Wealthiest Is Not Always Healthiest: What Explains Differences in Child Mortality in West Africa?

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Abstract. Ghana has the lowest under-five mortality rate in West Africa. Understanding why Ghana's child mortality rate is lower than in neighboring countries may offer useful insights for other developing countries that are trying to improve child health. This paper explores whether Ghana's lower mortality rate is mostly a result of greater household wealth, better implementation of national health policies, or more favorable geography. The paper uses micro level data for children under five to examine relative child mortality risk between Ghana and each of its three immediate neighbors -- Burkina Faso, Côte d'Ivoire, and Togo. A Cox proportional hazards model is used to test which of the three 'contenders' – health policy, wealth, or geography – best explains Ghana's mortality advantage. The results of the analysis indicate that wealth variables are not able to explain any of the child mortality variation between Ghana and its neighbors. Geography and health policy variables each explain about 40% of the mortality gap between Ghana and Burkina Faso. Health policy differences alone are able to explain about 70% of the child mortality gap between Ghana and Côte d'Ivoire. These results suggest that even poor countries that have been 'cursed' by bad geography can potentially improve development outcomes and save children's lives.

Keywords: child mortality, geography, health policy, Africa, Ghana, Burkina Faso, Togo, Côte d'Ivoire

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I. Introduction

Ghana has the lowest under-five mortality rate in West Africa. The reasons for its relatively low child mortality are poorly understood (Balk et al., 2004) and could hold important lessons for developing countries in general and for neighboring countries in West Africa in particular. This paper explores whether Ghana's relatively low under-five mortality rate is mostly a result of greater household wealth, better national health policy, or more favorable geography.

Debate over the cause of variations in child mortality has been on-going in both the economics and sociological literatures (Preston, 1975 & 1985; McKeown, 1976; Caldwell, 1986; Pritchett and Summers, 1996; Filmer and Pritchett, 1999; Easterlin, 1999; Hanmer et al., 2003; Cutler et al., 2006; Deaton, 2006; Soares, 2007). Empirical research has largely tried to find explanations for the variation in country performance by using large cross country datasets to compare differences in average mortality rates. This paper uses micro level data for infants and children from a few neighboring countries in West Africa. The use of micro level data makes it possible to include a much richer set of independent variables than is possible with macro data. This enables a more nuanced exploration of the hypotheses and reduces the possibility of omitted variable bias. In addition, the focus on just a few countries in the same region makes it possible to better control for the heterogeneity that arises when comparing countries at very different levels of development.

This study uses household level data from six Demographic and Health Surveys (DHS) from four countries. The DHS data are integrated with GIS data from several sources to incorporate information on key geographical and spatial characteristics. The data are used to estimate a Cox proportional hazards model in order to examine relative child mortality risk between Ghana and each of its three immediate neighbors -- Burkina Faso, Togo, and Côte d'Ivoire. The model is used it to test whether Ghana's mortality advantage is best explained by its geography, the greater wealth of its citizens, or its implementation of health policies.

The results of the analysis indicate that differences in health policy can explain the majority of the difference in child mortality between Ghana and Côte d'Ivoire. Differences in health policy and geography each explain about the same amount of variation in child mortality between Ghana and Burkina Faso. None of the three contenders is able to explain much of the child mortality gap between Ghana and Togo, but data for several of the key health policy variables were missing for the Togo sample. Differences in wealth were not able to explain any of the child mortality variation between Ghana and its three neighbors. These results suggest that better implementation of relatively simple health policies in poor countries can save children's lives.

The outline of this paper is as follows: Section II presents a discussion of the competing hypotheses and the relevant literature. Section III offers some background on the countries and issues being considered as well as some motivation for the analysis. Section IV discusses the data used in the empirical analysis. The econometric methodology and the results of the analysis are presented in Section V. Section VI concludes.

II. Competing Hypotheses

A. The Debates

Conceptually, higher incomes, more effective health policies, and more advantageous geography are all plausible explanations for differences in mortality across countries. The main discussion in the literature on mortality has been about the relative importance of income versus health policy as rival explanations for declines in national mortality rates. There is clearly a positive association between higher incomes and better health at a broad scale both historically and across countries. Debate has centered around the exact causal mechanism and how much factors other than income matter for explaining the variation in health outcomes both across time and space.

Preston (1975) uses data from a panel of countries for the 1930s through the 1960s and plots life expectancy against income per capita for three different periods. He finds a clear concave relationship in each period, but also that the curve shifted upward over the course of the twentieth century. Hanmer et al. (2003) use the same framework to look at the relationship between infant mortality and income per capita between 1960 and 1997. They find a similar cross-sectional relationship (higher incomes are associated with lower infant mortality) as well as a shift in the curve over time. This upward shift in the relationship between health and income represents factors other than income that improved health outcomes in the last few decades of the 20th century more than in earlier periods. Several researchers have pointed to changes in health technologies, better hygiene, and improved sanitation infrastructure as playing important roles in reducing mortality both in the developed countries in the past and more recently in developing countries (Preston, 1975 &1980; Easterlin, 1999; Hanmer et al., 2003; Soares, 2006).

