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Research Article

A multilevel analysis of factors influencing child mortality in Ghana

Anthony Abbam

Department of Economics Education, University of Education, Winneba

Abstract: Child mortality being a core indicator for child health and the health status of children has significant effect on health in adulthood and socioeconomic development of a nation. This paper uses the Ghana Demographic and Health Survey (GDHS) 2013–2014 to investigate the predictors of child (age 1-4 years] mortality in a developing country like Ghana. The multilevel logistic regression technique has been used to estimate the predictors of child mortality. The study found that both child and mother-level characteristics such as birth weight, birth order, mother's age, educational attainment of the mother have substantial impact on child mortality in Ghana Besides, household wealth index has significant impact on child mortality. The findings also show that place of residence and southern-northern dichotomy has momentous effect on child mortality. The paper recommends that governments must pursue policies that seek to improve the economic conditions of households. In addition, steps should be taken by policy makers to reduce spatial disparities in the availability of maternal health services as the absence of this perhaps contributes to child mortality.

Key Words: Child mortality, multilevel logistic model, odds ratio, hierarchical structure.

Introduction

Undoubtedly, the mortality level of a society is closely linked to the health and well-being of the population with child mortality being a core indicator for child health. Indeed child mortality has for the past decades continues to attract the attention of demographers, policy makers and researchers of the developed and developing world alike. Globally, nearly 6.6 million under-five children die yearly, translating to about 18,000 under-five deaths every day (UNICEF, 2013). It is estimated that about 50% of under-five child deaths occur in only five countries of the world, namely, India, Nigeria, Democratic Republic of the Congo, Pakistan, and China. Sub-Saharan Africa and Southern Asia countries are witnessing an increase in under-five mortality despite a drop from 32 percent in 1990 to 18 percent in 2012 in the rest of the world UNICEF (2013). Sub-Saharan Africa records the highest rates of under-five child mortality in the world, 98 deaths per 1,000 live births (You et al., 2013). This figure is 15 times the average for developed countries (UNICEF, 2013). In Ghana, overall, infant mortality has declined by 47 percent since 1988, from 77 deaths per 1,000 live births in 1983-1987 to 41 per 1,000 live births in 2010-2014. Specifically, under-5 mortality decreased by 61 percent from 155 deaths per 1,000 live births to 60 deaths per 1,000 live births over the same period (GDHS, 2014).

Despite the significant decline in the prevalence of child mortality, it remains still at unacceptably high levels especially in Sub-Saharan Africa. Meanwhile the health status of children has effects on health in adulthood and socioeconomic status. Thus, investments in child health during critical periods of child development have long-term socio-economic consequences. Evidence of the long term benefits of investing in children exits warranting the need to improve the well-being of the child (Almond and Currie, 2010; Bhalotra and Rawlings, 2011).

The growing body of empirical literature on determinants of child mortality demonstrates a composite index reflecting biological, socio-economic, demographic and environmental aspects. Previous studies have demonstrated the strong impact of breastfeeding in reducing child mortality (Mustafa and Odimegwu, 2008). Breastfeeding not only provides protection against gastrointestinal and respiratory disease, but also meets infants' nutrition requirements. Maternal age at birth and birth order also tend to have impact on child survival. For instance Kumar and File (2011) found that the risk of child mortality remained high among adolescents and older mothers. Similarly, Edmund et al. (2014) also found that a mother's age had significant influence on under-five mortality. A study by Nazrul et al. (2009) found that in Bangladesh, the neonatal and post-neonatal mortality level is the lowest for children whose birth order is fourth and greater. Furthermore, gender of children affect child mortality rate. Generally, the mortality rate of female infants is lower because of biological and genetic advantage (UNICEF, 2010a). Ssewanyana and Younger (2005) confirmed that girls have lower infant mortality than boys.

In connection with socio-economic and demographic factors, maternal education plays an important role in reducing child mortality. Basu, et al (2005) noted the importance of mother's education on child survival. Education helps to delay marriage which prevents women from having children at younger age. Also, educated mothers are able to utilize health information such as having a better perception of how to handle children during illness, provision of better nutrition and the use of contraceptives to space births. Kembo and Jeroen (2009) suggested a decrease in child mortality with an increase in education level of mothers. Evidence has shown that household income affect child mortality negatively. For example, Ssewanyana and Younger (2004) found that in Uganda higher household income and infant mortality were negatively correlated. This may be explained by the fact that wealthier households have the capacity to provide good nutrition, shelter and health care services for children. On the contrary, Mustafa and Odimegwu (2004) opine that household wealth does not have any impact on infant and child mortality. Moreover, a mother's marital status has been noted as another major determinant of child mortality (Edmund et al., 2014). It was established that births to mothers who had never been married had higher rates of child mortality.

