Does health aid matter? Impact of aid on infant mortality

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Declaration

This thesis is the sole work of the author whose name appears on the title page and contains no material which the author has previously submitted for assessment at Deakin University or elsewhere. To the best of the author's knowledge and belief, this thesis contains no material previously published or written by another person except where reference is made in the text of the thesis.

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1 Introduction

1.1 Health and developing countries

Mahatma Gandhi is said to have stated that ‘it is health that is real wealth and not pieces of gold and silver’ (Holmes 2014, p. 10). In this respect, we can view health as a universally important aspect of every individual’s life. Similarly, Maslow’s hierarchy of needs describes physiological wellbeing as the most important and basic human need that must be present for growth as an individual (Simons, Irwin and Drinnien, 1987).

While the importance of health to an individual’s wellbeing has been well documented (Røysamb *et al*, 2003), healthy individuals provide direct benefits to the economy of which they are a part of. Healthy individuals are less of an economic burden on healthcare systems (Rasmussen *et al*, 2005), and they are able to be more economically productive for longer periods of time (Arora, 2001). Bloom, Canning and Sevilla (2001) note that low health in developing countries may stifle economic growth, potentially preventing countries from making social and economic improvements in the long term.

There are vast differences in the health status between countries. For example, OECD (2016) data show that life expectancy is 84 years of age in Japan compared to just 49 years in Swaziland. The number of women dying from pregnancy-related causes (maternal mortality) was just 3 per 100,000 in Poland, compared to 1,360 in Sierra Leone. Similarly, the infant mortality rate (death of infants before reaching one year of age) was more than 30 times higher in Angola (96 deaths) compared to Australia (3 deaths). Such striking differences in health outcomes have an enormous impact on the society and economy. Consequently, four of the eight Millennium Development Goals (United Nations, 2016) directly target health outcomes in an attempt to alleviate global poverty and inequality.[1]

1.2 Development aid

Development aid is a common intervention employed by international governments and private companies to contribute to social and economic change in recipient countries (Crost, Felter and

[1] Goal 1: Eradicate extreme hunger and poverty, Goal 4: Reduce child mortality, Goal 5: Improve maternal health, Goal 6: Combat HIV/AIDS, Malaria and other diseases

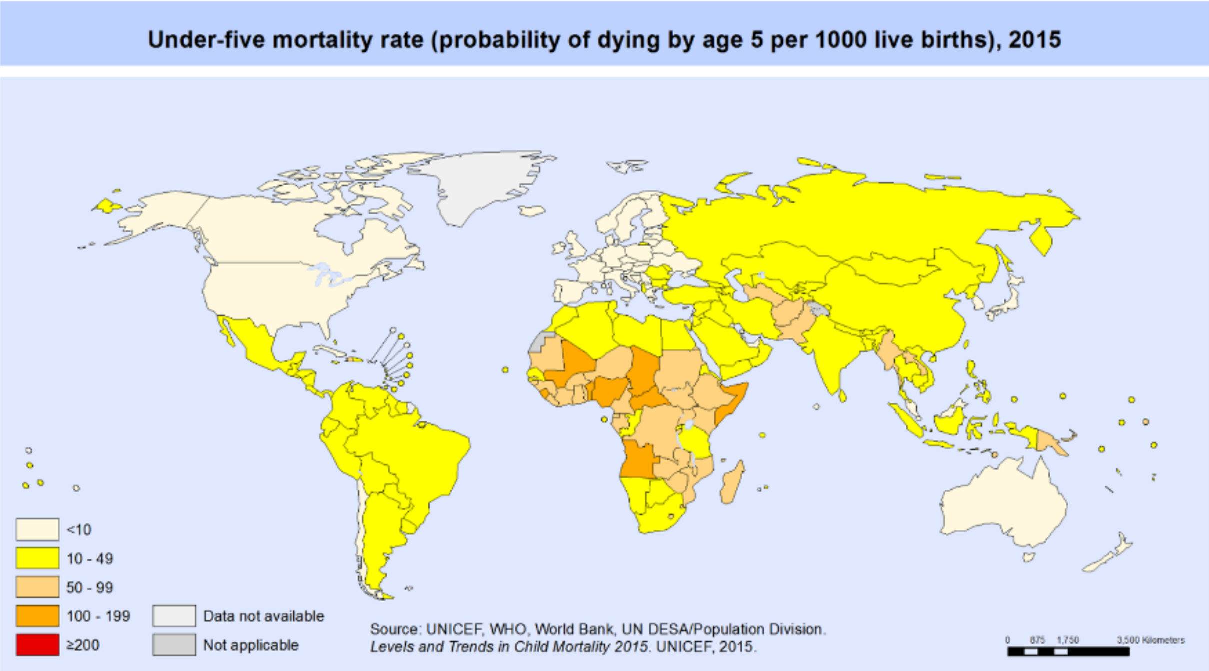
Johnston, 2014). Development aid can take the form of general transfers to recipient governments, which are then entrusted with utilising the money in areas of their choice. However, recently there has been a shift to transfers tied to a specific purpose, which are given with the caveat that they are used as an investment into a target area (Mishra and Newhouse, 2009). Such aid may be tied to several areas, such as education, construction, military training, core support for non-government organisations, or health. Health-specific aid (health aid) is of particular interest, due to the vast potential benefits and the large increases in health aid given in recent years (OECD, 2016). Health aid can influence basic healthcare, health infrastructure, vaccination programs and many other projects, often with a specific aim of improving an individual health outcome, such as tuberculosis vaccination, provision of trained nurses, or the construction of a hospital (Mary and Gomez y Paloma, 2015).

According to the OECD Development Assistance Committee (2016), or the DAC, total development aid was over $114 billion United States dollars in 2013, while health aid exceeded $11 billion United States dollars in the same year. Both aid and health aid have risen dramatically in recent years, with total aid and health aid rising more than 15 and 4 billion, respectively, since 2007. The effectiveness of this aid has been disputed in recent times, with many arguing that while potentially effective at the project level, development aid fails to contribute any aggregate effects at a country or regional level (Mary and Gomez y Paloma, 2015).

1.3 Aid and infant mortality

Many African countries have historically high levels of infant mortality, accounting for the top twelve of countries with the highest infant mortality rates in 2014 (OECD, 2016). Figure 1 presents infant mortality rates throughout the world; it is clear that this is a particularly pressing issue in Africa. It is interesting to note that there is a consistent pattern in these areas of high infant mortality, where the government relies heavily on external resources for health as a portion of their overall health expenditure. For instance, more than 50% of health expenditure in the Democratic Republic of Congo is provided by external resources, outlining the importance of development aid as a funding source for health improvements (OECD, 2016).

Figure 1: Infant mortality, 2015



Source: (OECD, 2016)

Infant mortality is a particularly appropriate measure of health in developing countries (Mishra and Newhouse, 2009). It is highly sensitive to changes in economic conditions and uses empirical data rather than predictions (such as those utilised in life expectation estimates). Similarly, infant mortality relates directly to improvements in life expectancy and is dependent on medical facility access, maternal health, water and sanitation, nutrition and disease exposure, economic inequality and per capita GDP. Hence, it is a good proxy for a large range of socio-economic health outcomes.

Reductions in infant mortality is a specific target of many developing countries. For example, Vietnam has targeted reductions in infant mortality as a key part of its governance strategy (Glewwe, Agrawal and Dollar, 2004). In this respect, it is beneficial for a country to target such reductions, as mortality is an area of clear importance that is also of interest to many donors. It is likely that a country investing in reductions in child mortality may attract additional aid because of such policies. Further, infant mortality is an area of rational interest for many developing country's efforts to increase the rate of economic growth. A case can be made that scarce funds may be spent preventing deaths during childhood than covering healthcare-related costs to the elderly (Joyce, Corman and Grossman, 1988). As such, it is in a country's interest to target infant mortality reductions - potentially with development and health-specific aid.

1.4 Aid and democracy

Numerous authors have attempted to explain why aid may be ineffective at achieving its desired outcomes. One explanation identified in the literature is the displacement of aid (Farag *et al*, 2009). Also known as fungibility of aid, this process arises when donor funding substitutes for, rather than complements financing of recipient governments. For instance, health aid tied to a specific use may be invested as intended; however, the recipient government may withdraw some or all of their own expenditure for use on other, non-related projects. In this instance, it is possible to theorise that aid itself could have a negligible effect on its intended outcomes.

Farag *et al.* (2009) support these findings and outline that displacement occurs at higher rates in low-income countries. Similarly, extreme cases of displacement have occurred in highly autocratic regimes, with development aid instead used to invest in tools of repression (*eg* soldiers and war) or to benefit a small group of the country's elite (Kosack, 2003). Navia and Zweifel (2003) apply this theory to the study of aid on infant mortality, showing that aid can actually increase infant mortality in autocratic regimes. While difficult to imagine, it is possible that displacement of aid in such regimes could be used to fuel war efforts or conflict, thus potentially increasing the death of infants. In this respect, the level of democracy in a recipient country may be a key contributor in the effectiveness of aid.

1.5 The Mishra and Newhouse (2009) study

There have been many studies discussing the effects of aid on various health outcomes, including infant mortality. Such studies and their results are outlined in the literature review below and include the relatively recent study by Mishra and Newhouse (2009). Mishra and Newhouse (2009) looked at 118 aid recipient countries from 1975-2007 and found that a doubling of health aid can lead to a 1.1% reduction in infant mortality across the studied countries. Additionally, their study found that basic health aid (tied to basic healthcare, infectious disease control, health infrastructure and other primary healthcare programs) was effective at reducing infant mortality, while general health aid (health policy and administration, medical research and education/training) had no statistically significant effect.

1.6 Research questions

As noted above, the Mishra and Newhouse (2009) study used data up to 2007. Since 2007 health aid has increased by 91.8% (OECD, 2016). The key motivation of this research is to determine if this aid has been effective in reducing infant mortality. Similarly, more countries have transitioned to democracy since 2007[2] (Freedom House, 2016), and the research presented in this thesis aims to understand if the levels of democracy in aid-recipient countries have an impact on child mortality. Further, the effects of basic health aid, general health aid, and total development aid are studied to identify the most effective streams for donors and policymakers alike.

The importance of health and the large investments associated with development aid provide the primary motivation for this study. It is important to understand if aid impacts mortality and if aid's impact is moderated by the governance of recipient countries. This will inform on how future aid can be used in the most effective way possible and contribute to greater health improvements in the developing world.

This thesis is structured into four distinct sections. The next section presents a review of the relevant literature. This is followed by an independent replication of Mishra and Newhouse (2009). The thesis then presents a new contribution in the form of a new model to estimate the effects of aid on infant mortality that involves interactions between aid and democracy and estimating using long differences. The significance of the findings, limitations, and potential extensions are discussed in the final section of this thesis.

2 Literature review

The effectiveness of development aid on the economic growth of foreign countries has been extensively researched (Doucouliagos and Paldam, 2009). Some authors have argued that there are no empirical effects of aid on recipient countries, with the literature pointing to three main research areas of the aid-efficacy debate. The first looks at a broad approach to aid evaluation, assessing the impact of overall development aid on economic growth of recipient countries. Rajan and Subramanian (2008) argue that aggregate aid is not linked with economic growth,

[2] Bosnia-Herzegovina (2009), Bhutan (2013), Libya (2013), Nepal (2014), Pakistan (2014), Tanzania (2011), Tonga (2011), and Tunisia (2012).

and may even have a negative growth effect in recipient countries. Conversely, Reddy and Minoiu (2006) find that overall development aid has a positive, long run effect on economic growth.

The second aid evaluation area looks at the effects of health aid on health-related spending in recipient countries. Proponents of health aid have found that an increase in health aid is positively correlated with health spending in African countries (Gyimah-Brempong, 2015), especially in settings where fungibility of aid is low due to low initial resources. Others find that health aid can display significant fungibility, whereby health aid reduces recipient government health expenditure in place of the use of foreign aid (Kea, Saksena and Holly, 2011).

The third area of aid effectiveness literature focuses on evaluating the effectiveness of health aid on health outcomes. Many different measures of health have been used in such research. Odokonyero *et al.* (2015) use disease burden and severity as health metrics, finding that health aid can reduce the burden of disease in at-risk populations. Hsiao and Emdin (2015) find that targeted health aid can reduce malaria and HIV mortality. However, they find no significant impact on tuberculosis mortality. Many studies use infant mortality as a measure of aid effectiveness, with Mishra and Newhouse (2009) showing a robust, positive and statistically significant relationship between health aid and a reduction in infant mortality.

There are conjectures in the literature as to which health metrics may be more responsive to increases in aid. Clemens, Kenny and Moss (2007) explain that elimination of vaccine-preventable diseases can be very responsive to increases in health aid. This is due to the relatively simplistic nature of vaccine-program implementation, with funding for vaccines and medical personnel often the only barrier preventing the vaccination of individuals in vulnerable communities. Health aid is, therefore, able to make a relatively immediate impact on the incidence of such diseases. Anyanwu and Erhijakpor (2009) explain that maternal mortality is less responsive to health aid due to the larger range of factors that influence maternal health. Health infrastructure, medical training, sanitation, nutrition and a range of other health metrics influence maternal health, thus the effect of health aid on maternal mortality relies on appropriate investment in many different areas of health. In comparison to a vaccination program, the effects of health aid may be less direct and thus empirical results may differ.

2.1 Empirical studies on aid and infant mortality

Infant mortality is used as a measure of health outcomes in relation to aid effectiveness for a number of reasons. Mishra and Newhouse (2009) suggest that infant mortality is useful due to the extensive availability of data, its sensitivity to economic conditions, and its impact on a broad range of other health outcomes, such as life expectancy. Steketee *et al.* (2001) link infant mortality to a broad range of maternal and socio-economic health areas, including malarial infection, undernutrition, HIV, and anaemia. The authors employed a combination of societal healthcare-related variables, including the availability of medical personnel and hospital beds and percent of total households with access to sanitation and clean drinking water, to explain 87% of infant mortality levels in the model. Among the most statistically significant aspects of health availability was the percent of total households with access to sanitation, suggesting that it is likely improvements in sanitation status, potentially through the provision of health aid could lead to reductions in infant mortality rates across the 66 studied countries. Additionally, Yousuf (2012) suggests that infant mortality data is more reliable than life expectancy indicators, as it uses real historical data, rather than predictive equations.