Filmer and Pritchett (1997) use cross-country data to examine the impact of health expenditures, economic, and social variables on under-five mortality. They find that per capita income is the most powerful predictor of the variation in child mortality rates across countries and that public health expenditures explain only a tiny fraction of mortality differences. Hanmer et al. (2003) also use cross-country data to test the robustness of the various determinants of child mortality that are often used in the literature. They find that immunization against tuberculosis and measles are robust and statistically significant along with income per capita. They take this as a refutation of what they see as the main message of Filmer and Pritchett (1997) and other researchers at the World Bank (Ravallion, 1997; Dollar and Kraay, 2000) that "…sustained improvements in welfare are best brought about by increasing incomes" (Hanmer et al., p.102, 2003).

Two of the three contenders examined in this paper, health policy and income[1], follow from this long-standing debate. The third contender, geography, is usually considered as the rival contender to institutions in the debate over what is the 'deep' determinant of development as measured by income per capita (Engerman and Sokoloff, 1997; Acemoglu et al. 2001; Sachs, 2003; Easterly and Levine, 2003; Rodrik et al. 2004; Cartensen and Gundlach, 2006). Since one of the principal ways geography is argued to affect income is through health (Bloom and Sachs, 1998; Sachs 2001; Sachs, 2003; Cartensen and Gundlach, 2006), it seems natural to consider geography as a contender on its own in investigating explanations for differences in mortality as well.

B. The Contenders

1. Income

There are two main channels through which income per capita could affect under-five mortality. First, higher levels of national income could be used by governments to provide quality health infrastructure that could potentially reduce mortality rates. Thus for higher incomes to actually translate into better health through this channel, national governments need to spend their revenues on effective health care interventions. Filmer and Pritchett (1997) show that this is not always the case. In this paper, instead of relying on the indirect channel between national income and health policy implementation, health care interventions are examined more directly. Second, higher incomes at the household level could reduce infant and child mortality if this income is used to purchase better nutrition, effective health care or health promoting assets such as toilets or piped water. Here again though, the connection between higher household income and better health is not immediate. Quality health care and nutritious food must be widely available so that households can actually transform their incomes into these health inputs. Publicly provided sewerage and water distribution systems clearly make the private purchase of toilets and water hookups more

[1] Although the debate reviewed here focuses on income per capita, the analysis in this study uses data on household wealth instead of income. This issue is discussed in Section IV.

attractive. In addition, households need to have the information and preferences that result in the demand for these inputs to health. Thus it is by no means inevitable that higher household incomes will result in better health.

2. Health Policy

There are several ways that national health policy could theoretically affect under-five mortality. Successful immunization campaigns can reduce infection and thus mortality from some diseases that are still prevalent and sometimes deadly in developing countries such as measles, meningitis, tuberculosis, rotavirus, tetanus, and pertusis (Jones et al., 2003; Bryce et al., 2005). The education of a country's citizens about healthy behaviors such as boiling water, breastfeeding, using oral rehydration therapy during bouts of diarrhea, proper disposal of human waste, and hand washing can promote better health and reduce mortality. And finally, the provision of broad-based access to quality medical care for both prevention and cure of diseases can save lives at all ages.

3. Geography

There are two basic ways that geography might have direct impacts on child mortality rates. First, temperature and rainfall affect both the prevalence and transmission rates of infectious diseases. (Bloom and Sachs, 1998; Sachs, 2001). In addition, a country's soil resources, climate, and natural water sources will all affect agricultural productivity (Bloom and Sachs, 1998; Masters and Macmillan, 2001) which can affect nutrition levels.[2] There are also indirect ways that geography can affect health through its impact on the other two contenders. A country's natural resource base may affect national income (although in which direction is itself the subject of debate (Sachs and Warner, 2001; Mehlum et al., 2006; Brunnschweiler and Bulte, 2008). Geographical accessibility and proximity to trading partners can affect trading costs (Frankel and Romer, 1999; Gallup et al., 1999) which in turn can affect income. Finally, within a country, differences in geography may affect the

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[2] The link between agricultural productivity and nutrition presumes some market imperfections in the agricultural sector.

provision of health infrastructure with governments providing fewer health services in areas that are more geographically inaccessible. Care, therefore, must be taken in interpreting the empirical results that follow with the possibility of these indirect links kept in mind.

III. Background and Motivation

Table I shows the infant and child mortality rates for Ghana and each of its neighbors for the five years preceding the DHS surveys used in the analysis.

(Insert Table I here)

The study makes use of data from six DHS surveys: two surveys done in Ghana and Burkina Faso in 1998 and 2003 and one each for Togo and Côte d'Ivoire from 1998. The differences in mortality rates are quite substantial. Under-five mortality rates were lowest in Ghana and highest in Burkina Faso. For the 1993-1998 period, Ghana's overall under-five mortality rate was half that of Burkina Faso's, 40% lower than Côte d'Ivoire's and 25% lower than Togo's.

Figure 1 gives a visual representation of the variation in under-five mortality rates across communities in the four countries. I use the DHS data to calculate the cluster level (almost always a village or small town in this sample) average number of deaths of children under five in the five years preceding the surveys as a proportion of births. Next, these community averages are characterized as 'high', 'medium', and 'low' based on how far they are from the mean.[3] The map below shows the distribution of these categories. The black dots signify a 'high' community under-five mortality rate; the white dots represent 'low' death rates; and the gray dots represent 'medium' death rates.

