

## Re-Examining the Correlation of Under-Five Mortality to Economy and Health Expenditure Indicators in Sub-Saharan African Countries (1990-2013)

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**Abstract** Under-five mortality is still a major global burden though much effort has been made to reduce its magnitude as from 1990 to 2013. Child mortality rate is still high in sub-Saharan countries compared to other regions of the world. Understanding both direct and indirect factors contributing to child mortality is of importance in public health in helping tackle the burden of child mortality. In this current review we have explored some of the indirect factors contributing to child mortality at country level, specifically we have done longitudinal (1990 to 2013) and cross-sectional (2012) correlation analysis to determine the correlation of under-five mortality rate to country economy (GDP per capita) and other country health expenditure indicators (Health expenditure %GDP, country Health expenditure per capital, country Public health expenditure) as observed in sub-Saharan countries. We have found very strong negative linear correlation ( $r=-0.902$ ,  $p<0.01$ ) between under-five mortality and GDP per capital among sub-Saharan countries as from 1990 to 2013. We also found very strong negative linear correlation between under-five mortality rate and health expenditure per capital ( $r=-0.917$ ,  $p<0.01$ ) & percentage public health expenditure ( $r=-0.902$ ,  $p<0.01$ ) as from 1990-2013. The correlation between under-five mortality and % GDP used as health expenditure also showed strong negative correlation ( $r=-0.402$ ,  $p<0.05$ ) as observed from 1990 to 2013. Cross sectional correlation analysis among variables as observed in 2012 among sub-Saharan countries revealed non-significant to moderate negative linear correlation between under-five mortality rate and GDP per capital so as all other health expenditure indicators stated ( $r<-0.4$ ). As from year 1990 to 2013, reduction in under-five mortality rate correlated well with increase in country economy (GDP per capital) in majority of sub-Saharan African countries. We have come into terms with the fact that increase in sub-Saharan country economy played significant indirect role in reduction of under-five mortality, we propose additional efforts to boost economy in these countries. As from 1990 to 2013, increase in health expenditure [Health expenditure per capita, Total Health expenditure (Given as % of GDP) and Public Health expenditure] correlated well with reduction in under-five mortality rate. Together with other focused intervention, we propose more funding of health sector plans in order to boost pace in which desired outcomes are achieved overtime (eg. reduction in under-five mortality).

**Keywords** *Child Mortality; Correlation Analysis; Health Expenditure; Sub-Saharan Africa*

## 1. Introduction

### 1.1. The Levels and Trends of Child Mortality

For sustainable development of any society, it is expected that children grow to reach their adult hood in healthier way in order to become productive member of the society. Death of a child before his adulthood is generally detrimental to the family, community and country as a whole. It has been observed that many children, who die, die before their fifth birthday [1]. Under-five mortality rate is the number of children dying before their fifth birthday per 1000 live birth [1]. Upon recognizing the magnitude and consequential burden of high under-five mortality, many countries made reduction of under-five mortality a public health priority. The world community recognized under-five mortality as global burden then formulated MDG 4 in 2000 to try to speed the reduction of under-five mortality with the aim of reducing by two thirds the deaths observed in 1990 by the end of 2015 [2; 3]. In 1990, the under-five mortality rate in sub-Saharan Africa was high compared to other regions in the world; this fact has not changed despite the observed trend of rapid reduction in under-five mortality in sub Saharan Africa (annual reduction rate of 0.8 percent in 1990–1995 to 4.1 percent in 2005–2012). By the end of 2012 the U5MR in sub-Saharan Africa was estimated to be 98 deaths/1000 live births this is almost 15 times of what was observed in developed countries [1].

### 1.2. Causes of Child Mortality

Understanding both direct and indirect causes/factors contributing to child mortality is of importance in public health in helping to tackle the situation. From the year 1990 we have witnessed the changes in level of under-five mortality rate though proportionally the leading causes of deaths have changed slightly in developed countries while in developing countries (especially sub-Saharan Africa) the leading causes of deaths have remained the same. The pattern of causes of under-five deaths in 1990 vary slightly from 2012, Frankly, we have witnessed Preterm birth complications, intrapartum-related complications, pneumonia, diarrhea, sepsis and malaria having root in most of under-five deaths in sub-Saharan countries [1; 4; 5; 6].

### 1.3. Preventive Strategies of Child Mortality

In the past two decades much efforts have been made to hasten reduction in child mortality by focusing on immunization through vaccination for some bacterial and viral infections, proper use of antibiotics against infections causing sepsis and pneumonia, Use of oral rehydration salt (ORS) for diarrhea, malaria prevention (by use of insecticide treated nets (ITN), improving diagnostic test for malaria and use of effective ant-malarial drugs for the child with malaria) and prevention of neonatal deaths [7; 8].

As far as public health is concern, successful prevention strategies should encompass both hospital based intervention, community based intervention, and the national wide interventions. The previous paragraph mainly mentioned hospital based interventions and are mainly directed towards direct causes of child mortality but it is of essence that community and country level intervention should as well be addressed as they indirect contribute to child mortality. For example in community level, health education on recognizing danger signs of child illness and early seeking of medical treatment is of essence. In national level, building awareness among leaders on the magnitude of child mortality may help to boost priorities towards reducing child mortality.

