

The role of health systems strengthening and HIV in under-five mortality trends: time series
analyses from 2000 to 2010 in Mozambique

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Abstract

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Globally, the number of deaths of children under 5 (U5) decreased substantially from 12 million in 1990 to about 6.9 million in 2011; during the same period under five mortality (U5M) decreased steadily in Mozambique as a result of the implementation of several interventions. This study aimed to determine the role of health systems strengthening and HIV in U5 mortality trends in Mozambique. We performed an exploratory analysis with U5M as the outcome variable. First, we conducted a univariate analyses by provinces over time periods, as well as Pearson correlations between each independent predictor and the outcome; second a bivariate analysis was performed to determine the association between each independent variable and the outcome variable followed by a multivariate analysis. Model selection was achieved by using backward selection where in each step were removed the variable with the highest p-value, The

final significance level selected was 0.05. Overall the U5M in Mozambique dropped substantially during 2000 to 2010 and for each additional year we predicted a decrease of 7.4 per 1000 live births of the U5M on average across all provinces (95% CI: -9.4 , -5.3). After adjusting for time trend population per health facility with $\beta= 2.7$ (95% CI 0.19, 5.2), health work force density with $\beta= -0.41$ (95% CI: -0.81, -0.01) and institutional birth attendance $\beta= -0.45$ (95% CI:-0.77, -0.14) remained significantly associated to U5M. These results suggest that improvements on health human resources particularly with maternal and child nurses and interventions which resulted in improvements of institutional birth attendance were important in the reductions of the U5M rates in Mozambique during the period of the study. If these results are confirmed with other studies, investments on health should prioritize innovative interventions to accelerate human resources trainings, health infrastructure buildings and better access and quality of services for pregnant women.

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Acronyms

AIDS	Acquired Immunodeficiency Syndrome
DHS	Demographic Health Survey
GDP	Gross Domestic Product
HAART	Highly Active Antiretroviral Therapy
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
HWD	Health Workforce Density
IMCI	Integrated management Childhood Illnesses
INSIDA	HIV Community Survey
MDG	Millennium Development Goals
MICS	Multiple Indicator Cluster Survey
MOH	Ministry of Health
NGO	Non-governmental Organization
OE	Government Revenues
PMTCT	Mother to Child prevention
U5M	Under Five Mortality
UN	United Nations
UNICEF	United Nations Children's Fund
WHO	World Health Organization

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Dedication

I dedicate this thesis to my parents Cacilda Tam-san and Francisco Fernandes for the words of encouragement during my entire journey and to my loving wife Naziat Carimo and kids Denilson Fernandes and Ivans Fernandes for their love and warmth.

I. Introduction and background

The Millennium Development Goals (MDG's), and particularly the MDG 4 (reduction of 2/3 of child mortality by 2015), have dominated the agenda of governments in sub-Saharan Africa where child mortality still a challenge. According to a UNICEF 2012 progress report, globally, the number of deaths of children under five has decreased substantially from 12 million in 1990 to about 6.9 million in 2011[1]. This rate of decline almost doubled from 1.8% to 3.2% in the same period, with most of these achievements being attributed to considerable integrated efforts made by states and governments as a result of their clear commitment to the MDG's. Despite these improvements there are still significant differences between and within regions. Currently, sub-Saharan Africa and southern Asia are the regions with the highest under five mortality (U5M) rates, with India (24%) and Nigeria (11%) together accounting for about 35 percent of all deaths of children under five worldwide [1]. Mozambique signed the MDG declaration in 2000 and has since introduced several initiatives and reforms to strengthen health systems, including decentralization of funding streams, acceleration of health human resources training and recruitment, new vaccines, malaria and HIV interventions, and targeting vulnerable areas and populations [2, 3]. All of these efforts were part of the government's national agenda to fight poverty, integrating other key components like nutrition, access to water and sanitation and education [4]. In the same period Mozambique progressed satisfactorily towards achieving MDG4 as the U5M rate decreased from 153 (DHS 2003) to 97 (DHS 2011) per 1,000 live births, representing an annual rate of decline of 1.2 percent in urban areas and 7.3 percent in rural areas [5-7]. However, despite these major and significant improvements, the U5M rate remains high and worrisome since Mozambique is among the 25 countries in the world with the highest U5M rate, and there are considerable disparities among provinces, ranging from 58 per 1,000 live

births in Inhambane to 142 in Zambezia [7]. More than 75 percent of child deaths are attributable to infectious and preventable disease; malaria is the number one cause of death in children (42.3%) followed by HIV (13.4%), pneumonia (6.4%) and diarrhea (5.9%) [8, 9]. Among children aged 0-11 months and 1-4 years the HIV prevalence is 2.3% and 1.7%, respectively [10, 11]. These diseases including malnutrition are recognized to contribute negatively to U5M even when programs to accelerate reduction are established [12].