(Insert Figure 1 here)

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[3] If $P = \frac{X_i - \overline{X}}{\sigma(x)}$ where X_i is the proportion of under-five deaths in cluster *i* and $\overline{X}$ is the average proportion of deaths across the clusters and $\sigma(x)$ is the standard deviation in proportion of deaths, then P<-1 is defined as 'low'; $-1 \leq P \leq 1$ is defined as 'medium'; and P>1 is defined as 'high'.

There are some interesting patterns that are visible even at this coarse level. For example, there are very few communities in Côte d'Ivoire with 'low' death rates. There are several communities with low death rates on the Ghana side close to the Ghana/Côte d'Ivoire border, but none on the Côte d'Ivoire side close to the border. This is also the case when comparing northwest Ghana to communities across the border with Burkina Faso. Patterns on the northeast border with Burkina Faso and on the eastern border with Togo are hard to detect at this level. This is only meant to give a rough visual representation in any case as a preliminary motivation for some of the issues that will be explored in greater depth below. In order to get a deeper understanding of mortality patterns, we will need to look at individual mortality risks and address issues of data censoring and take into account age of death.

Balk et al. (2004) use DHS data to examine causes of mortality in ten West African countries. They find that while the mean mortality rate in Ghana is lower than in the other countries, after using their complete set of controls in their regressions, the difference between Ghana and most of the other countries vanishes. The differences between Ghana and Burkina Faso and Côte d'Ivoire, however, remain statistically significant. This is especially interesting because these two countries are two of Ghana's three immediate neighbors. Thus if geographical differences were driving the variation, one might expect that these differences would be smaller for regions that are closer than those that are further apart. Just because countries are neighbors, however, does not mean that they share similar geographies. Substantial geographical heterogeneity exists among Ghana, Togo, Côte d'Ivoire, and Burkina Faso. While Ghana, Togo, and Côte d'Ivoire all have their southern borders on the coast, Burkina Faso is landlocked. The northern part of Burkina Faso lies within the Sahel which is a relatively dry tropical savanna; the other countries and the southern part of Burkina Faso enjoy more rainfall. A tropical forest belt covers part of the western side of Ghana and eastern side of Côte d'Ivoire, while Burkina Faso and Togo are largely covered by savanna. The regression analysis which follows will use several potentially important aspects of geography as controls to address some of this heterogeneity.

Though the empirical analysis to follow focuses on micro level differences in wealth as a potential explanation for variation in child mortality rates, it is interesting to compare national income across these countries to get a sense of whether the countries differ vastly in level of economic development. Table II shows gross national income per capita measured in purchasing power parity dollars for the countries in the study for each of the years covered by the surveys.[4] Income per capita was highest by far in Côte d'Ivoire and lowest for most of the period in Togo.

(Insert Table II here)

Average incomes in Côte d'Ivoire were more than double those in Burkina Faso and in Togo and were between 50 and 85% higher than in Ghana throughout the period. Thus at the national level, there does not appear to be a strict negative relationship between income and child mortality: Ghana has the lowest under-five mortality rate for the period, while Côte d'Ivoire has the highest average income. While Togo is the poorest country in the sample, Burkina Faso had the highest under-five mortality rate.

IV. Data

The Demographic Health Surveys are nationally representative household surveys developed by the United States Agency for International Development that collect data on health and fertility in many developing countries. The DHS uses model questionnaires and standardized data formats to ensure that data are comparable across countries. As part of these surveys, female respondents are asked detailed questions relating to their pregnancies,

[4] There are two DHS surveys included for Ghana and Burkina Faso, one each from 1998/9 and one from 2004. The surveys for Côte d'Ivoire and Togo were both from 1998/9. Each survey covers information on births and deaths for the five years preceding the survey.

prenatal care, and health of their children born in the last five years. This study makes use of data from six DHS surveys: two surveys done in Ghana and Burkina Faso in 1998 and 2003 and one each for Togo and Côte d'Ivoire from 1998. The sample used here includes a total of over 38,000 infants and children under five. Each DHS survey uses a two-stage stratified sample design. In the first stage, a country's census is used as a sampling frame for the selection of enumeration areas; in the second stage, households are randomly selected within each area chosen in stage one with the number of households chosen in proportion to population size. The children's sample for each survey consists of one record per child born in the last five years for each woman surveyed.[5]

Since the DHS contains longitude and latitude information for all clusters, it is possible to spatially join this data to other sources of available geographic information. Several other sources of data were thus used to enrich the set of geographical and regional controls used in the analysis. Data on malaria prevalence come from the *Malaria Atlas Project* (MAP)[6] which estimates the spatial distribution of *plasmodium falciparum* malaria endemicity based on medical intelligence and parasite rate surveys. Average monthly precipitation data for the station nearest to a household's cluster were obtained from the Food and Agricultural Organization's *FAO Clim-net* database.[7] Population density data from the Gridded Population of the World (CIESIN) at a resolution of 2.5 arc minutes were used to approximate population density in the region in which the household's cluster was located. Coastal boundaries, road locations, and elevation data were obtained from the National Imagery and Mapping Agency's *Vector Map (VMAP0).*[8] Distances to coast and to nearest roads for each cluster were then calculated using ArcGIS software. Soil data from the *Digital*

