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Published in:
Australian Economic Papers

DOI:
10.1111/1467-8454.12167

Publication date:
2019

Document Version
Peer reviewed version

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How to cite this article*:* Lu, Z., Bandara, J.S., and Paramati S.R. (2019) Impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies. Australian Economic Papers, 1–21. https://doi.org/10.1111/1467-8454.12167

The impact of sanitation, safe drinking water and health expenditure on infant mortality rate in developing economies

Abstract

Despite of significant growth in all walks of life, the issue of infant mortality still a major concern in most of the developing economies. The world development indicators (WDI) have reported that 4.45 million infants died across the globe in 2015, meaning that 32 deaths per every 1000 live births. A number of times, the World Health Organization (WHO) have stressed the significance of sanitation, safe drinking water and healthcare facilities in reducing infant mortality rate, though most developing countries still lacks in these services. Given this background, the present study aims to examine the role of sanitation, water facilities and health expenditure on infant mortality rate across a panel of 84 developing economies using annual data from 1995 to 2013. The study also account for per capita income and depth of food deficiency as the control factors in the model. The findings of this study establish a significant long-run equilibrium association among the variables. The long-run elasticities on infant mortality suggest that improved water and sanitation facilities, health expenditure and per capita income substantially reduce infant mortality rate, while food deficiency increases. Given these findings, we suggest that increasing access to improved water, sanitation and healthcare facilities will significantly reduce child mortality in developing economies around the world.

JEL classification: D31, H51, J13, Q53

Keywords: Infant mortality rate; sanitation; drinking water; health expenditure; Developing economies

I. Introduction

Basic needs such as healthy food, safe drinking water, proper sanitation facilities and healthcare services are the fundamental rights for all of the human beings across the globe. If governments fail to provide these basic needs along with housing and clothing, it will have significant adverse effects on people's lifestyle. The infant or child mortality rate is primarily associated with the quality of the basic needs that are available to people. This means that the infant mortality rate can be significantly reduced by increasing the access to improved water, sanitation and healthcare facilities. However, most of the developing economies around the world are not able to provide these basic needs for all of their people. Consequently, these countries still have higher infant mortality rates. For this reason, reducing child mortality has been one of the main global challenges over the last several decades and reducing it by two-thirds between 1990 and 2015 has become the fourth Millennium Development Goal (MDG) of United Nations (UN). Likewise, under Sustainable Development Goals (SDG), the countries aim to reduce preventable deaths of newborns to at least as low as 12 per 1000 live births and under-5 children mortality to at least as low as 25 per 1000 live births.[1]

The last few decades have experienced a significant decline in infant mortality rate across the globe. For instance, as per World Development Indicators (WDI), the infant mortality rate underwent a considerable reduction between 1960 and 2013. On the basis of the statistics obtained from the WDI, it is observed that the rate of infant mortality has reduced from 122 to 34 per 1000 live births at the global level during 1960-2013. According to MDG data, the global under-five mortality rate has declined by more than half, dropping from 90 to 43 deaths per 1000 live births between 1990 and 2015, and the number of deaths in children under five worldwide declined from 12.7 million to almost 6 million during the same period.[2]

However, the infant mortality rate is still very high in many low and middle-income countries and aggregated figures do not reflect the true picture in many developing countries. For instance, the infant mortality rate in the selected sample countries of this study reduced from 71 to 40 (per 1000 live births) during 1995-2013. This implies that these countries still had an average of 40 infants' death even in 2013, which was much higher than the world's average of 34. Similarly, the percentage of people who have access to sanitation and safe drinking water facilities increased from 44% and 68% in 1995 to 55% and 80% in 2013, respectively. These statistics suggest that, on average, approximately 45% and 20% of people are still without access to sanitation and safe drinking water facilities in the sample countries, respectively.

Among a number of determinants of infant mortality rate, there are four important factors which have a greater influence across countries and families. These are safe drinking water, access to sanitation, access to healthcare facilities, and the quality of food available. Each of these factors plays an important role in determining the health of an infant during the pregnancy and after the birth. For example, Ridder and Tunali (1999) argued that the socio-economic conditions and environmental factors of households play a pivotal role in determining the higher or lower infant mortality rate.

It has been well documented that improved water supply and sanitation facilities have a considerable effect on infant mortality rate. For instance, the studies of Cutler and Miller (2005) as well as Watson (2006) suggest that the provision of improved sanitation and safe drinking water facilities have resulted in significant health improvements in developed economies. Similarly, Gamper-Rabindran et al. (2010) examined the effect of piped water access on infant mortality rate. Their findings suggest that while the piped water provision reduces infant mortality, other public healthcare facilities also play a dominant role in reducing the mortality rate. Prüss–Üstün and Corvalán (2006) document that approximately

94% of diarrhoeal borne disease is caused by unhygienic environmental factors that include precarious drinking water, poor sanitation, and unhealthy surroundings. The findings of Victora et al. (1988) show that diarrhoea is a significant factor for infant mortality and diarrhoea is mainly caused due to unavailability of piped water, the absence of a flush toilet, residing in a poorly built house and also overcrowded houses. Similar conclusions have also been drawn by Kumar and Vollmer (2013).

Given the significance of safe drinking water on the infant or child mortality rate, Galiani et al. (2005) analyze the effect of privatization of water supply services on child mortality in Argentina. Their findings confirm the reduction of child mortality in Argentina after the privatization of water supply provision. This is mainly due to the fact that the safe drinking water facilities have considerably reduced the infectious and parasitic diseases which were previously associated with child mortality. Similarly, Kalipeni (1993) argued that the infant mortality level is connected to a number of demographic and socioeconomic variables such as age at the first marriage, total fertility rate, female literacy rate and economic conditions of the family. This suggests that clean drinking water, sanitation and other socioeconomic factors play an important role for infant mortality.

Healthcare expenditure can also play a vital role in reducing infant mortality rate across developing countries but very few studies have empirically examined the relationship between the two. For instance, Lin et al. (2006) document that Taiwan national health insurance policy strongly supports the health of child survival. However, Ssozi and Amlani (2015) have reached a consensus that health expenditure has a higher effect on immunization, malaria, HIV/AIDS, and nutrition and a lower impact on the ultimate goals which are life expectancy, infant and child mortality. Brown (2014) argues that extra spending on health tend to reduce all causes of mortality rate, and Jaba et al. (2014) found a significant relationship between health expenditures and life expectancy. Together, these results indicate that healthcare expenditure plays an important role on the quality of life.

