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Impact of food availability on child mortality: a cross country comparative analysis

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Abstract: The study examined the impact of food security on child mortality (infant mortality and under-five mortality), using a dynamic panel data analysis for 114 countries for the period 1995–2009 by considering a wide range of controlled variables such as income, social indicators and policy variables. The result suggests that food security has a negative impact on child mortality for all countries and even more impact on child mortality within the food insecure African countries. Therefore, based on the findings of the study; it is recommended that an increase in food security is indeed a positive policy option, particularly within the food insecure African countries, since it ensures a decrease in child mortality within these countries.

Keywords: Africa, African dummy, economic growth, food crisis

List of abbreviations

FAO = Food and Agricultural organization, **GDP** = Gross Domestic product, **GMM** = Generalized Method of Moments, **IMR** = Infant Mortality rate, **MDG** = Millennium development goals, **PPP** = Purchasing power parity, **ROW** = Rest of the world countries, **SSA** = Countries within African continent, **SSA2** = Countries within African continent with food insecurity, **SYS-GMM** = System Generalized Method of Moments, **U5MR** = Under age Five Mortality rate, **UN** = United Nations, **WDI** = World development indicator

ε_i = Country specific effect, X_{it} = Matrix of explanatory variables

Subscripts: i = countries, t = years

Infant mortality is defined as the demise in the first year of life, whereas the under-five mortality is described as the death between the first and the fifth years (Charmarbagwala et al. 2004). According to the United Nations report in 2009, the ten countries with the highest infant mortality are all in Africa except Afghanistan. Furthermore, in 2009 about 8.1 million children under the age of five were reported to have died, 7.6 million in 2010, 6.9 million in 2011 and about 50% of the reported child mortality took place in the Sub-Saharan Africa where the income is low, and the access to infrastructure is hardly available or accessible. A more recent World Bank-UN report in 2013 states that approximately 6.6 million children died in 2012 that is almost half of the 12 million children that died in 1990. The Sub-Saharan African countries have the highest incidence of child mortality; although the continent has shown a tremendous improvement in reducing child mortality, yet the continent recorded a death ratio of 98 deaths in 1000 births in 2012.

The World Health Organization 2012 report on African regions suggests that the reason for the death of both infant and children under age five within Africa is due to the preventable causes, some of which include the neonatal conditions and the critical respiratory infections and the AIDS.

The relationship between food security and child mortality is well established. Studies on child mortality have shown that the child mortality rates among the high-income earners are low compared to the low-income earners (Campbell et al. 2009). According to the findings of Campbell et al. (2009), households with food insecurity score are associated with a greater neonatal, infant, and under-five child mortality among rural families in Indonesia. Furthermore, the World

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Health Organization, 2012 Report, indicates that under-nutrition has both the direct and indirect impact on child mortality in Africa, about 3.5 million child deaths yearly and nothing less than 35% of the figure occurs among children under 5-year-old.

Although the relationship between food security and child mortality is well established in the literature, this study aims to investigate the effect of food security on child mortality, particularly among the food insecure African countries. To achieve this goal, the paper examines the determinants of child mortality and the impact of food security on child mortality within 114 countries for the period 1995–2009. Furthermore, the study explores the possibility of the impact of the identified determinants; whether they are different within the African continent (SSA) and among the African countries with food insecurity (SSA2).

LITERATURE REVIEW

Food security is one of the Millennium Development Goals (MDG) of the United Nations in conjunction with the governments of most developing countries; the number one goal of the MDG is to halve poverty and hunger by 2015 while the fifth goal is to reduce child mortality by two-thirds. To achieve these goals, the United Nations is encouraging the governments of these developing nations to pursue policies that will ensure food security and reduce child mortality within these developing countries. Food security is defined as a situation in which people have access to a sufficient quality and quantity of food at all times. The United Nations defined food security through three major concepts that are: Food Availability, Food Accessibility, and Food Utilization. These three concepts are hierarchical in nature. Food availability deals with the supply of food both at the national and domestic level, although very important, it does not guarantee food security; food accessibility refers to the demand for food at all times, hence influenced by the consumer preference and purchasing power. Food utilization, on the other hand, refers to the individual's ability to derive sufficient nutrients from the food consumed for growth. Despite the fact that these three concepts are very important, in conceptualizing food security is determined by the quantity and quality of the dietary intake, general childcare and feeding practices, along with health status and its determinants (Omonona and Agoi 2007). It is still difficult to quantify food accessibility and utilization; therefore, this study will focus on food availability as a proxy for food security.

Child mortality is an important objective for most developing countries. Achieving this objective requires understanding its determinants so as to follow the right policy paths in achieving this goal.

Determinants of child mortality

Reduction of child mortality is one of the United Nations (UN) Millennium Development Goals; the United Nations' target 5 aims to reduce the under-five mortality by two-thirds between 1990 and 2015. The Inter-agency Group for the Child Mortality Estimation Report (2010) showed that great efforts have been made over the last decade to achieve this goal; in fact, there has been a one-third decline in the global under-five mortality between 1990 and 2009, with North Africa and Asia making the greatest efforts. Despite this improvement in the global child mortality rate, many developing countries, particularly in Africa are still far from achieving this goal; the developing countries are far behind the developed world, with 66 per 1000 deaths compared to 6 per 1000 in the developed region (Kaldewei and Pitterle 2011).

Several studies have tried to explore the determinants of child mortality. The earliest of such studies was performed using a cross-country analysis; Rodgers (1979) investigates the impact of income inequality on child mortality, using the life expectancy at birth, the life expectancy at age five and infant mortality as the independent variables, the study posits that income strongly affects child mortality for all the countries studied.

Furthermore, Horbcraft et al. (1985), using data from 39 world fertility surveys, found the child spacing and the age of mother as important risk factors in the survival of a child. Also studies of Cleland and Van Ginneken (1988) using the findings of a multivariate examination of data from 16 countries presented by Hobcraft, et al. (1984), argued that changes in the reproductive pattern hide the relationship between education and child mortality. Instead, in average each one-year increment in the maternal education decreases the child mortality of under-five years by 7 to 9%.