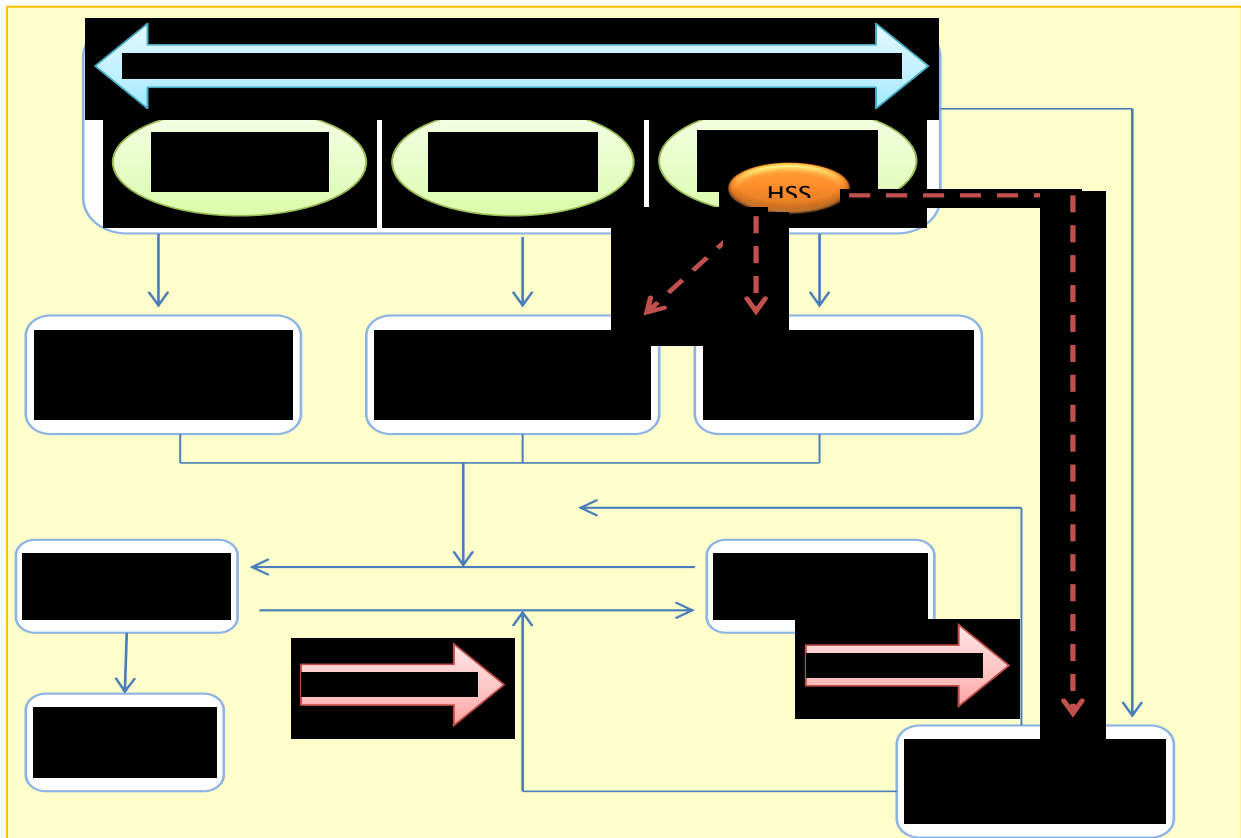
The ministry of health's (MOH) approach of health systems strengthening (HSS) is perfectly aligned with the governmental vision of service integration and may have contributed significantly to improvements in all 6 building blocks of the world health organization (WHO) framework (health service coverage, human resources, health information systems, medical products, vaccines and technologies, health financing and, leadership, and governance) [13]. The health workforce density (HWD) increased substantially from about 39.4 per hundred thousand people in 2000 to 63.2 in 2010 [14, 15]. Notwithstanding these improvements, Mozambique's HWD is still far from the 230 per 100,000 population as recommended by the WHO[14].

Similarly the ratio of doctors per hundred thousand inhabitants has increased from 2.51 in 2000 to 3.62 in 2010, but still much lower than other countries in the region and far from the 20 per 100,000 recommended by the WHO. Currently the public sector has about 1,435 health facilities which represent an increase of 12 percent over the last 5 years (since the last 2007 infrastructure survey), yet almost 50 percent of beds are located in Maputo, Beira, and Nampula Central Hospitals [16]. Global health expenditures in Mozambique were, 6.2 percent of Gross Domestic Product (GDP) in 2009, representing a per capita health expenditure of about USD \$27[3].

The determinants of child mortality have been deeply studied and the mechanisms through which they interact were described by Mosley and Chen (1984) who suggested that "all socioeconomic

determinants of child mortality necessarily operate through a common set of biological mechanisms or proximate determinants that ultimately influence the risk of the disease and the outcome of the disease process” [17]. Mosley grouped the proximate determinants into 5 categories: maternal factors, environmental contamination, nutrient deficiency, injury and personal illness control. Furthermore, he also grouped the socioeconomic determinants in three broad categories including individual, household, and community level variables.

