CHILD-MORTALITY PERFORMANCE IN SUB-SAHARAN AFRICA PRE- AND DURING THE MDGs ERA

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ABSTRACT

This study examined the role of health-related macroeconomic goals in child mortality decline during the Millennium Development Goals (MDGs) era among sub-Saharan African (SSA) countries. The MDG programmes effect was estimated using a macro-level time series approach – the interrupted time series analysis (ITSA). The ITSA model, a quasi-experimental design, was fitted to data sourced from the World Bank poverty initiative data catalogue. The results indicate that there was evidence of a treatment effect at the introduction of the MDGs, but no additional decrease in the rate of under-five mortality after the intervention. In fact, there is evidence of a rising trend in under-five mortality rate post-intervention for some countries. This raises the concern of a reversal of gains achieved with the introduction of the programmes. For sensitivity analysis, different baseline periods were modelled, different definitions of child mortality and varied lags were used, but all of these suggest evidence of a trend break in child mortality rate at the start year of the intervention. Using qualitative analysis, the mechanisms of the MDGs impacts are explained by exploring trends in preventative and treatment measures alongside cause-specific mortality. Findings from this study indicate that coverage of preventative actions such as immunization, safe water provision, and sanitation are associated with levels of under-five mortality. Seychelles, for instance, had 95% safe water provision coverage over a decade pre-MDGs with 1 under-five death per 1000 live births due to diarrhoea. This study insists that scaling-up of preventative programmes as well as complete overhauling of existing *implementation strategies, especially for countries with dismal performances in infectious disease control, is vital for attainment of the SDG target on child mortality.*

Key words: Child mortality, MDGs, SDGs, SSA

JEL classification: I15, I18, C22

1. Introduction

While research in developed countries focuses on child development, the major concern of research in developing countries is child mortality. Several reasons account for the prominence given to the goal of reducing child mortality. One motivation is the evidence of an association between mortality reduction and demographic transition (Belli, Bustreo and Preker, 2005; Bloom and Williamson, 1998).[1] Belli, Bustreo, and Preker argue that significant reductions in child mortality can reduce fertility, and the dependency ratio in the long run, and consequently enhancing economic growth. As an indicator of economic growth (Erdogan, Ener and Arica, 2013), child mortality can be a more equitable index of resource allocation compared to the gross national income (GNI) per capita. The distributional concerns associated with the GNI per capita are likely to be relatively lower where child mortality rate is used as a measure of the standard of living. In other words, child mortality rate appears to reflect the childhood environment better than the income per head index. Also, the child mortality rate has been used as an index of accessibility to critical infrastructure in an economy. It is considered as an "outcome measure" of the development process of a country's health system (Reidpath and Allotey, 2003). Additionally, from the normative paradigm, the number of preventable under-five deaths in developing countries is considered too high relative to developed countries. With

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[1] Bloom and Williamson argued that significant reductions in child mortality set in motion the so-called demographic transition. They identified three phases in this transition. In the first phase, the demographic burden phase, mortality declines without a corresponding decline in fertility rate. Hence, a glut of unproductive youth will ensue, which in turn increases the dependency ratio, and economic growth tends to fall. The second phase is characterized by declining birth rates which is cause by increased likelihood of children surviving. This reduces the dependency ratio and increases progressive entry into the labour force – the increase in the share of the working population resulting in higher potential economic growth. In the last phase, dependency ratio rises as the share of working population declines due to the lag effect of the decline in birth rates in the second phase. As a consequence, economic growth starts to decline.

over 90% of childhood deaths occurring in less developed countries (UNICEF, 2001), there are concerns to preserve lives based on the ethics of universalism of life claims.[2]

The core broad objective of the Millennium Development Goals is the reduction of poverty. As an outcome of a series of summits, the MDG was launched in 2000 by the United Nations as a global action to combat poverty, especially in developing countries. Of the eight goals contained in the Millennium Declaration, Goal 4 (MDG4) is focused on reducing child mortality. More formally, the target is to reduce under-five mortality rate by two-thirds over a 25-year period (1990-2015). National governments in SSA endorsed the MDGs in 2000 and is used as a framework for instituting interventions. In fact, in the 2010 Millennium Development Goals (MDGs) summit, SSA countries reaffirmed their commitment by endorsing the Global Strategy for Women's and Children's Health (United Nations, 2010). Following the global 'success' of the MDG, the SDG, which is an outcome of the Rio 1992 and 2012 summits, was launched.[3] It was instituted due to the global necessity for sustainable development. The SDG target for child mortality by 2030 is to reduce neonatal mortality to at least as low as 12 deaths per 1,000 live births and under-five mortality to at least as low as 25 deaths per 1,000 live births.

By 2015, the under-five mortality rate had declined considerably with the majority of the World Health Organization (WHO) sub-regions (Northern Africa, Latin America, Eastern & Western Asia) achieving the MDG-4 target. However, the sub-Saharan Africa (SSA) and Oceania sub-regions were unable to meet the MDG target. The majority of the 5.9 million under-five lives lost at the end of the MDG era in 2015 were from developing countries (IGME, 2015). These deaths were from preventable causes such as preterm birth complications (16% of deaths), pneumonia (16%), diarrhoea (9%), malaria (5%), undernutrition (45%), and low birth weight (80%) (Costello, Dalglish, Colbourn, et al., 2016). Equity analyses have continued to show a widening of the relative

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[2] The universalism of life claims in the Human Development Report states: "No new-born child should be doomed to a short life or a miserable one merely because that child happens to be born in the wrong class, or in the wrong country or to be of the wrong sex" (UNDP, 1994).