Results for the impact of health aid on infant mortality are varied. Williamson (2008) uses a fixed effects model to show that health aid is statistically insignificant in influencing five primary health indicators. Specifically, in the fixed effects instrumental variable model, health aid is correlated with a reduction in infant mortality of just .035%, and this result is not statistically significant. Similarly, Wilson (2011) uses a latent growth model to find that health aid has no aggregate effect on infant mortality across 84 countries. Such findings are not uncommon, and support what is known as the micro-macro paradox, where aid is effective at the individual project level, yet ineffective when viewed on its aggregate effect (Mary and Gomez y Paloma, 2015). Conversely, there are numerous studies that show health aid has a positive and significant effect on reducing infant mortality, even at the aggregate level. Kizhakethalackala, Mukherjeeb and Alvi (2013) find that health aid is significant and effective at reducing infant mortality, especially in populations where infant mortality is initially low. Further, Bendavid and Bhattacharya (2014) use cross-country panel data to show that a 1% increase in health aid leads to a 0.14 per 1000 live births decline in the probability of under-5 deaths (infant mortality). In their study, Mishra and Newhouse (2009) find that a doubling of health aid can lead to a 1.1% reduction in infant mortality across 118 studied countries.

There are several explanations for the contradictory findings of the above studies. Studies adopt different econometric specifications, cover different time periods, sample different countries, and employ different estimators. For example, Williamson (2008) uses data from 1973-2004, while Mishra and Newhouse (2009) use data from 1975-2004. Williamson (2008) and Mishra and Newhouse (2009) each use a lag of infant mortality (the dependent variable) in a fixed effects model with an instrumental variable; however, Mishra and Newhouse (2009) restrict the lags to two-periods, while Williamson (2008) uses both two period and three period lags. Similarly, Mishra and Newhouse (2009) extend their fixed effects model to include Generalised Method of Moments (GMM) estimation, which may account for the different results. Bendavid and Bhattacharya (2014) and Mishra and Newhouse (2009) both use Creditor Reporting System (CRS) and Development Assistance for Health (DAH) data in their analysis, while Williamson (2008) and Kizhakethalackala, Mukherjeeb and Alvi (2013) use only CRS data. The additional use of DAH data may account for differences in the results, due to the inclusion of non-government organisation donors, and imputation techniques used to complete missing data in the sample. Additionally, Williamson (2008) uses infant mortality data from the World Bank, while Mishra and Newhouse (2009) and Kizhakethalackala, Mukherjeeb and Alvi (2013) use data from the United Nations. A comparison of results between Williamson (2008) and Mishra and Newhouse (2009) may be limited due to the different countries included in the studies. Williamson (2008) uses 208 countries in her analysis, while Mishra and Newhouse (2009) choose to reduce this data set to include only 118 countries classified as developing (based on GNI per capita) by the World Bank (2006).

2.2 Democracy and aid

A common theme in the aid effectiveness literature is the varied impacts of aid in countries with different political institutions. Bräutigam and Knack (2004) explain that institutional quality in sub-Saharan Africa is a key indicator of aid efficacy, with aid flows to countries with poor governance records less likely to achieve the desired outcomes, compared to countries with a track record of strong institutional quality. A history of strong institutional governance is of such importance that many donor countries have selectively reduced their aid allocations to include only countries with strong track records of institutional quality. Herfkens (1999) notes that the Netherlands has taken the (then) significant step of selectively focusing its aid allocations, shrinking the number of countries receiving aid from 80 to 20 using past governance as an indicator. While institutional quality can be measured in a number of ways, a frequent metric in the aid literature looks at a quantified level of democracy as an institutional indicator. Kosack (2003) explains that democratic governments, due to the existence of competitive elections, availability of political participation, a free press and opposition parties, are inclined to treat their citizens better (*ceteris paribus*) than an autocratic regime. Przeworski *et al.* (2000) explain that democracies often utilise resources more efficiently than autocracies and that these resources, such as development aid, more effectively (and positively) impact on quality of life. Mishra and Newhouse (2009) use Country Policy and Institutional Assessment (CPIA) data to assess the institutional impact on foreign aid, and although a strong measure of institutional quality, the data is only available from 2005 and is thus weaker than other measures.

Several studies have used measures of democracy to study the institutional impact of foreign aid efficacy. Navia and Zweifel (2003) use a two-stage regression model to outline the influence of foreign aid on infant mortality in democratic and non-democratic regimes. The authors show that in 107 democracies and 121 dictatorships, aid has a statistically significant and negative effect on infant mortality in democracies, while aid has a positive effect on infant mortality in dictatorships. The authors explain that aid increasing infant mortality rates in non-democratic countries may be due to the way each type of government invests. Democratic regimes typically invest in human capital at a higher rate than non-democracies. Funding dictatorships (potentially through the displacement of development aid) can be linked to further decreases in human capital expenditure, which in turn is associated with low levels of infant mortality.

Similarly, Boone (1996) shows that aid is more effective in democratic regimes and in countries with greater political liberties using a scale developed by Gastil (1989). Boone (1996) does not find that aid can increase mortality in any political regime and that the impact of aid on infant mortality, although larger in democratic regimes, was minimal. Yousuf (2012) builds on the use of a quantifiable measure of democracy using the Polity scale. Yousuf (2012) finds that health aid has a greater effect on the reduction of infant mortality in more democratic countries, strengthening the idea that institutions may influence the effectiveness of health specific aid.

2.3 Data and econometric issues

Although many studies use similar data sources, the accuracy of health aid data is debatable. OECD data is easily obtainable and is a moderately robust source of health aid data, which is frequently used in health aid efficacy analysis (Dodd and Lane, 2010). However, many authors note that OECD data presents limitations, including the lack of information for non-OECD countries and exclusion of data from private sources (Piva and Dodd, 2009; Ravishankar *et al.*, 2009). Mishra and Newhouse (2009) use DAH data to supplement the OECD CRS data and account for donations from private sources. Similarly, Ravishankar *et al.* (2009) and Wilson (2012) tackle this problem by using OECD data supplemented with data from alternative aid agencies and private philanthropic sources. In recent years, OECD data has been supplemented with information from private donors (OECD 2016), and as such issues around the exclusion of private sources have largely disappeared. Similarly, Ravishankar *et al.* (2009) explain that non-OECD aid accounts for a typically small proportion of overall health aid, and thus omission of non-OECD aid data is not seen as a notable issue.

The econometric models chosen for analysis vary across studies. Most empirical studies use cross-country panel data; however, such data presents its own set of limitations; such as the aggravation of measurement errors, which can be prevalent in data from developing countries (Hsiao, 2007; Fields and Viollaz, 2013). Omitted variable bias is frequently addressed with a fixed effects model, by using estimators with time-invariant country fixed effects (Mary and Gomez y Paloma, 2015; Mishra and Newhouse, 2009). The endogeneity problem, suggesting that larger levels of infant mortality may attract more aid is addressed by Williamson (2008), where aid is instrumented with two and three period lags of aid. The advantages of including lagged aid are twofold. First, it reduces the effects of reverse causality, as aid from say two prior years is much less likely to be attracted to infant mortality in the current year. Second, lags allow aid to impact on mortality with some delay and may better reflect the data generating process. A lag length of two years implies that aid may take two years to produce measurable outcomes; a view that is supported by the literature (Mishra and Newhouse, 2009). Empirical models are further strengthened with dummy variables (such as the presence of war) and controls (Mishra and Newhouse, 2009). Control variables such as HIV incidence are instrumented with their lags to ensure that the instrumentation of aid has no effect on the overall model (Mary and Gomez y Paloma, 2015).

Mishra and Newhouse (2009) use a dynamic panel data model with country fixed effects. The country fixed effects control for the unobserved country-specific and time-invariant factors that could influence levels of infant mortality. In addition, all predetermined variables are instrumented by appropriate lags, avoiding spurious correlation of such variables and the error term, in line with previous work by Blundell and Bond (2000). Their empirical model is given by Equation (1):

$$\begin{aligned} Log\ IM_{rt} = {} & \beta_1 logAIDPC_{rt-2} + \beta_2 logIM_{rt-2} + \beta_3 logGDP_{rt-2} \\ & + \beta_4 logPOPULATION_{rt-2} + \beta_5 logFERTILITY_{rt-2} \\ & + \beta_6 WAR_{rt} + \beta_7 HIV_{rt} + s_r + v_t + \varepsilon_{rt}, \end{aligned} \tag{1}$$

where IM is infant mortality, $AIDPC$ is health aid per capita, $GDP,\ POP\ and\ FERTILITY$ are included as control variables, and HIV and WAR measure HIV incidence and war incidence. *s* is a vector of country fixed effects, which accounts for time invariant differences in infant mortality across countries, and v is a vector of period dummies, which accounts for universal time trends. *r* and *t* denote the country and time period, respectively.

While Mishra and Newhouse (2009) address many problems associated with empirical estimation of health aid efficacy, there are still limitations with their framework. For example, Roodman (2008) describes how the use of extensive instruments can decrease the efficacy of the Hansen J test, leading to circumstances where non-valid instruments are not rejected. Both Yousuf (2012) and Mishra and Newhouse (2009) acknowledge this problem and theoretically address such issues through the use of only two lags on each instrument. Additionally, many studies have tried to eliminate the impact of omitted variable bias by using a fixed effects estimator (Mishra and Newhouse, 2009; Williamson, 2008; Bendavid and Bhattacharya, 2014). However, it is likely that data used in the study of aid efficacy is not stationary, as it involves gradual changes in donor and recipient behaviour, which are expected to change through the time series (Enders, 1995). In such cases, where the error term may not be serially uncorrelated, a more suitable estimator may be the first difference estimator (Marcusse, 2005). The first difference estimator can be used to address omitted variable bias, and indeed is identical to the fixed effect model when t=2. The effects of the first difference estimator can be formally shown by lagging the below Equation (2) (Waldinger, 2014):

$$y_{it} = \beta x_{it} + c_i + u_{it} \tag{2}$$

Lagging the model by one period, and then subtracting (first-differencing) gives:

$$y_{it} - y_{it-1} = \beta x_{it} - \beta x_{it-1} + c_i - c_i + u_{it} - u_{it-1}$$

$$\Delta y_{it} = \Delta\beta x_{it} + \Delta u_{it}$$

From the above, we can see that the first difference estimator eliminates c_i and thus is strong in eliminating omitted variable bias in the model (Waldinger, 2014). However, Pischke (2009) explains that the first differences model can be inappropriate for data where there are only small changes between years. Infant mortality data is such an example, where infant mortality rates change by only decimal places in many cases[3]. Griliches and Hausman (1986) show that in such cases, a more robust method is to use a *long difference* estimator where multi-year differences are taken. A long difference model is very robust in establishing a link between explanatory and dependent variables, reduces bias for a large positive β compared to usual IV estimation, and can be used to eliminate potential positive correlations in measurement error (Hahn, Hausman and Kuersteiner, 2007).

2.4 Hypotheses

Drawing on the literature review and the extant empirical studies, this thesis explores two sets of analyses: (1) an independent replication of Mishra and Newhouse (2009) and (2) an alternative model to assessing aid effectiveness. The analysis involves testing four related hypotheses:

H1. Health aid is effective at reducing infant mortality.

This hypothesis reflects the views of Mishra and Newhouse (2009) that health aid has a statistically significant effect on decreasing infant mortality and takes into account the large increase in health aid donations in recent years (OECD 2016). Bendavid and Bhattacharya (2014) use aid data current to 2010 and find statistically significant effects of health aid on reductions in infant mortality. However, the authors use different methods and samples compared to Mishra and Newhouse (2009), complicating comparisons of effectiveness

[3] For example, between 2003 and 2012 Cabo Verde's infant mortality rate decreased from 23.8 to 22.4. This change reflects an annual average of just 0.14

between each. Mishra and Newhouse (2009) explain that in recent years, health aid has shifted from being primarily aimed at policy and administration reform towards resourcing for basic healthcare. Bendavid and Bhattacharya (2014) notes that this trend has led to decreased disease incidence in recipient countries. As such, I hypothesise that health aid is effective at reducing infant mortality across the sample period.

H2. Health aid will have a greater effect than total aid on the reduction of infant mortality.

Mishra and Newhouse (2009) found mixed results using total aid as a dependent variable. Using GMM estimation, the authors found no statistically significant effect of total aid on infant mortality. However, the authors found that total aid may have a significant and negative effect on infant mortality in the long run when using OLS. Williamson (2008) tests the effectiveness of both health aid and total aid and finds no significant effects on infant mortality of either. Similarly, Burnside and Dollar (1998) found that total aid has no significant effect. The theory behind this hypothesis is that total development aid can be spent in a large variety of ways. Aid that contributes to education and infrastructure may have an effect on improving the health of individuals in recipient countries; however, this aid could also be spent on military training, investment in the economic elite and in many other ways that may have no effect or a negative effect on the health of a country's citizens. Crost, Felter and Johnston (2014) support this theory by showing increases in total aid can cause greater loss of life in developing countries, such as the Philippines.

H3. Basic health aid will have a greater effect than general health aid on the reduction of infant mortality

This hypothesis reflects the findings from Mishra and Newhouse (2009) that basic health aid has a statistically significant and negative effect on infant mortality, while general health aid has no significant effect. As discussed, basic health aid largely funds basic and primary healthcare programmes at the district level, whereas general health aid is a more macro-based funding mechanism that funds to the broader health sector.[4] Therefore, this hypothesis is based

[4] The micro-macro paradox (Mosley, 1986) showed that while aid is effective at the project level, there is no aggregate effect. Basic health aid is conceptually similar to micro-level aid; it's targeted to more specific projects than general health aid. In this respect, I am treating general health aid as aggregate, less targeted aid, and arguing that we will not see a statistically significant effect of general health aid on infant mortality.

on the view that project-based, highly concentrated health aid donations will be more effective than the less targeted, more fungible forms of aid (Burnside and Dollar, 1998).

H4. The overall efficacy of health aid will be conditional on the level of democracy of the country. Aid will be more effective at reducing infant mortality in countries with higher levels of democracy.

This hypothesis reflects the theory that democracies actively seek to break cycles of underdevelopment in communities, due to their need to respond to the wishes of the people which they govern (Navia and Zweifel, 2003). This includes higher levels of investment in social services and human capital, in comparison to autocratic regimes. In terms of health aid, this hypothesis suggests that countries with higher levels of democracy will utilise their aid resources in a more effective way than those with lower levels of democracy, and thus reduce infant mortality to a greater degree. This theory is supported by Navia and Zweifel (2003) and Boone (1996) who both found that foreign aid is more effective at reducing infant mortality in democratic countries. The extension of this hypothesis implies that health aid, rather than total aid, will be causing these reductions at a greater rate in more democratic countries.