[5] The DHS survey for Togo only collected detailed information in the 'children's' file for those born in the last three years. Therefore, for Togo, I use the data from the 'births' file which has more limited information, but includes all births. I only use the data for those born in the last five years. Several of the health policy variables used later in the regressions are not available for all children in this dataset.
[6] http://www.map.ox.ac.uk/data/
[7] http://geonetwork3.fao.org/climpag/agroclimdb_en.php
[8] http://gis-lab.info/qa/vmap0-eng.html

Soil Map of the World (FAO, 2003) were used to characterize the dominant soil types for the region in which each household's cluster was located.

V. Empirical Analysis

A. Estimating the Size of the 'Ghana Effect'

The standard way to estimate the impacts of various risk factors on mortality is to use a hazard model where the response variable is measured as the duration from birth to either death or to the threshold age that is being considered. The main advantage of such models is that they are able to effectively deal with the censoring problem that is inherent in survival survey data since most children who survive are 'right-censored' at the time of the survey. In other words, if we are interested in under-five mortality, we fail to observe the child's survival to age five if s/he is younger than five at the time of the survey. I first estimate a Cox proportional hazards models for all children under five including a country dummy for each of Ghana's neighboring countries and a dummy for the year of the survey since data from two surveys are used for Burkina Faso and Ghana. This will enable us to check whether the differences in mortality rates that we observed in Table I are actually statistically significant. The model to be estimated takes the following form:

$$\ln[h(t)/h_0(t)] = \alpha_1 * Burkina\ Faso + \alpha_2 Cote\ d'Ivoire + \alpha_3 Togo + \beta Survey98 \quad (1)$$

where h(t) represents the 'hazard' (in this case death) at time t and h_0 represents the baseline hazard; so the model estimates the proportional change in the risk of death from living in one of Ghana's neighboring countries compared to that in Ghana (the omitted baseline category). Survival times are measured as months until death or until the survey was conducted. Results are reported in Table III for three different age groups: under-five, infant, and child mortality.[9]

(Insert Table III here)

Results in Table III column 1 show that under-five mortality rates are substantially and statistically significantly lower in Ghana compared with those all of its neighbors. The risk of dying for children under five based on the regression results was about 59% higher in Burkina Faso, 66% higher in Côte d'Ivoire, and 13% higher in Togo. Risks for causes of death can differ between infants and young children (Razzaque et al., 1990; Mahy, 2003; Balk et al., 2004). Preterm births, birth asphyxia, neonatal tetanus, and congenital anomalies are among the most important contributors to infant deaths in the region, while malaria, diarrheal diseases, and pneumonia are the leading causes of death in children under five (WHO, 2006). I, therefore, run the same Cox regression as above on infants and children separately. The infant sub-sample is defined as age 0 to 12 months and the child sub-sample as ages 13 to 59 months. Results for the two sub-samples are reported in columns 2 and 3 of Table III. It appears that the differences in under-five mortality rates between Ghana and its neighbors are a result of differences in child mortality rates since none of the results for the infant mortality rates were statistically significant. The differences in child mortality follow the same pattern seen in the under-five regressions with risk of death higher in all three neighboring countries compared to Ghana.

[9] The regression coefficients in Cox proportional hazards model are known as 'hazard ratios' and indicate how the covariate in question affects the probability that the event occurs before the end of the specified time period; in this case, the probability that the child dies before age five. If the coefficient is less than one, then the presence of that covariate is associated with a lower probability that the event occurs, if it greater than one, then it is associated with a higher risk that the event occurs. Z-values associated with covariates that reduce the probability that the event occurs are negative and those associated with higher risk are positive.

A potential source of measurement error is caused by age heaping in reports of age at death. One of the most common ages for heaping of reported death and the most complicated for measuring infant and child mortality occurs at 12 months (Curtis, 1995). While this would not affect under-five mortality rates, it could bias estimates of both infant and child mortality rates. Since 12 months is the threshold dividing infant and child mortality rates, misreporting of age at death at 12 months can result in an underestimation (overestimation) of infant mortality and an overestimation (underestimation) of child mortality depending on whether age at death was rounded up or down. Some heaping at 12 months was found for four out of six of the surveys used in the dataset with the greatest amount in the Ghana 1998 survey.[10] In order to check whether this biases the estimates of the 'Ghana' dummy in either the infant or child regressions, I ran the regressions using 13 and 11 months as alternative cut-offs for the infant and child samples. The results were relatively robust to these alternate thresholds; the only substantive change was that the difference in infant mortality between Ghana and Burkina Faso became statistically significant when infants were defined as being up to 13 months in age.[11] None of the results for the child sample changed qualitatively with the alternate thresholds.