Figure 1: Conceptual framework



Adapted from Mosley & Chen (1984)

Based on Mosley’s model one would hypothesize that HSS is strongly related to child mortality reduction by influencing proximate determinants of personal illness control, (personal illness control) whether by establishment of conditions to prevent disease or by providing appropriate

resources for treatment of the most direct causes of death. Given the broad definition of the health system it is always possible to argue for relationships between HSS and any of the U5M proximate determinants. Indeed, child death is a result of multifactorial causation, and it is not always easy to determine the most important factor [18-21]. Using this model, it is necessary to understand the complexity of underlying mechanisms and interactions that result in a child's death. Considering that Mozambique is among the four African countries with the highest poverty rate and ranked third to last globally in the 2013 human development index (HDI) report, this complex causal model represents our knowledge of the determinants of U5M in Mozambique and can be used to understand deeply and explain the child mortality scenario in the country [22]. In Mozambique different studies indicate that the main determinants of infant mortality are associated with antenatal care, birth order, the child's weight at birth, the mother's level of education, access to water and sanitation, the local birth, age of mother at delivery and place of residence [19, 23, 24].

Over the past decade a lot of interest has concentrated on HSS and several studies have been conducted to verify its role in child mortality. An exploratory cross-sectional analysis of UN member countries has established important associations between potential indicators of HSS and child mortality. Results of this study, which used linear and multiple linear regression models, showed significant associations between physicians density (aRR 0.80; 95% CI 0.70-0.92), out-of-pocket expenditure on health (aRR 1.29; 95% CI 1.01-1.65) and child mortality [25, 26]. Similarly Sudhir Anand, et al. (2004) in his cross-country study of human resources and health outcomes demonstrated that human resources density and doctors density remained significantly associated with child mortality after adjusting for gross national income per person and female adult literacy rates [27]. More recently Honorati Masanja (2008) in a study of child

survival in Tanzania demonstrated a high correlation between improvements in child mortality (about 40% reduction of child mortality) and HSS which included increased public expenditure on health, funding decentralization, and increased coverage of key child survival interventions[28]. Although findings are consistent regarding human resources density and service delivery, there are some different results regarding the role of public health expenditure worldwide. Using data from 127 countries, Bokhari et al. (2007) concluded that a 10% increase in per capita public health expenditure was associated with an average reduction of U5M of 3.3% [29, 30]. On the other hand, Kaushalendra Kumar (2011) found in a study of Public Spending on Health and Childhood Mortality in India that a 10% increase in per capita public health expenditure was associated to 3.2% reduction of infant mortality, but this association was insignificant after adjusting for other variable[30-32]. To date, and so far as we know, there are no studies assessing the role of HSS in U5M trend in Mozambique. A recent study of “Geographic differentials in child mortality in Mozambique” (Gloria Macassa, et al. 2012) suggested the need to account for HSS indicators when studying U5M determinants in Mozambique [23].

To achieve the MDG 4 target by 2015, Mozambique must increase the reduction of mortality rates to 4.3% per year compared to current reduction of 3 percent [6]. Thus, it is necessary to understand the role of the different determinants that contribute to child mortality, including the role of HSS. This study aimed to determine whether HSS was associated with U5M reduction at the provincial level over the period of 2000 to 2010. We focused our attention on assessing the role of health facilities building and upgrading and human resources allocation and the availability and financial allocation across provinces. We hypothesized that improvements in these components of the health systems may have contributed to the actual trend of the U5M in

each province in Mozambique. Additionally, we aimed to determine whether U5M was associated with HIV prevalence at the provincial level, hypothesizing that the U5M rate was positively associated with HIV prevalence.

II. Methods

II.1 Study Design, data sources and variables

Based on disseminated data from 2000 to 2010, a descriptive quantitative study was conducted to evaluate the role of HSS and HIV in the trend of U5M in all 11 provinces of Mozambique. This was a secondary analysis which used data from official reports of the National Institute of Statistics, National Institute of Health and other relevant and reliable sources at the MOH mainly the Health Information System (HIS) and programmatic parallel databases.

The outcome variable of this study was U5M computed based on the 2003 and 2011 demographic health surveys (DHS) and the 2008 Multiple Indicator Cluster Survey (MICS). In these surveys the U5M was defined as the probability of a child die before five years of age and was obtained based on full birth histories of women aged 15 to 49 years. From full birth history data we used the standard life table method to determine the probability of a child dying before their fifth birthday. Each of the three data sources used (DHS 2003, DHS 2011, and MICS 2008) were used to retrospectively estimate yearly estimates of U5M from 2000-2010. That is, the DHS 2003 resulted in yearly estimates from 2000-2003, the MICS 2008 resulted in yearly estimates from 2000-2008, and the DHS 2011 had yearly estimates for the whole study period (2000-2010). The final outcome measure of annual U5M for each province was calculated by averaging each existent yearly U5M point estimate based on the three survey datasets since the methods and the sample size of the three surveys were similar. The 2003 DHS interviewed

12,315 households in which 12,418 women aged 15 to 49 participated with a complete response rate of 91%; similarly the DHS 2011 interviewed 13,964 households where 13,718 women participated and with a complete response rate of 98.9%. The MICS 2008 interviewed 13,955 households with a complete response rate of 97.9%.