Based on the above discussion, it is understood that access to safe drinking water, sanitation facilities and healthcare expenditure are the most important factors in determining the level of infant mortality rate. Previous studies, however, failed to empirically examine the effect of safe drinking water, sanitation, health expenditure and the quality of food on the infant mortality rate using a comprehensive panel data set. This, therefore, motivates us to empirically investigate the role of improved water and sanitation facilities, health expenditure per capita, GDP per capita and depth of food deficiency on infant mortality rate across a panel of 84 developing economies around the world.[3] To achieve the study objectives, we use annual data from 1995 to 2013 (19 observations for each of the cross-section) and panel econometric techniques. Specifically, we examine the long-run impacts of improved water sources, sanitation facilities, health expenditure per capita, GDP per capita and depth of the food deficiency on infant mortality using two robust models such as the dynamic ordinary least square (DOLS) and fully modified ordinary least square (FMOLS) methods. The significance of these methods is that they account for endogeneity, serial correlation and heterogeneity that may present in the model.

Given that, the findings derived from this paper will offer numerous policy and practical implications for the countries that have higher infant mortality. Further, this paper makes considerable value to the empirical literature. More specifically, this is the first study to consider 84 countries that have higher infant mortality rate and incorporates variables that have significant relevance to control and prevent the growth of infant mortality such as access to safe drinking water, sanitation, health care expenditure and depth of food deficiency. Therefore, this is the first of its kind to consider all these factors to investigate the factors that play crucial role in preventing infant mortality in developing countries. The paper also makes methodological contributions by addressing the issue of cross-sectional dependence in the estimation. Finally, this study provides long-run parameters which will help us to understand the degree and nature of impact of the selected variables on infant mortality rate. Hence, this study not only adds new knowledge to the literature but also provides relevant policy implications.

The paper is organized into six sections. Section 2 presents a critical review of the literature, including methods and findings. Section 3 introduces empirical methodologies that are used in this paper. Section 4 presents the nature of data and preliminary statistics. Section 5 reports the empirical results and discussion and finally, Section 6 presents the conclusion and policy implications arising from this study.

II. Literature review

There has been a significant debate in the socio-economic literature on the issue of infant mortality and its potential determinants, and subsequently a number of important empirical studies involving both single-country and cross-country studies have been produced. With respect to single-country studies, Mutunga (2007) used Kenyan Demographic and Health Survey data to look at household's environmental and socioeconomic characteristic determinants (which include maternal education, access to safe drinking water, sanitation facilities and others) of infant and child mortality using a survival analysis framework. Child survival rate was found to be higher in affluent households who have better housing condition, access to healthy food and better education. This implies that the households who can afford to receive proper healthcare services are likely to enhance the survival probability of infant and child. Similar conclusions are also drawn by Agha (2000). The unadjusted effects (not controlling for other demographic factors) of socioeconomic characteristics of infant and child mortality in India using survival analysis was investigated by Pandey et al. (1998). In this study, it was found that mortality tends to be higher among those children born to illiterate mothers, born in rural areas and with no access to sanitation facilities. However, authors suggested that the effect of these socioeconomic factors become small when other demographic variables are included in their models.

A number of authors (e.g. Watson, 2006) argued that the provision of improved sanitation and safe drinking water facilities have contributed to significant health improvements in developed economies. Gamper-Rabindran, et al. (2010) suggested that the piped water provision promotes a considerable reduction in infant mortality rate, when other public health inputs were put in place. Kumar and Vollmer (2013) argued that diarrhoea is considered to be the second leading cause for under-five mortality in developing countries and that diarrhoea incidence has only significantly reduced in households who pay considerable attention to treating the water before they drink. Further, Esrey et al. (1991) suggested that improvements in water supply and sanitation substantially reduce the rates of morbidity and severity of ascariasis, diarrhoeal diseases, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. To analyzes the effect of privatization of water service provision on child mortality in Argentina, Galiani et al. (2005) used a matching estimator. The findings implied that the variation in ownership of water service provision across time and space led to a fall in child mortality in areas where the water service was privatized. The reduction in mortality rate following water service privatization was associated with reductions in deaths from infectious and parasitic diseases and uncorrelated to deaths unrelated to water conditions.

Despite continued national and international efforts, access to improved water and sanitation facilities remain limited in many developing countries around the world. Victora et al. (1988) established a significant association between an increased risk of death from diarrhoea and non-availability of piped water, the absence of a flushing toilet, residing in a poorly built house and households with overcrowding. Bähr and Wehrhahn (1993) found that the development of primary and secondary health care and improvement in sanitary conditions, especially when applied to rural and marginal urban populations, turn out to be the most important factors for reductions in infant mortality. Fink et al. (2011) also investigated the associations between child health and access to water and sanitation. Their findings suggested that an absence of access to water and sanitation for children aged under five had significant and negative health consequences.

The child mortality differentials with respect to water supply and sanitation in many developing countries suggest that access to piped water and toilet facilities may improve survival chances of children. In saying this, Ridder and Tunali (1999) could not find any evidence to support this relation. Similarly, Lee et al. (1997) documented that neither water sources nor improvements in sanitation facilities appeared to significantly affect child survival, although wealth and parental schooling levels were significantly and positively associated with higher survival in the case of Bangladesh and the Philippines. In a panel study, with thirty sub-Saharan countries, Ssozi and Amlani (2015) investigated the effectiveness of health expenditure. Their findings suggest that health expenditure has a higher effect on proximate targets such as immunization, malaria, HIV/AIDS, and nutrition; and a lower effect on the ultimate goals of life expectancy, infant, and child mortality.

Health is one of the necessary elements in order to socially develop a society. Providing quality and affordable healthcare services is one of the most important challenges for many low and middle-income countries around the world. Thus, there has been a strong relation between level of social welfare and health expenditure. Using panel data analysis techniques, Erdoğan et al. (2013) identified a significant and negative relationship between infant mortality rate and real per capita GDP. Renton et al. (2012) further reported that socio-economics changes improve health capacity in poor countries and similarly, Kalipeni (1993) found demographic and socioeconomic variables such as age at the first marriage, total fertility rates, female literacy rates and a number of home craft centres' determine the level of infant mortality rates. The findings of Agha (2000) established that socioeconomic factors and access to improved water and sanitation facilities have an important role on the infant mortality rate. Hajizadeh, et al. (2014) argued, in the case of 53 low-and-middle-income countries (LMICs), that the understanding of infant deaths among socioeconomically disadvantaged households in majority of LMICs remains an important health and social policy concern. Policies designed to reduce concentration of teenage pregnancy among mothers in lower socioeconomic groups may mitigate relative social inequalities in infant mortality. Another study, Rammohan et al. (2013), documented that the supply side health factors play an important role in reducing infant mortality rate in India, particularly the closeness of hospital and availability of emergency obstetric care facilities.