[3] The SDGs are a set of 17 goals, 169 targets with 230 indicators agenda to guide global development over a 15 year-period (2015 to 2030).

mortality gap between rich and poor countries, and within most developing countries (Moser, Leon, and Gwatkin, 2005; Victora et al., 2003). For instance, child mortality in the world's poorest countries is about 120 per 1000 live births while on average, only 6 deaths per 1000 occur in developed countries (Victora et al., 2003). While some of the cause-specific mortality rates have stagnated with others declining, new causes with novel signatures appear to be evolving. It is most likely that mortality rates are going to rise in the future given the increasing population growth rate of the region. Hence, there is the need to accelerate progress in *sustainable* child survival in order to reduce fertility rate and consequently, population growth rate.[4]

The MDGs advocate medical interventions with important characteristics that are associated with child mortality reduction which this study assesses. This study seeks to evaluate the pattern and trends of under-five mortality decline as well as specific causes of mortality following the MDGs intervention. This study thus seeks to address the following research questions:

- What is the effect of the MDGs on the pattern of under-five mortality change in the SSA region?
- How sustainable is the rate of under-five mortality decline?

Investigating the above research questions is vital for informing actions on the on-going SDGs campaign. To be precise, trend analyses of child mortality rates in SSA and the causes can be informative in policy design to enhance the effectiveness of health systems.

A major contribution of this study is the attempt to retrospectively evaluate if there is a valid treatment effect following the start of the MDGs campaign and how subsequent international development agenda can tease out manipulable influential variables that affect causes of mortality in the SSA region. Explicitly, uncovering to what extent the failure or success of the MDGs can be explained by their health-related goals will be instructive in providing guidance for any ongoing process. Also, providing evidence on the pattern of change associated with the treatment (MDGs) is needful. A sustainable decline in child mortality would suggest a general improvement in the standard of living of the region, improved health systems, and a possible escape from the possible demography

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[4] Belli, Bustreo, and Preker (2005) argue that significant reductions in child mortality can reduce fertility, dependency ratio, and consequently enhance economic growth in the long run.

trap. Thus, validating or debunking the myth of a sustainable decline in mortality levels as well as specific-cause mortality associated with implemented health-related MDGs programmes will provide opportunities to affect the on-going process (SDGs). The Sustainable Development Goals (SDGs) were launched in 2016 to replace the MDGs. While the MDGs focused on ending extreme poverty, hunger and preventable disease, the SDGs are continuing the fight against extreme poverty, but also providing solutions to the problems identified with the MDGs, such as inequality, sustainability, institutional resourcefulness, implementation efficacy, and environmental deterioration (Sachs, 2012).

In addressing the research questions, this study used temporal series of under-five mortality rate as a health-related MDGs outcome for the SSA region between 1990-2015. Data were sourced from the World Bank poverty data catalogue and are available online.[5] The trend analysis was situated within a comparative framework that stratified countries into achievers and non-achievers. A quasi-experimental design – the interrupted time series analysis (ITSA) – was used to evaluate under-five mortality trend before and after the MDGs intervention. The ITSA was considered a reasonable choice of instrument to evaluate the MDGs intervention for obvious reasons. First, the MDGs were essentially public health interventions implemented to a whole population without randomization or a control group, making the gold standard evaluation technique – the randomized controlled trial (RCT) – an unlikely candidate. The ITSA may be considered a reasonable replacement for the RCT, especially where the study designs are without controlled populations nor any form of randomization in their implementation. In a multiple design, the ITSA attempts to emulate the randomization process of an RCT by finding (or creating) a control group that is approximately equivalent to the treatment group on known pre-intervention characteristics, assuming that the remaining unknown characteristics are strongly unlikely to bias the results. Second, with a defined start year, the MDGs effect can be analysed as discrete since under-five mortality rate can be ordered as a time series with number of observations available in both the pre-MDGs and post-MDGs periods. The ITSA has been

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[5] Different time series data were explored in constructing and analysing trends for the study. The use of the World Bank poverty data catalogue, World Health Organization Global Health Observatory data repository and World Health Organization Global Action Plan for Pneumonia and Diarrhoea data base was instructive in achieving the objective of the study.

used to evaluate the impact of preventive and treatment interventions (Lau et al., 2015; Hawton et al., 2013), effect of ban/legislation introduction (Dennis, Ramsay, Turgeon and Zarychanski, 2013; Grundy et al., 2009) and random financial shocks (Lopez, Gasparrini, Artundo, and Mckee, 2013). Also, the use of ITSA as a study design in the evaluation of population-level health interventions has historical support in the literature (Campbell and Stanley 1966; Glass, Willson, and Gottman 1975; Shadish, Cook, and Campbell 2002; Linden, 2015).

We assume linearity in modelling mortality rates within the ITSA framework. In effect, the OLS Newey-West estimator was used, adjusting for autocorrelation in the mortality series. Estimates were compared with the Prais-Winsten estimator that returns with a Durbin-Watson (DW) statistic. Residual autocorrelations were tested using the DW test. For sensitivity analyses, the lag period was varied, alternative definitions of child mortality used, and different baseline periods adopted, but results were robust to major findings from the basic model. Results from the ITSA indicate significant MDGs treatment effect at the first year of the intervention for all categories of countries with the exception of Seychelles. However, effect sizes appear to dwindle post-intervention with some possible reversal of gains achieved at the introduction of the MDGs. For instance, while countries like Cabo-Verde and Seychelles witnessed a rise in annual under-five mortality rates post-intervention, only Angola witnessed a progressive decline from the start of the intervention and subsequently. Put differently, while there was a decline in the rate of child survival annually relative to the initial "jump" with the introduction of the MDGs for some countries, there was a rise in mortality rate for other countries post-intervention. Thus, there is reasonable apprehension of a reversal of the "supposed gains" recorded with the MDGs intervention for some countries.