3 Revisiting the literature: an independent replication of Mishra and Newhouse (2009)

3.1 Econometric specification

This section of the thesis presents an independent replication of Mishra and Newhouse (2009), reporting various estimates of their basic model; recall Equation (1):

$$\begin{aligned} Log\ IM_{rt} = {} & \beta_1 logAIDPC_{rt-2} + \beta_2 logIM_{rt-2} + \beta_3 logGDP_{rt-2} \\ & + \beta_4 logPOPULATION_{rt-2} + \beta_5 logFERTILITY_{rt-2} \\ & + \beta_6 WAR_{rt} + \beta_7 HIV_{rt} + s_r + v_t + \varepsilon_{rt}, \end{aligned} \quad (1)$$

where IM_{rt} is the dependent variable, the infant mortality in recipient country r at time t, and $AIDPC$ is the explanatory variable, health aid per capita. GDP, POPULATION, FERTILITY, HIV and W are included; HIV measures the incidence of HIV/AIDS, and W is a war dummy that controls for the presence of war. v is time fixed effects, s is a vector of country fixed effects, which accounts for time invariant differences in infant mortality across countries, and ε represents the random error component of the regression. The control variables are included to account for other factors that affect infant mortality and to reduce the likelihood of omitted variable bias (Mishra and Newhouse, 2009). The use of a log-log specification smooths the data and facilitates the interpretation of the coefficients as elasticities. All variables are averaged over five year periods to smooth out fluctuations in the annual data.

The explanatory variable and controls (with the exception of HIV and W) are lagged to capture initial health and economic status, and to control for potential endogeneity, in line with Mishra and Newhouse (2009). Addressing endogeneity is a key concern, as countries with high levels of infant mortality may naturally attract more health aid. Similarly, Herfkens (1999) has shown that countries with a past track record of effective use of aid may attract additional aid. In the context of infant mortality, a country that reduces infant mortality may receive additional development aid, creating an endogeneity problem that must be addressed. A two-year lag length assumes that it takes ten years (due to the five year averages used in the estimation) for health aid to effect infant mortality rates (Mishra and Newhouse, 2009)[5].

Three distinct models are estimated as variants on Equation 1 above. These are identical to the estimations performed by Mishra and Newhouse (2009). The models are described in Equation (3), (4), and (5). The first variant, Equation (3) removes the country fixed effects:

$$\begin{aligned} Log\ IM_{rt} = \ & \beta_1 logAIDPC_{rt-2} + \beta_2 logIM_{rt-2} + \beta_3 logGDP_{rt-2} \\ & + \beta_4 logPOPULATION_{rt-2} + \beta_5 logFERTILITY_{rt-2} \\ & + \beta_6 WAR_{rt} + \beta_7 HIV_{rt} + v_t + \varepsilon_{rt} \end{aligned} \quad (3)$$

Mishra and Newhouse (2009) justify the omission of country fixed effects by explaining that the fixed effects model may be more susceptible to omitted variable bias than an OLS specification. This is because initial infant mortality is an important determinant of both current infant mortality and of health aid. If countries with increasingly poor health outcomes receive

[5] Mishra and Newhouse (2009) justify using current HIV as it controls for the prevalence of AIDS in the current period. Therefore, the estimates do not capture the effect of health aid on infant mortality through any effect on AIDS prevalence rates occurring at the same time.

additional health aid, the fixed effects estimator will be biased towards zero; underestimating the beneficial impacts of aid. Further, if measurement error accounts for a greater proportion of the within-country aspect of health aid than the cross country component, then the fixed effects model may be subject to greater attenuation bias than the OLS estimator.

Equation 4 is estimated using additional control variables (in comparison to Equation (3)):

$$\begin{aligned} Log\ IM_{rt} = {} & \beta_1 logAIDPC_{rt-2} + \beta_2 logIM_{rt-2} + \beta_3 logGDP_{rt-2} \\ & + \beta_4 logPOPULATION_{rt-2} + \beta_5 logFERTILITY_{rt-2} \\ & + \beta_6 WAR_{rt} + \beta_7 HIV_{rt} + \beta_8 logLITERACY_{rt-2} \\ & + \beta_9 logUNDERNUTRITION_{rt} + \beta_{10} logPHYSICIANS_{rt} \\ & + \beta_{11} logSANITATION_{rt} + \beta_{12} logWATER\varepsilon_{rt} + v_{rt} \\ & + \varepsilon_{rt} \end{aligned} \tag{4}$$

The additional control variables are female literacy rate, undernutrition, access to physicians, access to sanitation, and access to clean water. These additional controls are included to further reduce the possibility that omitted variables are biasing the OLS estimates (Mishra and Newhouse, 2009). By controlling for predetermined variables that are likely determinants of infant mortality, the estimation is able to more accurately estimate the specific effect of health aid on infant mortality.

The final variant involves removing the lagged dependent variable:

$$\begin{aligned} Log\ IM_{rt} = {} & \beta_1 logAIDPC_{rt-3} + \beta_3 logGDP_{rt-2} + \beta_4 logPOP_{rt-2} \\ & + \beta_5 logFERTILITY_{rt-2} + \beta_6 WAR_{rt} + \beta_7 HIV_{rt} \\ & + \beta_8 logLITERACY_{rt-2} + \beta_9 logUNDERNUTRITION_{rt} \\ & + \beta_{10} logPHYSICIANS_{rt} + \beta_{11} logSANITATION_{rt} \\ & + \beta_{12} logWATER_{rt} + s_r + v_{rt} + \varepsilon_{rt} \end{aligned} \tag{5}$$

Mishra and Newhouse (2009) explain that the inclusion of country fixed effects in the basic equation can lead to biased estimates. If fixed effects are used in panel data models with a lagged dependent variable and predetermined variables, the within-estimators of the lagged dependent and predetermined variables are inconsistent. Mishra and Newhouse (2009) explain that this inconsistency comes from the presence of the lagged error term in the residual, after subtracting within-country means. Therefore, Equation (5) is an estimation of Equation (4), without lagged log infant mortality, and with the additional of country fixed effects (s_r).

In order to estimate the effects of different types of development aid, Equation (3) is re-estimated using three alternative explanatory variables: total aid, basic health aid, and general health aid. The above models are estimated in STATA. Standard errors are clustered within country for all specifications of the model.

3.2 Data

This section describes the data sources for variables used in the analysis. Appendix Table 12 contains a summary description of variable definitions and sources.

Aid

Data on health aid and overall aid are taken from the OECD, from two different sources. Data on total aid is obtained from the Development Assistance Committee (DAC). The definition of total aid used in estimations consists of net Official Development Assistance (ODA): the difference between the value of aid disbursed by all donors and the return of unspent balances and principal repayments of earlier loans. Aid data does not include funds from Private Flows (non-government) and Other Official Flows (OOF: grants intended to promote development, but given for largely commercial purpose). Nyberg-Sorenson, Van Hear and Engberg-Pedersen (2002) explain that because private flows include remittances sent home by migrants; these essentially private transfer payments should not constitute aid. Similarly, Chang, Fernandez-Arias and Serven (2002) attest that the commercial lending component included in private flows (such as foreign direct investment) does not constitute aid by definition, and therefore should not be included in total aid estimates.

Health aid data is taken from the OECD Creditor Reporting System (CRS), which identifies aid commitments by purpose. Health aid is classified into two distinct streams: basic health aid and general health aid; summaries of which are included in Appendix Table 10. As noted by Mishra and Newhouse (2009), the CRS data suffers from a key limitation. The CRS collects data from donor commitments rather than receipts (as per DAC). This results in a significant level of underreporting when comparing CRS and DAC amounts. The DAC (2012) explains that the underreporting varies by sector, donor and time period. However, for the purposes of this research, as health aid is reported by donors, there is no indication that underreporting is correlated with characteristics of the recipient country (Mishra and Newhouse, 2009). While the data source is identical to that of Mishra and Newhouse (2009), the sample periods are different. Mishra and Newhouse (2009) use data from 1975 to 2004, while this study uses data from 1995 to 2014. Although CRS commitments by purpose are available for the periods 1975-1995, health-specific data by recipient country was unable to be obtained.[6] Currently available data commence from 1995.

The sample of aid recipient countries is confined to developing countries classified by the OECD (2016) as those with a per capita income below 12,276 United States dollars in 2010. Note that the classification of developing countries is different to that employed by Mishra and Newhouse (2009), who identify developing countries based on 2005 GNI per capita, as classified by the World Bank (2006). This study uses 181 countries, while Mishra and Newhouse (2009) use 118. A list of countries is included in Appendix Table 11.

In line with Mishra and Newhouse (2009), health aid per capita is used as the explanatory variable. Although clearly an incorrect assumption that health aid is distributed evenly throughout the population, it can be viewed as a closer measurement of effectiveness and is in line with other variables; such as GDP. Aid data is in constant 2014 United States Dollars, with levels reported in millions of dollars.

Infant mortality

Infant mortality data comes from the United Nations (2016) and is defined as the number of infants dying before reaching one year of age, per 1,000 live births in a given year. Appendix Figure 8 presents a scatter diagram of the health aid and infant mortality data.

Other variables

Other control variables including GDP, population, fertility, HIV prevalence, female literacy, the prevalence of undernutrition, access to physicians, access to sanitation and access to clean water are taken from the World Bank (2016).

Data for the war dummy (presence of war) is taken from the Heidelberg Institute for International Conflict Research (2016). As per Mishra and Newhouse (2009) specification, all

[6] Correspondence with OECD confirmed that CRS data prior to 1995 is not available.

variables are averages over five year periods (with the exception of W; the war dummy). A summary of data definitions and sources is included in Appendix Table 12.

3.3 Results: Health aid and infant mortality

This section describes the results of Equation (3), (4), and (5), comparing the new estimations to results from Mishra and Newhouse (2009).

Table 1 presents the results of Equation (3) for Mishra and Newhouse (2009) in column (1) and the new estimation in column (2). The new results are not consistent with Mishra and Newhouse (2009). Like Mishra and Newhouse (2009), I find that there is a negative effect of health aid on infant mortality, but this effect is not statistically significant. Mishra and Newhouse (2009) find that a doubling of health aid per capita leads to an approximately one percent decrease in infant mortality; the new results suggest aid ineffectiveness.

Table 1: Effect of health aid on infant mortality: comparison of Mishra and Newhouse (2009) and new estimation

Dependent variable:	**Log infant mortality rate (per 1000)**	
	Mishra and Newhouse (2009) (1)	New estimation (2)
Lagged log health aid per capita	−0.0110** (0.005)	-0.00496 (0.003)
Lagged log infant mortality	1.0408*** (0.021)	0.924*** (0.040)
Lagged log GDP	−0.0169** (0.008)	0.0144 (0.019)
Lagged log population	−0.0094** (0.004)	-0.0289** (0.009)
Lagged log fertility	0.028 (0.033)	0.190*** (0.050)
War dummy	0.0053 (0.012)	0.0380 (0.045)
HIV AIDS rate	−0.0110** (0.005)	0.00544 (0.003)
Number of countries	118	149
Number of observations	465	293

Notes: Basic model without country fixed effects; Equation (3). Standard errors are denoted in parenthesis and clustered at the country level. Estimation includes time dummies. All variables are averaged over five year periods (except for War dummy). Two year lags are used for all lagged variables. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

Similarly, the results of the new estimation of Equation (4) are not consistent with the Mishra and Newhouse (2009) results. I find that there is a positive and non-statistically significant effect of health aid on infant mortality. This differs to the results in Mishra and Newhouse (2009), who find that health aid has a negative and statistically significant effect on infant mortality; specifically, that a doubling of health aid per capita leads to an approximately one percent decrease in infant mortality. The regression results are outlined in Table 2.

Table 2: Effect of health aid on infant mortality: comparison of Mishra and Newhouse (2009) and new estimation

Dependent variable	**Log infant mortality rate (per 1000)**	
	Mishra and Newhouse (2009) (1)	New estimates (2)
Lagged log health aid per capita	−0.0096** (0.004)	0.00228 (0.015)
Lagged log infant mortality	1.0130*** (0.0017)	0 .872*** (0.045)
Lagged log GDP	0.0053 (0.008)	0.00302 (0.038)
Lagged log population	−0.0037 (0.004)	-0.0181 (0.016)
Lagged log fertility	0.0673*** (0.026)	0.133 (0.092)
Lagged log female literacy	−0.001 (0.008)	-0.124* (0.058)
Log undernutrition	0.0176** (0.008)	0.00917 (0.015)
Log physicians	0.0657*** (0.019)	0.0168 (0.011)
Log sanitation	0.0118 (0.013)	0.00749 (0.069)
Log improved water source	0.0601*** (0.021)	-0.0323 (0.150)
War dummy	-0.0053 (0.009)	-0.0147 (0.055)
HIV AIDS rate	0.0015*** (0.000)	0.00711 (0.004)
Number of countries	110	82
Number of observations	448	111

Notes: Basic model with additional controls and without country fixed effects; Equation (4). Standard errors are denoted in parenthesis and clustered at the country level. Estimation includes time dummies. All variables are averaged over five year periods (except for War dummy). Two year lags are used for all lagged variables. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

Discordantly, the results of the new estimation of Equation (5) are consistent with the Mishra and Newhouse (2009) results. I find that there is a positive and non-statistically significant effect of health aid on infant mortality. Mishra and Newhouse (2009) find the same relationship between health aid and infant mortality, however, the coefficients differ slightly. I find a positive coefficient (0.0137) approximately three and a three and a half times that of Mishra and Newhouse (2009) (0.004). While the additional controls are included in the regression, Mishra and Newhouse (2009) did not provide results. As such, the results below include only health aid coefficients. The regression results are outlined in Table 3.

Table 3: Effect of health aid on infant mortality: comparison of Mishra and Newhouse (2009) and new estimation

Dependent variable	**Log infant mortality rate (per 1000)**	
	Mishra and Newhouse (2009) (1)	New estimates (2)
Lagged log health aid per capita	0.004 (0.005)	0.0137 (0.014)
Number of countries	118	82
Number of observations	347	111

Notes: Basic model with additional controls, country fixed effects and without lagged dependent variable; Equation (5). Standard errors are denoted in parenthesis and clustered at the country level. Estimation includes time dummies. All variables are averaged over five year periods (except for War dummy). Two year lags are used for all lagged variables. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

Total aid, basic health aid, general health aid, and infant mortality

The results of the new estimation using alternate explanatory variables are presented in Table 4. The results are largely inconsistent with the Mishra and Newhouse (2009) results. Mishra and Newhouse (2009) find a negative and statistically significant effect of total aid on infant mortality. Their results suggest that a doubling of total aid per capita leads to an approximately one and a half percent decrease in infant mortality. I find a positive, non-statistically significant relationship between total aid and infant mortality. Mishra and Newhouse (2009) find a negative and statistically significant effect of basic aid on infant mortality. Specifically, a doubling of basic health aid per capita leads to an approximately 0.9 percent decrease in infant mortality. While I find a negative relationship between basic health aid and infant mortality; the effect is not significant.