B. Exploring the causes of the 'Ghana Effect'

1. Independent Variables

The Cox proportional hazards results confirm that children in Ghana have a statistically significant lower risk of mortality compared with children in neighboring countries, but this mortality advantage only begins for children after their first birthdays. The rest of the analysis will explore how much Ghana's lower child mortality rate can be explained by the three contenders that are the subject of theoretical debates: geography, income, and health policy. Many other controls are included as well to try to reduce the

[10] A heaping index was constructed by dividing deaths at age 12 months by the average number of deaths at ages 10, 11, 13, and 14 months for each survey (Rutstein, 1985).
[11] These results are available from the author upon request.

possibility of biasing the estimates of the variables of interest. The independent variables are grouped into several categories. In addition to the country dummies, health policy indicators, wealth variables, geographical characteristics, as well as a vector of 'other' characteristics (including birth characteristics, mother's characteristics, and household and community characteristics) are added to the regressions. The focus is on the child sample since the regression results indicate that this is where mortality differences are statistically significant. Similar regressions were carried out for the infant samples as well, but the country dummies remained statistically insignificant.[12] The next few subsections discuss the independent variables used in the analysis.

a. *Health Policy Variables*

Vaccinations are one of the most important health interventions, particularly in a developing country context, for reducing under-five mortality (Jones et al., 2008). The DHS data include variables for whether a child has received the following vaccines: polio at birth, polio1, polio2, polio3, DPT1, DPT2, DPT3, BCG, and measles. This information, however, cannot be used directly in the survival analysis because data on vaccinations are missing for all children who have died. A vaccine index is therefore constructed for all children who are still alive using principal components analysis with all of the above vaccinations included as components. This index is then averaged over each cluster and the resulting average is used in the regression. The index can be interpreted as a measure of the prevalence of vaccination in a particular area. The index also has the advantage of being a more convincing health policy variable than child specific vaccination information which is more likely to be affected by household preferences and information.

Breastfeeding is strongly encouraged by the World Health Organization as it has been shown to decrease infant under-nutrition and to prevent diarrhea and pneumonia (Black et al., 2003) which are two of the most important contributors to under-five mortality (Bryce et al.,

[12] Results from the infant regressions are available from the author.

2005). It is also found to more generally provide infants with antibodies that increase their immunity to diseases (Black et al., 2003). One study finds that if all children were breastfed, worldwide under-five mortality rates would drop by 13% (Jones et al., 2003). There is evidence from developed countries that breastfeeding not only reduces infant mortality, but provides lasting health effects beyond infancy. It has been found to reduce the incidence of asthma, diabetes, and leukemia in older children (AAP, 2005). The encouragement and promotion of breastfeeding to improve child health and reduce mortality has been the focus of both national and international health campaigns to raise awareness of the importance of breastfeeding (Wilmoth and Elder, 1995; UNICEF, 2010). While there will clearly be differences in breastfeeding behavior due to individual preferences and circumstances, the fact that there is substantial national variation in breastfeeding behavior (see Table IV below) is likely due to differences in health education. A recent UNICEF report claims that rates of exclusive breastfeeding vary widely across countries in West and Central Africa due to differences in cultural beliefs and attitudes (UNICEF, 2010). Breastfeeding behavior, therefore, is considered here to be a health policy variable. The DHS data include a variable for the duration of breastfeeding in months for each child. Since children who have died during the period when they were still being breastfed will necessarily have had shorter intervals of breastfeeding than their live counterparts, this variable cannot be used directly in the regressions. Instead, since the sample used here consists of children ages thirteen to 59 months, I use the number of months a child was breastfed as an infant until the age of twelve months with any time over twelve months assigned a value of twelve.

Educating the public about basic health care is an important function of good health policy. One of the cheapest and most effective interventions that parents can do to reduce child mortality is to administer oral rehydration therapy (ORT) to an infant or child suffering from diarrhea (Bryce et al., 2008; Jones et al., 2008). The DHS asks mothers if they have ever heard of ORT. I include a dummy for whether the mother has heard of ORT in the regression to try to capture health knowledge. I am assuming that those who have heard of ORT will have done so because of public health outreach.

Widespread access to basic health care services is an indicator of good health policy. The DHS datasets, however, do not have direct information on health care availability. This could be important in explaining differences in mortality performance across borders.[13] There is data, however, on the place of a child's delivery. I assume that women who live in communities where access to modern health care is more available, are more likely to have their babies delivered in a clinic or hospital. If the variable is included directly in the regression, however, there is a possibility that it would introduce simultaneity bias into the regression since women with more problematic pregnancies and those suffering from delivery complications might be more likely to have their babies in modern medical facilities. While this would more likely be an issue for the infant sample, it is possible that if infants survived difficult births, they could have long-lasting health issues making them more vulnerable. Therefore, the average response to that question for all other members of a household's cluster (i.e. with the household's response subtracted) is calculated. This should give a sense of how readily available health care facilities are for the community without being affected by the health status of the individual household.

b. *Wealth*

While income data are not collected in the DHS surveys, there is information on wealth in the form of asset ownership. This is not necessarily a shortcoming since it is not entirely clear that income would be theoretically superior to wealth in a model of child mortality. We are primarily interested in the household's ability to purchase food, health care, and health-promoting assets over the child's first five years of life (and during the mother's pregnancy) and so would prefer a relatively stable measure of a household's