Environmental factors such as access to health facilities, drinking water sources, access to latrine are important determinants of child survival. For example Hala (2002) has established that access to pipe borne water and latrines reduce child mortality. Also, Kembo and Van Ginneken (2009) have shown that access to sanitation is an important predictor of child survival. Further, Becher et tal (2004) find strong evidence for the importance of accessibility to health for determining child survival whereas Armstrong-Schellenberg et tal (2002) show the influence of household environment in reducing the risk of child mortality.

For the past two decades, child survival in developing countries has been explored in-depth (Bello & Joseph, 2004) in Nigeria, (Ladusingh & Singh, 2006) in India, (Mustafa, & Odimegwu, 2008) in Kenya, (Iram & Butt, 2008) in Pakistan, (Ayiko et tal, 2009) in Uganda, (Kumar & File, 2011) in Ethiopia, (Chowdhury, 2013) in Bangladesh, and (Edmund, et al, 2014) in Ghana. The realization is that these studies relied on traditional econometric techniques and without paying particular attention to the hierarchical nature of the data used. For instance, conventional regression assumes that all experimental units are independent therefore any variable that affects child mortality has the same effect in all households, communities or regions. A multilevel modeling relaxes this assumption and allows the effects of these variables to vary across the households, communities or regions. This paper employs a multilevel approach which takes into account the hierarchical structure of the 2014 Ghana Demographic and Health Survey data in which child/mother (level-1) is nested in households (level-2) and households are in turn nested within communities or regions (level-3). The multilevel approach explicitly takes into account these characteristics of data thereby correcting for the bias in the parameter estimates resulting from the nested data structure. This is because each particular level is represented by its own sub-model, which expresses the association between child mortality and explanatory variables within that level. Moreover, community heterogeneity in covariate effects is explicitly modeled and uncovered within the multilevel approach.

The remainder of this study is structured as follows. Section 2 reviews the literature. Section 3 outlines the methodology used. Section 4 presents and discusses the results. Section 5 provides conclusions and recommendations of the research.

Data Source

The 2014 Ghana Demographic and Health Survey (GDHS) was used to undertake the present study. The 2014 GDHS is the sixth in a series of population and health surveys conducted in Ghana as part of the global Demographic and Health Surveys (DHS) Program. The survey was implemented by the Ghana Statistical Service (GSS), the Ghana Health Service (GHS), and the National Public Health Reference Laboratory (NPHRL) of the GHS. It is a nationally representative survey of 9,396 women age 15-49 in all selected households and 4,388 men age 15-59 from 11,835 interviewed households. The 2014 GDHS followed a two-stage sample design in order to allow estimates of key indicators at the national level as well as for urban and rural areas and each of the 10 administrative regions of Ghana. The first stage involved selection of sample points (clusters) involving enumeration areas (EAs). The second stage involved the systematic sampling of households. A household listing operation was undertaken in all the selected EAs and households to be included in the survey were randomly selected. The GDHS generated detailed information on fertility, family planning, infant and child mortality, maternal and child health, and nutrition. In addition, the survey collected information on diseases and their prevention.

Statistical Analysis

In this paper, the predictors of child mortality were assessed using a multilevel binary logistic regression. The choice of multilevel modeling was based on the following considerations. First, the patterns of child mortality are influenced by the characteristics of different levels (individual, household and community). Analyzing variables from different levels at one single common level using the standard binary logistic regression model leads to bias (loss of power or Type I error). This approach also suffers from a problem of analysis at the inappropriate level (atomistic or ecological fallacy). Multilevel models allow us to consider the individual level and the group level in the same analysis, rather than having to choose one or the other. Secondly, due to the multistage cluster sampling procedure, children are nested in women while women are also nested within communities; hence, the likelihood of a child surviving is likely to be correlated to other women from the community. The assumption of independence among individuals within the same cluster and the assumption of equal variance across clusters are violated in the case of nested data. Hence, the multilevel analysis is the appropriate method for such cases.

Using a two-level binary logistic regression modelling, the effects of a number of individual, household, and community variables are examined. During the analysis, the characteristics of children and women were taken as individual level (level-1), and characteristics of the community (including characteristics of their health centers) were treated as level-2. For each of the three dependent variables, we estimated three models: intercept-only model; an empty model that contains no covariates, a model that included individual level variables and a full model that included community variables.