The remainder of this study is structured as follows. Following the introduction, section 2 presents a review of related literature while section 3 describes the method and data used. Trend analyses are presented in the fourth section with findings discussed in section 5.

2. Literature Review

Theories, as well as studies on child mortality, can be broadly classified into: (i) theories/studies explaining variations in mortality risk as a consequence of individual characteristics; (ii) theories/studies explaining variations in child mortality as a result of changes in macroeconomic determinants. The latter group of studies is seen to be an aggregation of micro-events in the former and focuses on aggregate socioeconomic determinants of child mortality. Such aggregate determinants measure structural phenomena that are mostly invariant within a group or population (Wennemo, 1993) and has been used for cross-country comparisons. Factors such as the distribution of income within a country, national coverage of public health goods, and national expenditure on critical infrastructure among others are established in the literature as determinants of between-country variations in the rate of mortality. This study is limited in scope for the latter.

Garenne and Gakusi (2006) used 56 demographic health surveys (DHS) and 10 world fertility surveys from 32 African countries between 1950 and 2000 to reconstruct and analyse mortality trends in children younger than five years. A logit model was fitted to mortality rates estimated from life tables and used to investigate if a smooth health transition period could be identified. On average, a consistent decline in under-five mortality observable over a long-term was noted in some countries which could be higher but for the effect of paediatric AIDS. Specific focus on the post-colonial period (1960-2005), when structural changes were suspected to have occurred across the SSA region, was evaluated with respect to child mortality levels and trend by Adetunji and Bos in Jamison Feachem and Makgoba et al. (2006). Their findings agreed with the pattern of decline established in the literature for the SSA region. A further disaggregation of the region into sub-regions, uncovers disparities in the rate of decline between West Africa and Middle Africa with the latter sub-region having the highest mortality rate which has been sustained since 1960.

In a recent study, Garenne (2015) reconstructed trends in U5MR for 35 SSA countries from 1985 to 2010 using the DHS. Findings from the study indicate that the contributions from HIV/AIDS, malaria, and emergency situations (political, economic and social crises) were significant to overall mortality levels and trends both at the regional level as well as country level. A comparison of historical under-five morality trends between developed and underdeveloped countries for the period 1950-2000 was provided in Ahmad, Lopez, and Inoue (2000). Results from the study suggest that a marked reduction in global trends in all WHO regions occurred in the early 1970s and continued throughout the

1990s with Africa as the least performer. The study failed to reject the hypothesis that there is no widespread rising child mortality rates in spite of the advent of HIV/AIDS and civil unrest in developing countries.

From the above review, surprisingly, little is known about the existence of any empirical estimate of the effect of the MDGs on child mortality or factors in the health interventions of the MDGs that explain the causes of child mortality. This study contributes to the literature by estimating a treatment effect of the MDGs while identifying influential factors that explain child mortality in the SSA region. This may be useful in shaping actions on the on-going SDGs.

3. Method

3.1 Data and variables

Data from the World Bank open data initiative was used for the study. It is a compilation of data from different sources such as the World Bank, UNICEF, WHO, and UN DESA population division. The World Bank open data initiative provides access to a data catalogue comprising datasets, databases, pre-formatted tables, and reports among others covering a broad range of topics such as agriculture and rural development, aids effectiveness, climate change, health, poverty, social development, education, environment, gender, science and technology, social development etc. It covers a 57-year period and is accessible online. These sources are considered plausible substitutes with no known less validity of mortality estimates when compared with estimated mortality rates from life tables of the demographic health surveys. Moreover, there appears to be a dearth of longitudinal individual data needed for evaluating changes in general child health in the region. The study is attracted to this data source because it allows for the extraction of aggregate annual series of child mortality outcomes at both the regional and country levels.

While under-five mortality rate is defined as the probability that one new-born baby per 1,000 will die before reaching the age of five, neonatal mortality rate is the number of neonates per 1,000 live births who die in a given year before reaching 28 days of age. Infant mortality rate is the number of infants per 1,000 live births who die each year before reaching one year of age.

3.2 Analysis

In evaluating the MDG treatment effect, this study uses the interrupted time-series analysis (ITSA) single design. This is possible given that under-five mortality is ordered as a time series with several observations available in both the pre-MDG and post-MDG periods. The ITSA framework is used to test the hypothesis that the introduction of the MDGs will interrupt the under-five mortality trend. The ITSA is considered suitable for the evaluation of population-based interventions that are implemented either without randomization or without a control (Bernal, Cummins and Gasparrini, 2017), a model to which the MDGs conform.

We specify the ITSA regression model for this study following Linden and Arbor (2015). They specify an ITSA regression model of single design-without a comparable group as:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \varepsilon_t$$

where:

- Y_t = aggregated outcome variable (child mortality rate) measured at each equally-spaced time *t*
- T_t = time since the start of the intervention
- X_t = dummy (indicator) variable representing the intervention (pre-MDG period=0, otherwise=1)
- $X_t T_t$ = interaction term,
- β_0 = intercept or starting level of under-five mortality in a country *i*
- β_1 = slope of under-five mortality until the introduction of the MDGs
- β_2 = change in under-five mortality rate following the introduction of the MDGs in comparison with the counterfactual
- β_3 = difference between the pre-MDG and post-MDG slopes of under-five mortality. While a significant p-value in β_2 indicates an immediate treatment effect (short-run effect), a treatment effect over time from the MDGs will be identified by a significant p-value of β_3.