The above literature indicates that access to sanitation, safe drinking water and healthcare facilities play an important role in reducing infant mortality rate. However, it is observed that there is very little evidence on the cross-country context. Most of the previous studies were focused on country specific or region specific and not much on global context. Further, the previous studies failed to investigate the impact of safe drinking water, sanitation, health expenditure, GDP per capita and depth of food deficiency on infant mortality using a large panel data set. Moreover, the previous studies have also failed to investigate the issue using robust panel econometric models, accounting cross-sectional dependence and heterogeneity in the analysis. Given that our study is going to address this issue in a global context. Specifically, we examine the role of improved water, sanitation facilities and healthcare expenditure on infant mortality across a panel 84 developing economies using annual data from 1995 to 2013, the findings will significantly contribute to the body of knowledge and may provide important policy and practical implications.

III. Empirical methodology

This study aims to address the impact of improved sanitation, water facilities and health expenditure on infant mortality rate using a panel data set of 84 developing economies. In addition, this study includes other important variables in the model such as GDP per capita and depth of the food deficiency. The significance of this study is that it is the first one to consider major infant mortality countries and employ robust panel econometric methods that account for cross-sectional dependence, endogeneity and heterogeneity. More specifically, we investigate the long-run equilibrium relationship among the variables using the cointegration methodology. Similarly, the long-run elasticities of infant mortality rate are explored using DOLS and FMOLS methods.

To achieve the study objectives, we developed the following model using the existing theoretical and empirical literature to determine the factors which drive infant mortality rate in developing economies. There are a number of economic theories that explain the factors that cause infant mortality. Our model inherently uses the theoretical approaches of theory modernization, theory of developmental state and theory of dependency/world systems. All of these theories highlight that the countries will reduce infant mortality as they become more and more modernized, developed and connected with the rest of the world. These theoretical approaches also suggest that the countries will improve their basic facilities such as sanitation, safe drinking water and healthcare facilities with the modernization, development and connecting with high income economies. Given this backdrop, we build the following equation for empirical investigation:

$$IMR_{it} = f(IWS_{it}, ISF_{it}, HEPC_{it}, GDPPC_{it}, DFD_{it}, v_i) \quad (1)$$

where, *IMR* represents infant mortality rate per 1000 live births, *IWS* represents improved water source, *ISF* signifies people with sanitation facilities as a percentage of the total population, *HEPC* indicates health expenditure per capita, *GDPPC* represents GDP per capita in current US dollars, and finally, *DFD* represents depth of the food deficit in kilocalories for each person per day. In Equation (1), countries and time periods are indicated by the subscript i $(i = 1,......, N)$ and t $(t = 1,......., T)$, respectively, and v_i represents individual fixed country effects.

As a first step of the empirical analysis, we investigate whether given a variable is cross-sectional dependent or independent. For this purpose, we employ Pesaran's (2004) cross-sectional dependence (CD) test. A number of previous studies document that conventional unit root tests do not provide reliable results when they are applied on a series that is cross-sectional dependence. Therefore, to investigate the order of integration of the variables, we apply Pesaran's (2007) CIPS unit root which is established on the assumption of cross-sectional dependence. The findings of CIPS test help to identify the appropriate empirical models for the analysis.

In the next step, the panel cointegration technique is applied to examine the long-run equilibrium relationship among the variables of infant mortality rate, improved sanitation and water facilities, health expenditure per capita, GDP per capita and depth of the food deficiency in a sample of 84 developing economies. Alam and Paramati (2015) argue that the panel cointegration techniques are more reliable than the models that are estimated using the individual time series. It is documented that this mainly arises because the models estimated from cross-sections of time series data set have a greater degree of freedom and provide more reliable results. Given the advantages of panel cointegration technique, in this paper, we use the Pedroni's (1999, 2004) panel cointegration methodology to explore the long-run association among the variables. This approach uses the Engle and Granger (1987) two-step (residual-based) cointegration procedure in the analysis.

In the third and final step, we aim to estimate a single cointegration vector, based on Equation (1), to investigate the long-run elasticities of infant mortality rate. It is also well argued in the literature that the application of ordinary least squares (OLS) on Equation (1) is asymptotically biased and its distribution relies on a nuisance parameter. For instance, Pedroni (2000, 2001) argues that these nuisance parameters can introduce unwanted endogeneity and serial correlation into the regression model. Further, it is evident from our sample data, please see Table 1, that there is a significant heterogeneity across the cross-sections. Hence, to address these issues, we make use of Dynamic OLS (DOLS) (Mark and Sul, 1999) and Fully Modified OLS (FMOLS) (Pedroni, 2000; Kao and Chiang, 2000) estimation techniques. The first method (DOLS) is based on the parametric approach, while the second method (FMOLS) comes from a non-parametric approach. The DOLS model uses leads and lags of differences in the right-hand side variables to overcome endogeneity and serial correlation, while FMOLS uses a non-parametric approach to address the issues of endogeneity and serial correlation in the analysis. It is also important to highlight that both DOLS and FMOLS methods provide reliable estimates even in the presence of heterogeneity across the cross-sections. Therefore, we make use of DOLS and FMOLS to estimate long-run elasticities of infant mortality rate in this paper.

IV. Data and preliminary statistics

a) Nature of data and measurement

In this section, we describe the nature of data, measurement, and normalization of the variables. The selection of the sample period and countries are based on the availability of annual data from 1995 to 2013 (i.e. 19 observations for each cross-section or country) and developing countries that have higher infant mortality rates, respectively.[4] This indicates that we use a balanced panel data set on 84 developing economies.[5] The considered time series data on infant mortality rate, access to improved water and sanitation facilities, health expenditure per capita, GDP per capita and depth of food deficiency are collected from the World Development Indicators (WDI) online database published by the World Bank. The measurement of above variables is as follows:

Infant mortality rate (IMR): Infant mortality rate is the number of infants dying before reaching one year of age, per 1,000 live births in a given year.

Improved water source (IWS): Access to an improved water source refers to the percentage of the population using an improved drinking water source. The improved drinking water source includes piped water on premises (piped household water connections located inside the user's dwelling, plot or yard), and other improved drinking water sources (public taps or standpipes, tube wells or boreholes, protected dug wells, protected springs, and rainwater collection).

Improved sanitation facilities (ISF): Access to improved sanitation facilities refers to the percentage of the population using improved sanitation facilities. The improved sanitation facilities include flush/pour flush (to piped sewer system, septic tank, and pit latrine), ventilated improved pit (VIP) latrine, pit latrine with slab, and composting toilet.