Assume the binary responses Y_{ij} depend on individual level explanatory variable X_{ij} and group-level explanatory variable Z_j. If deviation from the average intercept and slope due to cluster (level-2) effect are represented by u_{oj} and u_{1j}, the two models are given in the following way. The intercept-only model is expressed as

$$\log it(p_{ij}) = \gamma_{00} + u_{0j} \text{--} (1)$$

The full model is also specified as

$$\log it(p_{ij}) = \gamma_{00} + \gamma_{01}Z_j + \gamma_{10}X_{ij} + u_{0j} + u_{1j}X_{ij} \text{--------------------------} (2)$$

The intercept γ_{00} and slopes γ_{01} and γ_{10} are fixed effects whereas u_{0j} and u_{1j} are random effects of level-2. The intercept-only model allows us to evaluate the extent of the cluster variation influencing child mortality. The intra-class correlation coefficient (Rho) was calculated to evaluate whether the variation in the scores is primarily within or between clusters. In logistic distribution, level-1 residual variance, ε_{ij} is standardized and fixed with a mean of zero and variance $\pi^2/3$. Therefore, for a two-level logistic random intercept model with an intercept variance of σ^2_{uo}, the intra-class correlation coefficient (Rho) is given by

$$\rho = \frac{\sigma^2_{uo}}{\sigma^2_{uo} + \pi^2/3}$$

Table 1: Description of variables in the model

Variable	Description
Child Mortality	Binary: It measures the survival of the child. It assumes a value of 1 if the child survived till its fifth birth day and zero otherwise.
Age	Categorical: It captures the age of the woman and it assumes values from 1 to 4. It takes a value of 1 if the woman's age is between15 - 29; 2 if the woman's age is between 20 - 39; 3 if the woman's age is between 30 – 39; 4 if the woman's age is between 40 – 49.
Child Size	Categorical: It captures the size of the child and it assumes values from 1 to 3. It takes a value of 1 if the child's size is small; 2 if the child's size is average and 3 if the child's size is large.
Birth Order	Categorical: It measures the birth order of the woman and it assumes values from 1 to 3. It takes a value of 1 if the child is within 1–2 birth order; 2 if the child is within 3–4 birth order and 3 if the child is of 5+ birth order.
Highest Education	Categorical: It measures the educational attainment of the woman and it assumes values from 0 to 3. It takes a value of 0 if the head has no schooling record; 1 if head's highest educational attainment is primary; 2 if head's highest educational attainment is secondary; 3 if head's highest educational attainment is tertiary.
Wealth Index	Categorical: It captures the income of the household and it assumes values from 1 to 5. It takes a value of 1 if the household is within the bottom income quintile; 2 if the household is within the second income quintile; 3 if the household is within the third income quintile; 4 if the household is within the fourth income quintile; and 5 if the household is within the top income quintile.
Marital Status	Categorical: It measures the marital status of the woman and it assumes values from 0 to 2. It takes a value of 0 if the woman is not married; 1 if the woman is married and 2 if the woman is divorced.
Area	Binary: It captures the area of residence of the woman. It assumes a value of 1 if the woman is resident in an urban area and zero otherwise.
Locality	Binary: It captures the locality of the household of the woman. It assumes a value of 1 if the woman's household is located in the north and zero otherwise.

Source: GDHS-14

Discussion of the results

Table 2 presents the descriptive statistics of the dependent and independent variables in the multilevel level logistic model. The descriptive statistics show that 95% of children survived beyond their fifth birth day while 5% of them died before five years of age. Among the women surveyed, 43% were within 20 – 29 year bracket while 42% fell within the 30 – 39 age group. This signifies the youthful nature of the women and for that matter level of fertility in Ghana. With regard to size at birth, 33% of children were of average size with 49% of them being large size. From the descriptive results, 39% of children were within the 1 – 2 birth order of the women surveyed while 35% fall in the 3 – 4 birth order group. Among the women surveyed, 35% of them had no schooling experience, 21% have had primary education, 41% have had secondary education and 4% with tertiary education. Considering household wealth, 32% of women belong to households which are in the bottom income quintile, 22% in the fourth quintile, 18% in the third quintile, 15% in the second quintile and 12% in the first quintile. From table 2, 7% of the women surveyed had no marriage experience, 88% were married with 5% of them divorced. It can be observed that 60% of women are resident in urban areas while 40% are in rural areas. In terms of locality, about 67% of women are found in households located in the Southern part of the country while 28% are located at the Northern.