In identifying the ITSA model without a comparison group (single-group ITSA), the pre-MDG trend is projected into the MDG era and serves as the counterfactual. Effectively, it is assumed that the rate of change of any time-varying unobserved confounder is relatively slower and can be identified from the sharp fall of the intervention indicator. We also assume that under-five mortality is an outcome of all child health actions contained in the national socially inclusive macroeconomic goals, which are also reflections of the health-related MDGs. Given the above assumptions, we infer causality if the change in slope is significant following the introduction of the intervention. In other words, the above assumptions for implied causal inference in the single-group ITSA will be plausible when the pre-intervention trend is flat, followed by a significant change in slope after intervention. However, if a trend already exists in the time series prior to the intervention, attributing any change in trend slope to the intervention will need clear evidence of a significant break in trend at the intervention.

Another approach used in this study to investigate the pattern of mortality trends and the effects of preventative and therapeutic measures on child mortality was to compare a stratified group of countries, that is, countries are grouped based on a mortality level criterion. Effectively, countries were categorized into low mortality/achievers and high mortality countries/non-achievers using the international acceptable target of a 60 under-five deaths per 1000 live births for developing countries as a threshold. At the end of 2015, while 19 countries met the international acceptable level, 25 countries were yet to meet the target. We selected four representative countries each from the two groups using an inclusion criterion that was based on data availability. Among the countries that have made good progress and have available data on preventive and interventionist medicine measures, we chose Seychelles, Botswana, Mauritius, and Capo Verde to represent the achievers. Similarly, Nigeria, Angola, Mali, and Equatorial Guinea were selected among the countries with high under-five mortality rates that also have data on preventive and interventionist actions as representatives of the non-achievers. The basic intuition is to use a comparative framework to investigate the pattern and drivers of mortality decline in countries that have made good progress with implications for non-achiever countries.

4. Results

4.1 Descriptive statistics

Summary statistics of the aggregate series used to evaluate the MDG treatment effect are presented in tables 1A (see Appendix). We note first declining trends in the SSA region under-five, infant and neonatal mortalities rates over the period of analysis. More specifically, while the decline in the 5-year mean of under-five mortality rate is about 7 per 1,000 live births in the pre-MDG era (between 1990-95 and 1996-20), on average, about 20 under-five survivors per 1,000 births were gained across the MDG era. The gain in neonatal survival was about 4 per 1000 live births, on average, both before and after the introduction of the intervention. Second, we note that there is marked variation in the performance of countries in the progress of child survival. Using the comparative framework mentioned in the method section, we discover that the rates of under-five mortality decline amongst the achiever countries were much slower compared with the non-achiever countries. For instance, during the MDG era, on average, under-five morality declined by about 2 deaths per 1,000 live births in the group of achiever countries (except for Botswana). In contrast, on average, the non-achievers group gained a mean reduction of about 20 under-five deaths per 1,000 live births. The above descriptive evidence motivates the research question of what is the effect of the MDGs on child mortality outcomes? To what extent are medical interventions contained in the MDGs associated with cause-specific under-five mortality? We investigate these research questions in greater detail below.

4.2 ITSA regression results

The ITSA single group design was used to assess the impact of the MDGs in reducing child mortality for the selected countries. We performed the ITSA using the Newey OLS, adjusting for a single lag period. The Newey OLS estimator produces standard errors which are robust to autocorrelation and heteroscedasticity. As a robustness check, we use the Prais-Winston model which uses the generalised least-squares method where the errors are assumed to follow an autoregressive process-AR (1). The MDGs' immediate effect was identified by investigating whether there is a statistically significant 'jump' in the trend of under-five mortality rate at the introduction of the intervention in 2000. The basic intuition is that, where there is a repeated measure of the process of interest, annual under-five mortality series, the MDGs' treatment effect can be measured in terms of its impact on the mean or the trend slope.

We present our results in two phases. While in the first phase we present results for the SSA region, in the second phase, results for a stratified group of countries that are representative of achiever and non-achiever countries are presented. In general, our results indicate an undefined pattern in the effect of the MDGs on child mortality reduction. For some countries, we note statistically significant reduction in under-five mortality rates at the introduction of the MDGs. However, our results also suggest rising under-five mortality trends in some countries at the introduction of the MDGs and post-intervention.

Table 1 investigates the MDG treatment effect for the SSA region. In column 1, a one-year lag period was specified in the ITS model. The mean mortality rate was estimated at 182 deaths per 1000 live births with a pre-MDGs trend slope of -2.4 (p<0.0000, 95% CI= [-2.83, -1.91]). That is, an annual decline in under-five mortality of about 2 deaths per 1000 live births existed prior to the introduction of the MDGs. At the introduction of the MDGs, we note an apparent decline in the slope trend of -8.0 (p=0.002, 95% CI= [-10.88 -2.83]).