Health expenditure per capita (HEPC): Total health expenditure is the sum of public and private health expenditures as a ratio of total population. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health but does not include provision of water and sanitation. Data are in current U.S. dollars.

Gross domestic product per capita (GDPPC): GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.

Depth of the food deficit (DFD): The depth of the food deficit indicates how many calories would be needed to lift the undernourished from their status, everything else being constant. The average intensity of food deprivation of the undernourished, estimated as the difference between the average dietary energy requirement and the average dietary energy consumption of the undernourished population (food-deprived), is multiplied by the number of undernourished to provide an estimate of the total food deficit in the country, which is then normalized by the total population.

It is implied from the description of the variables that they are measured in different units. The previous literature documents the importance of converting all variables into a uniform measurement before commencing any econometric analysis. This will help us to avoid the problems associated with distributional properties of the data series. Therefore, we transform all series into natural logarithms before begin to analyse.

b) Preliminary analysis

The preliminary statistics on the selected individual countries are presented in this section. More specifically, Table 1 presents the summary statistics on 84 developing economies over a period of 1995-2013. Among the sample countries, on average, Panama (19.77), Fiji (20.38), and Jordan (20.97) have the lowest infant mortality rate per 1000 live births. On the other hand, Sierra Leone (130.28), Angola (120.69), Central African Republic (108.87), Mali (101.55), and Chad (101.03) have the higher infant mortality rate per 1000 live births in the world. On average, the lowest percentage of population with access to improved water sources is in Ethiopia (36.38%), while the highest is in Egypt (97.29%), Jordan (96.48%), and Maldives (96.41%). Similarly, the lowest percentage of population with access to improved sanitation facilities is in Niger (7.36%) and Tanzania (9.93%), while the highest is in Turkmenistan (98.64%), Jordan (97.73%), and Kazakhstan (97.02%).

The lowest average health expenditure per capita, in current US dollars, is possessed by Ethiopia (9.64$), Central African Republic (14.12$), and Guinea (14.68$), while Trinidad and Tobago (548.36$) and Brazil (528.29$) have the highest. On average, the lowest GDP per capita, in current US dollars, is attained by Liberia (212.12$), Ethiopia (224.89$) and Malawi (234.51$), whereas Trinidad and Tobago (11117.41$), Gabon (6683.81$), and Turkey (6545.80$) have the higher GDP per capita. Finally, on average, Turkey (4.42) and Tunisia (6.11) consume the lowest kilocalories per person per day (depth of the food deficit), while Haiti (554.11), Ethiopia (412.53) and Rwanda (401.63) consume the highest kilocalories. These preliminary statistics on individual countries indicate that most of these developing countries have less access to improved water and sanitation facilities and the lowest consumption of health expenditure and personal income. Further, these statistics suggest that the per capita consumption of kilocalories per person per day is also lower with these factors, together, contributing to higher infant mortality rates in these developing economies.

[Insert Table 1 here]

Table 2 presents summary statistics on a panel data set of 84 developing countries for the period of 1995-2013. The results show that the average infant mortality rate is 55.43 per 1000 live births. During this period, the higher recorded infant mortality rate is 153.00 and the lowest is 8.40 per 1000 live births. On average, 74.81% and 49.66% of the population have access to improved water and sanitation facilities across these developing countries.

Further, the average per capita health expenditure is only 106.31 current US dollars, while the average per capita GDP is 1850.00 dollars. Finally, the per capita consumption of kilocalories per person per day is only 155.24. For the same period, if we look at the world's average infant mortality rate, improved water, sanitation facilities, health expenditure per capita, GDP per capita and depth of food deficit are 46.59, 84.84, 61.21, 698.29, 7273 and 128.17, respectively. These statistics indicate that the sample countries of this study have a higher infant mortality rate and lower rate of access to water, sanitation facilities, health expenditure, GDP per capita and consumption of kilocalories as compared to world statistics for the same time period. This indicates that developing countries are lacking in terms of access to safe drinking water, sanitation facilities and health expenditure and also consumption of kilocalories. These factors might be playing an important role in rising infant mortality rate in these developing economies.

[Insert Table 2 here]

V. Empirical results and discussion

In this section, we first discuss the nature of relationship between the variables by making use of the results on unconditional correlations. We will then present the results on cross-sectional dependence and order of integration of the data series using CD and CIPS tests and discuss the long-run equilibrium relationship among these variables using Pedroni's (1999, 2004) panel cointegration test. Finally, we present the long-run elasticities of infant mortality rate which are based on fixed effect, DOLS and FMOLS methods. The empirical results of these methods are presented and discussed in the following sub-sections.

a) Unconditional correlations

The unconditional correlations among the variables are displayed in Table 3. The results show that the infant mortality rate has significant negative correlations with access to improved water and sanitation facilities, health expenditure per capita and GDP per capita. These findings suggest that increasing access to improved water sources and sanitation facilities significantly reduce infant mortality rate in developing economies. Similarly, the higher health expenditure per capita and GDP per capita also substantially reduce infant mortality rate. However, the lower consumption of per capita kilocalories seems to increase infant mortality rate in these countries. For these reasons, it is important to provide basic needs such as safe drinking water and sanitation facilities to all households. To further reduce infant mortality rate, it is important to improve health care facilities and availability of nutritional food for both mother and infant. By improving each of these factors, we can significantly reduce the infant mortality rate in developing economies. All these pairs of correlations are statistically significant at the 1% level.

[Insert Table 3 here]

b) The cross-sectional dependence and unit roo tests

Table 4 presents results on CD test and CIPS unit root test. The CD test results on panel data set show that the null hypothesis of cross-sectional independence is strongly rejected for all of the variables (IMR, IWS, ISF, HEPC, GDPPC and DFD). Further, results indicate that the null hypothesis is rejected at the 1% significance level. Hence, we establish that all of our considered variables have a cross-sectional dependence. Based on these findings, we conclude that it is inappropriate to use the conventional panel unit root tests, which work under the assumption of cross-sectional independence. To overcome this issue, we apply the recently developed CIPS unit root test which assumes cross-sectional dependence in data series. The CIPS unit root test results on level series indicate that the null hypothesis of unit root cannot be rejected for all variables at the 5% significance level. However, at first order difference, the null of non-stationary can be rejected at the 1% significance level for all of the variables. The CIPS unit root test results suggest that all the variables are non-stationary at levels and stationary at their first order differences (i.e. all variables are integrated of order I (1)). These results suggest that there may be a cointegration relationship among these variables in the long-run. This can be investigated in the following section using the panel cointegration methodology.

