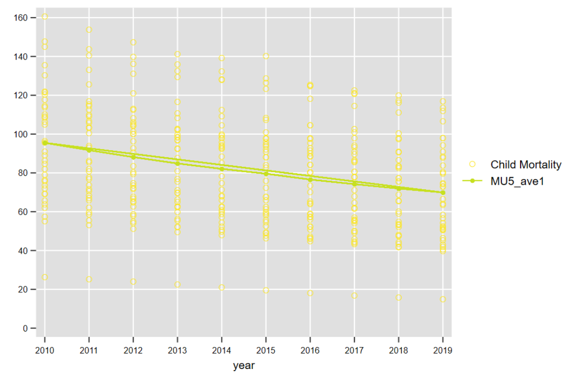
Fertility rate
FERT_ave1
year



Food insecuity
FINS_ave1
year



Incidence of Malaria
IMAL_ave1
year



Child Mortality
MU5_ave1
year

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