[13] In the later surveys for Ghana and Burkina Faso, there is a question that asks if the respondent (the mother) visited a health care facility in the twelve months preceding the survey, but unfortunately, this question was not asked in the earlier surveys.

purchasing ability. Income is notoriously volatile, particularly in developing countries, while a household's stock of assets is likely to be a more stable measure of its ability to make such purchases. In addition, income and expenditure data suffer from very large measurement errors particularly in developing countries (Sahn and Stifel, 2003). Perhaps for these reasons, Sahn and Stifel (2003) find that assets are as good as or a better predictor of child nutritional outcomes in most cases compared with expenditure data. Following the methodology outlined in a seminal paper by Filmer and Pritchett (1998), I use principal component analysis to construct an asset index as a proxy for wealth. Several studies have found that such indexes are relatively robust and give qualitatively similar information in terms of defining who is poor as consumption/income measures (Filmer and Pritchett, 1998; Wagstaff and Watanabe, 2003; Filmer and Scott, 2008).

The DHS datasets include such an index for each country, but since these indexes are constructed by principal component analysis, they are by nature comparative and therefore sample-specific. I, therefore, create an asset index for the households in the four country sample used here. The index is comprised of the following components: whether the household owns a radio, a TV, a bicycle, a motorcycle, a car, or a refrigerator. The DHS index includes these assets, but in addition includes the household's source of drinking water, the type of toilet facility, and the type of floor material of its house. These variables are omitted from the wealth index here because they are included directly in the regressions since they can potentially have direct effects on health.[14] Thus dummies for whether a household has piped water or gets water from a well (the main reference category is water from a 'natural' source), for whether it has a toilet or latrine (compared with no toilet), and whether it has a 'modern' floor material such as cement, tiles, linoleum or carpet (as opposed to mud,

[14] The DHS also includes a variable for whether the respondent works on her own or her family's land (as opposed to renting or working on someone else's land) in its index. Since this variable is only relevant for rural households and is missing for about 45% of the observations, it is not included in the wealth index here.

earth, or wood) are included in the main regression. The ranking of the countries with respect to the wealth index matches their ranking in terms of national income as reported in Table IV.

c. *Geographical Characteristics*

Like Balk et al. (2004), I include average monthly rainfall data and rainfall squared since they can affect disease prevalence and transmission as well as agricultural productivity. In addition, however, I include a measure of malaria prevalence based on *plasmodium falciparum* malaria endemicity. As far as I know, this is the first study of child mortality to include such a measure. A variable for elevation is also included since this can also affect the ecology of disease transmission and agriculture. Dummy variables for soil groups are included since these will likely affect agricultural productivity as well as the types of crops grown.

d. *Other Characteristics*

Multiple births increase the risk of both infant mortality and child mortality (Guo et al., 1993; Justesen and Kunst, 2000); thus a dummy for whether a child was a multiple is included in the regression. Male infants universally have higher mortality rates than female until about age 6 months due to greater biological weakness of male infants (Svedburg, 1990; Mahy, 2003). Between ages 1 and 5 years, there are regional and country-level differences in male child excess mortality with some sub-Saharan African countries exhibiting higher male child mortality (Svedburg 1990; Sullivan et al., 1994; Svedburg 1996). A dummy for whether the child is female is included to capture possible sex differences. While child's birth weight is an important predictor of child health and is collected in principle in the DHS, this information is missing for the vast majority of the sample (about 80%) and therefore not included in the analysis. The DHS does, however, collect data on a mother's perception of the child's size at birth[15]; a dummy for whether the child was perceived as small or very small is included in the regressions.[16]

A child's place in the birth order has been found to affect her/his survival prospects with first born children and very high order births exhibiting higher mortality rates (Hobcraft et al., 1985); dummies for first born to eighth born are included with birth orders higher than eight the baseline category. The length of interval between births has been associated with both infant and child mortality in several studies with short and very long intervals found to increase mortality risk (Hobcraft et al., 1983; Rutstein, 2008). Dummies for preceding and succeeding interval length are included with the omitted categories being 'medium' intervals for both preceding and succeeding intervals. 'Short' intervals are defined as those less than equal to eighteen months; 'medium' intervals are those between nineteen and thirty-six months; 'long' intervals are those between thirty-seven and forty-eight months; and 'very long' intervals are defined as greater than forty-eight months.

Mortality risk for both infants and young children is generally found to be higher for young mothers and for older mothers (Haaga, 1991; Preston 1985; Sullivan et al., 1994). For young mothers, this may be due to immature physical and reproductive development or to inexperience in caretaking (Haaga, 1991; Sullivan et al., 1994). The higher risk for the children of older mothers is a result of an increase in chromosomal abnormalities that are believed to arise from the aging of the ova (Haaga, 1991; Heffner, 2004). Mother's age at birth and her age at birth squared are included as regressors to try to control for these effects.