Similarly, the findings of Bicego (1990) applying a three-step procedure using the proportional hazards model for data from Haiti, suggest that the maternal education and low age at birth have a significant impact on the neonatal survival, but negligible effects

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afterwards. Similarly, findings of Bicego and Boerma (1990) using the demographic health survey (DHS) from Bolivia also show that the maternal level of education has a greater impact on the child survival in the first two years in the rural areas than in the urban areas. On the other hand, Streatfield et al. (1990) findings from Indonesia suggest that educated women are more aware of the appropriate immunization programs and it is this knowledge, not the formal education, which makes such mothers ensure that their children receive the available vaccines.

King and Rosenzweig (1991), using the quinquennial time-series data for 124 countries, revealed that both the income growth and changes in public spending have a negative significant impact on child mortality. Also Bhalla and Gill (1991), using a different approach on annual time series data from 68 countries, suggest that public spending and income both have a negative impact on infant mortality. Similarly, Pritchett and Summers (1994) using the cross country time series data on health (infant and child mortality and life expectancy), found that over 500 000 child deaths within the developing countries were due to a poor economic performance in the early 1980s. A similar study within urban areas in Ghana, Brazil and Thailand by Timaeus and Lush (1995) posits that the household economic and environmental status has a great impact on the children's morbidity and mortality rate. In fact, children from better-off families tend to have a lower diarrhoea morbidity compared to children from low-income families, and this is due to the differences in the childcare practices.

A more recent study by Wang (2003) using demographic and health survey data from 60 low-income countries has also shown that the determinants of child mortality differ between the rural, urban and national levels. The study revealed that the access to electricity, income, vaccination in the first year of birth and public health expenditures are important determinants of child mortality at the national level. Within the urban areas, only the access to electricity is an important determinant of child mortality, while in the rural areas, vaccination in the first year of birth appears to be the only significant determinant. Furthermore, using a competing risks approach, Jacoby and Wang (2003) explored the linkages in rural and urban China between child mortality and morbidity, and the quality of both household and community environment. The result of their findings suggests that the access to water/sanitation, a higher maternal education level; vaccination and the use of unclean cooking fuel are important determinants of child mortality.

Charmarbagwala et al. (2004), using a meta-analysis by combining the results of 38 different empirical studies in such a way that allows for statistical hypotheses to be tested, posit that the income, household size, parental education, location (urban or rural), the gender of the index child all explain both the child mortality and nutrition. Also, the findings of Wagstaff et al. (2003) suggest that a male child dummy is significantly negative in both 1993 and 1998 for Vietnam, but a similar study on Vietnam by Glewwe et al. (2002) found that this effect is insignificant. Ghosh and Bharati (2010) examined the impact of socioeconomic and demographic factors on infant and child mortality: the study compared two groups of women with similar access to health facilities in a peri-urban area of Kolkata City in India. The study posits that the two groups have different factors standing against the child and infant mortality, suggesting that there is the need for a more understanding of the determinants of infant and child mortality at the household or community level within culturally heterogeneous populations for more effective strategies for child development and survival.

Determinants of child mortality in Africa

Results from most studies on child mortality in Africa are not quite different from the results from other parts of the world. Defo (1994) found that using longitudinal data for Cameroon with a two-state parametric and nonparametric hazards model, socioeconomic factors, housing characteristics and immunization all have a deleterious effect on the infant and child mortality. Similarly, Manda (1999) employed the proportional hazards model on data from the 1992 Demographic and Health Survey in Malawi, to investigate the connection between the infant and child mortality and birth interval, maternal age at birth and, birth order, with and without controlling for other relevant explanatory variables. Also, the study examined the direct and indirect impact of breastfeeding on child mortality. The result from this study posits that the birth interval and maternal age impacts are essentially limited to the infant year of a child and as the child grows up, the impact of social and economic variables on mortality threat tends to increase. It further revealed that breastfeeding does not meaningfully change the effects of the preceding birth interval length on child mortality;

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instead it partially decreases the succeeding birth interval effect.

Zerai (1996), using the Cox regression model on the demographic and health survey from Zimbabwe, explored the impact of socioeconomic and demographic factors on infant survival in Zimbabwe. The finding of this study showed that the women's average level of education within the community has more impact on the infant survival than the actual mother's educational level. A similar study in Zimbabwe, using multivariate hazard analysis on demographic and health survey 2005–2006, suggests that the infant mortality risk is associated with multiple births and socioeconomic variables do not have a distinctive impact on the infant mortality. Therefore, the study argued that the health policy makers should intensify efforts to encourage family planning methods that will help improve child spacing (Kembo and Van Ginneken 2009).

Mutunga (2007) examined the determinants of the infant and child mortality in Kenya, using the survival analysis (hazard and survival functions) based on the 1998 data from the Kenya demographic and health survey. The findings of the study suggest that the household's environmental and socio-economic characteristics have a significant influence on the child mortality; therefore, policies to improve both the household's environmental and socio-economic status were advocated in order to ensure a reduction in the child mortality in Kenya. Using the 2011 demographic and health survey, Meseret et al. (2012) conclude that different factors affect the child and infant mortality which include the mother's educational status, birth order, number of children, birth intervals, household size, breast feeding, mother's marital status and source of drinking water.

A more broad work on the Sub-Saharan Africa revealed that the determinants of child and infant mortality differ between the urban and rural areas. Akoto and Tambashe (2002) found that there is a difference in the determinants of the overall mortality, child and infant mortality between urban and rural areas. The factors responsible for this difference include a better education, a higher income level of households, and the concentration of public infrastructures such as water, sanitation services and health services in the urban areas. Furthermore, Guillot et al. (2012), using data from the human mortality database (HMD), examined the global overview of child mortality and the findings from this study posit that the Sub-Saharan African countries have the tendency to exhibit a high child mortality and the reason for this are epidemiological causes.

