POLITICAL ECONOMY RESEARCH INSTITUTE

PERI

University of Massachusetts Amherst

POLITICAL ECONOMY RESEARCH INSTITUTE

Does Health Aid Reduce Infant and Child Mortality from Diarrhea in Sub-Saharan Africa?

Lynda Pickbourn and Léonce Ndikumana

October 2018

WORKINGPAPER SERIES

Number 471

Does Health Aid Reduce Infant and Child Mortality from Diarrhea in sub-Saharan Africa?

Lynda Pickbourn[1]

Léonce Ndikumana[2]

September 6, 2018

Abstract

Achieving sustained improvements in health outcomes remains a challenge for sub-Saharan Africa, where diarrhea remains a leading cause of death in children under the age of five. This paper examines the impact of foreign aid to the health sector on diarrhea mortality in children under five in 47 sub-Saharan African countries, using panel data on the sectoral allocation of official development assistance in conjunction with country-level data on health outcomes. After controlling for fixed effects and the potential endogeneity of health aid, we find that increased health aid and increased public health expenditure are associated with lower diarrhea mortality in children under five. In addition, health aid increases government spending on health, suggesting that the overall impact of health aid on diarrheal death rates could exceed the direct effect. Furthermore, increased access to improved sources of water and sanitation are important in reducing child mortality from diarrhea.

JEL Classification codes: O10; O15; O55; I10

Keywords

Health; Diarrhea mortality; Under-five mortality; Official development assistance; Water and sanitation; Sub-Saharan Africa

Acknowledgements

We would like to acknowledge the constructive comments and suggestions of two anonymous reviewers. All data and code used in this analysis are available from the authors upon request.

[1] Lynda Pickbourn is Assistant Professor of Economics, Hampshire College, Amherst, MA 01002 (lpickbourn@hampshire.edu), Corresponding author.

[2] Léonce Ndikumana is Professor of Economics, University of Massachusetts, Amherst (ndiku@econs.umass.edu); Honorary Professor of economics at the University of Cape Town and the University of Stellenbosch, South Africa.

1. Introduction

Globally, diarrhea remains the second leading killer of children under five. Every day, more than 1,400 children die from diarrhea – more than from malaria, measles and AIDS combined (Liu et al., 2015).[i] Diarrhea is also a disease of poverty: the greatest proportion of diarrhea deaths occur in the poorest parts of the world. In 2015, 11 of the 15 countries worldwide with the highest number of diarrhea deaths in children under five were in sub-Saharan Africa (SSA), where the percentage of all deaths among children under age five attributable to diarrhea was 13.7 percent, compared to 1-4 percent in Europe and North America (UNICEF, 2016). Although the number of children under the age of five who died from diarrhea fell by an average of 57 percent across all regions between 2000 and 2015, the rate of decline was lowest in sub-Saharan Africa – 48 percent, compared with 75 percent in Latin America and the Caribbean, and 62 percent in South Asia (UNICEF, 2016). For sub-Saharan Africa to reach Sustainable Development Goal (SDG) 3.2 of ending preventable deaths of babies and children under age five by 2030, diarrhea mortality rates have to be significantly reduced over the next decade.

Many of these deaths are preventable: 58 percent of deaths due to diarrhea in lower middle-income countries are attributable to unsafe drinking water, poor hygiene and sanitation (WHO, 2014). Improvements in access to these services can help to reduce the incidence of diarrhea, and increased aid to the water and sanitation sector has been shown to be associated with increased access to these services (Ndikumana and Pickbourn, 2017). However, increasing access to water and sanitation remains a challenge for sub-Saharan Africa, and death rates in the region from unsafe water, sanitation and hygiene are the highest in the world – 41 deaths per 1000 people, compared with less than 10 per 1000 in other developing regions (WHO, 2014). Given these challenges, can increased aid to the health sector help to reduce the burden of high mortality from diarrhea, which is associated with inadequate access to water and sanitation in sub-Saharan Africa? This is an important question: diarrhea incidence and mortality have adverse effects on the quantity, quality and productivity of labor in poor countries, with implications for growth, development and poverty reduction. Moreover, diarrhea can have a detrimental impact on childhood growth and cognitive development, and time must be spent caring for children who fall ill from diarrhea. But these outcomes can be avoided: the evidence points to a variety of interventions that can help to reduce diarrhea incidence and mortality. Increasing the number of health providers can help to stem the incidence of diarrhea and reduce the number of deaths resulting from diarrhea. In addition, vitamin A supplementation has been shown to reduce the incidence of diarrhea by 15 percent, while the rotavirus vaccine can provide protection against one of the most common causes of childhood diarrhea related deaths (UNICEF, 2016). Treatment with oral rehydration salts (ORS) and zinc has also been shown to reduce the loss of hydration and nutrients associated with diarrhea, helping to reduce diarrhea-specific mortality rates by up to 93 percent (Carvajal-Vélez et al., 2016).

However, consistently low levels of public spending on health in many of the countries with the greatest diarrhea burden suggests that the governments of these countries face significant constraints on their capacity to finance these interventions from domestic resources (WHO, 2013). In sub-Saharan Africa, public health expenditure over the period 2000-2014 averaged only

2.4 percent of GDP, compared to 6.8 percent in Europe and Central Asia and 4.6 percent in East Asia and Pacific regions.[ii] Such low levels of public spending on health translate into low levels of coverage for basic but effective interventions that can reduce diarrhea-specific mortality. In sub-Saharan Africa, only about one in three children who fall ill from diarrhea receives ORS, and less than 5 percent receive zinc (Carvajal-Vélez et al., 2016). These facts suggest that targeting official development assistance to the health sector in countries with high diarrheal death rates may help to reduce the rate of mortality from diarrhea, either by directly increasing access to these interventions through donor-funded projects and by encouraging other financing for health, for example from private donors, or indirectly, by expanding governments' financial capacity to allocate adequate budgetary resources to the health sector in general and to diarrhea prevention programs in particular.

Given the high rates of death from diarrhea in children under five in sub-Saharan Africa, this paper examines the impact of health aid on neonatal and post-neonatal deaths from diarrhea and on public health expenditure in the region. The study uses panel data on diarrheal death rates and aid disbursements to the health sector for a sample of 47 sub-Saharan African countries over the 2000-2013 period. The panel is unbalanced: five countries have data over 2005-2013, and one country has data over 2005-2011 (see Table A1). Data on diarrheal death rates are obtained from the Global Health Observatory of the World Health Organization; data on disbursements of official development assistance to the health sector are obtained from the OECD Creditor Reporting System (OECD-CRS) database, and data on other social and economic variables are sourced from the World Bank's World Development Indicators (WDI) database.

Focusing on aid targeted to the health sector instead of total aid allows us to avoid biases to the results that may arise from donor preferences for aid allocation across sectors. We utilize a fixed-effects instrumental variable regression with robust standard errors to empirically account for year effects, unobserved time-invariant heterogeneity across countries, and the endogeneity of health aid to health outcomes.[iii] The regression results show that increased aid to the health sector is directly associated with a reduction in neonatal and post-neonatal deaths from diarrhea. Health aid is also associated with higher public expenditure on health, which is in turn associated with a reduction in deaths from diarrhea. This suggests that health aid has both a direct and indirect impact on diarrheal mortality. Furthermore, increased access to improved sources of water and improved sanitation are also associated with reductions in diarrheal mortality. These findings have important policy implications for the allocation of aid and public expenditures if sub-Saharan Africa is to succeed in ending preventable deaths of infants and children by 2030.

The next section presents a brief review of the relevant literature. This is followed by a discussion of the empirical analysis, with a description of the data, some stylized facts and the empirical model in the third section. The results are discussed in the fourth section, and the final section concludes with a discussion of the policy implications of the findings.

2. A review of the literature

The economics and public health literature has linked health outcomes in developing countries to public health expenditure, the availability of external sources of funding (official development assistance) for health care and access to social services such as water and sanitation. This section provides a brief review of this literature.

Government spending on health is the primary vehicle by which health outcomes can be affected by public policy. Indeed, a number of studies have attempted to demonstrate a link between public expenditures on health and health outcomes, primarily at the macro level. However, the relationship between health expenditure and health outcomes is unclear: while some studies find evidence that increased spending on health leads to improved health outcomes (Baldacci, Cui, Clements and Gupta, 2004; Issa and Ouattara, 2005), others find no evidence of such a relationship (Burnside and Dollar, 1998; Filmer and Pritchett, 1999). However, the few studies that have focused on this relationship in the context of sub-Saharan Africa, using cross-country panel data, do find evidence of a positive relationship between public health expenditure and health outcomes (Anyanwu and Erhijakpor, 2009; Novignon, Olakojo and Nonvignon, 2012). Despite this, the governments of countries in the region have failed to prioritize health spending in their budgets: public spending on health in the region averaged only 11.6 percent of total government expenditure over the 2000-2011 period, with public expenditures in many countries falling well below the Abuja Declaration target of 15 percent of public expenditure (WHO, 2013). A major constraint on public expenditure on health in the region has been the limited capacity of African governments to raise public revenue. In the absence of domestic sources of financing for public expenditure, external resources become crucial for increased public investment in the health sector. Yet, in the majority of countries in the region, external sources account for less than 20 percent of total health expenditure (WHO, 2013). Moreover, the impact of foreign aid on public health expenditures is the subject of much debate. While some studies find that aid to the health sector stimulates increased spending on health from domestic sources, other studies suggest that aid to the health sector can crowd out public spending on health, which may then have adverse implications for health outcomes (Gormanee, Morrissey, Mosley and Verschoor, 2005; Lu et al., 2010; Mishra and Newhouse, 2009). Which of these outcomes prevails may depend to a large extent on the effectiveness of donor conditionality in ensuring that recipient governments do not use health aid as a substitute for domestic financing of public health expenditures (Van de Sijpe, 2012, 2013).