[Insert Table 4 here]

c) Cointegration test results

The above unit root test results show that all variables are integrated of same order (i.e. I (1)). Hence, we can apply a cointegration methodology to investigate whether any long-run relationship exists between the dependent variable (IMR) and independent variables (IWS, ISF, HEPC, GDPPC and DFD). As previously mentioned, in this study we employ Pedroni's (1999, 2004) panel cointegration methodology to explore the long-run equilibrium relationship among the variables. The empirical results of the Pedroni test are presented in Table 5. To perform the Pedroni cointegration test, we needed to select the appropriate lag length, which we chose based on the Schwarz information criterion (SIC) and confirm that the selected lag length residuals are random. The Pedroni test shows that out of the seven statistics, there were three (within-dimension) which rejected the null hypothesis of no cointegration at 1% significant level, and two (between-dimension) which rejected the null hypothesis at the 1% significant level. These results indicate that there is a significant long-run equilibrium relationship among infant mortality rate, improved water and sanitation facilities, health expenditure, GDP per capita and depth of food deficit. Together, these findings suggest that these variables share a common stochastic trend in the long-run.

[Insert Table 5 here]

d) Long-run elasticities of infant mortality rate

To begin our empirical estimation of long-run parameters of infant mortality rate, we first apply fixed effect methodology. The fixed effect methodology is preferred over random effect model due to the recommendations of Hausman specification test. We then estimate these long-run elasticities by making use of DOLS and FMOLS methods as these two techniques uses parametric and non-parametric approaches to counter the issues of endogeneity, serial correlation and heterogeneity in the model. The empirical results of fixed effect, DOLS and FMOLS methods are displayed in Table 6. These three approaches produce very similar results for each of the variables in terms of sign, statistical significance and magnitude. The results of these techniques are presented below:

- Fixed effect – a 1% raise in IWS, ISF, HEPC and GDPPC decreases IMR by -0.222%, -0.301%, -0.230%, and -0.049%, respectively.
- DOLS – a 1% increase in IWS, ISF, HEPC and GDPPC decreases IMR by -0.631%, -0.300%, -0.126%, and -0.097%, respectively.
- FMOLS – a 1% growth in IWS, ISF, HEPC and GDPPC decreases IMR by -0.207%, -0.301%, -0.223%, and -0.056%, respectively.

These results on elasticities of long-run infant mortality rate demonstrate that increasing access to improved water and sanitation facilities, higher health expenditure and GDP per capita significantly reduce infant mortality rate in developing economies. Among these indicators, the magnitudes of access to improved water, sanitation facilities and health expenditure per capita are higher than that of GDP per capita. This suggests that the safe drinking water, sanitation facilities and health expenditure play an important and crucial role for reducing infant mortality rate across developing countries of the world. It is also important to note that the per capita income also plays a significant role in reducing infant mortality rate.

- A 1% increase in depth of food deficit raises infant mortality rate by 0.032% (fixed effect), 0.033% (DOLS) and 0.020% (FMOLS), respectively.

Further, results show that a 1% increase in depth of food deficit increases infant mortality rate by 2 to 3%. This implies that a lack of nutritional food consumption has significant adverse impact on infant mortality rate across the selected developing economies. We therefore argue that one of the primary reasons for increasing infant mortality rate is due to depth of food deficiency. Overall, these results suggest that the significant infant mortality rate can only be reduced by improving access to safe drinking water, sanitation facilities, increasing health care facilities and income levels and also increasing the consumption of nutritional food. Therefore, policy makers and government officials in these developing economies should focus on improving the drinking water and sanitation facilities for all the households of rural and urban populations. Further, they should also work on improving the health care facilities and providing nutritional food during the maternity period. These factors play an indispensable role in reducing infant mortality rate across developing nations.[6] Our findings are consistent with previous literature (e.g. Kumar and Vollmer, 2013; Gamper-Rabindran et al., 2010; Prüss–Üstün and Corvalán, 2006; Galiani et al., 2005; Victora et al., 1988), who documented that safe drinking water, access to improved sanitation and healthcare facilities reduce infant mortality rate.

[Insert Table 6 here]

For the robustness purpose, we again re-estimate long-run elasticities of infant mortality by making use of data on 38 sub-Saharan African countries.[7] We do this because our preliminary analysis from Table 1 clearly shows that the sub-Saharan countries have higher infant mortality rates and lower access to sanitation and water sources and also low level of health expenditure. Therefore, we carry out robustness check estimation and results are displayed in Table 7. The results across fixed effect, DOLS and FMOLS show that the impacts of sanitation, water sources and health expenditure remain negative and statistically significant on infant mortality rate. The effect of depth of food deficiency on infant mortality is also remaining positive and significant in two models. However, the effect of per capita GDP on infant mortality varies across the models and insignificant in most cases. Overall, these results also confirm that the impact from our core variables (sanitation, water sources and health expenditure) to infant mortality is same in selected sub-Saharan African countries.

[Insert Table 7 here]

VI. Conclusion

The aim of this study was to empirically examine the impact of improved sanitation, water facilities and health expenditure on the infant mortality rate by accounting for other potential determinants in the model such as GDP per capita and depth of food deficiency. The balanced panel data set has been constructed using data from 84 developing economies around the world. The significance of this study is that it is the first one to cover 84 developing economies, which have higher infant mortality rates. It also employs robust panel econometric methods that account for cross-sectional dependence, endogeneity and heterogeneity in the analysis. More specifically, we investigate the long-run equilibrium relationship among the variables using the cointegration methodology. Similarly, the long-run elasticities of infant mortality rate are explored using the fixed effect, DOLS and FMOLS techniques.

The empirical findings of this study confirm the long-run equilibrium relationship among the variables of infant mortality rate, improved water, sanitation facilities, health expenditure per capita, GDP per capita and depth of the food deficiency. Further, the long-run elasticities suggest that an increase in improved water, sanitation facilities, health expenditure and GDP per capita reduces infant mortality rate. On the other hand, an increase in depth of food deficiency raises the growth of infant mortality rate. Results also suggest that the infant mortality rate can be further reduced by improving the quality of drinking water, sanitation facilities and increasing healthcare facilities, and that raising income levels will also reduce infant mortality rate. However, another significant factor which needs to be addressed is availability of nutritional food during the maternity period. By providing healthy food during the maternity, the infant mortality can be further reduced across developing economies.