CHILD MORTALITY AND FOOD SECURITY

Data

To be able to examine the determinants of child mortality, this study specifies the child mortality outcomes as a function of key variables. Both the theory and empirical evidence from the previous studies formed the basis of the choice of the explanatory variables used in this study. These explanatory variables include: (1) Income – GDP per capita measured in PPP using 2005 as the base year; (2) Social and Environmental Indicators – these variables include the access to potable water, proper sanitation, and female education; (3) Policy Variables such as the share of government expenditure on health, the government health expenditure per capita and (4) Food Security – proxied by food availability per capita. All variables except food availability per capita were obtained from the World Development indicator (WDI) data source, while the food availability per capita was obtained from the Food and Agriculture Organization (FAO) database.

Empirical strategy

This study made use of both the fixed effect model and dynamic panel model estimates System Generalized Method of moments (GMM) to analyse the relationship between child mortality, income, social and environmental indicators, policy instruments and food availability. Both infant mortality (IMR) and under-five mortality (U5MR) were used to capture the level of child mortality in each of the 114 countries considered for the period 1995–2009.

The fixed effect model was applied on the panel data to examine the effect of the explanatory variables on child mortality. The fixed effect model is represented thus:

$$IMR_{it} = \beta_1 X_{it} + \alpha_i + \mu_{it} \quad (1)$$

$$U5MR_{it} = \beta_1 X_{it} + \alpha_i + \mu_{it} \quad (2)$$

where X_{it} is the matrix of the explanatory variables in both models 1 and 2, α_i is the unknown intercept for each country.[1]

[1]Hausman test was also performed to justify the choice of Fixed effect as against Random effect.

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Due to the possibility of serial correlation and heterogeneity in the panel data, this work further made use of a dynamic specification to account for the occurrence of significant lagged effects of the dependent variable that account for the serial correlation in the dependent variable. The dynamic panel model for each of the dependent variables – IMR and U5MR is represented thus:

$$IMR_{it} = \alpha + \beta_1 IMR_{it-1} + \gamma X_{it}\beta_2 IMR_{it-2} + \gamma X_{it} + \varepsilon_i + \mu_{it} \quad (3)$$

$$U5MR_{it} = \alpha + \beta_1 U5MR_{it-1} + \beta_2 U5MR_{it-2} + \gamma X_{it} + \varepsilon_i + \mu_{it} \quad (4)$$

where the subscript t and i represent years and countries, respectively. From Equation 3, the dependent variable is infant mortality rate per 1000 (IMR_{it}). The independent variables are the first and second lag values of IMR_{it}. X_{it} is a set of explanatory variables which includes: food per capita, Income-GDP per capita, social indicator – access to water, access to sanitation, female primary school enrolment, policy variables – share of public health in GDP expenditure and health expenditure per capita. ε_i are the unobserved country-specific fixed-effects, and μ_{it} is the identical and independently distributed error term. Equation 4 represents the model for under-five mortality rate per 1000 ($U5MR_{it}$) with first and second lag values of $U5MR_{it}$ as the independent variable while X_{it} is the set of the same explanatory variables as in Equation 3.

Estimating Equations (3) and (4) with the OLS (Ordinary Least Square) regression method without a panel setting estimate can be problematic; since OLS ignores country-specific fixed effects. There is a possibility of serial correlation and endogeneity of all the regressors in the dynamic OLS regression. To control for the country-specific fixed effects ε_i, Equations (3) and (4) will be first differenced; first differencing removes any possible unobserved heterogeneity among the countries. The first-differenced specification can be represented thus:

$$\Delta IMR_{it} = \alpha + \beta_1 \Delta IMR_{it-1} + \gamma X_{it}\beta_2 \Delta IMR_{it-2} + \gamma \Delta X_{it} + \Delta\mu_{it} \quad (5)$$

$$\Delta U5MR_{it} = \alpha + \beta_1 \Delta U5MR_{it-1} + \beta_2 \Delta U5MR_{it-2} + \gamma \Delta X_{it} + \Delta\mu_{it} \quad (6)$$

where Δ represents the first difference operator.

The GMM (Generalized Method of Moments) estimate will be used to control for the endogeneity problem, in which the lagged levels of the regressors will serve as instruments. These instruments might be weak or poor instruments if the cross-section variability is greater than the time variability and if there is strong persistence in the examined panel series (Bond et al. 2001). This problem can be solved using the Arellano and Bover (1995), and Blundell and Bond (1998) augmented version of the difference GMM – system Generalized Method of Moments (SYS-GMM) estimator. This system GMM estimator includes both the first-differenced and equations in levels as a system. The system GMM estimator makes use of different instruments for each estimation equation simultaneously, and it also allows for the control of the dynamics of adjustment by including the lagged endogenous variable as one of the explanatory variables (Tongur et al. 2012). The system GMM is preferred to the first-difference estimator both when the time series is highly persistent and when the numbers of time periods available are small just like we have in this study (Favara 2003). And lastly, the system of GMM corrects for both heteroscedasticity and autocorrelation (Roodman 2009).

CHILD MORTALITY RESULT AND DISCUSSION

Fixed effect regression results

Tables 1–6 summarized the findings of the determinants of child mortality using the fixed effect model on panel data for periods 1995–2009. The Hausman test favours the use of the fixed effect over random effect; the result of the Hausman test is summarized in Table 7. Since the null hypothesis cannot be rejected with a p-value of zero, the Hausman test posits that the fixed effect estimator is appropriate for the data sets.[2]

Tables 1 and 2 below summarized the findings of the determinants of child mortality in 114 countries that were considered in this study. Column 1 on Table 1 revealed the determinants of infant mortality for all the countries that were considered in the study; the result from this column suggests that food availability has a significant negative impact on infant

[2]The Panel unit root test was performed on all the data set used to estimate the determinants of child mortality and the result of the unit root suggests that all the data sets are stationary. The Panel unit root result is reported in Appendix A.

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mortality. Also, the result shows that sanitation and measles vaccination both have negative impacts on infant mortality. This result implies that increasing each of these variables ensures a reduction in child mortality within all the studied countries. Column 2 of Table 1 reports that DPT[3] Vaccines are important determinants of child mortality aside from food availability, sanitation, and measles vaccines within all the studied countries.