Determinants of child mortality

In table 3, the results of two-level multivariable random intercept logistic regression models are presented. The model examines the effect of women's individual characteristics, household and contextual factors on child survival. The empty model (Model 1) includes only random intercept to capture between-cluster variability. The between-cluster variability declined over successive models, from about 11% in the empty model, to 9% in the individual and household-level characteristics (Model 2) and 4% in the combined model (Model 3). This indicated that addition of predictors improved the model. Accordingly, the combined model of individual, household-level and contextual factors was selected for predicting child mortality. It is shown from the estimations (Table 3), that mother's age, birth weight of the child, birth order of the child, educational attainment of the mother, household wealth index, area of residence and locality are important in explaining child survival.

Specifically, the likelihood children born to mothers within age group 15-19 dying before 5 years of age is high compared to children born to a mother in age group 40-49. The results show that children born to mothers in age groups 15-19 had almost 15 times odds of dying before 5 years of age compared to children born to mother of age group 40-49. Children born to mothers of age group 20-29 also had increased odds of dying before five years of age compared to children born to mother of age group 40-49 (OR= 3.09; CI=1.87, 5.13).

One plausible biological explanation could be that young teenage mothers have often not yet reached full physiological and reproductive maturity, thereby increasing their risk of complications during pregnancy and birth as well as the likelihood of inadequate weight gain during pregnancy. On the contrary, Akinyemi and colleagues (2013) found no evidence of an association between maternal age and under–five mortality in Nigeria.

Table 2: Descriptive statistics

Variable	Mean	Standard Deviation
Child Mortality		
Yes	0.95	0.22
No	0.05	0.22
Age		
15 – 19	0.04	0.18
20 – 29	0.43	0.49
30 – 39	0.42	0.49
40 – 49	0.12	0.32
Child Size		
Small	0.17	0.38
Average	0.33	0.47
Large	0.49	0.50
Birth Order		
1 – 2	0.39	0.49
3 – 4	0.35	0.48
5+	0.25	0.43
Educational		
No Education	0.35	0.48
Primary	0.21	0.40

Secondary	0.41	0.49
Tertiary	0.04	0.19
Wealth Index		
Poorest	0.32	0.47
Poor	0.22	0.42
Middle	0.18	0.39
Richer	0.15	0.36
Richest	0.12	0.33
Marital Status		
Not Married	0.07	0.25
Married	0.88	0.32
Divorced	0.05	0.21
Residence		
Rural	0.40	0.49
Urban	0.60	0.49
Locality		
South	0.67	0.47
North	0.33	0.47

Source: Authors' computations based on GDHS-2014

This could be exhibited by adolescent and older mothers who are likely to produce children of low birth weight. This finding corroborates the work of Kumar and File (2011) who found that the risk of child mortality remained high among adolescents and older mothers. Furthermore, children born by older mothers (30 and above) in the study were also found to have a higher risk of dying. Birth weight was found to be statistically significant to child mortality. Children born with average and large weights had almost 2 times reduced risks of dying before 5 years of age compared to children born when small respectively in the combined model. In a similar, study Madise, Banda and Benaya (2003) found that small birth size is associated with low survival chance.

Children who fall within the 1 – 2 birth order of their mothers significantly have increased odds of dying before reaching their fifth birth day compared to children born to those of the 5+ birth order. This finding is in tandem with Handa, Koch, and Ng (2010) who found a significant association between birth order and child mortality. However, Saha and van Soest (2013) did not find a significant association between birth order and infant mortality.

In this study, children born to a mother of primary school level had reduced odds of dying before 5 years of age compared to children born to mothers with no education. Children born to a mother of secondary level had reduced risks of dying before 5 years of age compared to children born to mothers with no education (OR= 1.76; CI= 1.20, 2.56). This is in line with the literature reviewed which showed that mothers who had primary and secondary level of education experienced fewer infant deaths. Though insignificant in the model estimated, children born to mothers with higher level of education had reduced risks of dying before 5 years of age compared to children born to mothers with no education (OR= 1.98, CI= 0.77, 5.08). Thus mothers with some level of education, at least secondary level, may be aware of the diseases caused by contaminated water thus able to use protected clean water, give good health care, get a job and be able to support the family in terms of provision of basic needs of life (Basu, et al, 2005). It reflects mother's level of knowledge and skills and the degree to which she can effectively make use of the resources at her disposal to increase survival chances of her infants.

Precisely, we observe that household wealth significantly predict child mortality. Relative to children born to women from households in the bottom income quintile, children whose mothers are from households in the top four income quintiles have significantly reduced odds of dying before their fifth birth day.