The effectiveness of foreign aid in improving health outcomes is also subject to debate. The literature on the impact of aid on health outcomes can be grouped into different categories, based on the degree of aggregation of the health outcomes under study, and the level of aggregation of the aid data. These categories also correspond to the degree of consensus among different studies. Studies of the impact of aggregate aid on aggregate health outcomes do not agree on whether or not aid helps to improve health outcomes in developing countries. For example, Gormanee, Girma and Morrissey (2005) and Arndt, Jones and Tarp (2016) find that aggregate aid reduces infant mortality, with the impact being strongest in the poorest countries (Chauvet, Gubert and Mesplé-Somps, 2013), while Boone (1996) and Easterly (2003) find no such impact of aid on health outcomes. Likewise, studies that focus specifically on the effectiveness of health aid on aggregate health outcomes also come to contradictory conclusions. While some studies find that aid targeted to the health sector can help to improve aggregate health outcomes (Afridi and Ventelou, 2013; Feeney and Ouattara, 2013; Mishra and Newhouse, 2009; Taylor, Hayman, Crawford, Jeffery and Smith, 2013), others conclude that aid to the health sector has no significant effect on infant mortality, maternal mortality or life expectancy (Kizhakethalackal, Mukherjee and Alvi, 2013; Mukherjee and Kizhakkethalackal, 2013; Williamson, 2008; Wilson, 2011). Others find that the effectiveness of health aid is largely dependent on the policy environment and the quality of governance (Farag et al., 2013; Fielding, 2011). In contrast, studies that focus on the effectiveness of health aid for a specific disease or program on outcomes in that sector or program exhibit a remarkable degree of consensus, concluding that targeted health aid significantly improves health outcomes in the target area. For example, health aid for HIV/AIDS programs is associated with lower infection and mortality from HIV/AIDS in Africa (Bendavid and Bhattacharya, 2009; Rasschaert et al., 2011; Shiffman, 2009; Youde, 2010). Similarly, Taylor et al. (2013) find that health aid to support maternal health contributes to lower maternal mortality.

The majority of the studies of health aid on aggregate health outcomes cited above examine the effectiveness of aid in a large sample of developing countries; relatively few studies focus exclusively on sub-Saharan Africa. The few that do, however, are unanimous in their conclusion that health aid has a positive impact on aggregate health outcomes in the region. Gyimah-Brempong (2015) finds that health aid is associated with improvements in multiple health outcomes, particularly in countries with higher domestic public expenditure and better governance. Moreover, health aid also increases domestic health expenditure, suggesting that the overall impact of health aid on the health outcomes under study is larger than accounted for by the direct effects alone. Yogo and Mallaye (2015) also find that health aid reduces child mortality and HIV prevalence, with the effects on child mortality operating through increased health expenditure and improvements in female education.

Public health expenditure and health aid aside, the importance of access to water and sanitation in reducing diarrhea prevalence and mortality cannot be overstated. A handful of studies have shown a link between aid to the water and sanitation sector and improvements in aggregate indicators of child health outcomes in a broad sample of countries (Botting et al., 2010; Wayland, 2013). Moreover, a number of empirical studies have confirmed the importance of access to water and sanitation in reducing diarrhea morbidity and mortality in infants and children under five (Esrey, Habicht, Latham, Sisler and Casella, 1988; Fewtrell et al., 2005; Fink, Günther and Hill, 2011; Gasana, Morin, Ndikuyeze and Kamoso, 2002; Pruss-Usten, Bos, Gore and Bartram, 2008). The available evidence suggests that well-implemented interventions in this sector, especially in areas where initial conditions are poor, can lower diarrheal disease prevalence by one-third (Bartram and Cairncross, 2010). This is especially pertinent for sub-Saharan Africa, where diarrheal morbidity and mortality rates are higher than in other regions, and where the share of population with access to improved water and sanitation is among the lowest in the world, with significant rural-urban disparities in access (Ndikumana and Pickbourn, 2017). Moreover, the increase in access to improved water sources and sanitation has not kept up with population growth in the region.[iv] The effects of inadequate access to water and sanitation in the region are further complicated by the fact that even when households have nominal access to these services, there are significant differences in the quality, cost, reliability and adequacy of these services, which may impact the degree to which they are actually utilized (Smiley, 2013). For example, in a study of the impact of different types of water sources on the incidence of diarrhea in children under the age of five in Senegal, water piped into the yard significantly outperformed all other water sources in reducing diarrhea incidence, while public taps and protected wells were not significantly different from unimproved water sources (Novak, 2014).

This paper adds to the understanding of the role of public health expenditure, aid to the health sector and access to water and sanitation in improving health outcomes. It builds on studies of the effectiveness of aid in sub-Saharan Africa by focusing on the impact of health aid on a specific health outcome – mortality from diarrhea among children under the age of five. The paper specifically investigates the impact of health aid on diarrheal death rates in different age categories: 0-27 days (the neonatal period), 1-59 months and 0-4 years (the post-neonatal period). These different measures help to account for the fact that approximately 70 percent of deaths associated with diarrhea occur during the first two years of life, with the death rate from diarrhea increasing exponentially in the post-neonatal period (UNICEF, 2016). In addition, the study explores the impact of aid on public health expenditures, as well as the impact of public health expenditures on diarrheal death rates, in view of the possibility that health aid has both direct and indirect effects on diarrheal death rates. Finally, in investigating the impact of aid, the study takes into account the impact of access to water and sanitation on diarrheal death rates.

3. Empirical Analysis

3.1 Data sources

This study uses data on official development aid disbursements at the project level from the OECD's Creditor Reporting System (CRS) database. Although this database excludes aid from non-OECD and private donors, it has the most complete information on actual disbursements of aid. Aid from all donors is aggregated to obtain aid targeted to the health sector by recipient country. Data on diarrheal death rates are taken from the WHO Global Health Observatory (GHO). Data on access to water and sanitation, rates of open defecation, population growth, as well as other country-level social and economic indicators are obtained from the World Bank's World Development Indicators (WDI).[v] The UNDP's education index is used to control for the impact of education and literacy on diarrhea mortality. The index is calculated using the mean years of schooling and expected years of schooling, and ranges from 0 to 1, with 0 representing the lowest achievement in education.[vi] To account for the impact of political institutions and the quality of governance on service delivery, we use an indicator of political rights and civil liberties taken from the Freedom House 'Freedom in the World' database as well as an indicator of government effectiveness taken from the World Bank's WDI database. The Freedom House indicator varies from 1 to 7, with 1 being the most free and 7 being the least free, while the WDI governance indicator ranges from -2.5 to +2.5.

3.2 Stylized facts

Death rates from diarrhea in all age cohorts have been on the decline in SSA between 2000 and 2013 (Figure A1). For example, for the 0-4 age cohort, the rate dropped from 18 to 8 deaths per thousand live births over the period. However, the rate of decline is slower than in other regions (UNICEF 2016) and diarrhea mortality rates in SSA remain high relative to other regions (Table 1). The death rates from diarrhea are lowest in the first 27 days of life due to the fact that babies in this age group are less likely than older children to be exposed to sources of diarrhea transmission, such as water, food and surfaces that have been contaminated with fecal matter. Table 2 presents the summary statistics for the variables used in the regression analysis for the sub-Saharan Africa sample.

Table 1 here.

Table 2 here

There is substantial variation in average diarrhea death rates for each age cohort across countries (Table A2). Over the 2000-2013 period, diarrhea death rates for children under the age of five (i.e. 1-59 months) were highest in Angola, followed by Chad, Somalia, Niger and Sierra Leone. The mean share of health aid disbursements in GDP over the same period ranges from 0.005 percent (Mauritius) to 3.63 percent (Sao Tome and Principe). Public health expenditure as a percentage of GDP ranges from 1.03 percent (Congo, DRC) to 5.7 percent (Lesotho). Access to water is lowest in Somalia (28.4 percent) and highest in Mauritius (99.5 percent), while access to sanitation is lowest in Niger (8.4 percent) and highest in Seychelles (98.4 percent).