From column 3 of Table 1; income measured in log GDP also has a significant negative impact on child mortality. Columns 4, 5 and 6 revealed that sanitation, both forms of vaccination, food availability per capita, the share of health and log of GDP are important determinants of child mortality within all the studied countries.

Using the fixed effect estimates, Table 2 reports the determinants of the under-five mortality rates within all the studied countries. The results in Table 2 are quite similar to the results in Table 1 except that for the under-five mortality rate, income seems not to be significant, while every other variable obtained for infant mortality has a significant negative impact on the under-five mortality within all the studied countries. The results from Tables 1 and 2 are similar to findings from several studies such as Wang (2002), Charmarbagwala et al. (2004), Van der Klaauw and Wang (2004) just to mention a few. Using a meta-analysis, Charmarbagwala et al. (2004) found that income/expenditure or proxy variables have a significant negative impact on infant mortality. Also, Wang (2002) using the ordinary least square and the weighted least square approach, found that income and the share of health expenditure both have a significant negative impact on the infant and child mortality at the national level and within the urban areas of the studied countries. Furthermore, findings of Van der Klaauw and Wang (2004), using a flexible parametric framework of the hazard rate models on child and infant mortality for India, were similar to this work. The authors found a strong negative relationship between child mortality and both socio-economic and environmental characteristics; the study predicts that most under-five mortality can be prevented if there is a sufficient access to sanitation facilities.

This study further explores the determinants of child mortality in all the African countries that were included in the study. Data from 37 African countries

Table 1. Fixed effect estimate on the panel data from model 3. Dependent variable: Infant Mortality Rate

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	IMR	IMR	IMR	IMR	IMR	IMR
Femaleprim	3.05e-08*** (1.04E-08)	2.34e-08** (9.04E-09)	2.92e-08*** (9.92E-09)	2.28e-08** (8.79E-09)	2.97e-08*** (9.85E-09)	2.49e-08*** (8.36E-09)
Percapitaheal	0.000543 (0.00042)	0.000328 (0.00039)				
Safewater	−0.149 (0.185)	−0.135 (0.16)	−0.143 (0.176)	−0.133 (0.156)	−0.111 (0.179)	−0.105 (0.156)
Sanitation	−0.961*** (0.168)	−0.898*** (0.154)	−0.684*** (0.174)	−0.722*** (0.164)	−0.937*** (0.157)	−0.880*** (0.147)
Vaccinationmeasles	−0.122* (0.0719)		−0.115* (0.0612)		−0.0756 (0.0778)	
Foodpercapita	−0.0260*** (0.00533)	−0.0210*** (0.00439)	−0.0181*** (0.00511)	−0.0164*** (0.00481)	−0.0231*** (0.0047)	−0.0191*** (0.00408)
Loggdp			−33.38** (13.25)	−21.13** (8.914)		
Shareofhealth					−2.482** (1.025)	−1.953** (0.837)
Vaccinationdpt		−0.219*** (0.0525)		−0.213*** (0.0527)		−0.188*** (0.0547)
Constant	195.6*** (18.31)	184.9*** (16.62)	295.4*** (46.63)	249.3*** (29.64)	188.0*** (15.44)	180.3*** (14.63)
Observations	1603	1599	1603	1599	1588	1584
R-squared	0.508	0.554	0.544	0.568	0.542	0.578
Number of country	114	114	114	114	113	113

Robust Standard errors in parenthesis; $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

[3]DPT vaccine refers to vaccines against three infectious diseases in human-diphtheria, Pertussis also known as Whooping Cough and Tetanus.

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Table 2. Fixed effect estimate on the panel data from model 4. Dependent variable: Under-Five Mortality Rate

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	u5mr	u5mr	u5mr	u5mr	u5mr	u5mr
Femaleprim	1.72E-08 (1.75E-08)	3.42e-08* (1.98E-08)	3.21e-08* (1.87E-08)	2.00E-08 (1.60E-08)	1.65E-08 (1.73E-08)	3.20E-08 (1.95E-08)
Percapitaheal	0.00167** (0.0008)	0.00213** (0.00089)				
Safewater	–0.319 (0.291)	–0.34 (0.339)	–0.267 (0.33)	–0.261 (0.285)	–0.316 (0.289)	–0.331 (0.332)
Sanitation	–1.290*** (0.309)	–1.427*** (0.326)	–1.381*** (0.307)	–1.254*** (0.294)	–1.130*** (0.326)	–1.091*** (0.343)
Vaccinationmeasles		–0.283** (0.129)	–0.189 (0.135)			–0.267** (0.118)
Foodpercapita	–0.0396*** (0.00976)	–0.0497*** (0.0116)	–0.0435*** (0.0105)	–0.0351*** (0.00905)	–0.0345*** (0.011)	–0.0392*** (0.0122)
Loggdp					–18.87 (16.88)	–40.28 (24.55)
Shareofhealth			–4.700** (1.823)	–3.778** (1.589)		
Vaccinationdpt	–0.491*** (0.114)			–0.430*** (0.116)	–0.485*** (0.115)	
Constant	317.3*** (36.09)	337.8*** (39.27)	321.7*** (33.87)	306.7*** (32)	372.8*** (52.65)	456.0*** (83.49)
Observations	1599	1603	1588	1584	1599	1603
R-squared	0.499	0.452	0.487	0.523	0.5	0.466
Number of country	114	114	113	113	114	114

Robust Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 3. Fixed effect estimate on the panel data from SSA countries using model 3. Dependent variable: Infant Mortality Rate