### 1.4. The Role of Economy in Reduction of Under-Five Mortality

The review of data from 1990 to 2013, have repeatedly shown high child mortality in low income countries especially that of sub-Saharan Africa as compared to high income countries [1]. This brings

to the question that does economy play significant role in reducing child mortality? The logical answer is yes, however this answer is relatively simple considering that there are so many other factors influencing child survival hence under-five mortality. To elaborate this point, the previous researches have explored other factors contributing to child death which can be essentially grouped as a) Individual factors such as; Genetical factors and disorders, risk physical and mental conditions b) Hospital based factors such as; inadequate skilled personnel, inadequate material resources, unethical or poor medical practices, inadequate hospital income, poor hospital management practice c) Household and community factors such as; risk culture and belief, parent education, gender equity, maternal age, fertility rate, household economy, household stability d) Physical environment factors such as; natural disaster, climatic condition, Pollution e) National level based factors such as; Country economy, Leadership and politics, Policies and priorities, country stability.

Some of the factors contributing to child ill health and mortality are influenced by economy while other factors are not, so we can say that modifying the country economy will only partly affect the child health and survivals. Because we have witnessed the significant differences in child mortality between high income country (Low child mortality) and low income countries such as sub-Saharan Africa (high child mortality) it is of essence to acknowledge that country economy plays significant role in child survival despite of presence of other factors mirroring this relationship. The question now remains on how and to what extent does the economy impacts child health and survival? The simple model to explain this is by keeping other factors on check and make a logical assumption that the countries with high income are able to fund and implement their health plans to much extent to facilitate both preventive and curative services therefore appropriate preventive and curative interventions to conditions leading to child deaths may impact child survival resulting in reduction of child mortality. On the other hand, Low income countries are partially able to fund and implement their health plans therefore the preventive and curative services may be partially implemented resulting in increased or slow reduction in child mortality.

It has been also learned that the health status of the community also affects the country economy in proportional manner while household economy is directly affected. By using child health as an example; the healthier adults in the community resulting from healthier childhood rearing are expected to engage themselves in works which contribute to the economy therefore in long term the country economy is expected to flourish while household economy is normally immediately impacted [15]. In the society where there is high child morbidity and child mortality both the household economy and country economy is in jeopardy. The later mentioned idea can be demonstrated by 4 points; caretakers losing much resources (time, savings) in caring for the sick child, caretaker become less or not productive during child illness, children death causes loss in future labour force which drive the economy, child surviving with disability will provide sub optimal labor force in future.

From the stated accounts it can be deduced that the relationship between economy and Child mortality is logically inverse and form a vicious circle which can be moderated by properly planned and focused interventions. Frankly, poor child health can be the result of poor economy or the cause of poor economy in long term.

### **1.5. Country Economy (GDP Per Capita) and Under-Five Mortality**

In many previous researches country economy has been repeatedly measured by GDP per capita. We have witnessed increase in income therefore economy (GDP per capita) of many sub-Saharan Africa countries in the past 24 years (from 1990) so as reduction in under-five mortality/child mortality. We have acknowledged the positive interventions which lead to reduction of under-five mortality but we have remained curious on role of economic growth to such reduction. Some researcher argue that there is no or small correlation of country economic growth/economy and reduction of child mortality [11] while other researchers have supported the idea that Country economy plays significant role in

reduction of child mortality therefore is strongly negatively correlated to under-five mortality/child mortality [12; 13]. In this dilemma it is important to review again the nature of relationship between country economy and child mortality.

To our knowledge many previous research works were being focused in checking the relationship between economy (especially household economy) and child health intermediate effects/outcome such as certain diseases incidence, prevalence and severity [14; 15; 16; 17; 18; 19]. Recent opposing researches on the correlation between mortality and country income left us with more dilemma on the correlation [11; 12; 13]. Thus in this research we reinvestigated correlation between country Economy /economic growth to the trends in reduction of under-five mortality in each sub-Saharan Africa country as observed from year 1990 to 2013 (time series). We also reviewed the cross sectional data in the year 2012 to determine the later correlation across countries in sub-Saharan Africa.

### **1.6. Health Expenditures and Under-Five Mortality Rate**

The efforts made by both private and public health practices in reduction in under-five mortality in sub-Saharan African countries cannot be underestimated. Private practice is still growing in many sub-Saharan countries though most of Health services are still provided by public rather than private practice. Many studies have proposed more engagement of private care in country health system with caution [24]. Because much of health services are provided by Government institution it is logical expectation that injection of funds in different Public preventive and curative services translates into desired outcomes (e.g., reduction in under-five mortality). Different studies have examined this relationship globally and proposed that introduction of funds into different curative and preventive services may result in reduction in under-five mortality [22; 23]. These health outcomes (e.g., reduction in under-five mortality) normally become apparent in long run however may appear in short term [e.g. Help baby breath (HBB) program conducted in many sub-Saharan Africa have immediate effect of reduction in neonatal mortality rate etc]. In our research we plan to widen the investigation to encompass 3 Health expenditure indicators and provide our findings as to what extent under-five mortality rate reduction correlates with these Health expenditure indicators (% GDP used in health, % public expenditure, and Health expenditure per capita) by using available information from year 1990 to 2013.

## **2. Methods**

### **2.1. Study Design and Duration**

Our study was retrospective cross sectional analysis done towards the end of 2014 by correlating retrieved data on under five mortality rate to that of health and economic indicators of sub-Saharan Africa countries as published from reliable researches/reports within previous 25 years(as from 1990's).

### **2.2. Study Area and Study Population**

Our target population was in sub Saharan Africa. Sub-Saharan Africa constitute countries lying south of Saharan Desert. These countries includes Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo (Brazzaville), Congo DRC (Zaire), Cote d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Reunion, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe, Lesotho, Liberia [25].

### 2.3. Sampling Techniques

We aimed to include all sub-Saharan countries in our study however due to some circumstances such as unavailability of sufficient data we only included countries whose data (U5MR, GDP per capital and health expenditure indicators) are available for more than previous 15 years.