Evidence suggests that maternal under-nutrition is correlated with infant and young children's under-nutrition (Mosley and Chen, 1984; Benson and Shekar, 2006).[17] This may be because it is an indicator of household food availability so that if there is not enough

[15] This information was missing for more than half of the Togo sample so the variable was not included in the regressions that included Togo.
[16] I thank an anonymous referee for this suggestion.
[17] We cannot use nutritional information for children since children who have died are missing information for nutritional variables.

nutritious food for the mother, there is unlikely to be sufficient quality food for her children. There is also a more direct link to the nutritional status of her infants since maternal nutrition during pregnancy affects birth weight and during breastfeeding can affect the quality of breast milk (Mosley and Chen, 1984). Two measures of the mother's nutritional status are included to serve as proxies for household nutritional status: mother's height for age is included as a long-term measure of maternal nutrition and her body mass index (BMI) is included to capture her current nutritional status.

Many studies have reported a positive association between mother's education and her children's health and some limited evidence for a positive impact of father's education (Block, 2007; Breierova and Duflo, 2004; Christiansen and Alderman, 2004; Glewwe, 1999; Mosley and Chen,1984; Penders and Staatz, 2001). Since the data for highest year of education were highly skewed (more than half of the mothers across samples did not have any education), a dummy variable for whether the child's mother had reached grade 6 or above is included (data for father's education was missing for the Côte d'Ivoire sample so this variable is not included in the regressions).

Dummy variables for religious identification (Catholic, Protestant, Muslim, or Traditional religions) are included to capture cultural characteristics that might potentially affect health through behavior. The excluded category used as the baseline consists of those who report traditional religions and no-religion.[18] Children in urban households have generally been found to have lower mortality rates than their rural counterparts (Fotso, 2007; Van de Poel et al., 2007) so a dummy for 'rural' location is included. Population density may affect the success of infectious disease transmission and therefore may be positively linked to mortality. It also, however, may be associated with better access to markets, education, and health facilities which could have beneficial effects on child health. The log of population density in 2000 for the region in which the household's cluster is located is

[18] The traditional category was not an option in the Côte d'Ivoire survey.

included to try to control for such effects. The log of the distance to the nearest road from the cluster center is also included since it could affect the household's access to markets as well as its ease of accessing health and education facilities.

2. Summary Statistics

Summary statistics for the key variables of interest for each of Ghana's neighbors are presented below in Table IV and compared with those for Ghana. Summary statistics for the rest of the variables are presented in the appendix. T-tests were done to check whether differences in means between Ghana and each of its neighbors were statistically significant with the results indicated by asterisks. In terms of the key variables examined here, there are some notable patterns. Ghana outperforms all of its neighbors with respect to its vaccine index and with the percentages of mothers who had heard of ORT. Burkina Faso, however, outperforms Ghana with respect to delivery in a medical facility. Ghana does better than its richest neighbor, Côte d'Ivoire, with respect to all of the health policy variables examined here.

Ghanaian households are wealthier than both their Burkina and Togolese neighbors as measured by the wealth index, but they are poorer than Ivoirians. The ownership of 'health assets' such as toilets, piped water, and 'good floors' roughly follows that of the wealth index, with more households in Ghana enjoying these assets compared with Burkina Faso and Togo, but with more households in Côte d'Ivoire having such assets than in Ghana. Households in Ghana, however, are less likely to have access to a well than those in Burkina Faso and Togo; since only about a quarter of households in Ghana have piped water, overall, they are more likely to get their water from 'natural' sources.

Ghana enjoys higher average rainfall than both Burkina Faso and Togo, but less than in Côte d'Ivoire. Malaria prevalence is significantly lower in Ghana than in its neighbors. Ghana is at a lower elevation than Burkina Faso and Togo, but higher than Côte d'Ivoire.

There are statistically significant differences in all of the major soil dummies across all samples.

(insert Table IV here)

3. Regression Model and Results

The main objective of the empirical analysis is to test whether the differences in mortality across countries can be explained by differences in the three key sets of explanatory variables: health policy, wealth, and geography. Table V tests this by including one set of explanatory variables at a time with no other control variables. Thus the regressions are three versions of the following model:

$$\ln[h(t)/h_0(t)] = \alpha_1 Burkina + \alpha_2 Cote\ d'Ivoire + \alpha_3 Togo + \beta Contender_i + \delta svy98 \quad (2)$$

where i = 1,2,3 and represents health policies, wealth, and geography respectively.
Table VI presents results for the complete model with an extensive set of control variables (described above in Section V.B.1.d) as well as for regressions for the complete model, but with each set of contending variables omitted one at a time. This allows us to compare the effect of the addition of each contender to the complete model. The complete model is the following:

$$\ln[h(t)/h_0(t)] = \alpha_1 Burkina + \alpha_2 Cote\ d'Ivoire + \alpha_3 Togo + \gamma Health\ Policy + \delta Wealth + \varphi Geog + \eta Other + \beta svy98 \quad (3)$$

These two approaches allow us to balance concerns of possible multicollinearity in the full model (which includes over 50 explanatory variables) and possible omitted variable bias in the more restricted models. All models are estimated with errors clustered at the village/town level.

(insert Table V here)

a. Health Policy, Wealth, or Geography?