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	IMR	IMR	IMR	IMR	IMR	IMR
Percapitaheal	0.0104 (–0.0141)	0.00928 (–0.0137)				
Femaleprim	5.64E-09 (–3.01E-08)	1.05E-08 (2.97E-08)	2.21E-08 (–2.48E-08)	2.54E-08 (2.47E-08)	1.01E-08 (2.88E-08)	1.20E-08 (2.89E-08)
Safewater	–1.417*** (0.406)	–1.291*** (0.383)	–1.267*** (0.359)	–1.186*** (0.348)	–1.339*** (0.403)	–1.269*** (0.389)
Sanitation	–1.084* (0.582)	–1.047* (0.585)	–0.694 (0.43)	–0.739 (0.44)	–0.625 (0.5)	–0.901* (0.525)
Vaccinationmeasles	0.0647 (0.137)		0.121 (0.127)		0.0344 (0.103)	
Foodpercapita	–0.0202 (0.0123)	–0.0154 (0.0124)	–0.0198 (0.0122)	–0.0155 (0.0123)	–0.014 (0.0117	–0.0149 (0.0122)
Shareofhealth			–3.734** (1.419)	–2.872** (1.227)		
Loggdp					–36.78* (20.64)	–5.153 (19.27)
Vaccinationdpt		–0.0395 (0.0765)		–0.00286 (0.0707)		–0.0397 (0.0761)
Constant	253.8*** (29.2)	239.7*** (27.04)	234.8*** (22.22)	227.0*** (21.73)	363.8*** (75.56)	253.1*** (66.21)
Observations	507	503	507	503	507	503
R-squared	0.646	0.664	0.688	0.692	0.667	0.663
Number of country	37	37	37	37	37	37

Robust Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

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was examined, and the results of the findings using the fixed effect estimates are reported in Tables 3 and 4.

Table 3 reports the determinants of infant mortality while Table 4 reports the determinants of the under-five mortality rate within the 37 African countries. Results in Table 3 suggest that important determinants of infant mortality in all African countries included within the study are safe water, sanitation and income.

Table 4 reports the important determinants of the under-five mortality rate within Africa as a continent. The results in Table 4 suggest that safe water and the share of public health in GDP are the most important determinants of child mortality; ironically food security appears to be insignificant in all cases. These results suggest that for all African countries, food security does not impact the under-five mortality, although it does impact the under-five mortality within all the 114 countries that were considered in Table 2.

The findings on Tables 3 and 4 are similar to the findings of Mutunga (2007) in Kenya; the study suggests that both environmental and socio-economic variables are important determinants of infant and child mortality using a hazard rate framework. Also, a similar study carried out on three sub-Saharan African countries by Kazembe et al. (2012) on Senegal, Uganda and Rwanda, found that the mother's level of education and socio-economic variables are important determinants of child mortality within these three countries.

Results in Tables 5 and 6 report the findings of the determinants of the infant and under-five mortality within 17 food insecure African countries. The results in Table 5 revealed that important determinants of the infant mortality within food insecure African countries include: access to safe water, share of health, female primary school education and food availability. Each of these variables have a significant impact on the infant mortality within the 17 food insecure African countries that were considered in the study. Results reported in Table 5 further suggest that the increasing access to safe water ensures a decrease in the mortality. Likewise, an increase in the share of public health in GDP and food availability ensures a decrease in the infant mortality within the 17 food insecure African countries. This result differs from the determinants of infant mortality within the 37 African countries reported in Table 3. Environmental factors and income appear to be the only important determinants for all African countries, while for African

Table 4. Fixed effect estimate on the panel data from SSA countries using model 4. Dependent variable: Under-Five Mortality Rate

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	u5mr	u5mr	u5mr	u5mr	u5mr	u5mr
Percapitaheal	0.0399 (0.0287)	0.0425 −0.0294				
Femaleprim	−3.28E-08 (6.54E-08)	−3.57E-08 (6.50E-08)	8.86E-10 (5.48E-08)	−1.24E-09 (5.52E-08)	−2.75E-08 (6.40E-08)	−2.64E-08 (6.30E-08)
Safewater	−2.526*** (0.682)	−2.737*** (0.709)	−2.269*** (0.651)	−2.413*** (0.664)	−2.453*** (0.709)	−2.595*** (0.725)
Sanitation	−2.14 (1.318)	−2.220* (1.302)	−1.288 (0.989)	−1.239 (0.963)	−1.838 (1.192)	−1.373 (1.12)
Vaccinationmeasles		0.0122 (0.222)		0.125 (0.196)		−0.0161 (0.178)
Foodpercapita	−0.0368 (0.0264)	−0.0446* (0.0262)	−0.037 (0.0269)	−0.0444 (0.0265)	−0.0384 (0.0278)	−0.0381 (0.0278)
Shareofhealth			−5.906** (2.4)	−7.139*** (2.55)		
Loggdp					12.35 (41.93)	−42.47 (39.16)
Vaccinationdpt	−0.146 (0.157)		−0.0748 (0.145)		−0.158 (0.159)	
Constant	464.6*** (60.96)	489.2*** (62.76)	430.6*** (52.26)	445.2*** (52.52)	409.9*** (135.8)	605.9*** (135.6)
Observations	503	507	503	507	503	507
R-squared	0.656	0.65	0.677	0.682	0.648	0.649
Number of country	37	37	37	37	37	37

Robust Standard errors in parenthesis; $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$

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Table 5. Fixed effect estimate on the panel data from SSA2 countries using model 3. Dependent variable: Infant Mortality Rate

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	IMR	IMR	IMR	IMR	IMR	IMR
Loggdp	−30.38 (23.76)	21.39 (14.88)				
Femaleprim	−0.113 (0.12)	−0.179* (0.0903)	−0.101 (0.124)	−0.155 (0.0926)	−0.142 (0.0943)	−0.171** (0.0793)
Safewater	−2.130*** (0.614)	−1.884*** (0.582)	−2.171*** (0.597)	−1.944*** (0.586)	−1.703*** (0.493)	−1.671*** (0.503)
Sanitation	0.573 (0.605)	0.526 (0.366)	0.637 (0.526)	0.67 (0.438)	0.614 (0.445)	0.674 (0.397)
Vaccinationmeasles	0.183 (0.151)		0.228 (0.176)		0.279 (0.166)	
Foodpercapita	−0.0248 (0.0198)	−0.0305** (0.0143)	−0.0316* (0.0168)	−0.0234 (0.0156)	−0.0400** (0.015)	−0.0291** (0.0134)
Percapitaheal			−0.0615 (0.0578)	−0.0328 −0.0353		
Shareofhealth					−3.894** (1.342)	−2.465** (0.871)
Vaccinationdpt		0.0125 (0.0954)		0.0353 (0.102)		0.0571 (0.095)
Constant	361.9*** (90.08)	189.8*** (59.1)	268.3*** (35.23)	249.8*** (30.08)	265.8*** (30.51)	250.4*** (26.89)
Observations	227	223	227	223	227	223
R-squared	0.749	0.77	0.736	0.766	0.776	0.787
Number of country	17	17	17	17	17	17