The data shows strong relationships between diarrhea death rates for all age groups and key variables of interest, and also points to the presence of outliers such as Angola, Chad, Somalia, Sierra Leone and Niger, all of which have diarrhea death rates in the 0-4 age group exceeding 25 deaths per 1000 live births (Figures A2-A5). Figure A2 shows a negative relationship between public health expenditures as a percentage of GDP and diarrhea death rates in the 0-4 age cohort. Not surprisingly, we see that greater access to improved water sources and improved sanitation is associated with lower diarrhea death rates (Figures A3 and A4). Figure A5 exhibits a positive relationship between health aid and public health expenditure.

4. *Model specification and estimation methodology*

The empirical analysis in this study tests for the direct and indirect impacts of foreign aid to the health sector on diarrhea mortality. We test for the presence of fixed effects arising from unobserved time-invariant country characteristics using the Sargan-Hansen test. The test results presented in Tables 3, 4 and 5 confirm that the fixed effects estimation is the appropriate approach. The direct impact of health aid on diarrhea mortality is estimated with a fixed effects model that relates the diarrheal mortality rates in different age cohorts (0-27 days, 0-4 years, 1-59 months) to aid disbursements to the health sector, controlling for other factors that influence diarrheal mortality rates. To ensure that the results are not driven by possible endogeneity of health aid to health outcomes, we use two- and three-year lags of health aid as instruments for current health aid. Lagged aid reflects the permanent interests of donors and is a strong predictor of current aid; deeper lags of health aid are therefore unlikely to be driven by or exert a strong impact on current health outcomes (Boone, 1996; Williamson, 2008). The instrumental variables are strongly correlated with current health aid ($\rho = 0.775$ and 0.729, respectively). Various test statistics for the instrumental variable estimation (weak-identification, under-identification, over-identification tests) are reported in Table 3.[vii] The model is specified as follows:

$$\text{Diarrhea death rate}_{a,i,t} = b_0 + \theta \text{Health Aid}_{i,t} + Z'_{i,t}\,\Omega + \alpha_i + \mu_{i,t} \quad (1)$$

where the subscripts a, i, t, denote the age cohort, the country and year, respectively. *Health Aid* represents disbursements of foreign aid targeted to the health sector as a percentage of GDP. *Diarrhea death rate* is the number of deaths from diarrhea per thousand live births for each age cohort; Z is a vector of control variables that influence diarrhea mortality rates; α accounts for unobserved country-specific factors, such as the quality of health delivery services, and μ is a random error term.

The control variables in this analysis include the percentage of the population with access to improved water and sanitation sources, the UNDP education index, the rate of population growth (to capture stress on infrastructure and demand for health services), and an index of political rights and civil liberties.[viii] As noted above, access to water and sanitation is not necessarily a good measure of actual utilization. We therefore use an additional variable, the prevalence of open defecation among the total population, as a proxy for the extent to which improved sanitation facilities are utilized by the population.

The next step of the analysis is to explore the impact of public health expenditures on diarrheal death rates, by estimating a version of the empirical model in which the aid variable is replaced by public health expenditure as a percentage of GDP. This version of the model includes the same set of control variables as equation (1) and is specified as follows:

$$\text{Diarrhea death rate}_{a,i,t} = b_0 + \lambda \text{Public Health Exp}_{i,t} + Z'_{i,t}\,\delta + \alpha_i + \mu_{i,t} \qquad (2)$$

The third step is to examine the impact of foreign aid on public health expenditures as a means of investigating indirect effects of foreign aid on diarrhea mortality. Foreign aid to the health sector can expand the financing capacity of the government, enabling it to spend more on public health than might otherwise have been possible. Alternatively, if external resources intended for the health sector simply replace public health spending from domestic resources, then total public health expenditure may remain unchanged or even fall as health aid increases. Either of these possibilities may occur in the year in which the aid is received, or in a later year. These possibilities are explored by estimating the following model:

$$\text{Public Health Exp}_{i,t} = b_0 + \psi \text{HealthAid}_{i,t} + \Phi \text{HealthAid}_{i,t-1} + Z'_{i,t}\,\omega + \alpha_i + \varepsilon_{i,t} \qquad (3)$$

The variables *Public Health* $Exp_{i,t}$ and $HealthAid_{i,t}$ are defined as in equations 1 and 2. $Health\text{Aid}_{i,t-1}$ is health aid received in year *t-1* as a share of GDP. The set of control variables included in this model are the log of per capita GDP, which captures the impact of the government's financing capacity; the rate of population growth to capture pressure on public resources; and indicators of government effectiveness and corruption control, which are used in separate estimations to capture the effects of institutional quality.

5. Econometric results

Table 3 presents the results of the regression estimation for equation 1. Table 4 presents estimation results for equation 2, while the results from the estimation of equation 3 are presented in Table 5. Because of the strong correlation between access to water, access to sanitation and the prevalence of open defecation, these variables are entered in the regressions separately.

The regression results suggest that aid to the health sector helps to reduce death rates from diarrhea, both directly and indirectly. Because of the significant differences in diarrhea mortality rates across the three age cohorts, converting the regression coefficients to their implied elasticities allows a clearer interpretation of the magnitude of the effect of the key variables of interest on diarrhea death rates, and makes it easier to compare the impact of aid on death rates in each age group.[ix] From the fixed-effect regression results of the impact of health aid on diarrhea mortality rates presented in Table 3, we see that increased aid to the health sector is consistently associated with a decrease in the diarrhea death rates across all age groups, when access to improved water is used as a control. A one percent increase in health aid as a share of GDP is associated with a reduction in diarrhea death rates of between 0.24 to 0.36 percent in the diarrheal mortality rate, or 2.4 to 3.6 fewer deaths per 1000 live births depending on the age cohort (columns 1-9).

The results in Table 3 also confirm the importance of increasing access to improved sources of water and sanitation for reducing diarrheal mortality in children under the age of five in sub-Saharan Africa. A one percent increase in access to an improved water source is associated with a 2.4 percent reduction in the diarrheal mortality rate, or 24 fewer deaths for every 1000 live births (columns 1, 4 and 7), while a one percent increase in access to improved sanitation is associated with a 0.45 percent reduction in diarrhea death rates, or 4.5 fewer deaths per 1000 live births in the post-neonatal age groups (columns 5 and 8). Finally, a one percent decline in the prevalence of open defecation is associated with a reduction in diarrhea death rates of between 0.53 to 0.6 percent, or between 5 and 6 fewer deaths per 1000 live births in all age groups (columns 3, 6 and 9).

Table 3 here

The regression results for the relationship between diarrhea mortality rates and public health expenditure also suggest that public health expenditure exerts a negative impact on neonatal and post-neonatal death rates from diarrhea (Table 4). A one percent increase in public health expenditure as a share of GDP is associated with a reduction in diarrhea death rates of between 0.08 to 0.21 percent in the diarrhea mortality rate, or between 0.8 to 2.1 fewer deaths per 1000 live births, with the greatest impact being on the neonatal death rate from diarrhea. The results for the impact of increased access to improved sources of water and open defecation on diarrheal mortality are comparable to the results in Table 3.

As expected, improvements in education, as measured by the education index, are consistently associated with decreased diarrhea death rates across all age groups in both sets of regressions, suggesting that the effects of health aid and public health expenditure on diarrheal mortality can be enhanced by improvements in educational attainment. Also as expected, faster population growth is associated with higher diarrhea mortality rates. In contrast, improvements in political rights and civil liberties do not have any impact on diarrheal death rates, a result that did not change even when we used other measures of institutional quality, such as the World Bank's governance indicators.[x] In general, our results suggest that mortality rates from diarrhea in sub-Saharan Africa can be reduced through a combination of greater external support for the health sector, increased public spending on health and education, and greater access to improved sources of water and sanitation.

Table 4 here

Finally, the results for the third set of regressions indicate that aid to the health sector is associated with increased public expenditure on health (Table 5).[xi] Although the country's capacity to finance health care spending, as measured by the log of per capita GDP, is an important determinant of public health care expenditure, health aid is also important: a 1 percent increase in aid to the health sector as a share of GDP is associated with a 0.3 percent increase in public expenditure on health as a share of GDP, in the year in which the aid is disbursed to the government. There is also a lagged effect, whereby an increase in health aid as a share of GDP received in year *t-1* increases public health expenditure as a share of GDP in year *t* by 0.15 percent. Government effectiveness is also an important determinant of public health expenditure, although these results are significant only in the random effects model presented in column 2. These results, coupled with the results from Table 4, suggest that in addition to the direct effect of health aid on diarrhea mortality rates, health aid may help to further reduce diarrhea mortality through its positive impact on public health expenditure in the region.

Table 5 here

6. Conclusion

Reducing diarrhea morbidity and mortality in children under five remains a significant challenge to human development in sub-Saharan Africa. This paper sought to explore whether increasing the amount of aid targeted to the health sector could help to reduce diarrheal death rates in children under the age of five. The empirical results presented here show that both increased aid to the health sector as well as increased public expenditure on health are associated with reductions in diarrhea mortality rates. Furthermore, in addition to the direct impact of aid to the health sector on diarrheal death rates, health aid may indirectly help to reduce under-five mortality from diarrhea through its positive impact on public health expenditure. By reducing the constraints on the government's financing capacity, health aid makes it possible for the government to finance interventions that can reduce the likelihood of death from diarrhea in children under the age of five.