### 2.4. Data Handling

Data collected were Under-five mortality rate, Gross domestic product per capital (GDP per capital), % of country GDP used as Health expenditure, % of country total health expenditure designated as of public, health expenditure per capita (in US \$).

Data Collection procedure; was through online review of demographic health surveys and substantiated reports/researches on U5MR, GDP per capital and various health expenditure indicators.

Data sources; our main sources of data concerning country economic status and health expenditure was from recent online publication by World Bank [20; 21]. The information on child mortality [U5MR] was from recent estimates on under-five mortality published online by UN-interagency group (WHO, UNICEF and World bank) [1]. Other sources included CIA fact sheet, IMF and various country level survey reports.

### 2.5. Outcome (Dependent Variable)

Our main outcome was child mortality as estimated by Under-five mortality rate. We have decided to take unidirectional approach in which we check under-five mortality rate (U5MR) as consequence of low economy rather than low economy as the consequence of increased child mortality. In this case the under-five mortality assumes status of dependent variable.

### 2.6. Exposure (Independent Variable)

Our main independent variable was country economic status measured by country GDP per capital (in US \$) however in this research we have explored various health expenditure indicators as alternative country level factors correlating to child health. These alternative indicators are such as % of GDP used as health expenditure, country health expenditure per capital (in US \$) and public health expenditure (% of total health expenditure).

### 2.7. Data Analysis

Collected data was entered into SPSS 16, processed and then analyzed. After checking data distribution for linearity by scatter plot graphs we conducted correlation analysis in which strength and direction of person's correlation coefficient was obtained together with their significance. Student T test was used to check significant correlations and level of significance set was at 0.05. Analysis was done in 3 parts.

**1st Part:** In this part of analysis we did four longitudinal correlation analyses (from year 1990 to 2013) within each country of sub-Saharan Africa, these correlation analysis were between 1) under-five mortality rate and GDP per capital, 2) under-five mortality rate and total health expenditure (% of country GDP), 3) under-five mortality rate and public health expenditure (as % of country total health expenditure), 4) under-five mortality rate and Health expenditure per capita (in US \$).

Explanatory example; Analysis done in Angola as one of Sub-Saharan African country, between under-five mortality rate and GDP per capita (in US dollars)

Assume  $x$ = Under-five mortality rate values and  $Y$ =GDP per capital (in US \$), so the set of  $x$  values as observed from 1990 to 2013 (24 years) from Angola will be ( $x_{1990}$ ,  $x_{1991}$ ,  $x_{1992}$ ,  $x_{1993}$ ,  $x_{1994}$ ,  $x_{1995}$ ,..... $x_{2013}$ ) while the set of  $y$  values as observed from Angola as from 1990 to 2013 will be ( $y_{1990}$ ,  $y_{1991}$ ,  $y_{1992}$ ,  $y_{1993}$ ,  $y_{1994}$ ,  $y_{1995}$ ,..... $y_{2013}$ ). Conducting correlation analysis between these 2 sets is what we designated as longitudinal correlation analysis/time series correlation. The value obtained is person's correlation coefficient  $r$  and the significance level is  $p$ . The interpretation was based on the strength and direction of correlation coefficient. Our statistical significance level was  $<0.05$ ,  $-r$  meant negative/inverse correlation while  $+r$  meant positive correlation between 2 data sets. The absolute values of  $r \geq 0.7$  were considered to implicate very strong linear correlation while the absolute values fulfilling these math's inequalities; 1)  $0.4 \leq r < 0.7$ , 2)  $0.3 \leq r < 0.4$ , 3)  $r < 0.3$  were signifying strong linear correlation, moderate linear correlation and weak or no significant linear correlation respectively.

**2nd part** of analysis involved cross correlation analysis of previous mentioned variables across Sub Saharan African countries, but only as observed in year 2012.

Explanatory Example; Cross-analysis between under-five mortality rate and GDP per capita (in US dollars)

Assume  $x$ =Under-five mortality rate values and  $Y$ =GDP per capital (in US dollars), as per year 2012, observed set of  $x$  values will be ( $X_{Angola}$ ,  $X_{Burundi}$ ,  $X_{Botswana}$ ..... $X_{Zimbabwe}$ ) while observed set of  $Y$  values will be ( $Y_{Angola}$ ,  $Y_{Burundi}$ ,  $Y_{Botswana}$ ..... $Y_{Zimbabwe}$ ). Note  $X_{Angola}$  means  $x$  observed in Angola as per 2012 while  $Y_{Angola}$  means  $Y$  observed in Angola as per 2012. The correlation analysis done between these two sets of data is what we have designates as cross correlation analysis as per year 2012. The interpretation of  $r$  obtained is the same as seen in part 1 of analysis.

**3rd Part of Analysis (Regression Analysis):** In this part we generate the regression coefficient between variables compared in part 1 (Correlation series from 1990-2013). We used only correlations which showed very strong  $r$  (absolute value of  $r > 0.7$  for sub-Saharan region) so that we can find the linear equation among the variables correlated. These correlations were U5MR with GDP per capita, Health expenditure per capita and Public Health expenditure (% of total health expenditure). The model used is simple linear regression for partial correlation whereby other factor affecting dependent variable (U5MR) and independent variable are kept constant. [Equation;  $y = \beta_0 + \beta_1 x + \epsilon$ ; where by  $y$ =Under five mortality rate values,  $\beta_0$  is  $y$  intercept,  $\beta_1$  is gradient known as regression coefficient and  $x$  are values of either GDP per capita (in US dollars), Health expenditure per capita (in US dollars) or public Health expenditure (in percentage).