The Mishra and Newhouse (2009) results for the general health aid regression are notably similar to the new estimation. Mishra and Newhouse (2009) find a negative and non-statistically significant effect of general health aid on infant mortality (-0.0051), while I find the same relationship with a comparable coefficient (-0.0048).

Table 4: Effect of aid on infant mortality: comparison of Mishra and Newhouse (2009) and new estimation

Dependent variable	**Log infant mortality rate (per 1000)**	
	Mishra and Newhouse (2009) (1)	New estimates (2)
Lagged total aid per capita	−0.0162*** (0.006)	0.00248 (0.003)
Lagged basic health aid per capita	−0.0087** (0.004)	-0.0039 (0.003)
Lagged general health aid per capita	−0.0051 (0.004)	-0.0049 (0.003)
Number of countries	118	150
Number of observations	347	293

Notes: Basic model without country fixed effects and alternative explanatory variables. Standard errors are denoted in parenthesis and clustered at the country level. Estimation includes time dummies. All variables are averaged over five year periods (except for War dummy). Two year lags are used for all lagged variables. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

3.4 Analysis and discussion

It is clear from the above results that the new estimations are inconsistent with those in Mishra and Newhouse (2009). I find no statistically significant effect of health aid on infant mortality in any of the models. Similarly, I find no statistically significant effect of total aid on infant mortality. The only notable similarities were that both estimations found no statistically significant effect of health aid using a fixed effects model and that general health aid had a positive and non-statistically significant effect on infant mortality. There are two reasons why the results may differ. Firstly, there are inconsistences in the data used by Mishra and Newhouse (2009) and the new estimation. Secondly, it is possible that the effectiveness of aid has decreased in recent years, to a point where it crowds out the previously beneficial effect seen from 1975-2004.

The discordant classification of developing countries is a notable issue in comparison of the studies. Mishra and Newhouse (2009) manually trim the aid recipient countries using data based on GNI per capita from the World Bank (2006). The new estimation uses the classification provided by the OECD, which is based on GDP per capita for developing countries. This difference results in a discrepancy between the number of countries included in each sample. In the estimation of Equation 3, Mishra and Newhouse (2009) have 118 countries, while the new estimation has 149. It should be noted that the number of countries differs in each estimation due to the availability of data. For countries where the five year averages do not produce data in some variable for the 1995 to 2014 period, these are dropped from the sample. Hence, in the results of different estimations, the number of countries may not be consistent.

Additionally, the sample period of data differs between the studies. Mishra and Newhouse (2009) use data from 1975 to 2004, while the new estimation uses data from 1995 to 2014. While there is some crossover in the data sets (1995 to 2004), the use of different periods can be a source of error in comparison of the two studies (Tomek, 1993).

A comparison of aid data sources, flows, years and developing country classifications are outlined in Table 5.

Table 5: Comparison of aid data: Mishra and Newhouse (2009) and new estimation

Aid data:	**Study**	
	Mishra and Newhouse (2009)	New estimates
Source (health aid)	CRS	CRS
Source (total aid)	DAC	DAC
Flows (total aid)	***ODA***	***ODA***
Years	***1975-2004***	***1995-2014***
Classification of developing countries (source)	***GNI per capita (World Bank)***	***GDP per capita (OECD)***

Despite inconsistencies with Mishra and Newhouse (2009), the new estimation delivers important insights. The findings of health aid ineffectiveness are in line with a number of previous aid-efficacy studies (Williamson, 2008; Wilson, 2011). A common theme identified in aid effectiveness literature, is the fungibility of aid (Farag *et al*, 2009). The results from the years 1995 to 2004, where we find no effect of health aid on infant mortality may be attributed to the fungible nature of aid. It is possible that despite increasing dispersions of aid in recent years, the fungible nature of aid has prevented the transfers from making any significant impact.

Another potential explanation for the ineffectiveness of aid revealed in the new estimation relates to the nature of the projects funded by aid agencies and governments. Banerjee (2008) explains that many donors seek to fund quick impact, visible projects that highlight the effectiveness of their distributions. Similarly, Hatcher (2004) explains that governments are typically exposed to at least some form of external evaluation; from citizens or opposition parties, and are likely to invest in short-term solutions rather than more complex, longer-term programs. As outlined previously, infant mortality is a complex issue driven by a range of socio-economic factors. In this respect, it can be theorised that some governments may look to invest health aid in less complex projects with a greater chance of success and more easily quantifiable outcomes in the short term (Carstensen, 2006). Such investment may drive money away from infant mortality-related projects, and contribute to the aggregate ineffectiveness of health aid in reducing infant mortality.

4 A new approach: application of a long difference model and health aid and democracy interactions

In this section, I estimate a number of alternate models that expand upon the Mishra and Newhouse (2009) model. Specifically, two contributions are made to the literature: (1) incorporating additional control variables and interactions between aid and democracy, and (2) estimating health aid effectiveness using a long difference model.

4.1 Econometric specification

The analysis commences with the baseline model, Equation (6):

$$\begin{aligned} IM_{rt} = {} & \beta_1 HEALTHAID_{rt-5} + \beta_2 GDP_{rt-5} + \beta_3 POP_{rt-5} \\ & + \beta_4 FERTILITY_{rt-5} + \beta_5 HIV_{rt-5} + \beta_6 LITERACY_{rt-5} \\ & + \beta_7 UNDERNUTRITION_{rt-5} + \beta_8 PHYSICIANS_{rt-5} \\ & + \beta_9 SANITATION_{rt-5} + \beta_{10} WATER_{rt-5} + \beta_{11} POLITY_{rt-5} \\ & + \beta_{12} TUBERCULOSIS_{rt-5} + s_r + v_t + \varepsilon_{rt}, \end{aligned} \tag{6}$$

where the variable definitions are the same as outlined in the independent replication section above. As discussed in the data section below, the key differences are that my estimations employ non-logarithmic forms, use five year lags,[7] use aggregate aid, and use total yearly values. Tuberculosis is included as an additional control to further address omitted variable

[7] Multiple lags of up to eight years were used as a robustness check. All results held with a lag length greater than two years.

bias, and Polity is included as a measure of democracy to investigate the effect that democracy has on aid and infant mortality.

Explanatory and control variables are lagged to address endogeneity. A lag period of five years is used to capture the country's initial health and economic status and to reflect the idea that it can take up to five years for aid flows to have an impact on infant mortality.[8] The model includes time and country fixed effects. However, the lagged dependent variable is removed, as its inclusion in a fixed effects estimation results in a downwards bias on the coefficient of the lagged dependent variable (Hurwicz, 1950). This type of bias arises because the realised error terms appear in the sample mean of the lagged dependent variable.

All variables are included without converting to logarithms. The non-log specification is not uncommon in the aid effectiveness literature. For example, Boone (1996), Hansen and Tarp (2001), and Angeles and Neanidis (2009) all use the non-log specification in aid efficacy studies. However, as noted by Mishra and Newhouse (2009) the non-log specification can lead to less stationary data, which can lead to bias in the estimators. A solution to this bias is the use of difference models, which are discussed in the next section.

Aid and democracy interactions

The baseline specification, Equation (6), allows for both democracy and health aid to affect infant mortality. Equation (7) augments this by introducing interactions between health aid and democracy: the logic behind this is to capture the combined effects of democracy and health aid on infant mortality, the two variables are multiplied and regressed as a new variable in the estimation. Interactions have been used in the aid effectiveness literature, including Jones and Tarp (2016) who interact aid with institutional governance. This model is outlined in Equation (7):

[8] Aid could have a more immediate effect on mortality, e.g. within a year. However, it is then harder to establish causality. Estimation using a five year lag is less likely to be prone to reverse causality. An alternative approach would be to use an IV approach. However, instruments for aid are notoriously scarce. Hence, a five-year lag offers a more practical approach to addressing endogeneity.

$$IM_{rt} = \beta_1 HEALTHAID_{rt-5} + \beta_2 GDP_{rt-5} + \beta_3 POP_{rt-5} + \beta_4 FERTILITY_{rt-5} + \beta_5 HIV_{rt-5} + \beta_6 LITERACY_{rt-5} + \beta_7 UNDERNUTRITION_{rt-5} + \beta_8 PHYSICIANS_{rt-5} + \beta_9 SANITATION_{rt-5} + \beta_{10} WATER_{rt-5} + \beta_{11} POLITY_{rt-5} + \beta_{12} TUBERCULOSIS_{rt-5} + \beta_{13} (HEALTHAID \times POLITY)_{rt-5} + s_r + v_t + \varepsilon_{rt} \quad (7)$$

The inclusion of the interaction means that the effect of aid on infant mortality is now evaluated by looking at the coefficients β_1 and $\beta_{13} \times POLITY$. Similarly, the effect of democracy is given by β_{11} and $\beta_{13} \times HEALTHAID$.

First difference model

As discussed above, the fixed effects component of the baseline specification may be subject to potential bias if the error term is serially correlated and there is less stationary data. In line with Marcusse (2005), a first difference estimator is used to address the omitted variable bias. The first difference transformation also removes the lagged dependent variable as an explanatory variable from the estimation (but it is still effectively part of the model) and removes the country fixed effects. In addition to the difference transformation, all variables are lagged to address potential reverse causality between all the variables and infant mortality.

This model regresses the first difference of all variables, in order to produce a robust model that sufficiently controls for unexplained noise, which may be causing fluctuations in infant mortality. The model is outlined in Equation (8):

$$
\begin{aligned}
(IM_{rt} - IM_{rt-1}) \\
&= \beta_1(HEALTHAID_{rt} - HEALTHAID_{rt-1})_{rt-5} \\
&+ \beta_2(GDP_{rt} - GDP_{rt-1})_{rt-5} \\
&+ \beta_3(POPULATION_{rt} - POPULATION_{rt-1})_{rt-5} \\
&+ \beta_4(FERTILITY_{rt} - FERTILITY_{rt-1})_{rt-5} \\
&+ \beta_5(HIV_{rt} - HIV_{rt-1})_{rt-5} \\
&+ \beta_6(LITERACY_{rt} - LITERACY_{rt-1})_{rt-5} \\
&+ \beta_7(UNDERNUTRITION_{rt} \\
&- UNDERNUTRITION_{rt-1})_{rt-5} \\
&+ \beta_8(PHYSICIANS_{rt} - PHYSICIANS_{rt-1})_{rt-5} \\
&+ \beta_9(SANITATION_{rt} - SANITATION_{rt-1})_{rt-5} \\
&+ \beta_{10}(WATER_{rt} - WATER_{rt-1})_{rt-5} \\
&+ \beta_{11}(POLITY_{rt} - POLITY_{rt-1})_{rt-5} \\
&+ \beta_{12}(TUBERCULOSIS_{rt} - TUBERCULOSIS_{rt-1})_{rt-5} + s_r \\
&+ v_t + \varepsilon_{rt}
\end{aligned} \tag{8}
$$

Note that the country fixed effects are eliminated by differencing.

Long difference model

As noted earlier, a potential issue with the use of a first difference model is that it can overestimate the effects of explanatory variables when the differences in the dependent variable are very small (Pischke, 2009). This is an issue for infant mortality estimations; as year-to-year differences are very small. As discussed in the *literature review*, Griliches and Hausman (1986) show that in such cases, a more robust method is to use a long difference estimator. The long difference estimator adopted here takes a five-year difference for all variables and controls for omitted variable bias and data fluctuation in the sample. The long difference model is outlined in Equation (9):

$$
\begin{aligned}
(IM_{rt} - IM_{rt-5}) \\
&= \beta_1(HEALTHAID_{rt} - HEALTHAID_{rt-5})_{rt-5} \\
&+ \beta_2(GDP_{rt} - GDP_{rt-5})_{rt-5} \\
&+ \beta_3(POPULATION_{rt} - POPULATION_{rt-5})_{rt-5} \\
&+ \beta_4(FERTILITY_{rt} - FERTILITY_{rt-5})_{rt-5} \\
&+ \beta_5(HIV_{rt} - HIV_{rt-5})_{rt-5} \\
&+ \beta_6(LITERACY_{rt} - LITERACY_{rt-5})_{rt-5} \\
&+ \beta_7(UNDERNUTRITION_{rt} \\
&- UNDERNUTRITION_{rt-5})_{rt-5} \\
&+ \beta_8(PHYSICIANS_{rt} - PHYSICIANS_{rt-5})_{rt-5} \\
&+ \beta_9(SANITATION_{rt} - SANITATION_{rt-5})_{rt-5} \\
&+ \beta_{10}(WATER_{rt} - WATER_{rt-5})_{rt-5} \\
&+ \beta_{11}(POLITY_{rt} - POLITY_{rt-5})_{rt-5} \\
&+ \beta_{12}(TUBERCULOSIS_{rt} - TUBERCULOSIS_{rt-5})_{rt-5} + s_r \\
&+ v_t + \varepsilon_{rt}
\end{aligned} \tag{9}
$$

In order to estimate the combined effects of health aid and democracy on infant mortality, the model is augmented to include an interaction between the two variables (in line with Equation (7) above). The long differences of health aid and infant mortality are multiplied and regressed as a new variable in the long difference estimation. The model is outlined in Equation (10).

$$
\begin{aligned}
(IM_{rt} - IM_{rt-5}) \\
&= \beta_1(HEALTHAID_{rt} - HEALTHAID_{rt-5})_{rt-5} \\
&+ \beta_2(GDP_{rt} - GDP_{rt-5})_{rt-5} \\
&+ \beta_3(POPULATION_{rt} - POPULATION_{rt-5})_{rt-5} \\
&+ \beta_4(FERTILITY_{rt} - FERTILITY_{rt-5})_{rt-5} \\
&+ \beta_5(HIV_{rt} - HIV_{rt-5})_{rt-5} \\
&+ \beta_6(LITERACY_{rt} - LITERACY_{rt-5})_{rt-5} \\
&+ \beta_7(UNDERNUTRITION_{rt} \\
&- UNDERNUTRITION_{rt-5})_{rt-5} \\
&+ \beta_8(PHYSICIANS_{rt} - PHYSICIANS_{rt-5})_{rt-5} \\
&+ \beta_9(SANITATION_{rt} - SANITATION_{rt-5})_{rt-5} \\
&+ \beta_{10}(WATER_{rt} - WATER_{rt-5})_{rt-5} \\
&+ \beta_{11}(POLITY_{rt} - POLITY_{rt-5})_{rt-5} \\
&+ \beta_{12}(TUBERCULOSIS_{rt} - TUBERCULOSIS_{rt-5})_{rt-5} \\
&+ \beta_{13}[(HEALTHAID_{rt} - HEALTHAID_{rt-5}) \times (POLITY_{rt} \\
&- POLITY_{rt-5})]_{rt-5} + s_r + v_t + \varepsilon_{rt}
\end{aligned} \tag{10}
$$

The effects of different types of development aid are investigated through the re-estimation of the long difference model (Equation (9)) using three alternative explanatory variables: total aid, basic health aid, and general health aid. Regressing these alternate explanatory variables will address the hypotheses predicting the effectiveness of health aid in comparison to total aid (H2) and basic health aid in comparison to general health aid (H3). All the models are again estimated in STATA, with standard errors corrected for clustering within countries.