Furthermore, our results also highlight the importance of access to improved water and sanitation in lowering mortality from diarrhea in children under the age of five. These findings have additional implications for the sectoral allocation of aid to sub-Saharan Africa. Ndikumana and Pickbourn (2016) show that greater aid to the water and sanitation sector in sub-Saharan Africa can contribute to expanding access to water and sanitation services. Aid donors need to direct more aid to the water and sanitation sector, if they wish to support African governments in their efforts to end preventable deaths of children under the age of five. However, as discussed above, merely expanding access to these services is not enough; the degree to which they are actually utilized may be affected by their cost, ease of access and reliability. Thus, it will also be necessary to go beyond simply expanding access in numeric terms: African governments, in partnership with aid donors, also need to invest in improving the quality, reliability and affordability of these services.

Due to lack of data, this paper did not explore whether health aid and access to water and sanitation has any impact on the prevalence of diarrhea among children under the age of five. Presumably, many of the interventions that are made possible by increased aid to the health sector can help not only to reduce diarrhea mortality rates, but also to reduce the number of cases of diarrhea in this population, which is clearly the ultimate goal.

Whether or not sub-Saharan Africa will achieve Sustainable Development Goal 3.2 of ending preventable deaths of babies and children under age five by 2030 remains to be seen. What we do know is that this goal is unlikely to be realized without significant progress in two areas – increasing external support for public health spending through increased aid to the health sector, and increasing access to and utilization of improved water and sanitation services.

---

[i] https://data.unicef.org/topic/child-health/diarrheal-disease/

[ii] These figures are taken from the World Bank's World Development Indicators (WDI) database.

[iii] Tests for the endogeneity of health aid indicate that an instrumental variable model is appropriate. The results from these tests can be provided to the reader on request.

[iv] Data from the WHO shows that the rate of increase in access to improved sources of water and sanitation is significantly below the rate of population increase in SSA.

[v] Access to an improved water source refers to the percentage of the population using an improved drinking water source, defined by WHO/UNICEF as one that, by nature of its construction or through active intervention, is protected from outside contamination, in particular from contamination with fecal matter, such as piped water on premises, public standpipes, tube wells or boreholes, protected dug wells.

[vi] Between 1990-2010 the UNDP education index is available for every fifth year. We interpolate to generate annual values for the intermediate years.

[vii] We test for under-identification, weak-identification and over-identification of the instruments. The results of these tests are discussed in detail in the results section. The specifications meet the conditions for the relevance and validity of the instruments for aid when population access to improved water sources is used as a control in the specifications for all age groups.

[viii] The WHO uses different methods to estimate neonatal (1-27 days) and post-neonatal (1-59 months) causes of death. In countries with good quality vital registration (VR) data, the cause distributions are estimated directly from the VR data. The only data points in our sample for which this is true are the neonatal diarrhea mortality rates for South Africa. For lower mortality countries with poor quality VR data, the distributions are predicted from a regression fit to data from countries with high-quality VR data. Access to water is a covariate in this regression. In our sample, only Cape Verde and Seychelles fall into this group, and we estimate separate regressions with and without these two countries as a robustness check. Our results do not change when these countries are excluded from the regression. For higher mortality countries with poor quality VR data (all other countries in our sample), the distributions are predicted from a regression fit to data assembled from studies of causes of death in high mortality countries. The covariates included in these regressions are female literacy, Gini coefficient, neonatal mortality rate, infant mortality rate, under 5 mortality rate, low birth weight, GNI per capita, antenatal care coverage, percentage of births with skilled birth attendance, general fertility rate, BGC vaccine coverage, PAB vaccine coverage and indicator variables for world regions. To avoid spurious results, we do not include these variables in our regression models. For more information, see http://www.who.int/healthinfo/global_burden_disease/GlobalCOD_method_2000_2015.pdf?ua=1

[ix] The implied elasticity is computed by multiplying the regression coefficient by the ratio of the mean of the dependent variable (i.e., the average death rate for that age cohort) to the mean of the explanatory variable (e.g., mean health aid).

[x] The results for these regressions are available on request.

[xi] The Sargan-Hansen test statistic for this regression does not permit the rejection of the null; we provide the results from both the fixed effects and random effects estimations and find that the results are qualitatively similar.

References

Afridi, M. A. and Ventelou, B. (2013). Importance of Health Aid in Developing Countries: The Public vs.The Private Channel. *Economic Modelling, 31*, 759-765.

Anyanwu, J. C. and Erhijakpor, A. E. (2009). Health expenditures and health outcomes in Africa. *African Development Review, 21*(2), 400-433.

Arndt, C., Jones, S. and Tarp, F. (2016). *What is the aggregate economic return to foreign aid? The World Bank Economic Review*, Volume 30 (3), 446–474, https://doi.org/10.1093/wber/lhv033

Baldacci, E., Cui, Q., Clements, B. and Gupta, S., (2004). *Social spending, human capital, and growth in developing countries: Implications for achieving the MDGs*: International Monetary Fund Working Paper Series WP/04/217. Retrieved from https://www.imf.org/external/pubs/ft/wp/2004/wp04217.pdf

Bartram, J. and Cairncross, S. (2010). Hygiene, sanitation, and water: forgotten foundations of health. *PLoS medicine, 7*(11), e1000367.

Bendavid, E. and Bhattacharya, J. (2009). The President's Emergency Plan for Aids Relief in Africa: An Evaluation of Outcomes. *Annals of Internal Medicine, 150*(10), 688-695.

Boone, P. (1996). Politics and the Effectiveness of Foreign Aid. *European Economic Review, 40*(2), 289-329.

Botting, M. J., Porbeni, E., Joffres, M.R., Johnston, B.C., Black, R.E., and Mills, E.J. (2010). Water and sanitation infrastructure for health: The impact of foreign aid. *Globalization and Health, 6*(1), 1-8. doi:10.1186/1744-8603-6-12

Burnside, C. and Dollar, D. (1998). *Aid, the incentive regime, and poverty reduction*: World Bank Publications.

Carvajal-Vélez, L., Amouzou, A., Perin, J., Maïga, A., Tarekegn, H., Akinyemi, A., … Newby, H. (2016). Diarrhea management in children under five in sub-Saharan Africa: does the source of care matter? A Countdown analysis. *BMC Public Health*, *16*, 830. http://doi.org/10.1186/s12889-016-3475-1

Chauvet, L., Gubert, F. and Mesplé-Somps, S. (2013). Aid, remittances, medical brain drain and child mortality: Evidence using inter and intra-country data. *The Journal of Development Studies, 49*, 801-818.

Easterly, W. (2003). Can foreign aid buy growth? *Journal of Economic Perspectives, 17*(3), 23-48.

Esrey, S. A., Habicht, J., Latham, M.C., Sisler, D.G., and Casella, G. (1988). Drinking water source, diarrheal morbidity, and child growth in villages with both traditional and improved water supplies in rural Lesotho, southern Africa. *American Journal of Public Health, 78*(11), 1451-1455.

Farag, M., Nandakumar, A., Wallack, S., Hodgkin, D., Gaumer, G., and Erbil, C. (2013). Health expenditures, health outcomes and the role of good governance. *International Journal of Health care Finance and Economics, 13*(1), 33-52.

Feeney, S. and Ouattara, B. (2013). The Effects of Health Aid on Child Health Promotion in Developing Countries: Cross Country Evidence. *Applied Economics,45*(7), 911-919.

Fewtrell, L., Kaufmann, R.B., Kay, D., Enanoria, W., Haller, L., Colford, J.M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *The Lancet Infectious Diseases, 5*(1), 42-52.

Fielding, D. (2011). Health aid and governance in developing countries. *Health Economics, 20*(7), 757-769.

Filmer, D. and Pritchett, L. (1999). The impact of public spending on health: does money matter? *Social Science & Medicine, 49*(10), 1309-1323.

Fink, G., Günther, I. and Hill, K. (2011). The effect of water and sanitation on child health: evidence from the demographic and health surveys 1986–2007. *International Journal of Epidemiology, 40*(5), 1196-1204.

Gasana, J., Morin, J., Ndikuyeze, A. and Kamoso, P. (2002). Impact of water supply and sanitation on diarrheal morbidity among young children in the socioeconomic and cultural context of Rwanda (Africa). *Environmental Research, 90*(2), 76-88.

Gormanee, K., Girma, S. and Morrissey, O. (2005). Aid, public spending and human welfare: evidence from quantile regressions. *Journal of International Development, 17*(3), 299-309.

Gormanee, K., Morrissey, O., Mosley, P. and Verschoor, A. (2005). Aid, Government Expenditure and Aggregate Welfare. *World Development, 33*(3), 355-370.

Gyimah-Brempong, K. (2015). Do African Countries Get Health from Health Aid? *Journal of African Development, 17*(2), 83-114.

Issa, H. and Ouattara, B. (2005). The effect of private and public health expenditure on infant mortality rates: does the level of development matter? Unpublished manuscript, Economics Department, *University of Wales Swansea,* Swansea, UK.