To evaluate human resources allocation and availability, data was gathered from the human resources observatory 2011, the health sector review 2011, and MOH and provincial annual reports. The human resources observatory has disaggregated (by province and by categories) and updated data of human resources allocation for the period of this analysis, including all health professionals trained at health education institutions. Using the population annual projections we computed the HWD ratio as well as other important human resources indicators for each year between 2000 and 2010. HWD was defined as the number of physicians, nurses, midwives, medical assistants (clinical, surgery and psychiatry technicians), and environmental public health workers per 100,000 population. Doctor density and midwife density was defined as the number of doctors (physicians) or midwives per 100,000 people. Physicians and other health providers who had their primary job location at the ministry of health offices were excluded from the workforce density calculation.

Additionally, based on the annual financing reports we calculated health expenditures per capita using the annual provincial health expenditures. For the purpose of this study, expenditure on health was defined as expenditure of the provincial health budget coming from two different sources: the government funds and donors' funds allocated through a common budget (Prosaude). The central level management MOH budget and vertical funds were excluded from this analysis given the current constraints to get reliable provincial expenditures of these two

sources. Thus, the health expenditures per capita used in this study represents a proxy of the global expenditure on health at the provincial level.

Health services delivery was assessed by including in the model two main indicators, the population per health facility and institutional birth attendance (%). The 2008 national survey of infrastructure and the national HIS (*Módulo Básico*) were the main sources of data for these indicators. Annual population per health facility was defined as the total number of people at a given year over the total numbers of health facilities in the same period, regardless the level of the health facility. Birth attendance was defined according to WHO protocols as a birth attended by a skilled birth attendant who was a health professional such as a midwife, doctor or nurse and who had the skills to manage normal (uncomplicated) pregnancies, childbirth and the immediate postnatal period, and in the identification, management and referral of complications in women and newborns.

Provincial-level Gross Domestic Product (GDP) per capita was defined as the total annual production divided by the total population of the province. For this study, GDP per capita data was gathered in the profile of human development in Mozambique 2012, produced by the National Institute of Statistics [33].

HIV prevalence in Mozambique is monitored through a surveillance system established in 36 health facilities representing the 11 provinces. In 2009 the first national HIV/AIDS community based survey was conducted and provided better estimates of HIV prevalence. HIV prevalence amongst children under 5 used in this study was collected in the 2009 demographic impact of HIV report, which for the first time provided HIV prevalence estimations computed using

information from the surveillance system, the INSIDA, the census 2007, as well as data from PMTCT (prevention of mother to child transmission) and HIV programs.

To ensure quality, data gathered from different sources was triangulated and we selected the most consistent data from the different sources. Additionally, data resulted from the calculations made for this study were sent to the MOH in Mozambique for verification of the consistency, as well as final approval before data analyses was undertaken.

II.2 Statistical analysis

We conducted an exploratory analysis where the outcome and all independent variables were treated as continuous and none of them were log transformed. Since repeated time-series measurements over the 11 years (2000-2010) were clustered within provinces, and the study looked at changes of U5M over time, we used a linear mixed model with random intercepts for province and random slopes for time to generate better estimations of the coefficients and provide accurate standard errors. The necessity for random slopes was determined by looking at line plots of crude U5M over the 11 years and determining a large amount of variation in U5M rates over this time period. First, univariate analyses by provinces and over time periods, as well as Pearson correlations between each independent predictor and the outcome were conducted. Second, Bivariate analyses were performed to determine the association between each independent variable and the outcome (U5M) followed by a multivariate analysis which included each independent and the time variable to adjust for the linear time trend in U5M. Last, a multivariable model was built, with Model selection made using backward selection where in each step we removed the variable with the highest p-value, with a final significance level of 0.05. Maputo city has the biggest hospital in the country which holds residence programs for medical doctors for years, and with urban health facilities adapted to high demand and high

population density. These specific characteristics contribute to a different pattern of resources allocation and availability when compared to other provinces. For this reason, and knowing that only in 2005 Maputo city was effectively considered a province, was decided to exclude Maputo City from the analysis to reduce bias.

All the statistical analysis was conducted using Stata 12 (College Station, TX). This study was given an IRB exemption since it was based on secondary publicly available data.

III. Results

Table 1 illustrates the means and standard deviations of the main variables of the study.

Zambezia, with 169.6 deaths per 1,000 live births, followed by Cabo Delgado with 160 deaths per 1,000 live births, were the provinces with the highest mean U5M. On the other hand, Inhambane, with 93.9 per 1,000 live births, had the lowest mean U5M over the entire period of analysis. Overall, Nampula and Zambezia were the two provinces with the highest mean population per health facility with 19,020 and 20,154 people per health facility, respectively. Additionally, these two provinces had, on average, the lowest health workforce density and expenditure on health when compared to other provinces.

As expected, the descriptive statistics of Maputo city showed a different pattern regarding the indicators of resources availability, with a HWD almost two times higher than the other provinces and expenditure on health about 4 times higher.