## 2.8. Definition of Terms

**Under-five mortality rate (U5MR);** is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year.[1]

**GDP per capita (current US\$);** is gross domestic product divided by midyear country population. [20]

**Total Health expenditure (Given as % of GDP);** is the sum of public and private health expenditure. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation. [21]



**Public Health expenditure (Given as % of total health expenditure);** consists of recurrent and capital spending from government (central and local) budgets, external borrowings and grants (including donations from international agencies and nongovernmental organizations), and social (or compulsory) health insurance funds. It is part of Country Total health expenditure (public and private health expenditure). It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation. [21]

**Health expenditure per capita (current US\$);** is obtained by dividing Total health expenditure (sum of public and private health expenditures) to total midyear country population. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation. Data are in current U.S. dollars. [21]

### 3. Results

#### 3.1. Part 1

Our Search found most of data estimates on Under-five mortality rate (U5MR) GDP per capita (current US\$), Total Health expenditure, Public Health expenditure and Health expenditure per capita (current US\$) as from 1990 to 2013, the sources were as mentioned in methodology section [1; 20; 21]. The countries which had more than 10 years deficient in data per variable were not included in our study.

Generally, among 49 sub-Saharan African countries, we completely analyzed 41 while two were excluded in some analysis and the remaining 6 completely excluded because of unavailability of data. The countries completely analyzed were Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Côte d'Ivoire, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, South Africa, Swaziland, Tanzania, Togo, Uganda, Western Sahara, Zambia and Zimbabwe. The sub-Saharan African countries analyzed in some parameters were Sudan and Zimbabwe. The countries excluded in our study were Somalia, Democratic republic of Congo, Congo republic, Cape Verde and South Sudan.

#### 3.2. U5MR Correlated to GDP per Capita

Table 1 illustrate the correlation between under-five mortality rate and GDP per capita as observed across each stated country of sub-Saharan Africa from 1990 to 2013. It can be learned that among stated sub-Saharan countries 40(93%) had significant Negative linear correlation ( $p < 0.05$ ) between U5MR and GDP per capital while 3 countries (7%) had Insignificant correlation (observed  $p > 0.2$ ). Of those (40) sub-Saharan countries showing significant negative linear correlation 27 had very strong correlation (observed absolute value of  $r \geq 0.7$ ,  $r^2 > 0.56$ ), 12 had strong correlation while 1 showed moderate correlation. In looking the averaged data of U5MR and GDP per capital for sub-Saharan region as from 1990 to 2013, the correlation obtained was negative and very strong (-0.902, see yellow highlight in Table 1).

#### 3.3. U5MR Correlated With Health Expenditure Per Capita

Bivariate correlation between under-five mortality and health expenditure per capita (in US dollars) in sub-Saharan countries from year 1990 to 2013 reveals significant negative linear correlation in majority of countries (40) except few countries (3) (see Table 2). Among those sub-Saharan countries

which show significant negative linear correlation between U5MR and health expenditure per capita, 30 showed very strong correlation (observed absolute value  $r \geq 0.7$ ,  $r^2 > 0.53$ ) while 10 showed strong correlation (observed absolute value of  $r$ ,  $0.4 \leq r \leq 0.7$ ) (Refer to Table 2).

### 3.4. U5MR Correlated to %GDP used as Health Expenditure

Among 42 sub-Saharan countries analysed for existence of correlation between under-five mortality rate (U5MR) to % GDP used as Health expenditure from 1990 to 2013, 24 showed significant negative linear correlation while 18 didn't have any significant correlation between variables in question. Among these 24 countries which showed significant negative linear correlation 13 showed very strong negative linear correlation (observed absolute value  $r \geq 0.7$ ) while 11 showed strong negative linear correlation (observed absolute value of  $r$ ,  $0.4 \leq r \leq 0.7$ ). In the whole sub-Saharan region the correlation between under-five mortality rate (U5MR) to % GDP used as health expenditure from 1990 to 2013 is strongly negatively correlated (observed absolute value of  $r = 0.402$ ) (Refer to Table 3).

### 3.5. U5MR Correlated to % Public Health Expenditure

Data Analysis on under-five mortality rate since 1990 to 2013 correlated to % public health expenditure reveals significant negative linear correlation in sub-Saharan region ( $r = -0.902$ ) [refer Table 4]. However examining this correlation in each country separately, 23 out of 41 shows significant negative linear correlation ( $p < 0.05$ ) while 18 out of 41 shows non-significant linear correlation ( $p > 0.05$ ). Exploring the value of coefficient of determination ( $r^2$ ) reveals the hidden picture of this correlation, whereby in sub Saharan region the contribution of Public expenditure on curative and preventive services (does not include environment and water sanitation) to variability of under-five mortality (reduction of U5MR) is 81% ( $r^2 = 0.81$ ) however much variability in  $r^2$  is observed among these sub Saharan countries when assessed separately (Refer to Table 4).