The findings of this study make significant contribution to the existing body of knowledge and empirical literature on the issue of infant mortality and its potential determinants. Further, these findings provide important implications for the policy. In particular, we advise the policy makers of developing economies that a significant reduction in infant mortality can only be achieved by providing accessibility to safe drinking water and sanitation facilities, and by providing healthcare facilities and nutritional food during the maternity. Both policy makers and government officials of these developing nations should therefore consider the immediate policy actions, which can improve drinking water, sanitation and health care facilities for all households in rural and urban areas. Further, they should also initiate policies which provide nutritional food during maternity for poorer households. As evidenced by the findings of this study, the effective implementation of these policies would significantly reduce infant mortality rate across developing nations. Finally, the future studies may also incorporate supply side of health factors in the model such as distance to the hospital and availability of medical health professionals round the clock. Further, the studies may also consider other health outcomes such as child mortality, crude death rates and life expectancy. This will therefore further enhance the knowledge on the factors that assist to reduce mortality and improve life expectancy.

References

Agha, S. 2000. "The determinants of infant mortality in Pakistan." *Social Science & Medicine 51*(2): 199-208.

Alam, M. S., and S. R. Paramati. 2015. "Do oil consumption and economic growth intensify environmental degradation? Evidence from developing economies." *Applied Economics 47*(48): 5186-5203.

Bähr, J., and R. Wehrhahn. 1993. "Life expectancy and infant mortality in Latin America." *Social Science & Medicine 36*(10): 1373-1382.

Brown, T. T. 2014. "How effective are public health departments at preventing mortality?" *Economics & Human Biology 13:* 34-45.

Cutler, D., and G. Miller. 2005. "The role of public health improvements in health advances: the twentieth-century United States." *Demography 42*(1): 1-22.

Dumitrescu, E.-I., and C. Hurlin. 2012. "Testing for Granger non-causality in heterogeneous panels." *Economic Modelling 29*(4): 1450-1460.

Engle, R. F., and C. WJ. Granger. 1987. "Co-integration and error correction: representation, estimation, and testing." *Econometrica: journal of the Econometric Society:* 251-276.

Erdoğan, E., M. Ener., and F. Arıca. 2013. "The Strategic Role of Infant Mortality in the Process of Economic Growth: An Application for High Income OECD Countries." *Procedia-Social and Behavioral Sciences 99:* 19-25.

Esrey, S. A., J. B. Potash., L. Roberts., and C. Shiff. 1991. "Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma." *Bulletin of the World Health organization 69*(5): 609.

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

Galiani, S., P. Gertler., and E. Schargrodsky. 2005. "Water for life: The impact of the privatization of water services on child mortality." *Journal of political economy 113*(1): 83-120.

Gamper-Rabindran, S., S. Khan., and C. Timmins. 2010. "The impact of piped water provision on infant mortality in Brazil: A quantile panel data approach." *Journal of Development Economics 92*(2): 188-200.

Hajizadeh, M., A. Nandi., and J. Heymann. 2014. "Social inequality in infant mortality: What explains variation across low and middle income countries?" *Social science & medicine 101:* 36-46.

Jaba, E., C. B. Balan., and L.-B. Robu. 2014. "The relationship between life expectancy at birth and health expenditures estimated by a cross-country and time-series analysis." *Procedia Economics and Finance 15:* 108-114.

Kalipeni, E. 1993. "Determinants of infant mortality in Malawi: a spatial perspective." *Social science & medicine 37*(2): 183-198.

Kao, C., and M.-H. Chiang. 2000. "On the Estimation and Inference of a Cointegrated Regression in Panel Data" in Baltagi, B. H. et al. *eds., Nonstationary Panels, Panel Cointegration and Dynamic Panels* 15: Amsterdam, Elsevier 179–222.

Kumar, Santosh, & Vollmer, Sebastian. (2013). Does access to improved sanitation reduce childhood diarrhea in rural India? Health Economics, 22(4), 410-427.

Lee, L.-F., M. R. Rosenzweig., and M. M. Pitt. 1997. "The effects of improved nutrition, sanitation, and water quality on child health in high-mortality populations." *Journal of econometrics 77*(1): 209-235.

Lin, H.-C., S. Xirasagar., H.-C. Lee., and C.-Y. Chai. 2006. "Hospital volume and inpatient mortality after cancer-related gastrointestinal resections: the experience of an Asian country." *Annals of surgical oncology 13*(9): 1182-1188.

Mark, N., and D. Sul. 1999. "A computationally simple cointegration vector estimator for panel data." Ohio State University manuscript.

Mutunga, CJ. 2007. "Environmental Determinants of Child Mortality in Kenya." UNU-WIDER Research paper No. 2007/83. Helsinki: United Nations University World Institute for Development. *Economics Research*.

Pandey, A., M. K. Choe., N. Y. Luther., D. Sahu., and J. Chand. 1998. "Infant and Child Mortality in India" National Family Health Survey Subject Reports Number 11. *International Institute of Population Sciences: Mumbai*.

Pedroni, P. 1999. "Critical values for cointegration tests in heterogeneous panels with multiple regressors." *Oxford Bulletin of Economics and statistics 61*(s 1): 653-670.

Pedroni, P. 2000. "*Fully modified OLS for heterogeneous cointegrated panels*. In: Baltagi, B.H., Fomby, T.B., Hill, R.C. (Eds.), Adv. Econometrics, Vol 15. Nonstationary Panels, Panel Cointegration and Dynamic Panels, JAI Press, Elsevier Sciences, Amsterdam.

Pedroni, P. 2001. "Purchasing power parity tests in cointegrated panels." *Review of Economics and Statistics* 83 (4): 727–731.

Pedroni, P. 2004. "Panel cointegration: asymptotic and finite sample properties of pooled time series tests with an application to the PPP hypothesis." *Econometric theory 20*(03): 597-625.

Pesaran, M. H. 2004. "General diagnostic tests for cross section dependence in panels." Accessed from the SSRN.

Pesaran, M. H. 2007. "A simple panel unit root test in the presence of cross-section dependence." *Journal of Applied Econometrics 22*(2): 265-312.

Prüss-Üstün, A., and C. Corvalán. 2006. "*Preventing disease through healthy environments"* World Health Organization Geneva, Switzerland.

Rammohan, A., Iqbal, K., & Awofeso, N. (2013). Reducing neonatal mortality in India: critical role of access to emergency obstetric care. PloS one, 8(3), e57244.

Renton, A, M. Wall., and J. Lintott. 2012. "Economic growth and decline in mortality in developing countries: An analysis of the World Bank development datasets." *Public health 126*(7): 551-560.

Ridder, G., and İ. Tunalı. 1999. "Stratified partial likelihood estimation." *Journal of Econometrics 92*(2): 193-232.

Ssozi, J., and S. Amlani. 2015. "The effectiveness of health expenditure on the proximate and ultimate goals of healthcare in Sub-Saharan Africa." *World Development 76:* 165-179.

Victora, C. G., P. G. Smith., J. P. Vaughan., L. C. Nobre., et al. 1988. "Water supply, sanitation and housing in relation to the risk of infant mortality from diarrhoea." *International journal of epidemiology 17*(3): 651-654.