Table 1: Descriptive statistics

Province	U5M	population per health facility	Birth attendance	health workforce density (per 100000 people)	global expenditure on health (per capita)	Gross Domestic product per capita
	mean (sd)	mean (sd)	mean (sd)	mean (sd)	mean (sd)	mean (sd)
Niassa	126.5 (26.3)	8151.0 (672.5)	72.1 (12.8)	38.70 (10.3)	4.4 (1.3)	186.7 (36.8)
Cabo Delgado	160.0 (49.6)	15673.5 (450.1)	40.2 (13.9)	39.80 (11.5)	3.3 (1.4)	191.0 (60.5)
Nampula	104.2 (34.8)	19020.7 (1395.4)	43.3 (14.9)	38.70 (10.3)	2.9 (1.0)	258.7 (61.3)
Zambezia	169.6 (20.8)	20154.4 (806.9)	39.1 (9.5)	31.78 (8.7)	2.2 (0.7)	164.9 (47.4)
Tete	157.4 (19.6)	15407.4 (2093.7)	47.6 (3.8)	41.95 (3.9)	2.9 (0.8)	242.0 (41.2)
Manica	138.5 (22.7)	15693.0 (893.5)	56.0 (8.2)	45.62 (8.2)	3.3 (1.1)	184.3 (40.5)
Sofala	124.6 (34.5)	10687.2 (1130.4)	52.1 (9.2)	64.34 (8.3)	5.8 (1.8)	427.8 (114.6)
Inhambane	93.9 (21.2)	13005.6 (978.5)	44.0 (3.9)	57.17 (17.1)	3.8 (1.4)	374.8 (153.7)
Gaza	131.6 (16.8)	10376.2 (503.8)	51.7 (5.6)	50.51 (50.5)	3.7 (1.1)	251.2 (85.3)
Maputo Province	103.0 (7.0)	13511.4 (2140.7)	41.3 (4.6)	47.47 (4.9)	3.8 (1.1)	1000.7 (220.7)
Maputo City	89.7 (6.8)	25773.4 (2916.6)	78.8 (6.7)	132.57 (15.9)	14.1 (4.5)	1110.9 (343.0)

Irrespective of the differences in the rate of U5M decline among provinces, overall the U5M in Mozambique dropped substantially during the study period as showed in figure 2. For each additional year our linear mixed model predicted that the U5M decreased by 7.4 per 1000 live births on average across all provinces (95% CI: -9.4 , -5.3).

Figure 3 shows that the observed crude U5M based on the DHS and the fitted values based on our linear mixed model were very consistent. From 2000 to 2010, the U5M decreased progressively in almost all provinces, but Cabo Delgado had the most consistent and substantial drop. On the other hand, the U5M remained almost stationary in Maputo province.

Figure 2: Mozambique U5M trend (2000-2010)