Kizhakethalackal, E. T., Mukherjee, D., and Alvi, E., (2013). Quantile Regression Analysis of Health-Aid and Infant Mortality: A Note. *Applied Economics Letters, 20*(13), 1197-1201.

Liu, L., Oza, S., Hogan, D., Perin, J., Rudan, I., Lawn, J. E., … Black, R.E., (2015). Global, regional, and national causes of child mortality in 2000–13, with projections to inform post-2015 priorities: an updated systematic analysis. *The Lancet, 385*(9966), 430-440.

Lu, C., Schneider, M.T., Gubbins, P., Leach-Kemon, K., Jamison, D. and Murray, C. (2010). Public financing of health in developing countries: a cross-national systematic analysis. *The Lancet, 375*(9723), 1375-1387.

Mishra, P. and Newhouse, D. (2009). Does Health Aid Matter? *Journal of Health Economics, 28* (4), 855-872.

Mukherjee, D. and Kizhakkethalackal, E. T. (2013). Empirics of Health Aid, Education and Infant Mortality: A Semiparametric Study. *Applied Economics,, 45*(22), 3137-3150.

Ndikumana, L. and Pickbourn, L. (2017). The Impact of Foreign Aid Allocation on Access to Social Services in sub-Saharan Africa: The Case of Water and Sanitation. *World Development, 90*, 104-114.

Novak, L. (2014). The Impact of Access to Water on Child Health in Senegal. *Review of Development Economics, 18*(3), 431-444.

Novignon, J., Olakojo, S.A., Nonvignon, J. (2012). The effects of public and private health care expenditure on health status in sub-Saharan Africa: new evidence from panel data analysis. *Health Economics Review, 2*(1), 1-8

Prüss-Üstün, A., Bos, R., Gore, F. and Bartram, J. (2008). Safer water, better health: costs, benefits and sustainability of interventions to protect and promote health. Geneva: World Health Organization

Rasschaert, F., Pirard, M., Phillips, M., Atun, R., Wouters, E., Assefa, Y., …Van Damme, W. (2011). Positive spill-over effects of ART scale up on wider health systems development: evidence from Ethiopia and Malawi. *Journal of the International AIDS Society, 14*(Suppl. 1), S3. doi: 10.1186/1758-2652-14-S1-S3

Schaffer, M. E. (2005). XTIVREG2: Stata module to perform extended IV/2SLS, GMM and AC/HAC, LIML and k-class regression for panel data models. Statistical Software Components S456501: revised 22 Feb 2015.

Shiffman, J. (2009). A social explanation for the rise and fall of global health issues. *Bulletin of the World Health Organization, 87*(8), 608-613.

Smiley, S. L. (2013). Complexities of water access in Dar es Salaam, Tanzania. *Applied Geography, 41*, 132-138.

Taylor, E. M., Hayman, R., Crawford, F., Jeffery, P., and Smith, J. (2013). The Impact of Official Development Aid on Maternal and Reproductive Health Outcomes: A Systematic Review. *PLoS ONE, 8*(2), e5627. doi:doi:10.1371/journal.pone.0056271

UNICEF. (2016). *One is too many: ending child deaths from pneumonia and diarrhoea*. Retrieved from United Nations Children's Emergency Fund website, https://www.unicef.org/publications/index_93020.html

Van de Sijpe, N. (2012). Is foreign aid fungible? Evidence from the education and health sectors. *The World Bank Economic Review, 27*(2), 320-356.

Van de Sijpe, N. (2013). The fungibility of health aid reconsidered. *Journal of Development Studies, 49*, 1746-1754.

Wayland, J. (2013). *A Drop in the Bucket? The Effectiveness of Foreign Aid in the Water, Sanitation, and Hygiene (WASH) Sector* (Phd Master's Thesis), American University. Retrieved from http://hdl.handle.net/1961/16922

WHO. (2013). *State of health financing in the African region*. Retrieved from World Health Organization website: http://www.afro.who.int/sites/default/files/2017-06/state-of-health-financing-afro.pdf

WHO. (2014) Preventing diarrhoea through better water, sanitation and hygiene: exposures and impacts in low-and middle-income countries. Retrieved from World Health Organization website, http://www.who.int/water_sanitation_health/diseases-risks/gbd_poor_water/en/

Williamson, C. R. (2008). Foreign aid and human development: The impact of foreign aid to the health sector. *Southern Economic Journal*, 188-207.

Wilson, S. (2011). Chasing Success: Health Sector Aid and Mortality. *World Development, 39*(11), 2032-2043.

Yogo, U. T. and Mallaye, D. (2015). Health Aid and Health Improvement in Sub-Saharan Africa: Accounting for the Heterogeneity Between Stable States and Post-Conflict States. *Journal of International Development, 27*(7), 1178-1196. doi:10.1002/jid.3034

Youde, J. (2010). *Biopolitical Surveillance and Public Health in International Politics*: New York, NY: Palgrave Macmillan. **DOI** https://doi.org/10.1057/9780230104785

Table 1: Means of key variables by region, 2000-2013

	Death rate 0-27 days	Death rate 1-59 months	Death rate 0-4 years	Health aid (% of GDP)
Sub-Saharan Africa	0.240	12.177	12.417	0.883
North Africa	0.036	1.666	1.699	0.029
North and Central America	0.034	1.763	1.798	0.133
South America	0.012	1.668	1.680	0.102
Far East Asia	0.110	3.590	3.703	0.270
South and Central Asia	0.212	5.136	5.349	0.328
Europe	0.000	0.160	0.160	0.154
Middle East	0.051	1.725	1.780	0.262
Oceania	0.064	2.875	2.932	2.227

Sources: WHO Global Health Observatory, World Bank WDI, OECD Creditor Reporting System, and UNDP

Table 2: Summary statistics of key variables for sub-Saharan Africa, 2000-2013

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Death rate 0-27 days	47	0.228	0.170	0	1
Death rate 1-59 months	47	11.649	7.660	0.1	44.8
Death rate 0-4 years	47	11.877	7.777	0.1	45.2
Health aid (% of GDP)	47	0.882	0.978	0	7.796
Public health expenditure (% of GDP)	47	2.654	1.315	0.045	9.087
Log GDP per capita	47	6.702	1.124	4.891	9.732
Access to improved water source (% of total population)	47	68.675	16.190	28.9	99.9
Access to improved sanitation (% of total population)	47	33.452	21.724	6.6	98.4
Open defecation (% of total population)	47	27.776	21.797	0.1	82.7
Education index	47	0.402	0.127	0.118	0.717
Population growth rate	47	2.460	0.876	-2.629	5.598
Index of political rights and civil liberties	47	2.795	1.612	0	6
Index of government effectiveness	47	-0.726	0.597	-1.961	0.965

Sources: WHO Global Health Observatory, World Bank WDI, OECD Creditor Reporting System, and UNDP

Table 3: Impact of health aid on neonatal and post-neonatal death rates from diarrhea

VARIABLES	(1) 0-27 days Water	(2) 0-27 days Sanitation	(3) 0-27 days Open Defecation	(4) 1-59 months Water	(5) 1-59 months Sanitation	(6) 1-59 months Open Defecation	(7) 0-4 years Water	(8) 0-4 years Sanitation	(9) 0-4 years Open Defecation
Health aid (% of GDP)	-0.071***	-0.094***	-0.094***	-3.114***	-4.153***	-4.183***	-3.201***	-4.259***	-4.288***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Implied aid-mortality elasticity	*-0.275*	*-0.364*	*-0.364*	*-0.235*	*-0.314*	*-0.316*	*-0.238*	*-0.316*	*-0.318*
Access to improved water source (% of total population)	-0.008***			-0.408***			-0.415***		
	(0.000)			(0.000)			(0.000)		
Implied water-mortality elasticity	*-2.41*			*-2.405*			*-2.4*		
Education index	-0.491***	-0.721***	-0.565***	-30.595***	-48.972***	-41.941***	-31.068***	-49.974***	-42.699***
	(0.000)	(0.001)	(0.005)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Implied education index-mortality elasticity	*-0.863*	*-1.267*	*-0.993*	*-1.055*	*-1.688*	*-1.446*	*-1.05*	*-1.69*	*-1.444*
Rate of population growth	0.023***	0.019**	0.021***	0.595*	0.613*	0.708*	0.617*	0.637*	0.732*
	(0.001)	(0.020)	(0.010)	(0.076)	(0.081)	(0.055)	(0.070)	(0.074)	(0.050)
Implied population growth rate-mortality elasticity	*0.248*	*0.205*	*0.226*	*0.126*	*0.129*	*0.149*	*0.128*	*0.132*	*0.152*
Index of political rights and civil liberties	-0.005	-0.004	-0.007	-0.054	0.348	0.158	-0.062	0.345	0.154
	(0.493)	(0.637)	(0.319)	(0.852)	(0.340)	(0.652)	(0.833)	(0.354)	(0.666)
Access to improved sanitation (% of total population)		-0.003			-0.162**			-0.160*	
		(0.209)			(0.043)			(0.051)	
Implied sanitation-mortality elasticity		*-0.439*			*-0.465*			*-0.451*	
Open defecation (% of total population)			0.005***			0.226***			0.228***
			(0.002)			(0.001)			(0.001)
Implied open defecation-mortality elasticity			*0.61*			*0.54*			*0.533*
Within R-squared	0.452	0.289	0.304	0.557	0.375	0.385	0.558	0.374	0.384
Test for fixed effects									
Sargan Hansen statistic (df = 5)	22.311	8.813	11.954	37.092	25.798	40.957	37.396	25.872	41.053
Chi-sq p-value	0.001	0.117	0.035	0.000	0.000	0.000	0.000	0.000	0.000
Under-identification test									
Kleinbergen-Paap rk_LM statistic (df = 2)	10.63	10.11	10.02	10.63	10.15	10.01	10.63	10.15	10.01
Chi-sq p-value	0.005	0.007	0.007	0.005	0.006	0.007	0.005	0.006	0.007
Weak-identification test									
Cragg-Donald Wald F statistic	46.36	50.39	50.22	46.36	50.68	50.50	46.36	50.68	50.50
Kleibergen-Paap rk Wald F statistic	5.204	5.285	5.215	5.204	5.284	5.198	5.204	5.284	5.198
Stock Yogo weak ID test critical values									
10% maximal IV size	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93	19.93