**Table 1:** Bivariate Correlation of Under-Five Mortality Rate (U5MR) to GDP Per Capita in Sub-Saharan Countries (Annual Correlation from 1990-2013)

Sub-Saharan Country	r	Two Tailed (p)	Significance at 0.05	Strength of r	$r^2$
Angola	-0.819	0.000	S	Very strong	0.67
Burundi	-0.617	0.001	S	Strong	0.38
Benin	-0.871	0.000	S	Very strong	0.76
Burkina Faso	-0.854	0.000	S	Very strong	0.73
Botswana	-0.788	0.000	S	Very strong	0.62
CAR	0.167	0.218	NS	Insignificant Correlation	0.03
CIV	-0.836	0.000	S	Very strong	0.70
Cameroon	-0.612	0.001	S	Strong	0.37
Comoros	-0.695	0.000	S	Strong	0.48
Djibouti	-0.865	0.000	S	Very strong	0.75
Eritrea	-0.887	0.000	S	Very strong	0.79
Ethiopia	-0.615	0.001	S	Strong	0.38
Gabon	-0.813	0.000	S	Very strong	0.66
Ghana	-0.641	0.000	S	Strong	0.41
Guinea	0.012	0.478	NS	Insignificant Correlation	1.44E-4
Gambia,	0.468	0.011	S	Strong	0.22
Guinea-Bissau	-0.758	0.000	S	Very strong	0.57
Equatorial Guinea	-0.877	0.000	S	Very strong	0.77
Kenya	-0.893	0.000	S	Very strong	0.80
Liberia	-0.785	0.000	S	Very strong	0.62
Lesotho	-0.330	0.058	S	Moderate	0.11



Madagascar	-0.791	0.000	S	Very strong	0.63
Mali	-0.823	0.000	S	Very strong	0.68
Mozambique	-0.931	0.000	S	Very strong	0.87
Mauritania	-0.567	0.002	S	Strong	0.32
Mauritius	-0.870	0.000	S	Very strong	0.76
Malawi	-0.665	0.000	S	Strong	0.44
Namibia	-0.939	0.000	S	Very strong	0.88
Niger	-0.601	0.001	S	Strong	0.36
Nigeria	-0.905	0.000	S	Very strong	0.82
Rwanda	-0.751	0.000	S	Very strong	0.56
Senegal	-0.883	0.000	S	Very strong	0.78
Sierra Leone	-0.933	0.000	S	Very strong	0.87
STP	-0.742	0.001	S	Very strong	0.55
Swaziland	0.029	0.446	NS	Insignificant Correlation	8.41E-4
Seychelles	-0.782	0.000	S	Very strong	0.61
Chad	-0.748	0.000	S	Very strong	0.56
Togo	-0.697	0.000	S	Strong	0.49
Tanzania	-0.978	0.000	S	Very strong	0.96
Uganda	-0.903	0.000	S	Very strong	0.81
South Africa	-0.600	0.001	S	Strong	0.36
Zambia	-0.887	0.000	S	Very strong	0.79
Zimbabwe	-0.546	0.003	S	Strong	0.30
Sub-Saharan Africa (overall)	-0.902	0.000	S	Very strong	0.81

**Note;** CAR, Central Africa Republic; STP, Sao Tome and Principe; CIV, Cote d'Ivoire; r, Pearson's correlation coefficient; r<sup>2</sup>, coefficient of determination; S, significant; NS, not significant.

**Table 2:** Bivariate Correlation of Under-Five Mortality Rate (U5MR) to Health Expenditure Per Capita (Current US\$) in Sub-Saharan Countries (Annual Correlation From 1990-2013)

Country	r	Two Tailed Test (p)	Significance at 0.05	Strength of r	r <sup>2</sup>
Angola	-0.908	0.000	S	Very strong	0.82
Burundi	-0.789	0.000	S	Very strong	0.62
Benin	-0.912	0.000	S	Very strong	0.83
Burkina Faso	-0.836	0.000	S	Very strong	0.70
Botswana	-0.848	0.000	S	Very strong	0.72
CAR	0.281	0.129	NS	Insignificant correlation	0.08
CIV	-0.728	0.000	S	Very strong	0.53
Cameroon	-0.660	0.001	S	strong	0.44
Comoros	-0.725	0.000	S	Very strong	0.53
Djibouti	-0.955	0.000	S	Very strong	0.91
Eritrea	-0.652	0.002	S	strong	0.42
Ethiopia	-0.902	0.000	S	Very strong	0.81
Gabon	-0.931	0.000	S	Very strong	0.87
Ghana	-0.418	0.042	S	Strong	0.17
Guinea	-0.289	0.123	NS	Insignificant correlation	0.08
Gambia,	0.419	0.042	S	Strong	0.17
Guinea-Bissau	-0.672	0.001	S	Strong	0.45
Equatorial Guinea	-0.896	0.000	S	Very strong	0.80
Kenya	-0.925	0.000	S	Very strong	0.86
Liberia	-0.820	0.000	S	Very strong	0.67
Lesotho	-0.695	0.001	S	strong	0.48
Madagascar	-0.863	0.000	S	Very strong	0.74
Mali	-0.796	0.000	S	Very strong	0.63
Mozambique	-0.945	0.000	S	Very strong	0.89

Mauritania	-0.595	0.005	S	strong	0.35
Mauritius	-0.808	0.000	S	Very strong	0.65
Malawi	-0.895	0.000	S	Very strong	0.80
Namibia	-0.945	0.000	S	Very strong	0.89
Niger	-0.866	0.000	S	Very strong	0.75
Nigeria	-0.691	0.001	S	strong	0.48
Rwanda	-0.803	0.000	S	Very strong	0.65
Sudan	-0.855	0.000	S	Very strong	0.73
Senegal	-0.970	0.000	S	Very strong	0.94
Sierra Leone	-0.922	0.000	S	Very strong	0.85
STP	-0.591	0.005	S	strong	0.35
Swaziland	-0.118	0.320	NS	Insignificant correlation	0.01
Seychelles	-0.447	0.031	S	Strong	0.20
Chad	-0.798	0.000	S	Very strong	0.64
Togo	-0.875	0.000	S	Very strong	0.76
Tanzania	-0.922	0.000	S	Very strong	0.85
Uganda	-0.927	0.000	S	Very strong	0.86
South Africa	-0.679	0.000	S	Strong	0.46
Zambia	-0.917	0.000	S	Very strong	0.84
Sub-Saharan Africa (Overall)	-0.917	0.000	S	Very strong	0.84