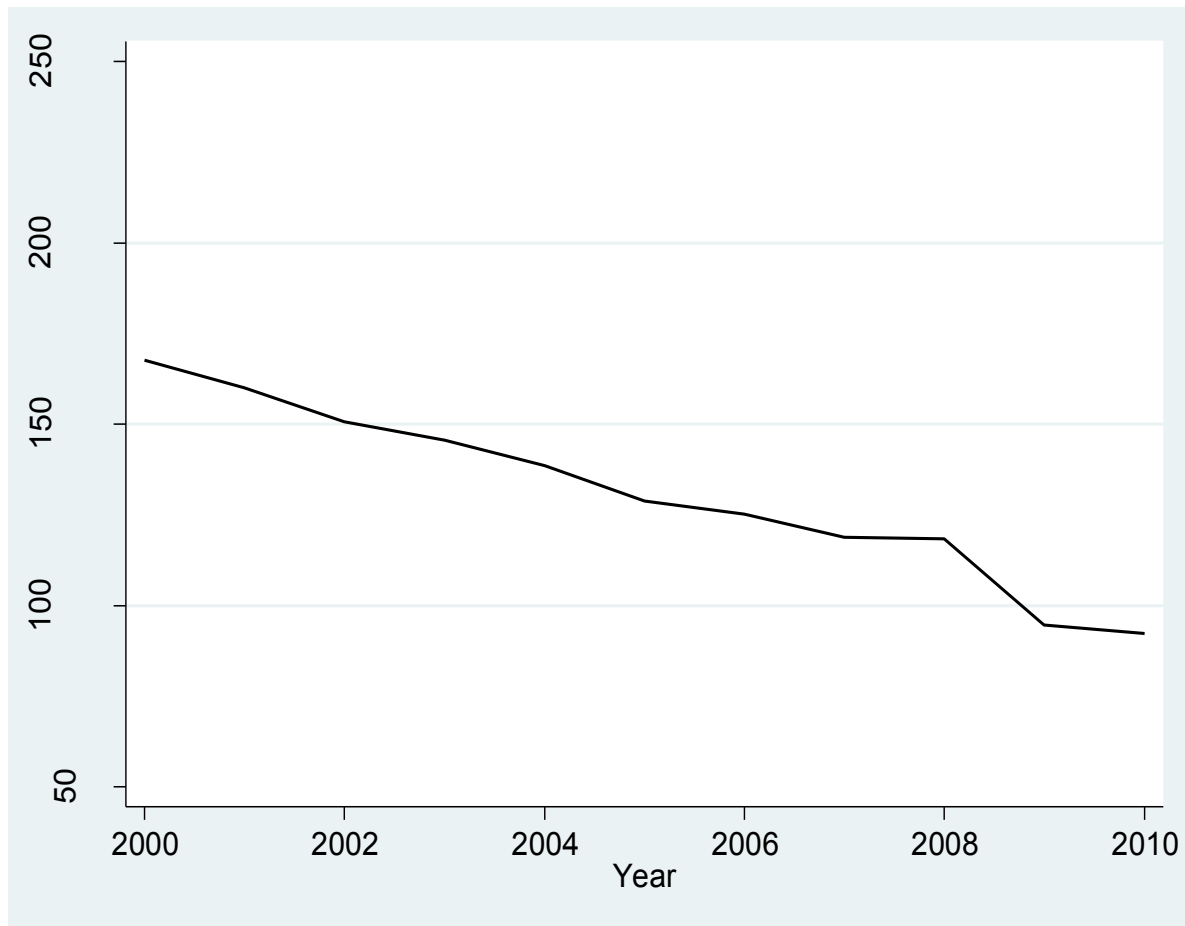
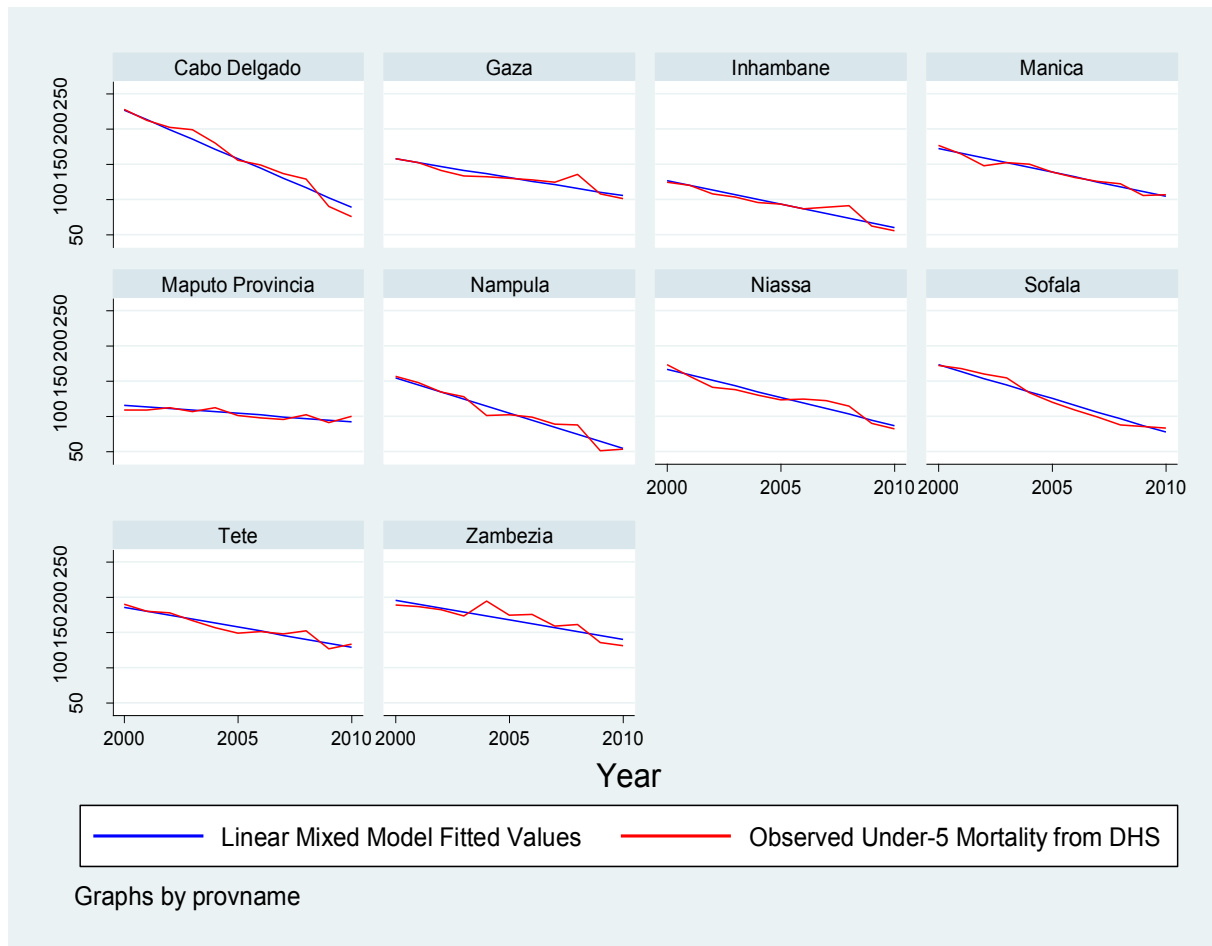


Figure 3: U5M trend by province (2000-2010)