15% maximal IV size	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59	11.59
20% maximal IV size	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75	8.75
25% maximal IV size	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.25
Over-identification test of all instruments									
Hansen J statistic (df = 1)	2.160	2.795	2.613	3.079	4.648	4.371	3.019	4.572	4.301
Chi-sq p-value	0.142	0.095	0.106	0.079	0.031	0.037	0.082	0.033	0.038
Observations	626	598	598	626	626	626	626	626	626
Number of countries	47	45	45	47	47	47	47	47	47

Notes: The dependent variable is the number of deaths attributed to diarrhea per 1000 live births in each age cohort. Robust p-values are given in parentheses. Asterisks indicate significance at 1% (***), 5% (**) and 10% (*). Djibouti and Equatorial Guinea are excluded from the regressions in Columns 2 and 3; including these countries in the regression gives rise to counter-intuitive and insignificant coefficients on sanitation and open-defecation. The regressions were estimated with the xtivreg2 command in STATA (Schaffer, 2005). Stock-Yogo critical values are for Cragg-Donald F statistic and i.i.d. errors. $Implied\ elasticity = \frac{\partial y}{\partial x} \times \frac{x}{y}$ where *x* and *y* are the sample means of mortality rate and health aid (or access to water), respectively.

Table 4: Impact of public health expenditure on neonatal and post-neonatal death rates from diarrhea

VARIABLES	(1) 0-27 days Water	(2) 0-27 days Sanitation	(3) 0-27 days open defecation	(4) 1-59 months Water	(5) 1-59 months Sanitation	(6) 1-59 months open defecation	(7) 0-4 years Water	(8) 0-4 years Sanitation	(9) 0-4 years open defecation
Public health expenditure (% of GDP)	-0.016*	-0.018*	-0.015*	-0.369*	-0.721**	-0.589*	-0.381*	-0.734**	-0.600*
	(0.054)	(0.084)	(0.065)	(0.099)	(0.049)	(0.068)	(0.092)	(0.049)	(0.067)
Implied public health expenditure-mortality elasticity	*-0.186*	*-0.209*	*-0.174*	*-0.084*	*-0.164*	*-0.134*	*-0.085*	*-0.164*	*-0.134*
Access to improved water source (% of total population)	-0.008***			-0.455***			-0.463***		
	(0.001)			(0.000)			(0.000)		
Implied water-mortality elasticity	*--2.41*			*-2.68*			*-2.68*		
Population growth (%)	0.013	0.011	0.027	0.280	0.075	0.753	0.290	0.083	0.778
	(0.282)	(0.376)	(0.124)	(0.598)	(0.891)	(0.241)	(0.592)	(0.882)	(0.237)
Index of political rights and civil liberties	-0.008	-0.003	-0.012	-0.347	0.010	-0.513	-0.362	0.001	-0.532
	(0.595)	(0.873)	(0.494)	(0.408)	(0.985)	(0.378)	(0.398)	(0.999)	(0.373)
Education index	-0.703***	-1.390***	-1.228***	-40.722***	-64.306***	-62.418***	-41.490***	-65.741***	-63.741***
	(0.003)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Implied education index-mortality elasticity	*-1.236*	*-2.443*	*-2.159*	*-1.404*	*-2.217*	*-2.152*	*-1.400*	*-2.223*	*-2.155*
Access to improved sanitation (% of total population)		0.002			-0.211			-0.209	
		(0.688)			(0.179)			(0.188)	
Open defecation (% of total population)			0.003			0.237**			0.239**
			(0.216)			(0.038)			(0.039)
Implied open defecation-mortality elasticity			*0.365*			*0.565*			*0.559*
Constant	1.098***	0.753***	0.655***	60.403***	45.975***	31.237***	61.516***	46.750***	31.965***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Within R-squared	0.544	0.458	0.459	0.643	0.553	0.561	0.647	0.555	0.563
Between R-squared	0.364	0.364	0.294	0.457	0.312	0.312	0.462	0.318	0.316
Overall R-squared	0.395	0.398	0.338	0.469	0.336	0.354	0.474	0.342	0.358
Test of fixed effects									
Sargan-Hansen statistic (df = 5)	27.014	16.15	21.689	45.340	29.993	54.239	45.972	30.370	54.687
Chi-sq p-value	0.000	0.006	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Observations	603	589	631	603	589	617	603	589	617
Number of countries	45	44	47	45	44	46	45	44	46

Notes: The dependent variable is the number of deaths attributed to diarrhea per 1000 live births in each age cohort. Equations were estimated using the xtreg command in

STATA. Robust p-values are given in parentheses. Asterisks indicate significance at 1% (***), 5% (**) and 10% (*). Sierra Leone and Zimbabwe are excluded from these regressions. Lesotho is also excluded from the regressions in column 2, 4 and 6. Including these countries reduces the significance of the results on public health expenditure. $Implied\ elasticity = \frac{\partial y}{\partial x} \times \frac{\bar{x}}{\bar{y}}$, where $\bar{y}$ and $\bar{x}$ are the sample means of the mortality rate and the explanatory variable x (e.g., public health expenditure or access to water), respectively.

Table 5: The Impact of health aid on public health expenditure

VARIABLES	(1) Fixed effects	(2) Random effects
Log GDP per capita	0.767**	0.429***
	(0.043)	(0.004)
Health aid (% of GDP) in year t	0.341***	0.354***
	(0.000)	(0.000)
Health aid (% of GDP) in year t-1	0.155**	0.174**
	(0.026)	(0.012)
Index of government effectiveness	0.311	0.481**
	(0.405)	(0.034)
Population growth rate	0.172	0.111
	(0.204)	(0.289)
Constant	-3.128	-0.628
	(0.242)	(0.585)
Within R-squared	0.187	0.181
Between R-squared	0.107	0.222
Overall R-squared	0.122	0.211
Test of fixed effects		
Sargan-Hansen statistic (df = 5)	5.820	
Chi-sq p-value	0.324	
Observations	653	653
Number of countries	47	47

Notes: The dependent variable is the number of deaths attributed to diarrhea per 1000 live births in each age cohort. Robust p-values are given in parentheses. Asterisks indicate significance at 1% (***), 5% (**) and 10% (*).

Appendix

Table A1: Country-year observations

Country	Year		
	Table 3	Table 4	Table 5
Angola	2000-2013	2000-2013	2000-2013
Benin	2000-2013	2000-2013	2000-2013
Botswana	2000-2013	2000-2013	2000-2013
Burkina Faso	2005-2013	2005-2013	2000-2013
Burundi	2000-2013	2000-2013	2000-2013
Cameroon	2000-2013	2000-2013	2000-2013
Cape Verde	2000-2013	2000-2013	2000-2013
Central African Republic	2000-2013	2000-2013	2000-2013
Chad	2000-2013	2000-2013	2000-2013
Comoros	2005-2013	2005-2013	2000-2013
Congo, Dem. Rep.	2000-2013	2000-2013	2000-2013
Congo, Rep.	2000-2013	2000-2013	2000-2013
Cote d'Ivoire	2000-2013	2000-2013	2000-2013
Djibouti	2000-2013	2000-2013	2000-2013
Equatorial Guinea	2000-2013	2000-2013	2000-2013
Eritrea	2005-2011	2005-2011	2000-2011
Ethiopia	2000-2013	2000-2013	2000-2013
Gabon	2000-2013	2000-2013	2000-2013
Gambia	2000-2013	2000-2013	2000-2013
Ghana	2000-2013	2000-2013	2000-2013
Guinea	2000-2013	2000-2013	2000-2013
Guinea-Bissau	2005-2013	2005-2013	2000-2013
Kenya	2000-2013	2000-2013	2000-2013
Lesotho	2000-2013	2000-2013	2000-2013
Liberia	2000-2013	2000-2013	2000-2013
Madagascar	2000-2013	2000-2013	2000-2013
Malawi	2000-2013	2000-2013	2000-2013
Mali	2000-2013	2000-2013	2000-2013
Mauritania	2000-2013	2000-2013	2000-2013
Mauritius	2000-2013	2000-2013	2000-2013
Mozambique	2000-2013	2000-2013	2000-2013
Namibia	2000-2013	2000-2013	2000-2013
Niger	2000-2013	2000-2013	2000-2013
Nigeria	2005-2013	2005-2013	2000-2013
Rwanda	2000-2013	2000-2013	2000-2013
Sao Tome & Principe	2000-2013	2000-2013	2000-2013
Senegal	2000-2013	2000-2013	2000-2013
Seychelles	2000-2013	2000-2013	2000-2013