**Note;** CAR, Central Africa Republic; STP, Sao Tome and Principe; CIV, Cote d'Ivoire; r, Pearson's Correlation coefficient; r<sup>2</sup>, Coefficient of Determination; S, Significant; NS, Not Significant

**Table 3:** Bivariate Correlation of Under-Five Mortality Rate (U5MR) to % GDP Used as Health Expenditure in Sub Saharan Countries from 1990 to 2013

Country	r	Two Tailed Test (p)	Significance at 0.05	Strength of r	r <sup>2</sup>
Angola	0.364	0.069	NS	IC	0.13
Burundi	-0.550	0.009	S	Strong	0.30
Benin	0.154	0.271	NS	IC	0.02
Burkina Faso	-0.645	0.002	S	Strong	0.42
Botswana	-0.571	0.007	S	Strong	0.33
CAR	-0.186	0.230	NS	IC	0.03
CIV	-0.010	0.484	NS	IC	1.0E-4
Cameroon	-0.492	0.019	S	strong	0.24
Comoros	-0.040	0.437	NS	IC	0.002
Djibouti	-0.943	0.000	S	Very strong	0.89
Eritrea	0.826	0.000	S	Very strong	0.68
Ethiopia	-0.600	0.004	S	strong	0.36
Gabon	0.070	0.391	NS	IC	0.005
Ghana	-0.223	0.187	NS	IC	0.05
Guinea	-0.526	0.012	NS	Strong	0.28
Gambia,	-0.471	0.024	S	Strong	0.22
Guinea-Bissau	0.081	0.375	NS	IC	0.006
Equatorial Guinea	0.009	0.485	NS	IC	8.1e-5
Kenya	-0.279	0.131	NS	IC	0.08
Liberia	-0.877	0.000	S	Very strong	0.77
Lesotho	-0.757	0.000	S	Very strong	0.57
Madagascar	0.109	0.333	NS	IC	0.01
Mali	0.039	0.439	NS	IC	1.5e-3
Mozambique	-0.639	0.002	S	Very strong	0.41
Mauritania	-0.410	0.045	S	strong	0.17
Mauritius	-0.866	0.000	S	Very strong	0.75
Malawi	-0.863	0.000	S	Very strong	0.74
Namibia	-0.899	0.000	S	Very strong	0.81

Niger	-0.544	0.010	S	Strong	0.30
Nigeria	-0.557	0.008	S	Strong	0.31
Rwanda	-0.867	0.000	S	Very strong	0.75
Senegal	-0.580	0.006	S	Strong	0.3364
Sierra Leone	0.079	0.378	NS	IC	0.01
STP	0.110	0.332	NS	IC	0.0121
Swaziland	-0.059	0.409	NS	IC	3.4e-3
Seychelles	0.263	0.146	S	Strong	0.07
Chad	0.742	0.000	S	Very strong	0.55
Togo	-0.962	0.000	S	Very strong	0.92
Tanzania	-0.840	0.000	S	Very strong	0.71
Uganda	-0.852	0.000	S	Very strong	0.73
South Africa	0.043	0.432	NS	IC	1.8e-3
Zambia	-0.360	0.071	NS	IC	0.13
<b>Sub-Saharan Africa (Overall)</b>	<b>-0.402</b>	<b>0.049</b>	<b>S</b>	<b>Strong</b>	<b>0.16</b>

**Note;** CAR, Central Africa Republic; STP, Sao Tome and Principe; CIV, Cote d'Ivoire; r, Pearson's Correlation coefficient;  $r^2$ , Coefficient of Determination; S, Significant; NS, Not Significant; IC, Insignificant Correlation

**Table 4:** Bivariate Correlation of Under-Five Mortality Rate (U5MR) to % Public Health Expenditure in sub Saharan Countries from 1990 to 2013

Sub-Saharan Africa Country	r	Two Tailed Test (p)	Significance at 0.05	Strength of r	$r^2$
Angola	-0.440	0.034	S	Very strong	0.19
Burundi	-0.779	0.000	S	Very strong	0.61
Benin	-0.871	0.000	S	Very strong	0.76
Burkina Faso	-0.689	0.001	S	Very strong	0.47
Botswana	-0.275	0.135	NS	IC	0.08
CAR	0.162	0.260	NS	IC	0.03
CIV	0.150	0.276	NS	IC	0.02
Cameroon	-0.688	0.001	S	Strong	0.47
Comoros	0.418	0.042	S	Strong	0.17
Djibouti	-0.111	0.331	NS	IC	0.01
Eritrea	-0.466	0.026	S	Strong	0.22
Ethiopia	-0.611	0.004	S	Strong	0.37
Gabon	-0.803	0.000	S	Very strong	0.64
Ghana	-0.322	0.096	NS	IC	0.10
Guinea	-0.575	0.006	S	Strong	0.33
Gambia	-0.909	0.000	S	Very strong	0.83
Guinea-Bissau	0.067	0.396	NS	IC	4.4E-3
Equatorial Guinea	-0.195	0.219	NS	IC	0.04
Kenya	0.461	0.027	S	Strong	0.21
Lesotho	-0.532	0.011	S	Strong	0.28
Madagascar	-0.854	0.000	S	Very strong	0.73
Mali	-0.167	0.253	NS	IC	0.03
Mozambique	0.767	0.000	S	Very strong	0.59
Mauritania	-0.215	0.195	NS	IC	0.05
Mauritius	0.635	0.002	S	Strong	0.40
Malawi	-0.895	0.000	S	Very strong	0.80
Namibia	0.180	0.238	NS	IC	0.03
Niger	-0.878	0.000	S	Very strong	0.77
Nigeria	-0.519	0.014	S	Strong	0.27
Rwanda	-0.847	0.000	S	Very strong	0.72
Senegal	-0.892	0.000	S	Very strong	0.80
Sierra Leone	0.311	0.104	NS	IC	0.10