4.2 Data

Aid data, infant mortality and other control data are obtained from the same sources as the independent replication described above. However, there are two specific changes to the data in the following estimations. Firstly, the data is not averaged over five year periods, rather, the data uses total yearly values. While averages can account for irregular fluctuations in the data (Mishra and Newhouse, 2009), the updated sample spans just 20 years. By using yearly values rather than averages, we are able to expand our sample size and include a larger set of data and thereby increase statistical power. This approach is recommended by Brückner (2013).

Similarly, we do not need to restrict the sample to only four time periods; essentially what is performed using the five year averages in Mishra and Newhouse (2009).

Secondly, aid data is included as an aggregate, rather than per capita amounts. Aggregate health aid has been used extensively in previous studies (Bendavid and Bhattacharya, 2014; Kizhakethalackala, Mukherjeeb and Alvi, 2013), and its use can be justified by the intuition that not all citizens of a country will receive aid in an equal proportion. In reality, citizens of a country will each receive disproportionate levels of health aid, and thus an aggregate value may be more appropriate for aid efficacy analysis.

Additional variables are included in the new model. To further reduce potential omitted variable bias, tuberculosis incidence is introduced as an additional control. Tuberculosis data is taken from the World Bank (2016), in line with other control variables. To estimate the impact of a country's level of democracy on infant mortality, Polity IV data is obtained from Centre for Systemic Peace (2015), which employs a country-based score to quantify the level of democracy on a scale between -10 (complete autocracy) and 10 (consolidated democracy). The Polity IV data is calculated using several component measures relating to executive recruitment, authority, and political competition. The score also incorporates changes in institutional quality of the governing authority.

Aid data is in constant 2014 United States Dollars, with levels reported in millions of dollars. All other variables are defined as per the independent replication described above and outlined in Appendix Table 12.

4.3 Results: Health aid and infant mortality

Table 6 shows the results of the baseline specification in column (1) and the baseline specification with aid-democracy interaction in column (2). In each specification there is a negative and statistically significant effect of health aid on infant mortality.

In the baseline specification, a one-million-dollar increase in health aid leads to approximately 13.5 fewer infant deaths per thousand live births. The associated estimated elasticity is -1.11, *i.e.* a 1% increase in health aid reduces infant mortality by 1.11%. Lagged democracy is also statistically significant in both specifications. The effect of democracy on infant mortality is negative and statistically significant; a one-unit increase in democracy leads to approximately 230 fewer infant deaths per thousand live births. Similarly, the effect of population is negative and statistically significant, while somewhat counterintuitively the effects of GDP and improved access to sanitation are positive and statistically significant.

Results from the baseline specification with health aid/democracy interaction show that health aid and democracy are again each independently negative and statistically significant, however, there is a positive and non-statistically significant effect of the interaction between the two variables. These results appear to suggest that while health aid and democracy are each individually negatively correlated with infant mortality, there is no interaction effect of health aid and democracy on infant mortality, where one variable moderates the effects of the other. The statistical insignificance of the interaction variable suggests that the baseline model might be the preferred specification. However, a Wald test confirms the joint statistical significance of the two health aid variables: lagged health aid and the lagged health aid-democracy interaction. In this respect, health aid has a smaller effect on infant mortality in more democratic countries.

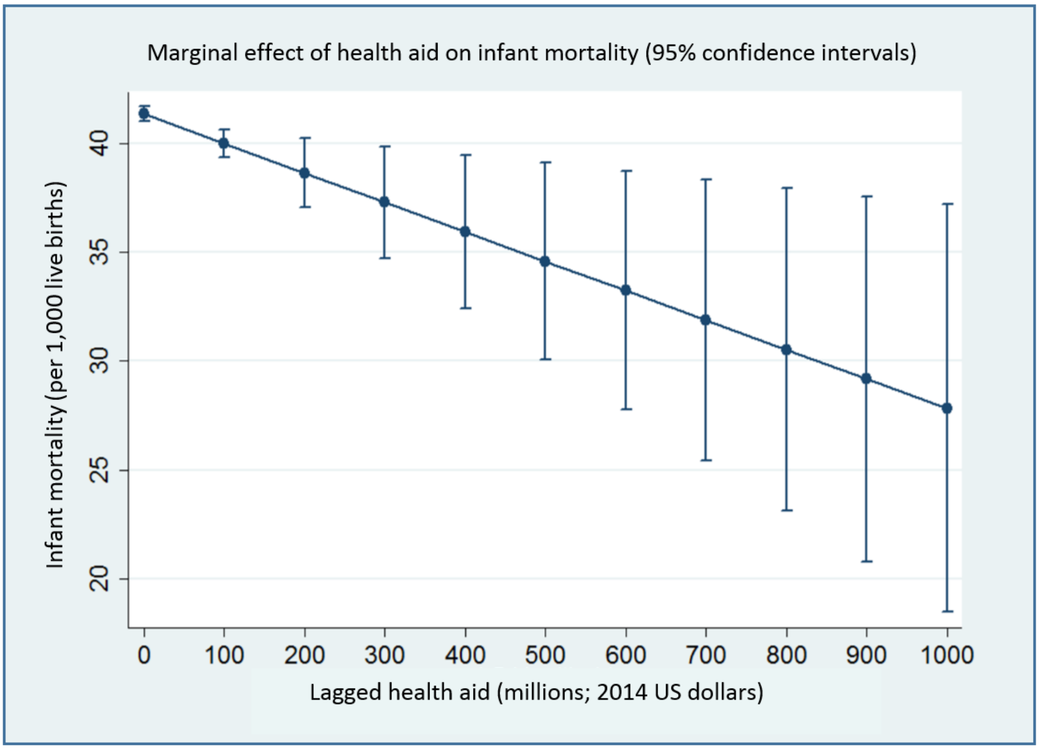
Table 6: Estimated effect of health aid on infant mortality: baseline specification and aid-democracy interaction

Dependent variable:	**Infant mortality rate (per 1000)**	
	Baseline specification (1)	Baseline specification with aid/democracy interaction (2)
Lagged health aid	-0.0135** (0.005)	-0.0156** (0.006)
Lagged democracy	-0.230* (0.107)	-0.251* (0.118)
Lagged health aid-democracy interaction	-	0.000594 (0.000)
Lagged GDP	0.000434*** (0.000)	0.000434*** (0.000)
Lagged population	-0.0000000371* (0.000)	-0.0000000369* (0.000)
Lagged fertility	3.405 (1.723)	3.343 (1.722)
Lagged female literacy	0.00666 (0.004)	0.00637 (0.004)
Lagged undernutrition	0.222 (0.126)	0.219 (0.126)
Lagged physicians	-0.0431 (0.202)	-0.0452 (0.203)
Lagged sanitation	0.111** (0.042)	0.112** (0.042)
Lagged improved water source	-0.131 (0.083)	-0.132 (0.083)
Lagged tuberculosis	-0.000161 (0.008)	-0.000166 (0.008)
Lagged HIV AIDS rate	0.0930 (0.645)	0.0863 (0.643)
Number of countries	132	132
Number of observations	1938	1938

Notes: Equations (6) and (7). Standard errors are denoted in parenthesis and clustered at the country level. All variables are total yearly values and include time fixed effects. Estimation includes time dummies. Five year lags are used for all lagged variables. Country and time fixed effects included but not reported. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

The marginal effects of health aid are illustrated in Figure 2. Holding democracy constant, there is a clear negative relationship between the level of health aid and the infant mortality rate. At low levels of health aid infant mortality is relatively higher, while at high levels of health aid infant mortality is relatively lower. To the extent that the model corrects for reverse causality through lags, we can interpret the results as causal and conclude that larger amounts of health aid are effective in reducing infant mortality.

Figure 2: Marginal effects of health aid on infant mortality (95% confidence intervals)



The marginal effects of democracy on infant mortality are illustrated in Figure 3. In line with the regression results, there is a negative relationship between the level of democracy and infant mortality rate. Holding aid constant, as the level of democracy increases, the level of infant mortality decreases. However, while it is a negative relationship, the confidence intervals are larger for the most and least democratic regimes, meaning that there is less precision in the effects of democracy on infant mortality rates at these levels of democracy.

Figure 3: Marginal effects of democracy on infant mortality

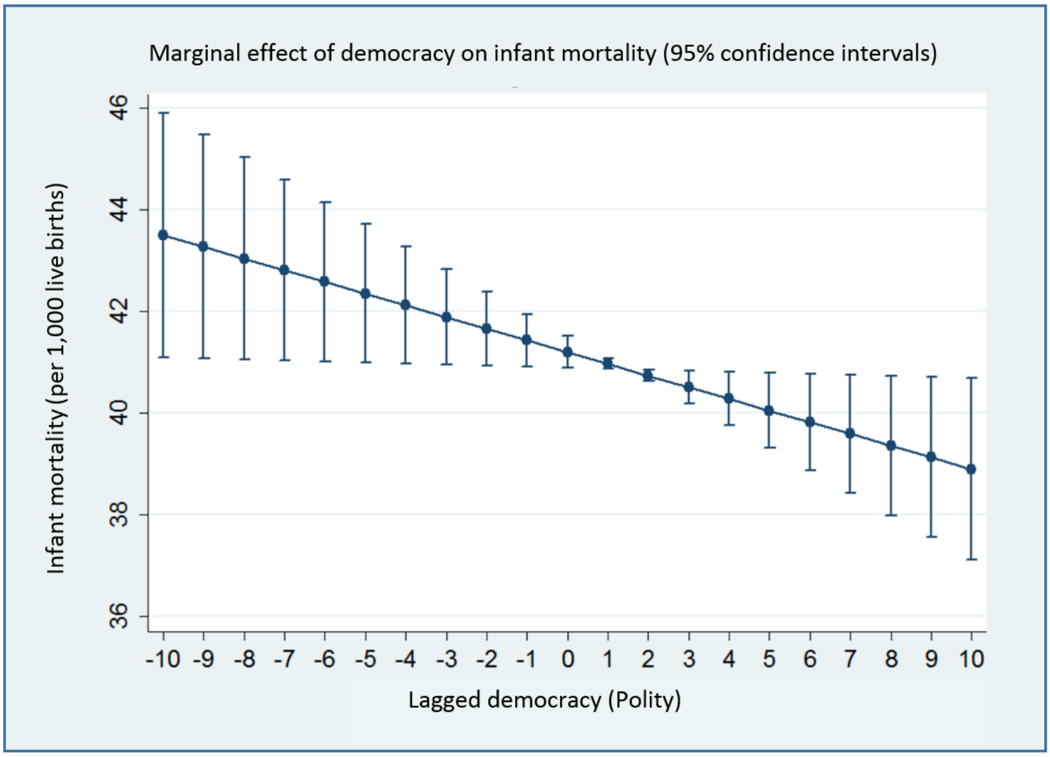
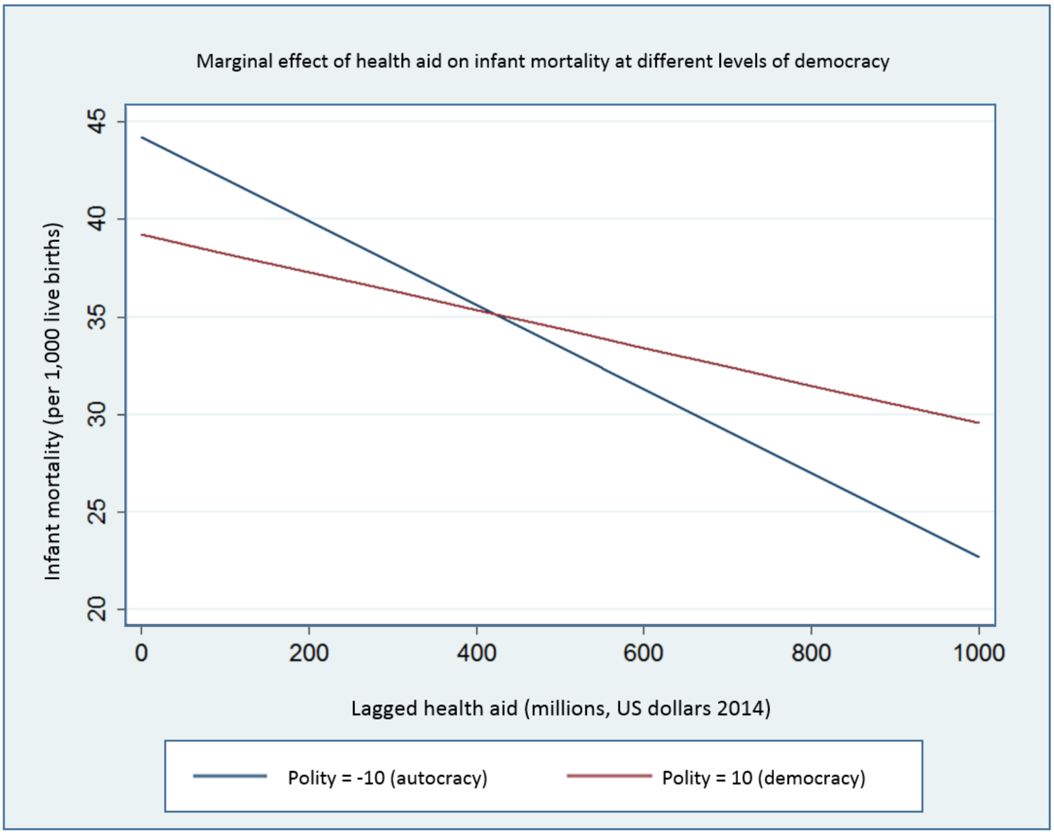


Figure 4 shows the marginal effects of health aid on infant mortality evaluated at two levels of democracy: complete democracy (a score of 10) and complete autocracy (a score of -10). The figure shows that infant mortality is lower in the most democratic countries than in the least democratic countries for most levels of aid. There is a negative relationship between health aid and infant mortality in both regimes, however, this effect is stronger in the least democratic countries. Therefore, this suggests that health aid reduces infant mortality in all regimes but reduces infant mortality more in the least democratic (more autocratic) countries. At the highest levels of aid, aid has a greater impact on health in the least democratic countries. However, this finding needs to be interpreted with caution as there are only nine observations of full democracy at levels of health aid above the intersection ($420 million). Similarly, there are only 21 observations of health aid receipts greater than $420 million (see Appendix Figure 10); hence, these results are indicative only and further research is necessary.