Table 1. ITS Regression results for SSA-U5MR, IMRT and NMRT (Newey OLS)

	(1)	(2)	(3)	(4)	(5)
Variables	Lag(1)	Lag(2)	GDPpc	IMRT	NMRT
_t	-2.413***	-2.413***	-2.825***	-1.348***	-0.435***
	(0.238)	(0.240)	(0.166)	(0.118)	(0.0317)
_x2000	-7.997***	-7.997***	-6.081***	-4.255***	-1.267***
	(2.317)	(2.596)	(1.773)	(1.239)	(0.355)
_x_t2000	-2.229***	-2.229***	0.263	-1.066***	-0.322***
	(0.286)	(0.280)	(0.625)	(0.146)	(0.0385)
GDPpc			-0.0257***		
			(0.00541)		
Treated	-4.642***	-4.643***	-2.562***	-2.414***	-0.757***
	(0.191)	(0.207)	(0.509)	(0.104)	(0.0275)
Constant	182.0***	182.0***	250.7***	108.4***	45.70***
	(1.200)	(1.250)	(14.66)	(0.565)	(0.138)
Observations	26	26	26	26	26

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Put differently, an annual reduction of about 8 under-five deaths per 1000 live births occurred with the introduction of the MDGs campaign in 2000. When we invoked the post-trend option to produce the lincom estimate, our result suggested a dwindling in the rate of mortality decline to about 5 deaths per 1000 live births (-4.642; p<0.0000, 95% CI= [-5.22, -4.63]) post-MDGs. In column

2, we varied the lag period to check for robustness of the MDG treatment effect. Using a two-year lag period option produced identical results with a single year-lag option (though with a slight increase in standard errors in the former). In column 3, we adjusted for income using GDP per capita as a proxy. Again, the result is consistent indicating a statistically significant MDG treatment effect. However, controlling for income showed a fall to 2 under-five deaths per 1,000 live births post intervention. Figure 1 corroborates our findings and provides a visual display of the result for the SSA region.

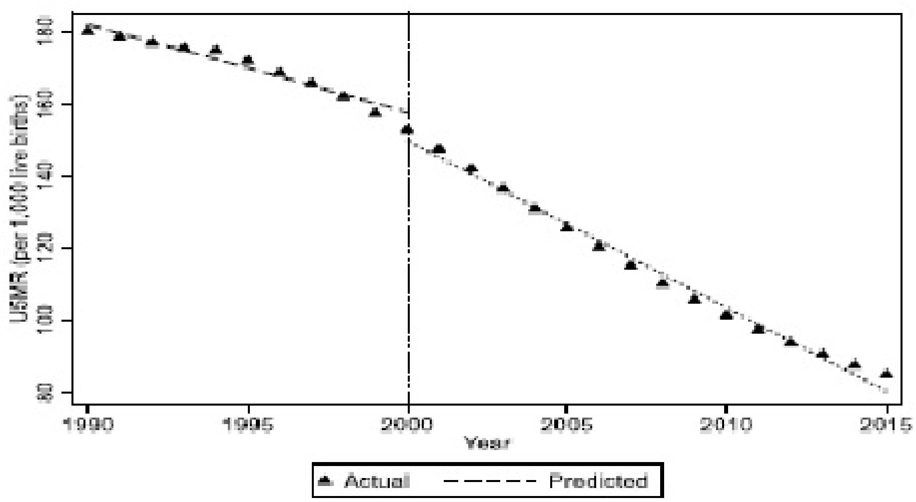

Figure 1. Single-group ITSA for SSA with Newey–West standard errors using year 2000 as intervention start year.

Next, in tables 2 and 3, the results of the ITSA are presented using the comparative framework. We note that while a declining trend in under-five mortality exists for all non-achiever countries prior to and after the introduction of the interventions, the pattern of decline in achiever countries is undefined. More specifically, our findings in table 2 (Non-achievers) indicate statistically significant annual decreases in under-five mortality ranging from 1 under-five death per 1000 live births in Angola to about 4 under-five deaths per 1000 live births in Mali prior to the introduction of the MDGs. At the introduction of the MDGs, while the annual under-five mortality rate declined to about 13 deaths per 1000 live births in Nigeria (-13.7; p=0.004, 95% CI= [-22.5, -4.90]), on average, it was above 5 deaths per 1000 live births in all non-achiever countries.

Table 2. ITS Regression Results for Selected Non-MDG Achiever countries, (Newey-West OLS)

Variables	(1) Angola U5MR	(2) E.Guinea U5MR	(3) Mali U5MR	(4) Nigeria U5MR
_t	-1.227***	-1.948***	-3.803***	-2.208***
	(0.360)	(0.201)	(0.115)	(0.373)
_x2000	-6.607**	-5.422***	-6.618***	-13.02***
	(2.619)	(1.565)	(1.664)	(3.947)
_x_t2000	-7.125***	-2.325***	-1.456***	-1.834***
	(0.428)	(0.213)	(0.162)	(0.459)
Treated	-8.352***	-4.273***	-5.259***	-4.042***
	(0.209)	(0.089)	(0.140)	(0.326)
Constant	226.2***	180.8***	229.8***	214.1***
	(1.646)	(0.887)	(0.415)	(1.793)
Observations	26	26	26	26

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

In contrast, from the results in the compliant/achievers' countries in table 3, we note an unclear pattern in under-five mortality rate decline. For instance, while under-five mortality in Seychelles appears to decline prior to the introduction of the intervention (-0.32; p<0.000, 95% CI=[-0.40, -0.24]), a rising trend is apparent both at the start of the MDGs (0.51; p=0.044, 95% CI= [0.01, 0.99]) and post-MDGs (0.07; p<0.000, 95% CI= [0.05, 0.09]). Botswana recorded an annual increase of 4 under-five mortality deaths (4.0; p<0.000, 95% CI=[3.77, 4.21]) prior to the introduction of the intervention, followed by a statistically insignificant reduction at intervention, but experienced a statistically significant annual decline of about 4 deaths per 1,000 live births post intervention (see column 1, Table 3)

A test for autocorrelation was conducted given that the current mortality level is likely to be correlated with previous observations (a potential case of serial dependence) and this is common when using linear regression models to t-time series data. We uses the "actest" command in Stata (Baum and Schaffer 2013) to test for autocorrelation. From the results, autocorrelation was only present at lag (1) but not at any higher lag orders. We argue that the Newey OLS regression-based model specifying lag (1) used in fitting data is sufficient to account for any potential autocorrelation.