Sierra Leone	2000-2013	2000-2013	2000-2013
Somalia	2000-2013	2000-2013	2000-2013
South Africa	2000-2013	2000-2013	2000-2013
Sudan	2000-2013	2000-2013	2000-2013
Swaziland	2000-2013	2000-2013	2000-2013
Tanzania	2000-2013	2000-2013	2000-2013
Togo	2000-2013	2000-2013	2000-2013
Uganda	2000-2013	2000-2013	2000-2013
Zambia	2000-2013	2000-2013	2000-2013
Zimbabwe	2000-2013	2000-2013	2000-2013

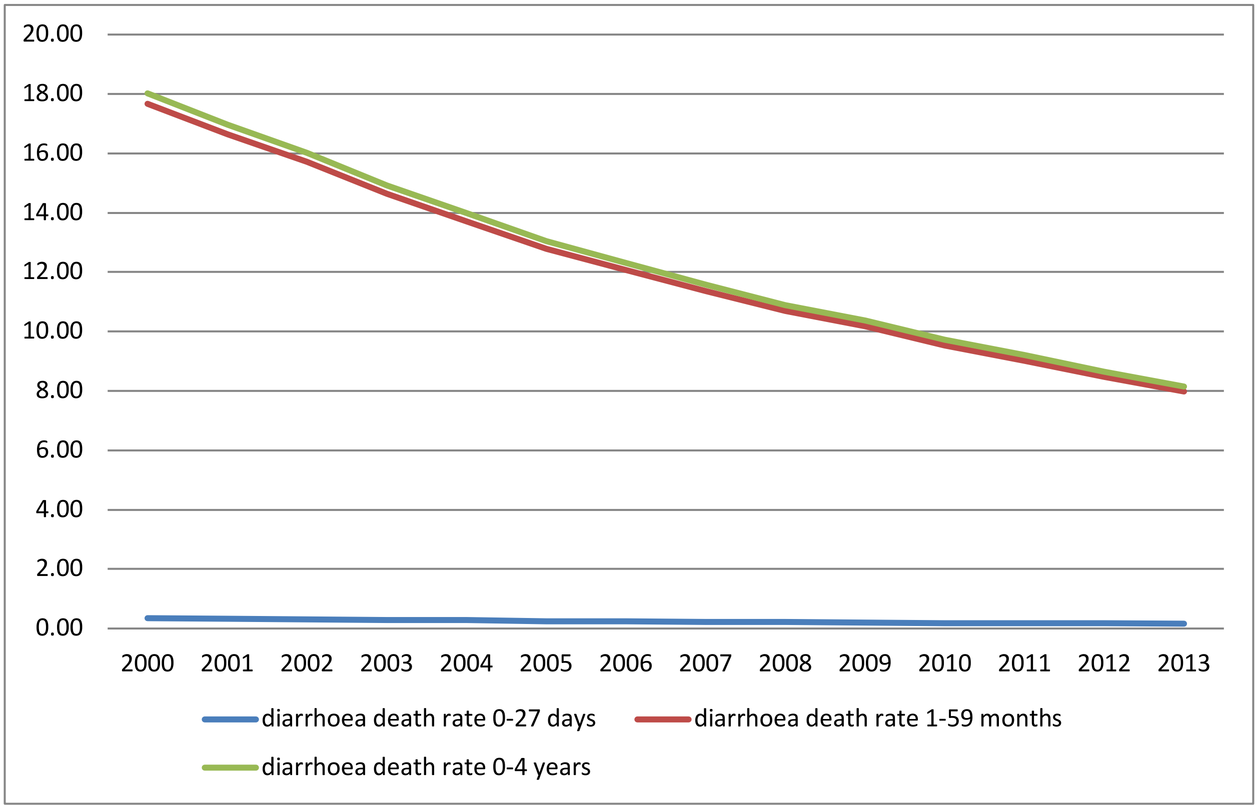
Table A2: Mean diarrhea death rates by country, 2000-2013

Country	Diarrhea death rates (0-27 days)	Diarrhea death rates (1-59 months)	Diarrhea death rates (0-4 years)
Angola	0.471	34.143	34.621
Benin	0.200	14.821	15.029
Botswana	0.100	3.864	3.957
Burkina Faso	0.236	11.850	12.086
Burundi	0.271	14.993	15.257
Cameroon	0.179	14.786	14.979
Cape Verde	0.000	1.993	1.993
Central African Republic	0.479	15.507	15.986
Chad	0.500	28.343	28.829
Comoros	0.321	9.229	9.564
Congo, Dem. Rep.	0.257	11.200	11.457
Congo, Rep.	0.136	8.714	8.850
Cote d'Ivoire	0.357	7.793	8.129
Djibouti	0.479	8.079	8.571
Equatorial Guinea	0.664	11.486	12.143
Eritrea	0.107	7.679	7.786
Ethiopia	0.321	12.286	12.621
Gabon	0.150	5.243	5.400
Gambia	0.136	11.614	11.743
Ghana	0.171	6.564	6.750
Guinea	0.257	13.664	13.921
Guinea-Bissau	0.400	17.807	18.200
Kenya	0.136	7.829	7.957
Lesotho	0.271	11.779	12.064
Liberia	0.250	12.493	12.750
Madagascar	0.171	9.957	10.121
Malawi	0.150	12.100	12.243
Mali	0.407	21.207	21.593
Mauritania	0.300	12.707	13.000
Mauritius	0.000	0.293	0.293
Mozambique	0.286	12.036	12.314
Namibia	0.100	5.800	5.886
Niger	0.293	25.921	26.207
Nigeria	0.400	17.921	18.350
Rwanda	0.164	14.900	15.064
Sao Tome & Principe	0.107	5.671	5.771
Senegal	0.179	11.171	11.350
Seychelles	0.000	0.136	0.136

Sierra Leone	0.536	24.514	25.050
Somalia	0.536	27.979	28.493
South Africa	0.000	6.443	6.443
Sudan	0.300	11.457	11.757
Swaziland	0.079	12.350	12.429
Tanzania	0.129	9.279	9.379
Togo	0.186	7.736	7.936
Uganda	0.136	9.100	9.243
Zambia	0.136	13.250	13.379
Zimbabwe	0.100	8.829	8.943