Robust Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 6. Fixed effect estimate on the panel data from SSA2 countries using model 4. Dependent variable: Under-Five Mortality Rate

Variables	(1)	(6)	(2)	(3)	(4)	(5)
	u5mr	u5mr	u5mr	u5mr	u5mr	u5mr
Loggdp	58.86 (36.59)	−31.66 (45.3)				
Femaleprim	−0.370** (0.139)	−0.258 (0.197)	−0.326** (0.15)	−0.342** (0.121)	−0.300* (0.15)	−0.246 (0.202)
Safewater	−3.594*** (0.849)	−4.043*** (0.941)	−3.706*** (0.889)	−3.256*** (0.778)	−3.346*** (0.804)	−4.085*** (0.936)
Sanitation	1.722** (0.741)	1.795 (1.139)	1.925* (0.965)	2.041* (0.995)	1.922* (1.011)	1.856* (1.031)
Vaccinationmeasles		0.188 (0.245)			0.321 (0.267)	0.234 (0.285)
Foodpercapita	−0.0930** (0.0435)	−0.0828 (0.0539)	−0.0786 (0.0466)	−0.0857* (0.0418)	−0.101** (0.041)	−0.0900* (0.0471)
Percapitaheal			−0.0158 (0.0634)			−0.0621 (0.09)
Shareofhealth				−4.329*** (1.395)	−6.290*** (2.04)	
Vaccinationdpt	−0.0753 (0.159)		−0.0358 (0.174)	0.0155 (0.155)		
Constant	340.9*** (97)	645.6*** (153.5)	518.4*** (85.73)	512.5*** (74.42)	537.2*** (76.92)	548.6*** (91.9)
Observations	223	227	223	223	227	227
R-squared	0.817	0.784	0.804	0.822	0.812	0.78
Number of country	17	17	17	17	17	17

Robust Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

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Table 7. Hausman test rest

Variables	(1) u5mr	(2) u5mr	(3) u5mr	(4) IMR	(5) IMR	(6) IMR
Loggdp	0.51					0.784
	−3.92					−2.079
Femaleprim	−0.295***	5.63E-08	5.11E-08	4.63E-08	4.47E-08	−0.139***
	(0.0719)	(1.21E-07)	(1.51E-07)	(7.52E-08)	(6.23E-08)	(0.0413)
Safewater	−3.619***	−0.187***	−2.227***	−1.169***	−0.0725***	−1.862***
	(0.288)	(0.0379)	(0.19)	(0.0958)	(0.0201)	(0.164)
Sanitation	0.988**	−1.135***	−0.522***	−0.354***	−0.770***	0.211
	(0.387)	(0.072)	(0.185)	(0.0968)	(0.038)	(0.218)
Vaccinationmeasles	0.233**	−0.269***	0.105	0.112***	−0.114***	0.225***
	(0.0943)	(0.0397)	(0.0749)	(0.0374)	(0.0205)	(0.0543)
Foodpercapita	−0.0858***	−0.0378***	−0.0511***	−0.0242***	−0.0210***	−0.0365***
	(0.0128)	(0.00325)	(0.00755)	(0.00384)	(0.0017)	(0.00727)
Shareofhealth		−4.284***	−8.230***	−4.218***	−2.339***	
		(0.452)	(0.893)	(0.447)	(0.234)	
Constant	531.5***	287.9***	426.4***	228.3***	170.5***	269.3***
	(25.86)	(7.772)	(14.45)	(7.412)	(4.083)	(14.37)
Observations	227	1 588	507	507	1 588	227
Number of country	17	113	37	37	113	17
Hausman p-value	0.000	0.000	0.000	0.000	0.000	0.000
chi square	32.77	88.74	29.28	30.49	90.6	43.63

Robust Standard errors in parenthesis; ***p < 0.01, **p < 0.05, *p < 0.1

countries with the food insecurity, food availability also has an impact on the infant mortality as well as female primary education, the share of public health in GDP, environmental and policy variables.

Table 6 reports the result of the findings of the determinants of the under-five mortality within the food insecure African countries; the result in the table suggests that the female primary school enrolment, safe water, the share of public health in GDP and food availability are important determinants of the under-five mortality. This result posits that to ensure a reduction in the under-five mortality rates, it is imperative to increase food security, female education, access to safe water and public health expenditure. This result differs from the determinants of the under-five mortality within all African countries as reported in Table 4. The important determinants of under-five mortality are just safe water and share of public health in GDP, therefore, grouping all African countries together conceals the reality of the determinants of child mortality.

SYS-GMM estimate regression results

To ensure that heterogeneity and autocorrelation do not plague the result of the fixed effect, this study further investigates the determinants of child mortality using the SYS-GMM estimate on the dynamic panel data. Tables 8 and 9 summarized the findings from the dynamic panel model for the determinants of the child mortality: infant mortality and under-five mortality rates; the SYS-GMM estimator was applied to a panel with annual observations from 1995–2009. The dependent variable is the child mortality, infant mortality and under-five mortality rates measured in thousands, the independent variables are per capita health expenditure, access to sanitation, and access to safe water, vaccination (measles and DPT); food security proxied by food availability per capita, and the female primary school enrolment rate.