Table 3. ITS Regression Results for Selected MDG Achiever countries (Newey-West OLS)

Variables	(1) Botswana U5MR	(2) Capo-Verde U5MR	(3) Mauritius U5MR	(4) Seychelles U5MR
_t	4.005***	-2.085***	-0.0976	-0.318***
	(0.106)	(0.393)	(0.105)	(0.0400)
_x2000	-0.960	-10.89***	-4.189***	0.506**
	(1.541)	(3.323)	(0.971)	(0.237)
_x_t2000	-7.513***	1.387***	-0.101	0.387***
	(0.216)	(0.379)	(0.102)	(0.0424)
Treated	-3.508***	-0.699***	-0.198***	0.068***
	(0.182)	(0.124)	(0.045)	(0.009)
Constant	49.86***	63.27***	22.27***	16.18***
	(0.625)	(1.812)	(0.499)	(0.214)
Observations	26	26	26	26

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Robustness Checks

A brief historical account of the development of the MDGs suggests that it has its roots in the World Summit for Children in 1990 (Bradford, 2002).[6] We reasonably suspect that this might have introduced some time varying confounders that are likely to affect the outcome. In other words, we tested for an "interruption" away from the true start of the MDGs in 2000. To investigate if such an effect exists, we used a multiple-baseline design whereby the intervention is introduced at two different periods (hypothetically):1990 and 2000. We extended our aggregate outcomes series to start from 1980 and re-estimated our model. From tables 1A.2 and 1A.3 (Appendix), a hypothetical programme intervention in 1990 did not indicate any reduction in under-five

[6] The World Summit set specific goals on global child and maternal mortality, reduction in malnutrition, completion of primary education, and adult literacy and access to safe water and sanitary services. There were follow-up summits within the same periods such as the 'Earth Summit' or 'Rio Summit' by the United Nations Conference on Environment and Development in June 1992, the World Conference on Human Rights in Vienna in 1993 and the Rome International Conference on Food and Nutrition in 1992. These summits motivated discussion on the global need to achieve freedom from hunger, which later became an MDG target of halving the number of malnourished people (Hulme, 2009).

mortality. In other words, there is no evidence of a “treatment effect” beginning in 1990. In fact, there appears to be a rising under-five mortality trend in the year of the hypothetical intervention for all the selected countries except Mauritius, where a statistically insignificant decline appears to exist, as seen in column 3, Table 1A.3 (Appendix). Thus, we conclude that a statistically significant MDG treatment effect is only present at the true intervention year for all the selected countries. Thus, our choice of 2000 as start year is valid.

We had implicitly assumed that the under-five mortality decline would occur with a year lag. This assumption was relaxed, and the model re-estimated assuming a gradual reduction in mortality with a two-year lag period. The results in columns 1 &2 (Table 1) using the Newey-West OLS were robust to variation in lag. We investigated whether the estimated treatment effects are robust to alternative definitions of child mortality. Two definitions were used: neonatal mortality and infant mortality. Results presented in table 1 indicate a statistically significant treatment effect at the introduction of the MDGs for both child mortality outcomes.

An alternative approach to correct for the likelihood of residual autocorrelation is the use of the Prais-Winston estimator, which implements the generalized least-squares method.[7] The Prais-Winston estimator transforms the time series by removing possible dependencies before analysing the treatment effects using the generalized linear model. In addition to using the Prais-Winston estimator, we specify the rhotype (tscorr) option, which bases rho on the autocorrelation of the residuals, and adds robust standard errors. The results indicate marginal changes in the treatment effect estimates after the above adjustment. This is because the estimates produced by Prais are transformed and are not directly comparable with those of Newey, produced using the OLS estimator. However, these results in general confirm a significant decrease in the annual trend of under-five mortality at the start of MDGs for the SSA region. The Durbin-Watson statistics showed no evidence of autocorrelation, given its p-value ($p>0.05$).

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[7] Using the Prais-Winston alternative, a Durbin-Watson d statistic is provided as an indicator of how well the model corrects for rst-order autocorrelation. Formally, the D-W can take on values between 0 and 4 under the null hypothesis that d is equal to 2. If the value of d is less than 2, a positive autocorrelation ($p > 0$) is suggested. On the other hand, if the value of d is greater than 2, a negative autocorrelation ($p< 0$) is inferred.

5. Discussion

Findings from this study suggest fluctuations in child mortality trends across countries and over time in the SSA sub-region. Similar findings have been reported in the literature (Garenne, and Gakusi, 2006; Garenne, 2015; Adetunji and Bos in Jamison, Feachem, and Makgoba, et al., 2006). Assessing fluctuation in the aggregate under-five mortality trend for the SSA sub-region, we discover that a statistically significant reduction in the trend of under-five mortality appears to have begun before the introduction of the MDGs. However, a significant jump was apparent at the introduction of the MDGs, which could possibly be causally associated with the intervention. In other words, there is evidence of a treatment effect beginning at the introduction of the intervention, but also no additional decrease in the rate of mortality decline after the intervention. In fact, there was a reduction in the rate of decline in under-five mortality post-intervention for the SSA region.