Watson, T. 2006. "Public health investments and the infant mortality gap: Evidence from federal sanitation interventions on US Indian reservations." *Journal of Public Economics 90*(8)" 1537-1560.

Table 1: Summary statistics on sample countries, 1995-2013

S. No	Country	IMR	IWS	ISF	HEPC	GDPPC	DFD
1	Panama	19.77	91.59	69.03	404.80	5502.35	160.05
2	Fiji	20.38	93.14	79.11	119.27	3187.06	31.05
3	Jordan	20.97	96.48	97.73	236.29	2788.53	29.16
4	Tunisia	21.50	91.91	84.74	188.61	3156.63	6.11
5	El Salvador	22.44	85.89	64.54	195.23	2746.69	79.74
6	Armenia	22.56	94.99	89.49	82.73	1786.98	104.26
7	China	23.19	84.42	52.17	117.48	2423.81	127.11
8	Trinidad and Tobago	23.39	92.78	92.26	548.36	11117.41	92.37
9	Brazil	23.54	94.74	76.72	528.28	6344.61	57.68
10	Iran, Islamic Rep.	23.83	94.73	82.53	232.97	3222.95	40.05
11	Georgia	24.28	92.43	94.68	146.36	1665.00	127.16
12	Vietnam	24.55	83.27	61.17	45.57	819.64	179.68
13	Peru	24.79	82.67	66.44	162.04	3323.59	134.05
14	Paraguay	24.84	80.32	66.21	162.88	2193.83	84.95
15	Ecuador	25.63	81.86	74.06	190.07	3225.18	108.21
16	Maldives	25.70	96.41	86.39	295.58	3979.75	75.21
17	Honduras	27.20	83.74	68.82	113.03	1446.09	117.68
18	Suriname	27.25	91.17	80.41	282.32	4512.36	83.74
19	Cabo Verde	27.75	84.87	51.14	106.07	2259.96	105.58
20	Philippines	28.17	89.18	68.75	57.54	1495.43	128.00
21	Turkey	28.24	95.34	88.54	343.30	6545.80	4.42
22	Nicaragua	28.65	81.93	49.59	81.52	1222.31	223.00
23	Algeria	29.47	87.15	93.29	131.37	2979.38	49.16
24	Egypt, Arab Rep.	29.81	97.29	89.56	88.22	1791.42	18.68
25	Kazakhstan	30.17	93.54	97.02	202.42	4930.36	26.32
26	Dominican Republic	30.35	84.19	78.95	182.85	3664.29	182.05
27	Guatemala	35.55	89.64	74.23	143.52	2242.91	106.05
28	Indonesia	35.83	80.01	50.85	45.35	1671.37	114.79
29	Kyrgyz Republic	36.08	82.28	91.61	38.12	604.55	85.26
30	Guyana	36.14	90.17	80.76	108.84	1757.90	80.00
31	Morocco	37.53	79.94	67.72	106.53	2027.53	43.05
32	Mongolia	41.37	74.23	51.47	81.73	1404.46	286.37
33	Namibia	44.26	83.29	29.15	243.21	3403.69	233.89
34	Botswana	45.86	95.55	56.41	246.05	4730.80	236.53
35	South Africa	45.95	89.56	68.21	397.82	4938.25	29.05
36	Uzbekistan	47.71	88.14	94.66	50.56	849.41	68.00
37	Bolivia	48.24	82.09	40.27	75.08	1381.03	209.21
38	Azerbaijan	49.67	76.54	70.91	150.79	2798.10	92.95
39	Gabon	50.21	86.72	39.69	227.48	6683.81	32.68
40	Sao Tome and Principe	50.89	85.29	25.93	72.42	847.21	104.84
41	Nepal	51.21	80.69	25.85	21.11	374.06	130.74
42	Kiribati	51.55	61.13	35.81	116.61	1149.30	30.53

Cont'd

S. No	Country	IMR	IWS	ISF	HEPC	GDPPC	DFD
43	Bangladesh	54.63	78.89	48.65	14.98	510.51	163.05
44	India	58.56	84.58	28.95	33.47	813.91	131.47
45	Gambia, The	58.87	85.20	60.65	25.55	562.15	88.74
46	Senegal	59.15	68.89	45.73	35.55	754.94	159.95
47	Yemen, Rep.	59.38	57.77	44.71	45.58	841.51	191.21
48	Madagascar	59.77	41.84	11.67	14.86	328.06	233.42
49	Turkmenistan	59.96	77.79	98.64	82.02	2490.92	45.95
50	Congo, Rep.	60.24	71.39	13.37	49.28	1753.70	260.79
51	Cambodia	60.54	51.29	23.03	31.27	523.57	168.95
52	Ghana	60.89	76.19	11.65	40.80	787.25	95.42
53	Kenya	61.49	55.07	27.77	25.85	659.68	201.95
54	Tajikistan	62.23	63.87	91.78	23.89	431.95	277.05
55	Sudan	63.17	59.46	24.48	55.69	819.17	185.58
56	Tanzania	64.05	53.96	9.93	19.85	455.97	256.11
57	Haiti	69.37	61.73	22.22	35.19	521.83	554.11
58	Togo	70.22	55.53	11.91	26.36	405.27	188.89
59	Djibouti	72.38	85.87	61.62	71.29	1022.74	370.42
60	Swaziland	72.42	59.17	53.67	151.28	2200.52	137.79
61	Uganda	72.52	62.52	31.13	34.14	370.74	172.58
62	Lao PDR	73.55	54.77	40.92	20.95	651.23	246.05
63	Mauritania	73.64	43.96	22.89	30.85	695.84	70.42
64	Ethiopia	73.87	36.38	13.34	9.64	224.89	412.53
65	Benin	77.62	69.58	10.83	24.28	529.09	127.32
66	Rwanda	78.09	67.65	52.61	29.32	346.74	401.63
67	Lesotho	79.07	79.82	25.93	61.84	690.88	83.47
68	Cameroon	80.19	65.82	43.18	43.07	897.15	176.16
69	Malawi	81.56	69.87	10.20	18.31	234.51	205.26
70	Pakistan	82.27	89.39	41.07	22.59	749.78	170.74
71	Zambia	82.84	56.83	41.57	44.77	876.36	356.00
72	Burkina Faso	85.62	67.12	13.91	25.10	410.98	184.37
73	Niger	87.11	45.48	7.36	17.34	266.94	132.26
74	Cote d'Ivoire	89.91	78.39	19.06	60.83	998.31	96.21
75	Guinea	90.49	66.69	14.86	14.68	408.93	164.74
76	Liberia	95.38	65.89	14.73	20.08	212.12	267.00
77	Mozambique	97.32	43.66	16.32	19.32	337.47	301.26
78	Guinea-Bissau	99.07	59.03	14.82	23.95	390.06	170.11
79	Nigeria	99.88	57.87	30.95	57.94	1041.58	52.74
80	Chad	101.03	46.69	10.43	22.67	544.06	321.89
81	Mali	101.55	52.65	19.43	30.70	452.60	70.84
82	Central African Republic	108.87	64.33	18.58	14.12	351.82	317.58
83	Angola	120.69	48.48	48.13	91.31	2298.76	294.95
84	Sierra Leone	130.28	51.46	12.24	39.30	339.70	274.00