STP	0.212	0.199	NS	IC	0.04
Swaziland	0.113	0.328	NS	IC	0.01
Seychelles	-0.386	0.057	NS	IC	0.15
Chad	0.432	0.037	S	Strong	0.19
Togo	-0.658	0.002	S	Strong	0.43
Tanzania	-0.232	0.177	NS	IC	0.05
Uganda	0.774	0.000	S	Very strong	0.60
South Africa	-0.700	0.001	S	Very strong	0.49
Zambia	0.015	0.477	NS	IC	2.25E-4
<b>Sub-Saharan Africa (overall)</b>	<b>-0.902</b>	<b>0.000</b>	<b>S</b>	<b>Very strong</b>	<b>0.81</b>

**Note;** CAR, Central Africa Republic; STP, Sao Tome and Principe; CIV, Cote d'Ivoire; r, Pearson's correlation coefficient;  $r^2$ , Coefficient of Determination; S, Significant; NS, Not Significant; IC, Insignificant Correlation

### 3.6. Part 2

In this part we provide the results of correlations made in year 2012. The correlation analysis involved cross sectional analysis among sub-Saharan countries. The variables correlated were U5MR versus GDP per capita and various Health expenditure indicators.

**Table 5:** Bivariate Correlation Findings between U5MR as Correlated to GDP per Capital and Other Health Expenditure Indicators in Sub-Saharan African Countries as Per Year 2012

Variables Correlated	r	Two Tailed (p)	Significance at 0.05	Strength of r	$r^2$
U5MR VS GDPpc	-0.218	0.160	NS	IC	~0.05
U5MRVS HEpc	-0.280	0.097	NS	IC	~0.08
U5MR VS HEpgdp	-0.089	0.576	NS	IC	~0.01
U5MR VS HEpp	-0.311	- 0.045	S	Moderate	~0.01

**Note;** U5MR, Under-Five Mortality Rate; GDPpc, GDP Per Capita; HEpc, Health Expenditure Per Capita; HEpgdp, Health Expenditure Percentage of GDP; HEpp, Health Expenditure Percentage Public; r, Pearson's Correlation Coefficient;  $r^2$ , Coefficient of Determination; S, Significant; NS, Not Significant; IC, Insignificant Correlations; VS, Versus

In Table 5 it is clear that, in sub-Saharan Africa countries the stated variables showed moderate to no correlation with under-five mortality rate in year 2012. This is to say if GDP per capital is correlated with under-five mortality among sub-Saharan African countries in the same year (e.g., 2012) no significant linear correlation is found despite of direction of correlation being negative. As for correlation of under-five mortality with Health expenditure per capita and Health expenditure percentage of GDP no significant correlation was found in year 2012. Under-five mortality rate correlated moderately with percentage public Health expenditure in 2012 among sub-Saharan Africa countries.

### 3.7. Part 3

**Table 6:** Results of Simple Linear Regression Analysis between Under-Five Mortality Rate and Other Indicators (Economic and Health Expenditure Indicators) as from Year 1990 to 2013 in Sub-Saharan Countries

Variables Correlated	$\beta_1$	SE	p	95% CI
U5MR VS GDPpc	-0.064	0.007	<0.01	-0.077 to -0.050
U5MR VS HEpc	-.987	0.107	<0.01	-1.214 to -0.760
U5MR VS HEpp	-6.521	0.778	<0.01	-8.171 to -4.871

$\beta$ , Regression Coefficient; SE, Standard Error Note; U5MR, Under-Five Mortality Rate; GDPpc, GDP Per Capita; HEpc, Health Expenditure Per Capita; HEpp, Health Expenditure Percentage Public; VS, versus

As shown in Table 6, Simple linear regression analysis results between U5MR and GDP per capita revealed the historical association whereby unit increase in GDP per capita of sub-Saharan country (US Dollars) results in a 0.064 unit reduction in Under-five mortality rate if other factors are kept

constant. There is also association between U5MR and health expenditure per capita, whereby unit increase in Health expenditure per capita (US Dollars) results in a 0.987 unit reduction in Under-five mortality rate if other factors are kept constant. Looking at the other variables, unit increase in % Public Health expenditure as compared to private health expenditure overtime resulted in 6.521 units reduction in Under-five mortality rate if other factors are kept constant.

#### 4. Discussion

Under-five mortality is still a major global burden though much effort has been made to reduce its magnitude as from 1990. Child mortality rate is still high in sub-Saharan countries compared to other regions of the world. Understanding both direct and indirect factors contributing to child mortality is of importance in public health in helping tackle the situation. The aim of the current study was to explore the indirect factors contributing to child mortality at country level; therefore we investigated the correlation of under-five mortality rate to country economy and other country health expenditure indicators.