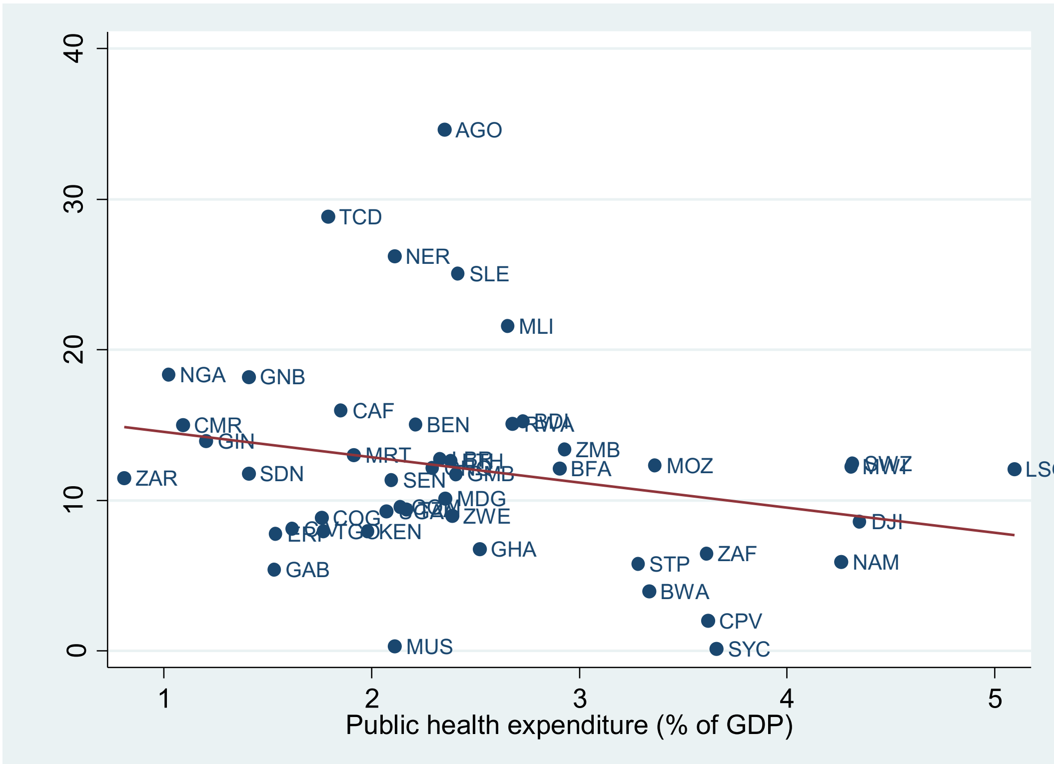
Source: WHO Global Health Observatory

Figure A1: Diarrhea death rates in sub-Saharan Africa, 2000-2013



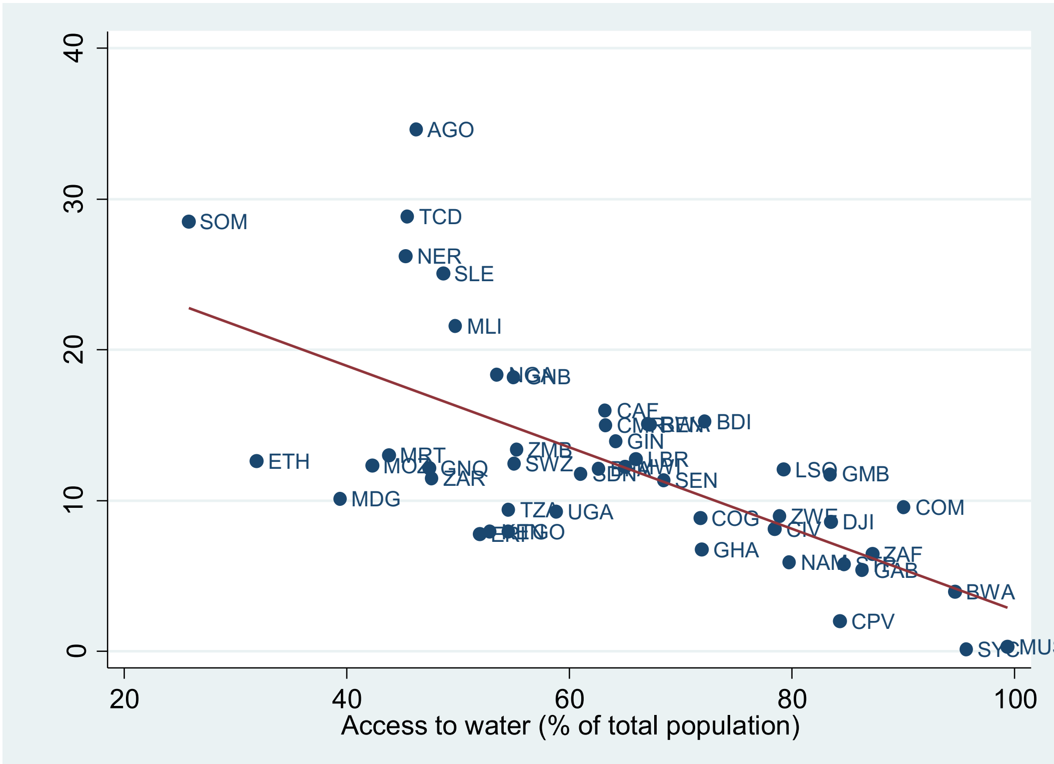
Source: WHO Global Health Observatory

Figure A2: Public Health expenditure and diarrhea death rates in the 0-4 years age cohort



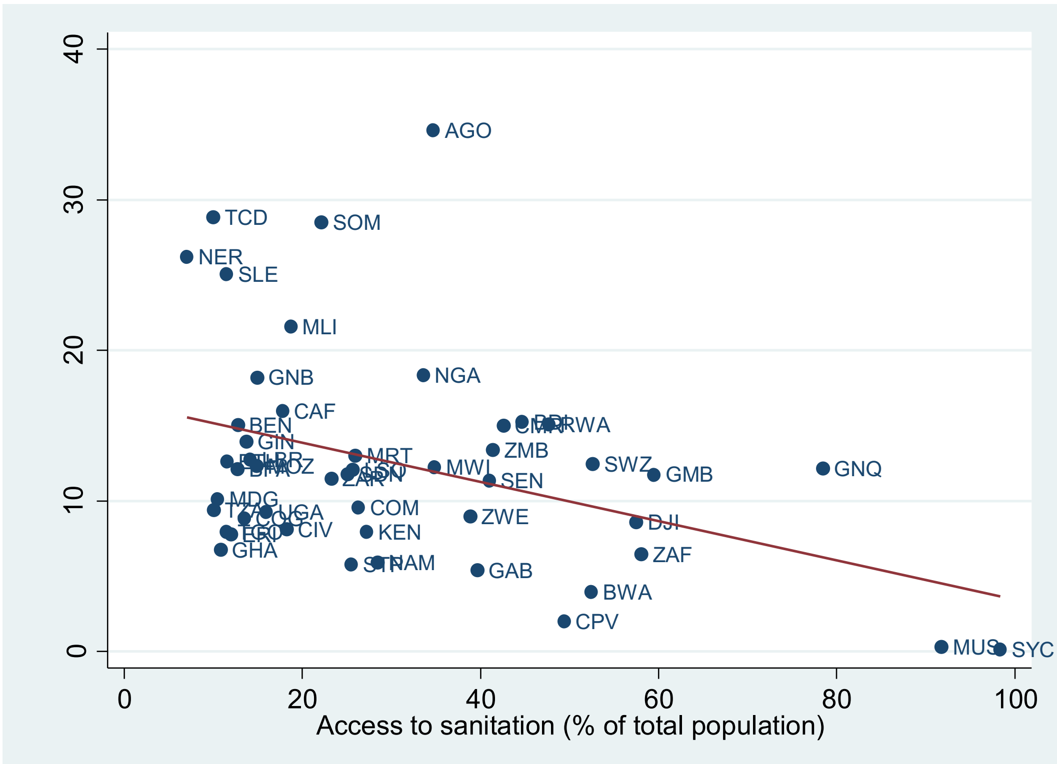
Source: WHO Global Health Observatory; World Bank World Development Indicators

Figure A3: Access to improved sources of water (% of total population) and diarrhea death rates in the 0-4 years age cohort



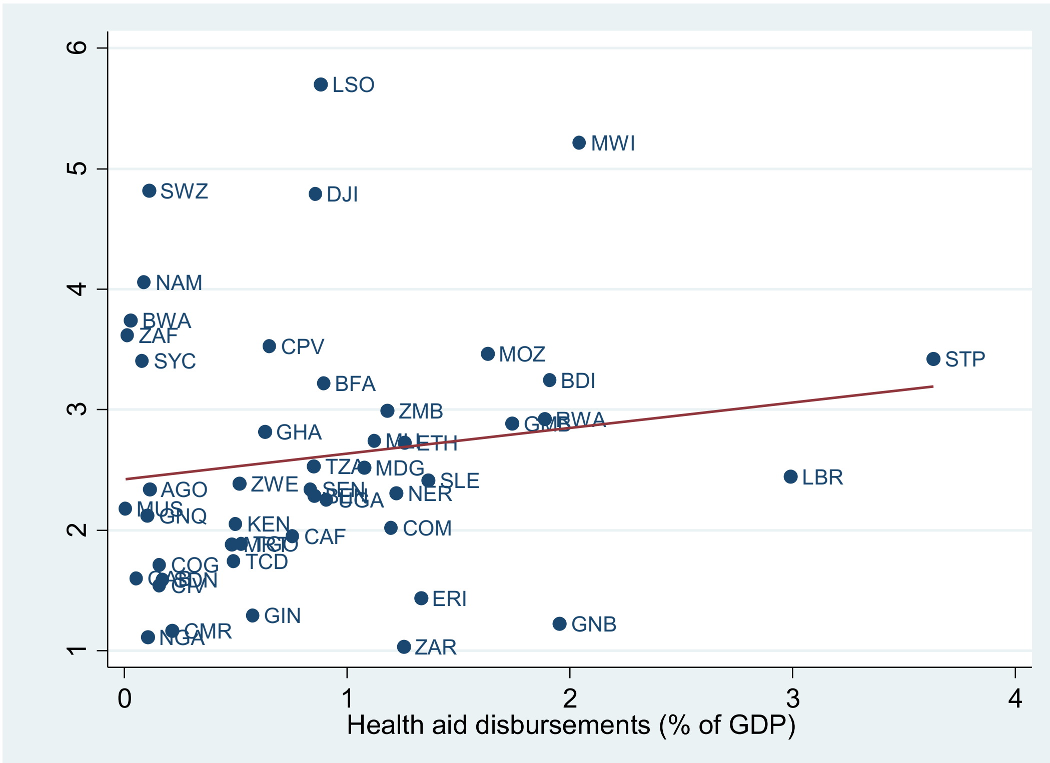
Source: WHO Global Health Observatory; World Bank World Development Indicators

Figure A4: Access to improved sources of sanitation (% of total population) and diarrhea death rates in the 0-4 years age cohort



Source: WHO Global Health Observatory; World Bank World Development Indicators

Figure A5: Public health expenditure and health aid disbursements (2000-2013)



Source: WHO Global Health Observatory; World Bank World Development Indicators