Table 8 compared the determinants of the infant and under-five mortality rate among all the countries considered in the study and the African countries with food insecurity while Table 9 compared the determinants of the infant and under-five mortality rates between 37 African countries and the African countries with food insecurity.

From Tables 8 and 9, it appears that all other variables apart from food availability, vaccinations and access to potable water are not significant. Variables such as the policy variables – the share of public health in GDP and per capita health expenditure, access to safe water and female enrolment, are not significant for all groups of countries using the SYS-GMM estimates. This result could be due to the correlation between the explanatory variables that are not obvious in the fixed effect estimates. The result from the SYS-GMM estimates helps to confirm the

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Table 8. System GMM estimate on the panel data: comparing rest of world countries with SSA2 countries

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IMR	IMR	IMR	IMR	u5mr	u5mr	u5mr	u5mr
L.IMR	1.774*** (0.0475)	1.762*** (0.0593)	1.910*** (0.0136)	1.904*** (0.0148)				
L2.IMR	−0.791*** (0.0503)	−0.781*** (0.0605)	−0.921*** (0.0133)	−0.918*** (0.0138)				
L.u5mr					1.038*** (0.208)	1.045*** (0.216)	1.908*** (0.0225)	1.909*** (0.0213)
L2.u5mr					−0.0857 (0.201)	−0.0956 (0.205)	−0.919*** (0.0212)	−0.920*** (0.0202)
Femaleprim	−5.57E-09 (1.07E-08)	−3.60E-09 (9.88E-09)	−6.82E-05 (0.0015)	−0.00146 (0.00183)	−1.00E-07 (1.27E-07)	−7.05E-08 (1.05E-07)	−0.00552 (0.00394)	−0.00341 (0.00295)
Percapitaheal	1.54E-05 (2.12E-05)	1.81E-05 (2.13E-05)	0.0002 (0.00109)	0.000179 (0.0013)	0.000126 (0.00011)	0.000101 (0.00012)	0.000869 (0.00225)	0.00121 (0.00204)
Safewater	−0.00114 (0.00089)	−0.00131 (0.00123)	0.00377 (0.00492)	0.00557 (0.0047)	−0.0170* (0.01)	−0.0163* (0.00957)	0.00208 (0.00595)	−0.00211 (0.00728)
Vaccination-measles	−0.00258 (0.00296)		−0.00646*** (0.00202)			−0.0780** (0.0362)		−0.00941** (0.00404)
Foodpercapita	−0.000273** (0.00012)	−0.000374** (0.00018)	−0.00031 (0.0002)	−0.000324* (0.0002)	−0.00488** (0.00232)	−0.00457** (0.00225)	−0.000670** (0.00031)	−0.000685** (0.00029)
Sanitation	−0.00466 (0.00568)	−0.00471 (0.00706)	0.00157 (0.00343)	0.00146 (0.00418)	0.0929* (0.0555)	0.0840* (0.0508)	−0.00056 (0.00872)	−0.00029 (0.00787)
Vaccination dpt		−0.00056 (0.00228)		−0.00590*** (0.00128)	−0.0676** (0.0311)		−0.00686*** (0.00254)	
Constant	1.745** (0.69)	1.917*** (0.407)	1.613*** (0.624)	1.779** (0.733)	14.90*** (5.757)	15.60** (6.522)	3.370*** (1.226)	3.566*** (1.118)
Observations	1 294	1 292	198	196	1 292	1 294	196	198
Number of country	105	105	17	17	105	105	17	17

Robust Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table 9. System GMM estimate on the panel data: comparing SSA countries with SSA2 countries

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	IMR	IMR	u5mr	u5mr	IMR	IMR	u5mr	u5mr
L.IMR	1.910*** (0.0136)	1.904*** (0.0148)			0.975*** (0.0143)	0.970*** (0.0187)		
L2.IMR	−0.921*** (0.0133)	−0.918*** (0.0138)						
L.u5mr			1.908*** (0.0225)	1.909*** (0.0213)			0.959*** (0.0139)	0.967*** (0.0113)
L2.u5mr			−0.919*** (0.0212)	−0.920*** (0.0202)				
Femaleprim	−6.82E-05 (0.0015)	−0.00146 (0.00183)	−0.00552 (0.00394)	−0.00341 (0.00295)	−1.17E-08 (1.36E-08)	−1.83E-08 (1.49E-08)	−3.84E-08 (3.23E-08)	−1.57E-08 (2.55E-08)
Percapitaheal	0.0002 (0.00109)	0.000179 (0.0013)	0.000869 (0.00225)	0.00121 (0.00204)	0.000154 (0.00248)	−0.00037 (0.00239)	−0.00431 (0.0043)	−0.00308 (0.00429)
Safewater	0.00377 (0.00492)	0.00557 (0.0047)	0.00208 (0.00595)	−0.00211 (0.00728)	0.0259 (0.0326)	0.0383 (0.0393)	0.0899 (0.0885)	0.0675 (0.0764)
Vaccination measles	−0.00646*** (0.00202)			−0.00941** (0.00404)	−0.0499*** (0.011)		−0.119***	(0.037)
Foodpercapita	−0.00031 (0.0002)	−0.000324* (0.0002)	−0.000670** (0.00031)	−0.000685** (0.00029)	−0.00061 (0.0008)	−0.00077 (0.0008)	−0.00196 (0.00124)	−0.00131 (0.00114)
Sanitation	0.00157 (0.00343)	0.00146 (0.00418)	−0.00056 (0.00872)	−0.00029 (0.00787)	0.024 (0.0225)	0.0173 (0.0202)	0.056 (0.0379)	0.0689* (0.041)
Vaccinationdpt		−0.00590*** (0.00128)	−0.00686*** (0.00254)		−0.0455***	−0.111*** (0.00993)	(0.029)	

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Continuated Table 9

Variables	(1) IMR	(2) IMR	(3) u5mr	(4) u5mr	(5) IMR	(6) IMR	(7) u5mr	(8) u5mr
Constant	1.613*** (0.624)	1.779** (0.733)	3.370*** (1.226)	3.566*** (1.118)	2.198 (3.224)	2.142 (3.877)	6.159 (5.739)	4.862 (4.883)
Observations	198	196	196	198	472	469	469	472
Number of country	17	17	17	17	37	37	37	37

Robust Standard errors in parenthesis; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

importance of food security on child mortality within the food insecure African countries.