Figure 4: Marginal effects of aid on infant mortality at different levels of democracy



Difference models: health aid, infant mortality, and democracy

Table 7 presents the results of the short difference model. I find that health aid has a negative and statistically significant effect on infant mortality. A one-million-dollar increase in health aid leads to approximately 7.85 fewer infant deaths per 1,000 live births. The associated estimated elasticity is 1.33, i.e. a 1% increase in health aid reduces infant mortality by 1.33%. Similarly, the effect of democracy on infant mortality is negative and statistically significant. A one-unit increase in democracy leads to approximately 178 fewer infant deaths per 1,000 live births.

Table 7: Estimated effect of health aid on infant mortality: short difference model

Dependent variable:	**Infant mortality rate (per 1000) (5-year difference)**
	Short difference model
Lagged health aid (1-year difference)	-0.00785* (0.0039)
Lagged democracy (1-year difference)	-0.178* (0.079)
Lagged GDP (1-year difference)	0.000333*** (0.000)
Lagged population (1-year difference)	-0.00000004* (0.000)
Lagged fertility (1-year difference)	2.611 (1.436)
Lagged female literacy (1-year difference)	0.001 (0.001)
Lagged undernutrition (1-year difference)	0.804 (0.443)
Lagged physicians (1-year difference)	-0.051 (0.139)
Lagged sanitation (1-year difference)	0.082** (0.029)
Lagged improved water source (1-year difference)	-0.092 (0.066)
Lagged tuberculosis (1-year difference)	0.043 (0.034)
Lagged HIV AIDS rate (1-year difference)	-0.104 (0.495)
Number of countries	129
Number of observations	1283

Notes: Estimation of Equation (8). Standard errors are denoted in parenthesis and clustered at the country level. All variables are one year differences of total yearly values and include time fixed effects. Estimation includes time dummies. Five year lags are used for all lagged variables. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

Table 8 shows the results from the long difference model in column (1) and the long difference model with aid-democracy interaction in column (2). The results from the short difference model largely hold, with health aid again showing a negative and statistically significant effect on infant mortality in both estimations. In the long difference model (ignoring the aid-democracy interaction) a one-million-dollar increase in health aid results in approximately 8.15 fewer infant deaths per 1,000 live births.[9] An elasticity interpretation implies that a 1% increase in health aid reduces infant mortality by 1.38%. Similarly, in the first long difference model, democracy is again negative and statistically significant. A one-unit increase in democracy results in approximately 195 fewer infant deaths per 1,000 live births.[10]

[9] This is the effect of aid on health assuming no democracy.
[10] This is the effect of democracy on health assuming no aid.

Although health aid is negative and statistically significant in the long difference model with the health aid-democracy interaction, I find no significant relationship between democracy and infant mortality. Similarly, I find that the health aid/democracy interaction is positive and non-statistically significant. However, a Wald test again confirms the joint statistical significance of the two health aid terms (aid and health aid-democracy interaction).[11] This again suggests that health aid and democracy moderate each other, *e.g.* health aid may be less effective in more democratic countries.

[11] A Wald test also confirmed the joint statistical significance of the two democracy terms (democracy and aid-democracy interaction), supporting the argument that health aid and democracy moderate each other.

Table 8: Estimated effect of health aid on infant mortality: long difference model

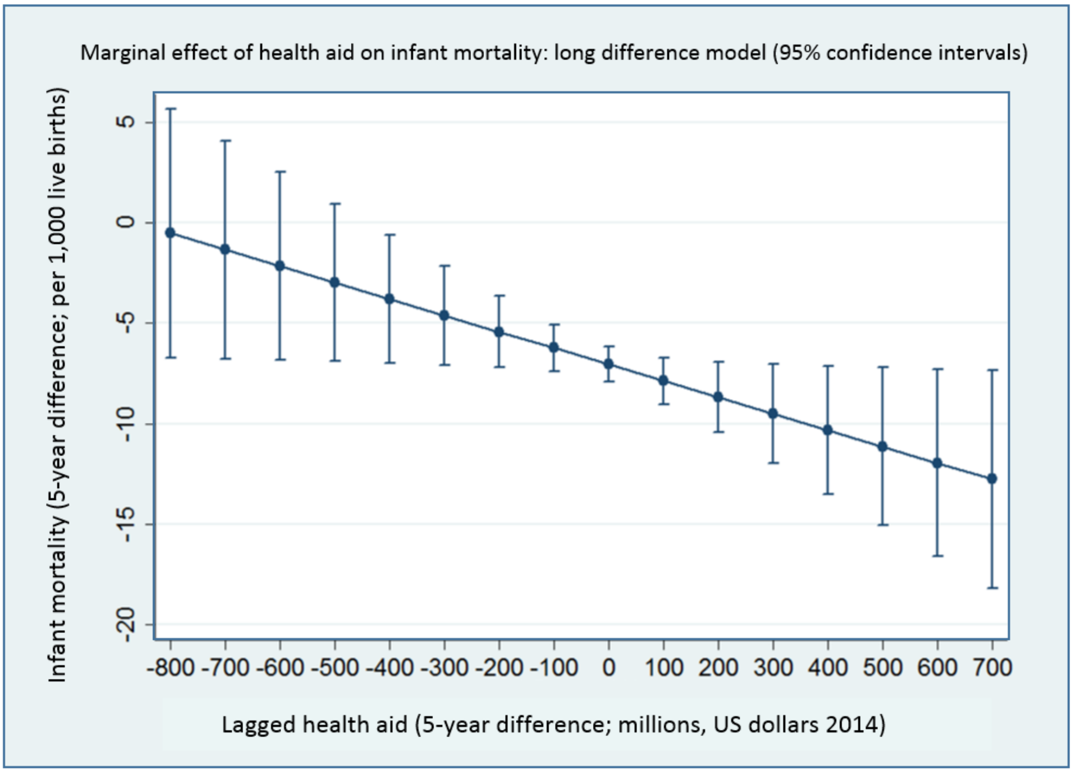
Dependent variable:	**Infant mortality rate (per 1000) (5-year difference)**	
	Long difference model (1)	Long difference model with health aid-democracy interaction (2)
Lagged health aid (5-year difference)	-0.00815* (0.004)	-0.00878* (0.004)
Lagged democracy (5-year difference)	-0.195* (0.080)	-0.221 (0.089)
Lagged health aid-democracy interaction	-	0.0008 (0.000)
Lagged GDP (5-year difference)	0.000323*** (0.000)	0.000323*** (0.000)
Lagged population (5-year difference)	-0.00000004* (0.000)	-0.00000004* (0.000)
Lagged fertility (5-year difference)	2.613 (1.494)	2.542 (1.498)
Lagged female literacy (5-year difference)	0.00521 (0.003)	0.00518 (0.003)
Lagged undernutrition (5-year difference)	0.204 (0.105)	0.203 (0.105)
Lagged physicians (5-year difference)	0.000117 (0.136)	-0.007 (0.136)
Lagged sanitation (5-year difference)	0.0780** (0.028)	0.0785** (0.028)
Lagged improved water source (5-year difference)	-0.0903 (0.064)	-0.0912 (0.064)
Lagged tuberculosis (5-year difference)	0.0000863 (0.007)	0.0000484 (0.007)
Lagged HIV AIDS rate (5-year difference)	0.223 (0.508)	0.226 (0.508)
Number of countries	129	129
Number of observations	1283	1283

Notes: Estimation of Equations (9) and (10). Standard errors are denoted in parenthesis and clustered at the country level. All variables are five year differences of total yearly values and include time fixed effects. Estimation includes time dummies. Five year lags are used for all lagged variables. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

The marginal effects of health aid on infant mortality, using the long difference model, are illustrated in Figure 5. In line with results from the baseline specification, there is a negative relationship between the level of health aid and the infant mortality rate. At low levels of health aid infant mortality is relatively high, while at high levels of health aid infant mortality is relatively low. It should be noted that Figure 5 includes five-year difference values in the axes. As such, a positive value of lagged health aid (along the horizontal axis) means that aid increased in the five-year difference period, and a negative value shows that aid decreased. Similarly, a negative value for infant mortality means that infant mortality has decreased in the difference period. Interestingly, the results indicate that extremely large decreases in health aid may actually lead to an increase in infant mortality. However, more research is needed to understand if this is correct.

To the extent that the model corrects for reverse causality through lags, we can again interpret the results as causal and conclude that larger amounts of health aid have an increasingly negative effect on infant mortality. The marginal effects of health aid are less than those seen in the baseline specification, potentially reflecting the increased robustness of the long difference model.

Figure 5: Marginal effects of health aid on infant mortality: 5-year difference (95% confidence intervals)



The marginal effects of democracy on infant mortality, using the long difference mode, are shown in Figure 6. In line with the baseline specification, there is a negative relationship between the level of democracy and infant mortality rate. As the level of democracy increases, the level of infant mortality decreases. However, in comparison to the baseline specification, the confidence intervals are notably smaller. As a more robust model, the long difference model indicates that democracy is negatively correlated with infant mortality, with the smaller confidence intervals leading to greater statistical accuracy of this result.

It should be noted that Figure 6 includes five-year difference values in the axes. As such, the figure can be interpreted to show the effect of changing democracy levels on infant mortality. If the lagged democracy is positive, it means that democracy has increased over the five-year difference period. Infant mortality is interpreted as per Figure 5 above. The results show that becoming more democratic leads to a large reduction in infant mortality.

Figure 6: Marginal effects of democracy on infant mortality: long difference model

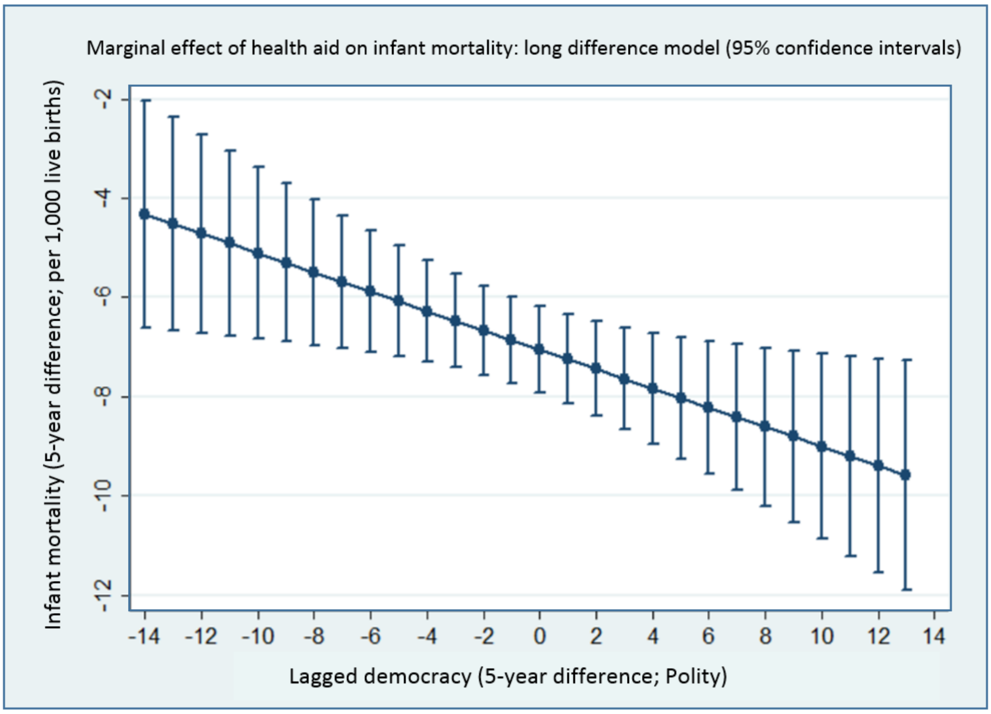
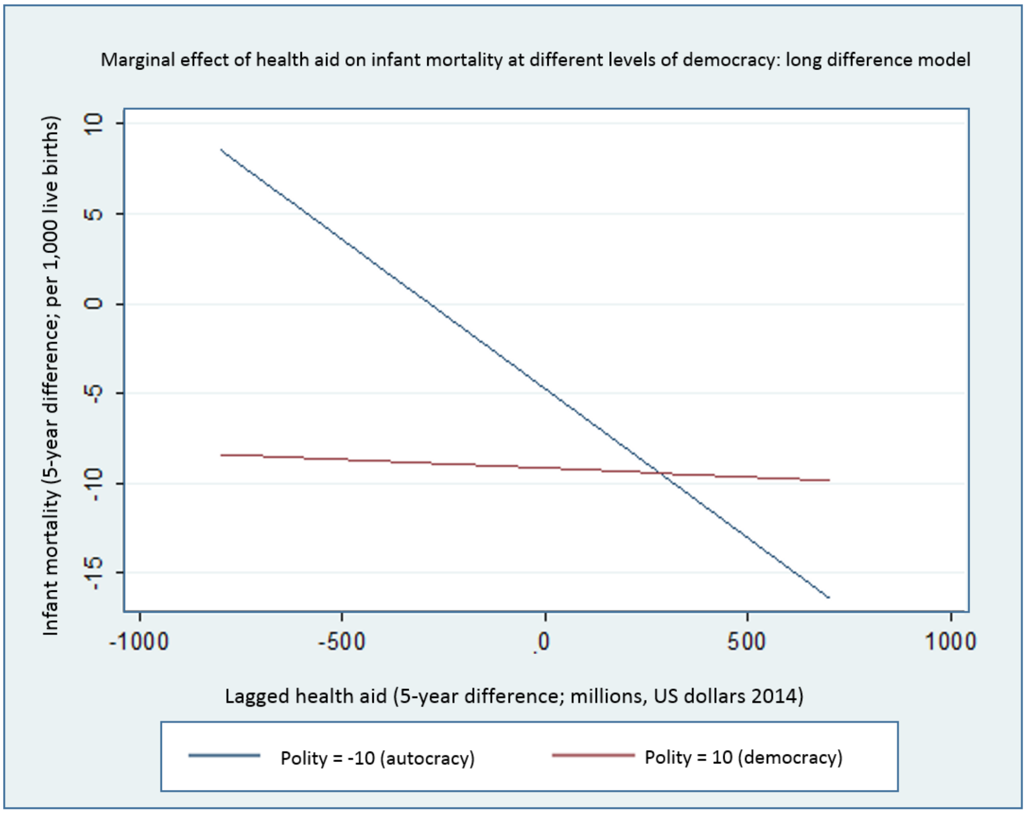


Figure 7 shows the marginal effects of health aid on infant mortality evaluated at two levels of democracy: complete democracy (a score of 10) and complete autocracy (a score of -10). The figure shows that infant mortality is lower in the most democratic countries than in the least democratic countries for most levels of aid. There is a negative relationship between health aid and infant mortality in both regimes, however, this effect is stronger in the least democratic countries. Therefore, this shows that health aid reduces infant mortality in all regimes but reduces infant mortality more in the least democratic (more autocratic) countries. Indeed, at the highest levels of aid, aid has a greater impact on health in the least democratic countries. It should be noted that confidence intervals are wide for these extremes, and only two observations receive above the intersection point of $280 million in health aid at total democracy or total autocracy. As such, the results are suggestive only and warrant further investigation.