The above effect is consistent with theory and can be explained using mechanisms that delineate relationships between child mortality and public health programmes promoted in the MDGs. For instance, the reduction in child mortality may have occur through the MDG 5 target that encourages programmes that reduce maternal mortality and improve reproductive health of women. The introduction of programmes that promote antenatal visits, family planning and use of maternal and child health care services is likely to reduce maternal mortality and improve child survival. Also, MDG 6 is expected to initiate and promote actions that control infectious diseases such as HIV/AIDS and malaria. A common medium of paediatric HIV infection is through vertical transmission during breastfeeding. Chances are high, 6 in 10 children, that HIV infected children are unlikely to survive their fifth birthday (Walker and Peter, 2003). Moreover, for surviving children, the mortality rate if the mother is infected with HIV/AIDS or becomes critically ill from HIV/AIDS, is reported to be higher compared with mortality after mother's death (Clark, Kahn, Houle, Arteche et al., 2013). Programmes that prevent mother to child transmission (PMTCT) which appear to be scaling up especially after the declaration on HIV/AIDS by the UN member states at the United Nations General Assembly meeting on AIDS in 2006, could have reduced paediatric HIV infection and consequently, child mortality.

Further, apart from the cost of illness (direct and indirect), malaria which is endemic to the SSA region is a major contributor to under-five mortality. It is common to find interventions associated with leading causes of child mortality in the region, such as malaria, pneumonia, diarrhoea, tuberculosis, and measles which have been identified with MDG 6 (for example, the Global Fund to fight AIDS, Tuberculosis, and Malaria). To be precise, prevention programmes against malaria, such as the distribution of insecticide treated nets, are known to be effective in preventing malaria especially where vectors bite indoors and at night (Alonso, Lindsay, Armstrong, et al., 1991; Lengeler, 2004; Phillips-Howard, Nahlen, Kolczak, et al., 2003; Steinhard, et al., 2016). It is likely that such programmes promoted by the UN have had impact in the reduction of child mortality in the region.

In addition, while MDG 2 (Achieving universal primary education) in part, is expected to increase the literacy rate of 15-24 years old, MDG 3 (Promote gender equality and women empowerment) is design to eliminate gender disparity in education at both the primary and secondary levels. Contributions of both goals (MDGs 2 and 3) to child health can be expressed through the role of mothers' education in child health. Literature is replete with evidence on the effect of mothers' education on child health especially in developing countries (For instance, Aslam and Kingdon, 2010; Desai and Alva, 1998). Pathways through the income effect, informational effect, and bargaining power effect are also well documented in the literature.

Finally, public health programmes that expand coverage of provision of safe water provision and improved sanitation as contained in MDG 7 are known to influence child mortality. Provision of safe water and improved sanitation can interrupt the transmission of diarrhoea at their sources. While diarrhoeal and other water-borne diseases can be effectively prevented through the provision of safe water, environmental sanitation can prevent the contamination of food and water at the household and individual level and reduce mosquito infestation. In addition, there are health programmes such as the low-osmolarity Oral rehydration salt (ORS) intervention sponsored by international health institutions such as the UN. The ORS is reported to reduce diarrhoea mortality in children by up to 90 percent (Koletzko and Osterrieder, 2009; Carvajal-Velez, et al., 2016). Perhaps this explains why countries with high coverage in preventative programmes have low under-five mortality rates. For instance, Seychelles and Mauritius, with significantly low under-five mortality due to diarrhoea, have extensive coverage of their population with safe-water provision (above 90% in both countries) (World Bank, 2018). More specifically, in Mauritius, the existing integrated water project is comprehensive, addressing both domestic water supply and sanitation problems. Similarly, the Seychelles integrated water strategy design to ensure sustainable and equitable development of water, land, coastal and estuarine environments is in effect. The integrated water projects have been in existence pre-MDGs and can be reasonably argued to be responsible for the zero-under-five death attributable to diarrhoea over time in both countries.

Limitations and scope for further research

In establishing a trend, the World Bank poverty data catalogue was relied upon for data. World Bank data is famous for using interpolations and extrapolations to fit observations. A fundamental weakness of extrapolation is that historical patterns may not hold for the future and structural changes might be missed. Caution should be exercised in the interpretation of effect estimates from such data. Further, a limitation to the findings from the ITSA model is the absence of a comparable "control group" to present a more robust causal inference. Adding a control group to this model could strengthen causal inference if the groups are comparable on the baseline level and the trajectory of the dependent variable. Also, the MDGs appear to be limited in the design to measure progress in the SSA region. It remains unclear how the effect of counterfactuals can be separated from the effectiveness of the intervention. Perhaps, using statistical techniques that can isolate the MDG effect from national interventions would be an important addition to this study. Finally, to draw policy conclusions, it will be relevant to provide more robust empirical evidence of causal pathways of the health-related MDGs.

6. Conclusion

This study has demonstrated that evidence of reduction in child mortality among sub-Saharan African (SSA) countries is mixed. Though there appears to be a consensus in the literature that under-five mortality has declined considerably in developing countries, the inability of the SSA region to meet the MDG4 target is a promise not kept to children, especially those in poverty, and this has implications for both international and national stakeholders of child health promotion. A sustained reduction in under-five mortality rate for the SSA region will be vital in meeting global child survival targets in the on-going SDGs.