In the bivariate analysis, all variables of interest, with the exception of those measuring health facilities improvements (population per health facility and population per primary health facility), had a significant negative association with the U5M rate. Nevertheless, after adjusting for the linear time trend, population per health facility, population per primary health facility, HWD, midwives density and institutional birth attendance remained significantly associated to the U5M as presented in table 2. We estimate that after adjusting for time trend a one unit higher workforce density is associated with a 0.41 lower mean U5M per 1000 live births (95% CI: -0.81, -0.01). When human resources data was desegregated by different categories, we verified

that midwives density was a stronger predictor of U5M since after adjusting for time trend a one unit higher midwives density was associated to 0.39 lower mean U5M per 1000 live births (95% CI: -0.72, -0.06). Similarly, for each additional percent of institutional birth attendance coverage we estimate that the mean U5M is lower by 0.45 per 1000 live births after adjusting for the linear time trend (95% CI: -0.77, -0.14).

Table 2: Factors associated with provincial-level changes in under-5 mortality in Mozambique, 2000-2010.

Characteristic	Adjusted β [§] (95% CI)
Health Service	
Population per health facility (1,000 person change)	2.7* (0.19, 5.2)
Population per primary health facility (1,000 person change)	2.4* (0.17, 4.7)
Institutional birth attendance coverage (%)	-0.45* (-0.77, -0.14)
Health workforce	
Health workforce density (per 100,000)	-0.41* (-0.81, -0.01)
Doctor density (per 100,000)	-0.62 (-6.1, 4.8)
Maternal & child nurse density (per 100,000)	-0.39* (-0.72, -0.06)
Health financing	
Global health expenditure per capita (\$)	0.17 (-2.6, 2.9)
Public expenditure on health per capita (\$)	-0.67 (-3.7, 2.4)
Prosaude expenditure on health per capita (\$)	3.8 (-2.2, 9.7)
Other variables of interest	
Regional under-5 HIV prevalence (%)	1.0 (-5.2, 7.2)
GDP per capita (\$100 change)	2.2 (-1.4, 5.7)

*P < .05

† P < .001

§ Adjusted for linear time trend in under-5 mortality (2000-2010).

As mentioned before, population per health facility was positively associated with U5M and it was estimated that, on average, each additional 1,000 individuals per health facility was significantly associated with an increase of 2.7 higher U5M after adjusting for the time trend (95% CI: 0.19, 5.2). Interestingly, in the analysis we verified that both HIV prevalence and global expenditure on health per capita were not strongly associated to U5M after adjusting for time. Institutional birth attendance coverage was the only variable that was retained when backward selection procedures were conducted to build a multivariable model.

IV. Discussion

The determinants of child mortality are multifactorial and dynamic in that their influence changes across years and decades. Indeed our results suggested that time was a key factor in the relationship between the independent variables and U5M, which calls our attention for a careful analysis of the results coming from cross-sectional studies of determinants of U5M since they fail to account for this effect. Indeed we confirmed an accelerated decline of U5M during the period of the study and the mean annual decline rate (7.4%) was greater than previous estimations from MICS 2008 (1.2% in urban areas and 7.3 in rural areas).

Corroborating previous studies from other similar countries, our results indicated that improving the availability of human resources at the provincial level in Mozambique had a positive effect in the reduction of U5M. This suggests that policies adopted by the government, particularly those related to acceleration of human resources training and hiring (particularly maternal and child health nurses) and decentralization of its management, may have contributed to better availability of human resources with greater ability to influence positive changes that leading to reductions in child mortality. The contribution of maternal and child (MCH) nurses of about 0.39 U5M mean reduction per 100,000 population for each unit density increase is a rational and

expected outcome considering that the number of nurses increased significantly over the years; MCH nurses play a large and important role in antenatal care and children illness management at primary level, in nutrition education, and in conducting community activities that positively influence determinants of child mortality [27, 34]. Although in the analysis we didn't find the same high level of significance with regard to doctors and U5M, overall the interpretation of this result should be done conservatively since doctors density remains quite low and only in 2010 Mozambique achieved the goal of at least one physician in each district, which means that inequalities between urban and rural areas are still high and as well as the differences between provinces. Moreover, a simple lack of statistical variation in the density of doctors between provinces and within provinces over time may have contributed to the lack of statistical significance. Nevertheless, the estimated beta was in the expected (negative) direction.

Although the coverage of institutional births was significantly associated with reduction of child mortality it is also correlated with the availability of MCH nurses. However, as evidenced in previous studies, institutional delivery not only provides better attention to the pregnant woman but also to the child, particularly in the case of Mozambique where maternal and child nurses are trained regarding these two objectives. In fact, since 2002 personnel providing care to newborns in the delivery room were extensively trained, and in 2006 the integrated management of childhood illnesses (IMCI) manuals were updated to incorporate newborn management and HIV/AIDS modules [35]. These national-level shifts in newborn care could be a factor in the relationship seen in our study between institutional birth attendance and U5M.