Figure 7: Marginal effects of health aid on infant mortality at different levels of democracy: long difference model



Total aid, basic health aid, general health aid, and infant mortality

Table 9 summarises the results of the total aid, basic health aid, and general health aid estimations. I find a negative and non-statistically significant effect of total aid or general health aid on infant mortality. However, I do find a negative and statistically significant effect of basic health aid on infant mortality. A one-million-dollar increase in basic health aid results in approximately 11.6 fewer infant deaths per 1,000 live births. These results suggest that total aid and general health aid do not have a significant effect on infant mortality rates, while basic health aid contributes to a reduction in infant mortality.[12]

Table 9: Estimated effect of aid on infant mortality (alternative explanatory variables; total aid, basic health aid, and general health aid): long difference model

Dependent variable	**Infant mortality rate (per 1000) (5-year difference)**
	Long difference model
Lagged total aid (5-year difference)	-0.0001175 (0.000)
Lagged basic health aid (5-year difference)	-0.0116* (0.005)
Lagged general health aid (5-year difference)	-0.00483 (0.003)
Number of countries	129
Number of observations	1283

Notes: Standard errors are denoted in parenthesis and clustered at the country level. All variables are five year differences total yearly values and include time fixed effects. Estimation includes time dummies. Five year lags are used for all lagged variables. *, **, and *** denote statistical significance at 10 percent, 5 percent, and 1 percent levels, respectively.

4.4 Analysis and discussion

In all specifications, there is a negative and statistically significant effect of health aid on infant mortality. The largest effect is found in the baseline specification; however, it is possible that the model may contain bias due to the fixed effects estimator. The most robust model, the long difference model, finds a negative and statistically significant effect of health aid on infant mortality associated with 8.15 fewer infant deaths per 1,000 live births. For a country like Sierra Leone, which had an infant mortality rate of 90 deaths per 1,000 live births in 2014 (OECD, 2016), an increase in health aid of one million dollars would account for an increase of just 0.4% on the 256.7 million dollars in health aid received in 2014. In this context, an increase in health aid of 0.4% would result in a 9% decrease in infant mortality.

To my knowledge, this study is the first to apply a long difference model to an aid effectiveness context, and as such results differ from previous research. Of previous studies that found a negative relationship between health aid and infant mortality, the effectiveness of health aid

[12] Alesina and Weder (1999) argue that private funding plays a key role in aid effectiveness, especially in countries with lower institutional quality. The total aid regression results were re-estimated using ODA, Other Official Flows (OOF) and private flows. The results above hold, with total aid positive and insignificant with the inclusion of these additional flows.

outlined above is comparably higher. Bendavid and Battachharya (2014) found that a 1% increase in health aid leads to 0.76 fewer infant deaths between 2000 to 2010. Again using Sierra Leone as an example, my results find that a 1% increase in health aid results in approximately 1.24 fewer infant deaths per 1,000 live births. Mishra and Newhouse (2009) found that a doubling of health aid leads to a 1.1% reduction in infant mortality. In the context of Sierra Leone, my results find that increasing health aid by 256.7 million dollars (a doubling of health aid) would effectively eliminate infant mortality. However, this result is obviously not realistic as we do not know the specific dynamics of increasing health aid in a single-country environment.

The results support calls from aid agencies and international bodies for a large increase in foreign aid to address health concerns in struggling, developing regions (Agency for Technological Cooperation and Development, 2016; Child Fund, 2011). Unlike Williamson (2008), I find support for policies that encourage foreign assistance and argue that an increase in health aid is a key factor in effectively addressing the Millennium Development Goals (2016). Importantly, in comparison to previous studies, I have found a greater effect of aid on infant mortality. Perhaps this is due to increased levels of health aid in recent years (OECD, 2016). Although more research is needed to estimate whether the effects of aid have improved in recent years, the hypothesis that health aid is effective at reducing infant mortality in the sample period (H1) is supported.

Through analysis of the marginal effects of health aid it is clear that larger amounts of aid have an increasingly greater effect on reducing infant mortality. These results are contrary to literature that supports investing in aid effectiveness at smaller amounts, rather than simply concentrating on driving increases in aid (House of Commons, 2008).

4.5 Health aid, democracy and infant mortality

In line with previous studies (*e.g.*, Boone, 1996; Yousuf, 2012, Navia and Zweifel, 2003), I find that the level of democracy in a country has a statistically significant impact on infant mortality. My results show that democracy reduces infant mortality independently of aid. However, the results also suggest that democracy might affect infant mortality conditional on the level of aid. This is opposite of what was hypothesized in H4; that democratic regimes more successfully utilise health aid. I find that the health aid and democracy interaction term on its own is not statistically significant and it has a positive coefficient, rather than the expected negative sign. There are a number of reasons for the statistical insignificance of the coefficient on the health aid and democracy interaction term. Firstly, there is multicollinearity in the variables and including health aid, democracy and the interaction of health aid and democracy in the one model deflates the *t*-statistics. Second, variables may be estimated with low statistical power given relatively fewer observations at some of the levels of democracy, making it difficult to detect a real association when it actually exists.

While the health aid and democracy interaction coefficient is not statistically significant, the Wald test of joint significance shows that health aid and the health aid-democracy interaction are jointly statistically significant. The Wald test also shows significance when interacting democracy and the health aid-democracy interaction. These results suggest that the link between democracy and infant mortality may indeed be related to effective use of health aid. Given the positive coefficient on the health aid-democracy interaction term, this implies that health aid is less effective in more democratic countries. Similarly, in analyzing health aid effectiveness at complete autocracy and complete democracy, the results show that although health aid reduces infant mortality in all regimes, it is most effective in the least democratic countries.

There a number of reasons for this surprising finding. Bueno de Mesquita *et al.* (2003) suggest that rather than spending foreign aid on public goods and services, democracies use aid to reduce the tax burden of their citizens. In this respect, health aid could potentially have a smaller effect on infant mortality in democratic countries, as instead of investing in programs to improve health, the money is simply spent on lowering the tax burden; in essence, a form of fungibility. In the support of autocratic aid efficacy, Wright (2008) argues that aid is effective at promoting growth in autocratic regimes with long time horizons. Long time horizons of autocracies have a positive impact on aid effectiveness, when compared to regimes with shorter time horizons. This concept can be applied to health aid and democracy. It is possible that autocratic regimes with a more secure, long-term time horizon of rule more successfully implement health aid into longer-term projects with greater chance of success. Democracies with threat from opposition parties and a short-term outlook may focus on shorter term projects with more attainable results and less impact in the longer term (Hatcher, 2004).

In this respect, the hypothesis that health aid is more effective at reducing infant mortality in more democratic countries (H4) is not supported. In fact, the results indicate the opposite effect: health aid is more effective at reducing infant mortality in less democratic countries.

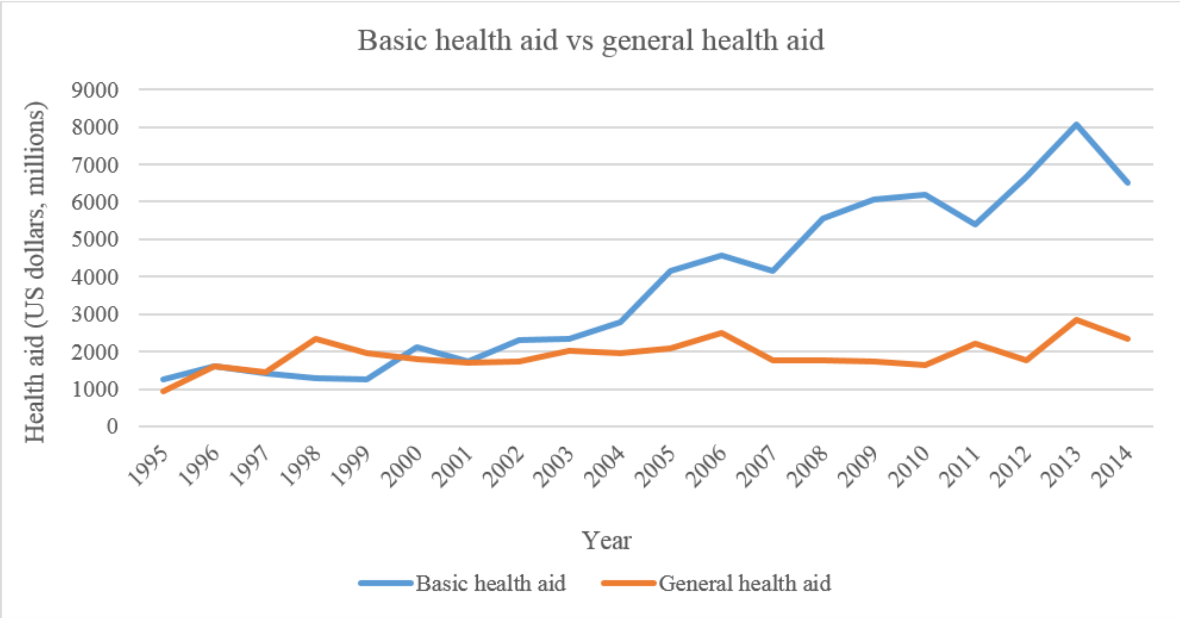
4.6 Total aid, basic health aid, general health aid, and infant mortality

My results suggest that total aid is ineffective at reducing infant mortality. These results are consistent with several previous studies (Williamson, 2008; Burnside and Dollar, 1998) and lend support to the micro-macro paradox often associated with aggregate aid studies (Mosley, 1986). It is intuitive that health aid, which is targeted to a specific sector and often linked to individual projects is more effective at reducing infant mortality than development aid as a whole. Total aid is given to a broad range of sectors, many of which are not intended to impact health outcomes. Production sectors, agriculture, trade policies and transport are all development aid sectors that likely have a negligible impact on infant mortality. In this respect, the findings are not surprising, and support the developing theories that aid should be tied to a particular sector/purpose in order to deliver the most effective outcomes (Mishra and Newhouse, 2009). The hypothesis that health aid is more effective than total aid in reducing infant mortality (H2) is supported.

In further support of the theory that more specific, micro-level aid dispersions are more successful, my results find that basic health aid is highly effective at reducing infant mortality, while general health aid has no significant effect. Using the long difference model, a one-million-dollar increase in health aid leads to 11.6 fewer infant deaths per 1,000 live births. This points to a greater effect of basic health aid than health aid as a whole, where a one-million-dollar increase results in 8.15 fewer infant deaths. As health aid is constructed of either basic health aid or general health aid, the results suggest that basic health aid is the component of health aid that is playing a role in the reduction in infant mortality.

These findings are complementary to Mishra and Newhouse (2009) who suggest that there has been a shift towards investment in basic health aid in recent years. Indeed, data on health aid dispersions supports this trend. Figure 8 shows the total amounts of basic and general health aid from 1995 to 2014. Since 2001, where basic and general health aid were largely equal, basic health aid has increased at a dramatic rate, while general health aid has remained relatively constant. In 2013, basic health aid was more than 5 billion dollars larger than general health aid. In comparison to older studies, I find a greater effect of health aid on infant mortality. It is possible that this improvement is due to the increased proportion of basic health aid as a percentage of overall health aid, however, more research is necessary to show this. The hypothesis that basic health aid is more effective than general health aid in reducing infant mortality (H3) is supported.

Figure 8: Basic health aid and general health aid: total dispersions 1995 to 2014



Source: OECD (2016)

5 Conclusions

The effectiveness of development aid is an increasingly important research issue; with over $137 billion United Stated dollars of net ODA dispersed in 2014 alone, governments, policy makers, and academics seek to establish if aid has achieved measurable results. A significant proportion of research investigates the role of aid in promoting economic development. However, the fungible nature of aid has led donors to tie aid to specific industries or purposes. Health is an area of particular concern for donors and recipient governments alike, and reducing infant mortality is a key aim of many health aid dispersions (United States Department of State, 2005). While there is some literature on the effectiveness of health aid on infant mortality, conclusions drawn from the extant studies are ambiguous. This thesis presents an independent replication of Mishra and Newhouse (2009) and also provides an alternative framework for investigating aid effectiveness on health.

With regard to the replication of Mishra and Newhouse (2009), the thesis fails to find robust results. Aid appears to be ineffective at reducing infant mortality using the Mishra and Newhouse (2009) methodology. However, there are a number of differences between the two studies, and key disparities in the data may explain the contrasting findings.

As an alternative to Mishra and Newhouse (2009), this thesis presents estimates using long differences and also investigates the impact of institutions on aid effectiveness. To my knowledge, this study is the first of its kind to apply a long difference model in the study of aid efficacy. This model is robust to a number of issues associated with measurement error and bias in fixed effects estimators and finds that health aid has a negative and statistically significant relationship with infant mortality. Using an appropriate long difference model, I find that a one-million-dollar increase in health aid is associated with approximately 8.15 fewer infant deaths per 1,000 live births, on average. The results for the study period suggest that health aid has a much larger effect on infant mortality than previous estimates (see section 4.4).