Notes: 1) IMR: Mortality rate, infant (per 1,000 live births); 2) IWS: Improved water source (% of population with access); 3) ISF: Improved sanitation facilities (% of population with access); 4): HEPC: Health expenditure per capita (current US$); 5) GDPPC: GDP per capita (current US$); 6) DFD: Depth of the food deficit (kilocalories per person per day). The countries are organized based on IMR from the lowest to the highest.

Table 2: Preliminary analysis

	Descriptive Statistics			
	Mean	Std. Dev	Minimum	Maximum
IMR	55.431	29.735	8.400	153.000
IWS	74.811	16.836	19.500	99.800
ISF	49.664	28.875	2.800	100.000
HEPC	106.312	140.377	3.010	1153.720
GDPPC	1849.999	2310.178	64.810	21395.280
DFD	155.243	114.509	2.000	666.000

Note: Estimated using original data.

Table 3: Unconditional correlations

	IMR	IWS	ISF	HEPC	GDPPC	DFD
IMR	1.000					
IWS	-0.711***	1.000				
ISF	-0.706***	0.715***	1.000			
HEPC	-0.733***	0.648***	0.640***	1.000		
GDPPC	-0.744***	0.665***	0.670***	0.949***	1.000	
DFD	0.503***	-0.500***	-0.476***	-0.558***	-0.560***	1.000

Notes: Variables are in natural logarithms.
'***' indicates statistical significance at 1% level.

Table 4: Cross-sectional dependence and unit root results

Variable	IMR	IWS	ISF	HEPC	GDPPC	DFD
Pesaran CD test	239.510***	156.690***	169.760***	223.160***	226.410***	99.000***
The unit root test with cross-sectional dependence						
CIPS test (level)	6.033	4.105	5.81	36.207	-0.506	3.411
CIPS test (first difference)	-4.502***	-10.155***	-12.148***	-17.714***	-13.042***	-3.816***

Notes**:** '***' indicates the rejection of the null hypothesis of cross-sectional independence (CD test) and the null hypothesis of the unit root at 1% significance levels, respectively. The CIPS test is estimated using constant and trend.

Table 5: Pedroni Residual Cointegration Test

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	16.076***	0.000	23.469***	0.000
Panel rho-Statistic	8.990	1.000	8.846	1.000
Panel PP-Statistic	-3.081***	0.001	-2.401***	0.008
Panel ADF-Statistic	-6.890***	0.000	-6.179***	0.000
Alternative hypothesis: individual AR coefs. (between-dimension)				
Group rho-Statistic	11.799	1.000		
Group PP-Statistic	-7.649***	0.000		
Group ADF-Statistic	-7.305***	0.000		

Notes: Trend assumption: Deterministic intercept and trend;
Lag selection: Based on SIC;
'***' denotes rejection of the null hypothesis of no cointegration at the 1% significance level.

Table 6: Panel data analysis of long-run infant mortality rate elasticities

Variable	Fixed effect			DOLS			FMOLS		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
IWS	-0.222***	-3.640	0.000	-0.631***	-11.043	0.000	-0.207***	-99.325	0.000
ISF	-0.301***	-8.570	0.000	-0.300***	-9.903	0.000	-0.301***	-69.644	0.000
HEPC	-0.230***	-14.619	0.000	-0.126***	-9.874	0.000	-0.223***	-44.492	0.000
GDPPC	-0.049***	-2.811	0.005	-0.097***	-6.781	0.000	-0.056***	-9.959	0.000
DFD	0.032***	2.584	0.010	0.033***	3.433	0.001	0.020***	6.358	0.000
Constant	7.037***	31.615	0.000						

Notes: '***' denotes the significance level at 1%.
DOLS and FMOLS are the dynamic and fully modified ordinary least square methods, respectively.

Table 7: Robustness check: Sub-Saharan African countries

Variable	Fixed effect			DOLS			FMOLS		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
IWS	-0.563***	-7.913	0.000	-0.749***	-9.753	0.000	-0.545***	-199.700	0.000
ISF	-0.115***	-2.822	0.005	-0.198***	-5.747	0.000	-0.135***	-21.282	0.000
HEPC	-0.237***	-11.704	0.000	-0.149***	-7.222	0.000	-0.231***	-25.615	0.000
GDPPC	0.032	1.452	0.147	-0.032	-1.448	0.148	0.025***	2.982	0.003
DFD	0.021	1.142	0.254	0.069***	4.567	0.000	0.011**	2.218	0.027
Constant	7.513***	27.125	0.000						

Notes: '***' and '**'denote the significance levels at the 1% and 5%, respectively.

[1] https://www.who.int/sdg/targets/en/

[2] (http://www.un.org/millenniumgoals/childhealth.shtml)

[3] We have chosen infant mortality over other indicators (such as child mortality and life expectancy) because infants are more vulnerable to the unsafe sanitation and drinking water. Therefore, in this paper, we particularly focus on infant mortality.

[4] Sample countries are selected based on the infant mortality of 20 and above (this is the average from 1995 to 2013) per 1000 live births.

[5] The selected developing economies are; Algeria, Angola, Armenia, Azerbaijan, Bangladesh, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Cabo Verde, Cambodia, Cameroon, Central African Republic, Chad, China, Congo, Cote d'Ivoire, Djibouti, Dominican Republic, Ecuador, Egypt, El Salvador, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran, Jordan, Kazakhstan, Kenya, Kiribati, Kyrgyz Republic, Lao PDR, Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritania, Mongolia, Morocco, Mozambique, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Panama, Paraguay, Peru, the Philippines, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Sudan, Suriname, Swaziland, Tajikistan, Tanzania, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Uzbekistan, Vietnam, Yemen and Zambia.

[6] We also estimated with system GMM method and results remain same. We didn't report these results to conserve the space in the paper.

[7] Angola, Benin, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, Rep., Cote d'Ivoire, Djibouti, Ethiopia, Gabon, Gambia, The, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda and Zambia.