Using the ITSA framework, we investigated the treatment effect of the MDGs on child mortality reduction for the SSA region as well as for groups of stratified countries. For the SSA region, we discovered a statistically significant MDG treatment effect. That is, a significant jump was apparent at the introduction of the MDGs that could possibly be causally associated with the intervention. The uncovered MDG treatment effect among the selected countries points to the fact that public health interventions were likely operational in influencing the marked reduction in under-five mortality. Also, we noted a dwindling in the rate of decline post-intervention points for some countries, which is suggestive of a reversal of gains in child survival recorded at the introduction of the intervention. With the SDGs targets of reducing neonatal mortality to at least as low as 12 deaths per 1,000 live births and under-five mortality to at least as low as 25 deaths per 1,000 live births by 2030, it becomes imperative to identify interventions that can effectively fast track progress in child mortality reduction efforts. The SDGs could focus on preventative actions such as the provision of safe water. Reactivating rural water projects and urban water development schemes could also be a plausible way forward. For rural communities, interventions to increase the number of stand posts, dug wells and tube wells can be a meaningful action to increase the percentage of rural dwellers with improved access to safe water. Reducing the travel time to access water supply in rural areas can also be a useful way to reduce time poverty, especially for females. On the other hand, urban settlements will require interventions that improve house connections (piped system). An extension of integrated interventions such as the water, sanitation and hygiene interventions (WASH) that include the provision of clean piped drinking water, enhanced facilities for excreta disposal and the promotion of handwashing with soap to rural areas where a disproportionate under-five mortality occurs could be relevant in the on-going SDGs. This is vital given the ease of spread of infectious diseases from unhygienic domestic practices.

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Appendices

Table 1A.1. Mean Child Mortality Rates of Selected SSA countries (1990-2015)

Country	1990-95	1996-20	2000-05	2006-10	2010-15
Infant Mortality Rate					
Angola	132.1	128.33	113.18	88.98	66.18
E. Guinea	119.36	112.98	100.95	87.08	74.88
Mali	127.04	120.98	105.4	85.98	73.85
Nigeria	124.88	118.13	104.03	88.4	74.58
SSA	105.9	98.56	85.78	71.47	59.6
Botswana	41.86	49.05	47.8	41.18	36.23
Cabo-Verde	46.84	37.58	24.18	21.95	19.3
Mauritius	18.82	19.15	14.2	13.95	13.1
Seychelles	13.92	12.05	11.8	12.1	12.35
Neonatal Mortality Rate					
Angola	53.98	52.63	47.68	40.08	33.35
E. Guinea	47.84	46.08	42.8	37.8	33.65
Mali	69.96	61.98	51.1	43.3	38.7
Nigeria	50.74	49.98	45.35	40.15	36
SSA	45.01	42.53	38.42	34.08	30.23
Botswana	25.28	25.35	28.18	31.03	28.8
Cabo-Verde	20.38	19.3	14.9	14.88	13.6
Mauritius	14.22	14.9	10.2	9.73	9.18
Seychelles	10.5	8.8	8.775	8.85	8.725
Under-five Mortality Rate					
Angola	223.62	216.8	189.1	144.05	102.95
E. Guinea	175.96	165.4	145.85	123.83	104.58
Mali	246.86	232.7	196.53	151.55	123.98
Nigeria	210.56	198.23	171.95	143	117.95
SSA	177.52	164.08	140.18	113.03	90.34
Botswana	57.72	80.25	82.78	60.58	45
Cabo-Verde	60.74	47.28	28.9	26.03	22.7
Mauritius	21.74	21.8	16.08	15.83	14.8
Seychelles	15.64	13.8	13.775	14.15	14.4

Source: Author's computation.

Table 1A.2 ITS Regression Results for Selected Non-MDG Achiever countries (Newey OLS) using two intervention periods: 1990 and 2000

VARIABLES	(1) Angola U5MR	(2) E.Guinea U5MR	(3) Mali U5MR	(4) Nigeria U5MR
_t	-1.679***	-2.900***	-7.037***	-0.0158
	(0.218)	(0.221)	(0.210)	(0.269)
_x1990	6.879***	4.670***	4.577***	4.552*
	(2.369)	(1.628)	(1.443)	(2.404)
_x_t1990	0.452	0.952***	3.234***	-2.192***
	(0.395)	(0.276)	(0.239)	(0.443)
_x2000	-6.607**	-5.422***	-6.618***	-13.02***
	(2.639)	(1.586)	(1.677)	(3.977)
_x_t2000	-7.125***	-2.325***	-1.456***	-1.834***
	(0.432)	(0.216)	(0.163)	(0.463)
Treated_1990	-1.227***	-1.948***	-3.803***	-2.208***
	(0.363)	(0.204)	(0.115)	(0.376)
Treated_2000	-8.352***	-4.273***	-5.259***	-4.042***
	(0.211)	(0.090)	(0.141)	(0.329)
Constant	236.1***	199.4***	295.6***	209.8***
	(1.133)	(0.881)	(0.997)	(1.669)
Observations	36	34	36	36

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 1A.3 ITS Regression Results for Selected MDG Achiever countries (Newey OLS) using two intervention periods: 1990 and 2000

VARIABLES	(1) Botswana U5MR	(2) Capo-Verde U5MR	(3) Mauritius U5MR	(4) Seychelles U5MR
_t	-2.469***	-2.928***	-1.533***	-1.416***
	(0.283)	(0.221)	(0.216)	(0.149)
_x1990	5.498***	1.088	-0.411	1.608*
	(1.733)	(2.097)	(1.246)	(0.804)
_x_t1990	6.474***	0.842*	1.435***	1.098***
	(0.328)	(0.473)	(0.244)	(0.160)
_x2000	-0.960	-10.89***	-4.189***	0.506**
	(1.552)	(3.348)	(0.978)	(0.238)
_x_t2000	-7.513***	1.387***	-0.101	0.387***
	(0.218)	(0.382)	(0.103)	(0.0427)
Treated_1990	4.005***	-2.086***	-0.098	-0.318***
	(0.107)	(0.396)	(0.105)	(0.040)
Treated_2000	-3.508***	-0.699***	-0.198***	0.0684***
	(0.183)	(0.125)	(0.045)	(0.009)
Constant	69.05***	91.47***	38.01***	28.73***
	(1.354)	(1.197)	(1.386)	(0.848)
Observations	36	36	36	36

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1