Results on columns 1, 2, 3, and 4 of Table 9 compared the determinants of infant mortality between all African countries and the food insecure African countries; the result posits that for the infant mortality, vaccinations are the most important determinants for both the African countries with food insecurity and all African countries. The impact of the vaccines-measles and DPT is higher within the food insecure African countries than compared to all African countries, this result suggests that more infant lives will be saved by ensuring the adequate vaccinations within the food insecure African countries than will be saved within all African countries. On the other hand, the results in columns 5, 6, 7 and 8 revealed that food availability and vaccinations-measles and DPT are important determinants of the under-five mortality rates within the food insecure African countries. But food availability is not significant in explaining the under-five mortality within all African countries, instead, only vaccinations-measles and DPT explain the under-five mortality within these African countries.

SUMMARY AND CONCLUSIONS

Summary

This paper examined important determinants of child mortality and whether there is a difference in the determinants of child mortality amidst 114 countries, 37 African countries and 17 African countries with food insecurity using the SYS-GMM estimates and the fixed effect estimates.

The results from the SYS-GMM estimates and the fixed effect estimates of the determinants of child mortality revealed that considering all African countries together concealed the true of picture of the determinants of the child mortality-infant and under-five mortality rates. The findings from this study posit that food security and vaccinations are important policy options paths to follow for the food insecure African countries to ensure a reduction in child mortality. For the rest of the world countries, sanitation, food security and vaccinations are important determinants of child mortality, while for all African countries together, only vaccinations stood out as an important determinant of child mortality.

Conclusions

The findings from this study posit that the determinants of child mortality are similar to the findings of Wang (2003), Charmarbagwala et al. (2004), Van der Klaauw and Wang (2004), among many works on child mortality that posit that the social, economic and income factors are important determinants of child mortality. This study further extends that for the food insecure African countries, increasing food security is another important determining factor of child mortality. Therefore, in conclusion, for the food insecure African countries ensuring food security guarantees a decrease in the child mortality.

Policy Recommendation

The findings from this research show that it would be of countless advantage for African nations with food crises, with famine conditions or near famine conditions, to pursue a reduction in child mortality via food security. Developed countries and organizations that donate food aid should intensify the aid supports to these African countries through the domestic food production plans to guarantee the domestic food security.

A future work would analyse the contribution of the different sources of food availability by comparing the domestic food production within the food insecure African countries with the food aid and food import and their impact on child mortality as this would help the policy makers and donor countries in choosing the best policy options for these food insecure African countries.

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Appendix A: Panel Unit Root Result Table

Ho: Panels contain unit root, Ha: Panels are stationary

Variable	No. of panels	No. of periods	*P*-value	Unadjusted *t*-value	Adjusted *t*-value
Under age five mortality (U5mr)	117	15	0.000	−27.5279	−26.7985
Infant Mortality (IMR)	117	12	0.000	−17.6158	−10.0068
Per Capita health Expenditure	117	15	0.000	−18.9791	−5.5061
Share of health	115	15	0.000	−24.7658	−7.1189
Gross domestic product (loggdp)	117	15	0.0030	−6.5658	−2.7439
Food per capita	116	15	0.000	−2.3910	−2.7577
Safe water	115	15	0.000	−4.9872	−10.8063
Measles Vaccination	117	15	0.000	−5.6504	−6.8272
(diphtheria, pertussis, and tetanus) Dpt Vaccination	117	15	0.000	−5.0823	−7.3051
Sanitation	117	15	0.000	−1.9634	−5.3353

Appendix B: List of countries in growth regression

ROW COUNTRIES			
Albania	Cuba*	Italy	Peru
Antigua &Barbados	Cyprus	Jamaica*	Philippine
Argentina	Denmark	Japan	Poland
Australia	Dominican Rep	Jordan	Portugal
Austria	Ecuador	Korea, Rep.	Romania
Bahamas	El Salvador	Laos	Solomon Island
Bangladesh	Fiji	Lebanon	Spain
Barbados	Finland	Malaysia	Suriname
Belgium	France	Maldives	Sweden
Belize	Germany	Malta	Switzerland
Bermuda*	Greece	Mexico	Syria
Bolivia	Grenada	Mongolia	Sri Lanka
Brunei*	Guatemala	Nepal	Thailand
Brazil	Guyana	Netherland	Trinidad &Tobago
Cambodia	Haiti*	New Zealand	Turkey
Canada	Honduras	Nicaragua	United Kingdom
Chile	India	Norway	United States
China	Indonesia	Pakistan	Uruguay
Colombia	Iran	Panama	Venezuela
Comoros*	Ireland	Paraguay	Vietnam
Costa Rica	Israel		
SSA2 COUNTRIES			
Angola	Congo, Dem. Rep	Kenya	Mauritania
Burkina Faso	Congo, Rep	Lesotho	Niger
Burundi	Cote d`Ivoire	Liberia	Sierra lone
Central African Rep.	Guinea	Madagascar	Uganda
Chad	Guinea-Bissau*	Mali	Zimbabwe*
SSA COUNTRIES			
Algeria	Congo, Rep	Liberia	Rwanda
Angola	Cote d`Ivoire	Madagascar	Senegal
Benin	Djibouti	Malawi	Sudan
Burkina Faso	Egypt	Mali	Sierra lone
Burundi	Gabon	Mauritania	South Africa
Botswana	Gambia	Mauritius	Togo
Cameroon	Ghana	Mozambique	Tunisia
Central African Rep.	Guinea	Morocco	Uganda
Cape Verde	Guinea-Bissau*	Namibia	Zambia
Chad	Kenya	Niger	Zimbabwe*
Congo, Dem. Rep	Lesotho		

*Represents countries that were not included in the child mortality regression analysis due to insufficient data.

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