##### 4.1. Reduction in Under-Five Mortality with Increase in Country Economy in Sub-Saharan African Countries

Longitudinally (from 1990 to 2013), our study found significant negative linear correlation between under-five mortality rate and country GDP per capital. This is to say increase in GDP over the years (from 1990 to 2013) in majority of sub-Saharan Africa countries correlates with reduction in under-five mortality rate. The relationship may be explained that, GDP per capita being indirect country level factor influencing child mortality influences other direct factors contributing to child mortality therefore resulted in reduction of under-five mortality. Whatever the reason, the correlation of increased economy (GDP per capital) overtime to reduction in under-five mortality rate cannot be denied. The stated correlation concurs with the findings from Wagstaff, A. et al. [12] and Cutler, David, M. et al. [13] while it contradict some of the findings from Subramanian, S.V. et al. [11]. The later can be explained by different methodologies used whereby our study also carried partial longitudinal correlation analysis.

We even went to the extent of developing perfect historical association between U5MR and GDP per capita in which unit increase in GDP per capita of sub-Saharan country (US Dollars) results in a 0.064 unit reduction in Under-five mortality rate if other factors are kept constant. We are aware that this correlation is affected by many factors but historically by using this relationship the variables in question can be estimated however we does not prove causal association. We also don't guarantee future prediction by using this historical association computed from year 1990 to 2013. We found no significant correlation in U5MR and GDP per capita in guinea, central Africa republic and Swaziland and this is because the pattern of change of U5MR as observed in previous 24 years in these countries didn't follow annual decreasing trend seen in other sub-Saharan countries even though the economy continued to grow.

Cross-sectionally (in year 2012) we found no significant negative linear correlation between under-five mortality rates with countries having different economy status (GDP per capital) in sub-Saharan countries. The determined correlation is generally inverse (negative) and very strong. This is to say income of the country didn't have impact on U5MR on the same year rather tend to result in reduction of U5MR in next years (as we saw in longitudinal correlation/time series in previous paragraph). Another explanation as to why we didn't find significant correlation between U5MR and GDP per capita in year 2012 among African countries it may be because many of these countries had GDP per capita and U5MR which do not differ significantly (sub-Saharan Africa). This finding concur with recent cross sectional analysis findings on correlation between GDP per capita and U5MR done by Subramanian, S.V. et al. [11].

#### 4.2. Reduction in Under-Five Mortality with Increase in Health Expenditure among Sub-Saharan African Countries

Our study went further by analyzing the country Expenditure on health (longitudinally as from year 1990 to 2013) if they translate to reduction in under-five mortality. We found strong to very strong correlation between increases in health expenditure indicators (Health expenditure per capita, Public Health expenditure, Total Health expenditure (Given as % of GDP) and reduction in under-five mortality. Though our aim was not to justify the causal association between these increases in health expenditure to reduction in under-five mortality rate, we have superficially noted clues to good trend in which increased expenditure by private and public institutions in curative and preventive services translates into reduction in under-five mortality. The stated relationship between reduction in under-five mortality as health expenditure increase is supported by previous findings from the studies done by Bokhari, et al. and Anyanwu, et al. [22; 23] we are aware this relationship is fundamentally affected by many intermediate factors such as country health policies and plans etc. We propose interdisciplinary prospective studies in order to adjust for the factors mirroring this relationship. We found no significant correlation in U5MR and Health expenditure per capita in guinea, central Africa republic and Swaziland and this is because the pattern of change of U5MR as observed in previous 24 years in these countries did not follow annual decreasing trend seen in other sub-Saharan countries even though the economy continued to grow. Some countries in sub-Saharan Africa has been having much variation in their percentage public health expenditure (sometimes low sometimes high) these countries also didn't show correlation between increase in percentage public health expenditure and U5MR [Botswana, Cote d'voire, Central Africa republic, Mali, Namibia, Tanzania, STP, Seychelles, Sierra Leone, Zambia, Swaziland, Equatorial guinea, Guinea Bissau, guinea and Mauritania].

Cross-sectionally (in year 2012, among sub-Saharan countries) we found almost moderate to no significant correlation between variation in health expenditure indicators (Health expenditure per capita, Total Health expenditure (Given as % of GDP) Public Health expenditure and under-five mortality. There are major two reasons for this, Firstly, the effects of health expenditure mostly occurs or determined in next year as opposed to same year, secondly, there are no significant difference in these health expenditure indicators in majority of sub-Saharan countries.

By Longitudinally analyzing the data of U5MR and Health expenditure per capita and Public Health expenditure by simple linear regression we came up with historical association between U5MR and these variables, in which unit increase in Health expenditure per capita (US Dollars) results in a 0.987 unit reduction in Under-five mortality rate if other factors are kept constant while unit increase in % Public Health expenditure as compared to private health expenditure overtime resulted in 6.521 units reduction in Under-five mortality. We cannot guarantee this historical relationship to produce post 2013 estimates rather than to enlighten us of the trends in U5MR and health expenditure indicators from year 1990 to 2013.

#### 5. Conclusion

As from year 1990 to 2013, reduction in under-five mortality rate correlated well with increase in country economy (Measured in GDP per capital) in sub-Saharan countries. Increase in sub-Saharan country economy played significant indirect role in reduction of under-five mortality. As from 1990 to 2013, Increase in health expenditure [Health expenditure per capita, Total Health expenditure (Given as % of GDP) and Public Health expenditure] correlated well with reduction in under-five mortality rate. Together with other intervention, at country level, more allocation of funds to health sector translates into desired outcomes overtime (e.g., reduction in under-five mortality).



## Recommendations

We recommend more multidiscipline studies to be done prospectively to explore in which ways increase in country economy and health expenditure in sub-Saharan Africa paves way in reduction of Under-five mortality.

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