While there has been some emerging research on the effects of governance and institutions on population health outcomes, this thesis is the first to explore the interaction of democracy with health aid. I find that democracy and health aid are each independently negatively associated with infant mortality, however, the interaction term of the two is positive, suggesting that health aid is less effective in reducing mortality at higher levels of democracy. This evidence, however, remains statistically weak and the size of the interaction is relatively small and further research is necessary to corroborate this finding.

My results support the recent literature, where targeted, purpose-specific aid is seen to be more effective than less specific development aid in achieving its goals. I find that there is a negative and statistically significant effect of basic health aid on infant mortality and no significant effect for total aid or general health aid. I find that a one-million-dollar increase in basic health aid leads to approximately 11.6 fewer infant deaths per 1,000 live births. The effect of basic health aid is stronger than overall health aid, implying that basic health aid is responsible for the reduction in infant mortality attributable to overall health aid. As basic health aid has dramatically increased in recent years, it is possible that this has contributed to the larger effect of health aid on infant mortality seen in this study. Nevertheless, more research is needed to determine if health aid has improved in effectiveness in recent years.

Of my four hypothesis, three were supported: health aid is effective at reducing infant mortality (H1); health aid is more effective than total aid (H2); and basic health aid is more effective than general health aid (H3). Although I found evidence that democratic countries have lower levels of infant mortality, the estimates of the interactions between health aid and democracy suggest that health aid is less effective in more democratic countries. This finding is the opposite of what was expected in H4; the efficacy of health aid is conditional on the level of democracy of a country, however, health aid is not more effective in countries at higher levels of democracy.

5.1 Limitations and extensions

Several limitations in the independent replication data have been previously discussed (see section 3.4). As such, there is a limited extent to which Mishra and Newhouse (2009) comparisons can be made. My new study also omits techniques that have been used in some previous aid-effectiveness research. Easterly, Levine and Roodman (2003) explain that the trimming of outliers can be useful in creating a more accurate picture of the aid effectiveness debate. This study has performed no manual trimming of outliers, and there is potential that inordinately large or small sums of health aid may influence the results. A limitation in the data that effects all regression estimates is the lack of data for certain countries. As information is collated from a range of sources (United Nations, World Bank, Centre for Systemic Peace), there are inconsistencies in developing country definitions and thus data is missing for some countries and periods.

While the study provides results that support health aid effectiveness, I do not attempt to explain the channels through which health aid is most successful at reducing infant mortality. By interacting health aid and various control variables, such as access to physicians or improved sanitation; important mechanisms may be revealed in the way that health aid acts with specific project-level outcomes to impact infant mortality rates. Similarly, while the difference models are a useful innovation, it would be interesting to control for different dispersions of aid at a country or regional level. Using assumptions on health aid distribution in particular countries could lead to a more accurate analysis of health aid efficacy in comparison to aggregate or per capita estimates. Such research may be useful in providing analysis on the inequality of health status frequently observed in developing countries (Deaton, 2003).

An interesting extension for future research is the analysis of different components of basic health aid. There is now extensive support for the theory that basic health aid is effective at reducing infant mortality, however, to my knowledge there are no studies that compare the efficacy of different components of health aid. By analysing the impact of the specific components identified in the OECD CRS (Appendix Table 10), donors and policy makers may be able to further drive funding into streams with a higher chance of success. Similarly, in order to address the contrasting results seen across different studies and sample periods, it would be useful to study the effects of health aid at different points in time. Moreover, aid consists of both concessional loans and grants. Investigating whether there is a difference in health effectiveness between these types of aid will also be potentially informative. Such research may give insight into how the changing components of health aid impact health outcomes, such as infant mortality.

6 Appendix

Table 10: Health aid classifications (OECD, 2016)

Health Aid	
General Health Aid	**Description**
Health policy and administrative management	Health sector policy, planning and programmes; aid to health ministries, public health administration; institution capacity building and advice; medical insurance programmes; unspecified health activities
Medical education/training	Medical education and training for tertiary level services
Medical research	General medical research (excluding basic health research)
Medical services	Laboratories, specialised clinics and hospitals (including equipment and supplies); ambulances; dental services; mental health care; medical rehabilitation; control of non-infectious diseases; drug and substance abuse control
Basic Health Aid	
Basic health care	Basic and primary health care programmes; paramedical and nursing care programmes; supply of drugs, medicines and vaccines related to basic health care
Basic health infrastructure	District-level hospitals, clinics and dispensaries and related medical equipment; excluding specialized hospitals and clinics
Basic nutrition	Direct feeding programmes (maternal feeding, breastfeeding and weaning foods, child feeding, school feeding); determination of micro-nutrient deficiencies; provision of vitamin A, iodine, iron etc.; monitoring of nutritional status; nutrition and food hygiene education; household food security
Infectious disease control	Immunisation; prevention and control of infectious and parasite diseases, except malaria tuberculosis HIV/AIDS and other STDs. It includes diarrheal diseases, vector-borne diseases (e.g. river blindness and guinea worm), viral diseases, mycosis, helminthiasis, zoonosis, diseases by other bacteria and viruses, pediculosis, etc
Health education	Information, education and training of the population for improving health knowledge and practices; public health and awareness campaigns; promotion of improved personal hygiene practices, including use of sanitation facilities and handwashing with soap
Malaria control	Prevention and control of malaria
Tuberculosis control	Immunisation, prevention and control of tuberculosis
Health personnel development	Training of health staff for basic health care services

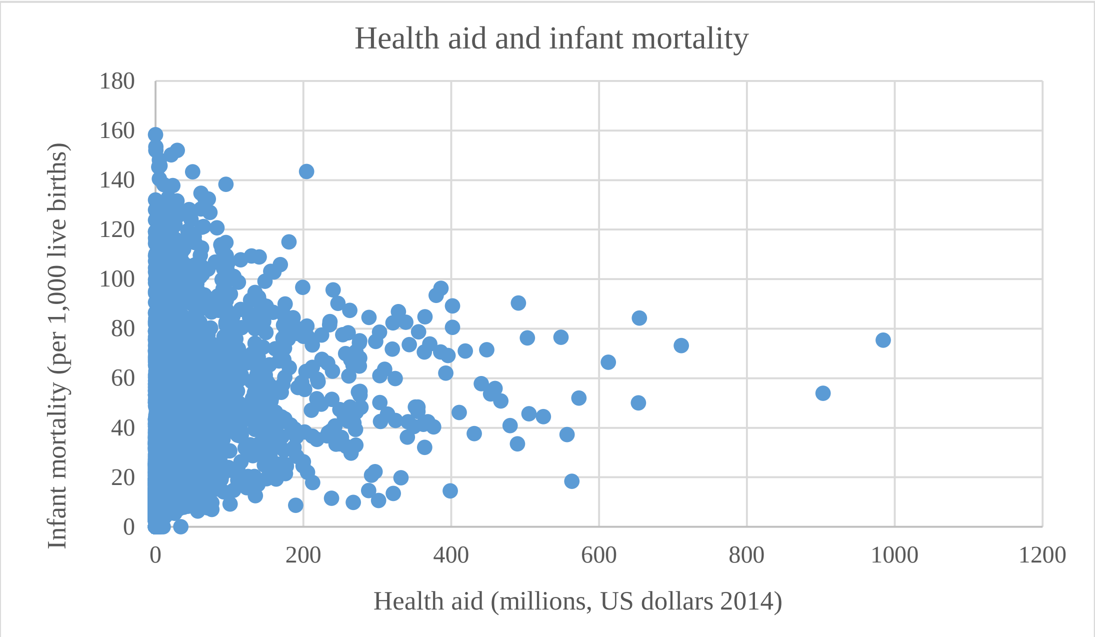
Table 11: List of developing countries included in analysis as defined by OECD (2016)

Afghanistan	Dominican Republic	Mali	South Sudan
Albania	Ecuador	Malta	Sri Lanka
Algeria	Egypt, Arab Rep.	Marshall Islands	St. Kitts and Nevis
Angola	El Salvador	Mauritania	St. Lucia
Anguilla	Equatorial Guinea	Mauritius	St. Vincent and the
Antigua and Barbuda	Eritrea	Mayotte	Grenadines
Argentina	Ethiopia	Mexico	States Ex-Yugoslavia
Armenia	Falkland Islands	Micronesia, Fed. Sts.	Sudan
Aruba	(Malvinas)	Moldova	Suriname
Azerbaijan	Fiji	Mongolia	Swaziland
Bahamas, The	French Polynesia	Montenegro	Syrian Arab Republic
Bahrain	Gabon	Montserrat	Tajikistan
Bangladesh	Gambia, The	Morocco	Tanzania
Barbados	Georgia	Mozambique	Thailand
Belarus	Ghana	Myanmar	Timor-Leste
Belize	Gibraltar	Namibia	Togo
Benin	Grenada	Nauru	Tokelau
Bermuda	Guatemala	Nepal	Tonga
Bhutan	Guinea	Netherlands Antilles	Trinidad and Tobago
Bolivia	Guinea-Bissau	New Caledonia	Tunisia
Bosnia and	Guyana	Nicaragua	Turkey
Herzegovina	Haiti	Niger	Turkmenistan
Botswana	Honduras	Nigeria	Turks and Caicos
Brazil	Hong Kong SAR,	Niue	Islands
British Virgin Islands	China	Northern Mariana	Tuvalu
Brunei Darussalam	India	Islands	Uganda
Burkina Faso	Indonesia	Oman	Ukraine
Burundi	Iran, Islamic Rep.	Pakistan	United Arab Emirates
Cabo Verde	Iraq	Palau	Uruguay
Cambodia	Israel	Panama	Uzbekistan
Cameroon	Jamaica	Papua New Guinea	Vanuatu
Cayman Islands	Jordan	Paraguay	Venezuela, RB
Central African	Kazakhstan	Peru	Vietnam
Republic	Kenya	Philippines	Wallis and Futuna
Chad	Kiribati	Qatar	West Bank and Gaza
Chile	Korea, Dem. People's	Rwanda	Strip
China	Rep.	Saint Helena	Yemen, Rep.
Chinese Taipei	Korea, Rep.	Samoa	Zambia
Colombia	Kosovo	Sao Tome and	Zimbabwe
Comoros	Kuwait	Principe	
Congo, Dem. Rep.	Kyrgyz Republic	Saudi Arabia	
Congo, Rep.	Lao PDR	Senegal	
Cook Islands	Lebanon	Serbia	
Costa Rica	Lesotho	Seychelles	
Cote d'Ivoire	Liberia	Sierra Leone	
Croatia	Libya	Singapore	
Cuba	Macao SAR, China	Slovenia	
Cyprus	Macedonia, FYR	Solomon Islands	
Djibouti	Madagascar	Somalia	
Dominica	Malawi	South Africa	
	Malaysia		

Table 12: Definitions and data sources of variables used in the analysis

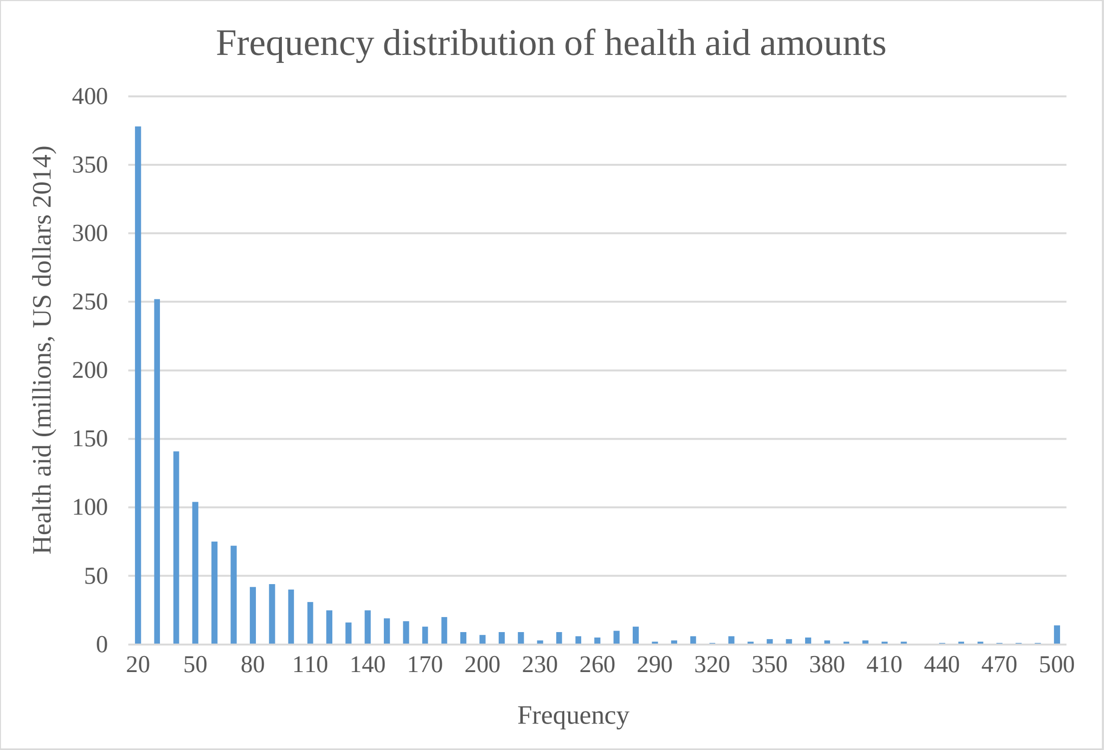
Variable (definition)	Source
Infant mortality (number of deaths before 1 year of age per 1,000 live births)	United Nations (2016)
Total aid (United States dollars, 2013)	OECD DAS (OECD 2016)
Health aid (United States dollars, 2013)	OECD CRS (OECD 2016)
Population (millions)	World Bank (2016)
GDP (per capita United States dollars, 2013)	World Bank (2016)
Fertility (births per woman)	World Bank (2016)
Female literacy (% of females aged 15 or over)	World Bank (2016)
Undernutrition (% of population undernourished)	World Bank (2016)
Physicians (number per 1,000 people)	World Bank (2016)
Sanitation (% of population with access to improved sanitation facilities)	World Bank (2016)
Water (% of population with access to improved water source)	World Bank (2016)
Tuberculosis (incidence per 100,000 people)	World Bank (2016)
HIV AIDS (% of population ages 15-49)	World Bank (2016)
Polity (democracy scale: autocracy (-10) to democracy (10))	Centre for Systemic Peace (2016)
War dummy (presence of war in a country)	Heidelberg Institute for International Conflict Research (2016)

Figure 9: Health aid and infant mortality data summary: 1995 to 2014



Source: OECD (2016)

Figure 10: Frequency distribution of health aid amounts: 1995 to 2014



Source: OECD (2016)

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