In particular, the estimates reveal that area of residence and locality are significantly related to child survival. According to the multilevel logistic model, children born to mothers from rural areas had increased risks of dying before 5 years of age compared to children born to mothers from urban setting (OR= 0.33, CI= 0.19, 0.58). The plausible explanation may be that the rural women are more likely to resort to self-medication especially if they are far from health facilities and are not enrolled on the health insurance scheme. Similarly, Gwatkin, Wagstaff and Yazbeck, (2005) posit that rural people do not comprehend modern medical care and its benefits thereby negatively affecting the survival chances of their children under five years of age. Further, children born to mothers from the southern sector had reduced risks of dying before 5 years of age compared to children born to mothers from the northern part of the country (OR= 2.72, CI= 1.62, 4.59).

Table 3: Multilevel Logistic regression analysis of child mortality

	Mode1		Model 2		Model 3	
Variable			OR	95%CI	OR	95%CI
Age (Ref: 40 – 49**)**						
15 – 19			14.75***	3.33, 65.36	12.45**	2.75, 56.49
20 – 29			3.09***	1.87, 5.13	2.79***	1.66, 4.69
30 – 39			1.29	0.86, 1.96	1.23	0.80, 1.89
Child Size(Ref: Small)						
Large			1.83***	1.31, 2.56	1.81***	1.29, 2.51
Average			1.95***	1.36, 2.81	1.89**	1.31, 2.75
Birth Order (Ref: 5+**)**						
1 – 2			0.34***	0.21, 0.53	0.33***	0.21, 0.52
3 – 4			0.76	0.53, 1.14	0.75	0.51, 1.09
Educational (Ref: No Education)						
Primary			1.52*	1.02, 2.3	1.49*	0.99, 2.23
Secondary			1.76**	1.20, 2.56	1.72**	1.16, 2.54
Tertiary			1.96	0 .77, 5.08	1.96	0.77, 5.04
Wealth Index (Ref: Poorest)						
Poor			0.49*	0.26, 0.94	0.42*	0.20, 0.88
Middle			0.45*	0.22, 0.93	0.40*	0.19, 0.84
Rich			0.40***	0.35, 0.46	0.39***	0.35, 0.45
Richest			0.39**	0.19, 0.77	0.34**	0.19, 0.59
Marital Status (Ref: Divorced)						
Not Married			1.03	0.41, 1.29	0.99	0.39, 2.46
Married			0.86	0.44, 1.69	0.84	0.43, 1.66
Residence (Ref: Urban)						
Rural					0.33***	0.19, 0.58
Locality (Ref: North)						
South					2.72***	1.62, 4.59
Constant	3.15***	2.97, 3.33	22.14***	8.85, 55.38	24.41***	7.39, 80.65
Random Effects						
Variance of Random Intercept			0.39	0.16, 0.93	0.34	0.11, 1.03
Conditional intraclass correlation	0.11	0.06, 0.19	0.09	0.04, 0.21	0.04	0.01, 0.21
Log likelihood	-1145.3886		-893.5324		-788.7405	
Observations	5,254		5,254		5,254	
Second level units: PSU	427		427		427	

*p≤0.1, **p≤0.05, ***p≤0.01.

Note: * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Authors' computations based on GDHS Survey Data

Conclusion and Policy Recommendations

Using data from the most recent Ghana Demographic and Health Survey conducted in 2014, the study sought to analyse the factors that impact childhood mortality. Findings from the study suggest that individual characteristics of the child and the mother, household socio-economic conditions, place of residence and southern-northern dichotomy are very influential in explaining child survival. In particular, the odds of children born with average and large weights dying before

5 years of age were found to be on the lower side. Children who fall within the 1 – 2 birth order of their mothers significantly have increased odds of dying before reaching their fifth birth day.

Also, the paper established that children born to adolescent mothers had higher risk of dying before 5 years of age. Children born to mothers with primary and secondary educational attainment had reduced odds of dying before their fifth birth day. In relation to children given birth to by women from households in the bottom income quintile, children whose mothers are in the top four income quintiles have significantly reduced odds of dying before their fifth birth day. After controlling for effects of both child and mother-level characteristics the paper shows that place of residence and southern-northern dichotomy significantly impact child survival.

Considering the findings of the study, it is recommended that interventions and strategies designed to reduce child mortality should focus on socio-economic factors and maternal practices that significantly impact child mortality. Specifically, the study recommends improvements in maternal health care delivery by way of educating women on the benefits of patronising postnatal services to reduce under-five child mortality. Improvements in postnatal dietary practices would be of significant benefit to child survival.

In addition, attempt should be made to eliminate all barriers to access to education beyond the primary and secondary levels particularly for girls. This would serve as positive catalyst towards the fight against child mortality. Further, governments must pursue policies that seek to improve the economic conditions of households.

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