Access to health facilities is an indicator which is rarely used and valued in studies of the determinants of child mortality. After adjusting for the time trend, we found it strongly associated to U5M that is, provinces which had a higher ratio of population per health facility

had a higher U5M. These results are consistent with our expectations and are of enormous value for definition of policies, since to keep the U5M reduction trend or maintenance, large investments in infrastructure are needed at a pace that follows the current population growth which, in Mozambique, is still characterized by high fertility rates. On the other hand, these results should stimulate deeper analysis about the prioritization of resource allocation in the sector, either by the government or by key partners that support programs for reduction of child mortality.

Given data availability constraints we used only two funding sources as a proxy of the global provincial expenditure on health. For this reason, the analysis of the results should be made with caution since considerable programs activities received vertical funds either through local NGOs or International Agencies. According to 2006 National Accounts, the main sources of funding for the sector were (a) the funds of the Rest of the World / Partners, with approximately 57% of total, (b) Government revenues (OE), with 29% and (c) direct payments made by families, with 13%. Considering that a significant part of the state budget went to recurrent expenditure including wages, the health sector was dependent on external funds to implement programs to reduce child mortality during the period of this analysis. On the other hand the way the money is spent is very important since it can likely improve the U5M if it is used effectively that is, creation of quality and cost effective services which target vulnerable population and which aim to improve equity [36].

Our results do not suggest a strong association between the prevalence of HIV and the U5M but several aspects have to be considered in the interpretation of these findings especially in the context of Mozambique, where important interventions to reduce the impact of HIV were implemented. In fact, it is useful to take into account that in Mozambique HIV treatment

(HAART) and PMTCT, experienced a rapid scale-up from 2006 to 2010[14]. Earlier beginning of HAART and a good adherence are associated with increased child survival and this fact can influence the prevalence of HIV as well as child survival that is, a high prevalence can be a reflex of a long child survival [37-40]. On the other hand PMTCT scale-up could have resulted in shifts of the HIV incidence and prevalence which also need to be considered in the interpretation. Given that Mozambique increased access to HAART and PMTCT since 2006 and that the results presented in this study are the average of the period of 2000 to 2010 that is, a period without these intervention and the other with them, we believe that this fact influenced our results. An analysis by periods would be important to clarify the role of the HIV prevalence on child mortality, with 2005 as the cutting point.

IV.1 Limitations

The main study limitation was related to availability and reliability of data to conduct these analyses. U5M is multifactorial and it would be important to control for other important determinants of child mortality like the female literacy rates, socio-economic status, and water and sanitation access. However, many of these variables are correlated to provincial-level GDP, so including this variable may have accounted for a number of these unmeasured variables. Second, reliability and quality of data was an important source of bias in this analysis since we used different sources of data, but we think that we were able to overcome this since we triangulated information from different sources and final data used in our analysis had an approval of the MOH in Mozambique. Third, our small sample size of 10 clusters (excluding Maputo City) over 11 years, together with fact that many of our independent variables were moderately to highly correlated, limited our ability to conduct multivariable analyses which are indispensable in attempting to characterize the myriad of factors that influence U5M. Last, this

was an ecological study without data at the individual level, and our results should be interpreted at the provincial level to avoid cross-level bias (ecological fallacy).

Our interpretation of the role of funds allocation in U5M may be biased since there is no way to determine which amount of provincial funds are attributed to specific activities related to mother and child health, and because each province distributes funds according to annual priorities.

Nevertheless, considering that U5M is a national priority, we assume that at the provincial level it is unlikely that U5M was not considered a priority for funds allocation. Because several stakeholders develop activities and their funds do not pass through provincial directorates we were not able to include vertical funds in the present analyses. Even so, we believe that this fact occurs in a similar way across all and therefore provinces did not affect greatly the analysis.

Also, as a result of the partnership coordination mechanism a lot has been done to ensure that local NGO's report their activities to provincial health directorates.

Even recognizing these potential limitations, the benefits of this study are immeasurable and future researches, policies, strategies and resources allocation may take advantage of these results.

IV.2 Implications

Considering that Mozambique is on track to achieve the MDG 4, we anticipate that the country will have to increase efforts to keep the same trend and reduce the disparities between provinces after 2015. Taking into account the scarce resources and that some large donors are reducing health resources allocations due to the global financial crisis, the results of this study may help the Mozambican MOH and partners prioritize funds allocation and define new, innovative, and

feasible policies to reduce U5M. Last, these results can be used to generate new hypotheses for future studies on the field of child mortality, HSS, and resources allocation.

V. Conclusions

Our results suggest that the role of HSS, particularly HR and health service delivery, were most strongly associated with reductions in provincial-level U5M rates in Mozambique during the period of 2000 to 2010. We believe that the interventions which led to improvements on human resources availability, particularly training and hiring of maternal and child nurses, as well as improvements in health infrastructure and birth attendance were important to achieving the observed reduction. Future investments on health should prioritize innovative interventions to accelerate HR trainings and health infrastructure, accounting for the population growth and time of the interventions. In addition, the strong association between institutional birth attendance and child mortality deserves further attention. Further studies are needed to determine the degree to which delivering in a health facility causally reduces child death in rural and urban Mozambique. Although our findings are consistent with past studies in similar settings, future studies are needed to corroborate our results, and other variables should be included in the models to improve future estimation and causal inference.

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