Results in Table V column I are for the same regression reported in Table III column 3 except that here the results are reported with clustered robust standard errors. They show that child mortality rates are about 75-80% higher in Côte d'Ivoire and Burkina Faso and about 35% higher in Togo than in Ghana. Column 2 shows the results with the addition of the health policy variables. The Togo child dataset does not have information on three of the four health policy variables (breastfeeding duration, vaccination, delivery in a medical facility) for children between the ages of 35 and 59 months. Thus the regression results reported in column 2 compare Ghana only with Burkina Faso and Côte d'Ivoire. Column 3 includes Togo, but uses information on whether mothers have heard of ORT as the single health policy variable.[19] Column 4 shows the results with the wealth variables. Column 5 uses the geographical variables.

The addition of the health policy variables reduces the estimated Côte d'Ivoire mortality differential from 80% to 22%, a reduction of about 70%. Neither the wealth variables nor the geographical variables can explain any of the difference in mortality between the two countries in the restricted models. In fact, the difference between the two countries widens when these controls are used. A comparison of the results from the complete model reported in column 4 in Table VI with those where all but the health policy variables are included (column 1 Table VI) confirm that the health policy variables are the big drivers of the mortality gap between the two countries.

(insert Table VI here)

When all of the control variables except for the health policy variables are included in the regression, there is about a 75% difference in child mortality between Côte d'Ivoire and Ghana; once the health policy variables are included along with the other control variables,

[19] There is strong correlation between the ORT variable and the other health policy variables. A probit regression of the ORT variable on the other health policy variables finds that both the breastfeeding and vaccine variables are statistically significant at the 99% level.

the difference in mortality between the two countries declines by 73% and is no longer statistically significant. Neither omitting the wealth variables (column 2) nor the geography variables (column 3) has a substantial effect on the Côte d'Ivoire dummy. The difference in mortality between Ghana and Côte d'Ivoire is not statistically significant in the complete model. These results contrast with those found in Balk et al. (2004) where the difference in mortality risk between these two countries in their full model remains statistically significant. This is almost certainly because Balk et al. (2004) do not include any of the health policy variables included here.[20]

The health policy variables explain some of the variation in mortality between Ghana and Burkina Faso, but not as much as in the case of Côte d'Ivoire. Controlling for health policy variables narrows the mortality gap between the two countries by about 22%. As can be seen in Table IV, however, Ghana does better with respect to vaccination and knowledge of ORT, while Burkina Faso's performance is better with respect to the likelihood of a delivery in a clinic or hospital (the difference for breastfeeding was not statistically significant). I, therefore, run another regression controlling only for the health policy variables for which Ghana's performance is better which results in a narrowing of the mortality gap of about 30% (these results are not reported, but are available from the author). The geographical variables appear to be the most important of the contenders in explaining the difference in mortality in the restricted regressions; controlling for geography reduces the mortality gap between the two countries by about 45%. The wealth variables have the smallest effect on the mortality gap.

The results reported in Table VI using the other independent variables imply that the impact of the health policy variables and the geography variables on the mortality gap is similar in magnitude. Comparing results in column 1 with column 4 and column 3 with column 4, we can see that moving from a model where all of the controls except for the

[20] Balk et al. (2004) also do not include malaria endemicity, birth spacing variables, elevation, or soil type variables.

health policy variables or the geography variables are included to the complete model reduces the mortality gap by about 40% in each case. Omitting the wealth variables (column 2) does not have an effect on the mortality gap (it actually slightly reduces the gap). Overall, the complete model is able to explain about 62% of the mortality gap between the two countries.

None of the contenders alone seems to explain very much of the mortality difference between Togo and Ghana as seen in Table V. The results from these restricted regressions though imply that the wealth variables explain more than the other contenders. However, when we examine the results in Table VI and compare the results where each of the contenders is omitted (columns 6-8) with the complete model (column 9)[21] the wealth effect does not hold up; the coefficient on the Togo dummy barely changes when comparing the model where the wealth variables are omitted (column 7) with the complete model (column 9). The complete model with all control variables reduces the mortality gap between the countries by about 27%. We know, however, that there are important omitted variables here since we do not have data on vaccinations, breastfeeding, or type of delivery. Thus in the case of Togo and Ghana, the existing data do not support any of the contenders as the primary explanation for the mortality gap between the two countries. It is possible that the health policy variables for which there are no data for the Togo sample are the key contributors or that there are other important factors that are outside of the model.

b. Discussion of individual variable effects

Since the restricted regressions do not include all of the covariates that are potentially important, they may suffer from omitted variable bias. In comparing the results from the restricted regressions with those from the complete model, several of the variables in the different contending groups are statistically significant when considered on their own, but their significance declines in the full model. In addition, there are large differences across

[21] Since most of the health policy variables for Togo are missing and therefore cannot be included in the complete model, I run these regressions without those missing variables separately in columns 6-9.

countries in some of the independent variables leading to potential multicollinearity between some of the explanatory variables and the country dummies (see Table IV). In order to better understand the effects of the individual variables, therefore, column 5 in Table VI presents results from a regression with all of the independent variables except for the country dummies.

The vaccination index is not statistically significant in the complete model (Table VI, column 4), but there are very large differences in the index across countries as shown in Table IV. The results in Table VI column 5 show that when the country dummies are omitted, the coefficient is statistically significant (at the 99% level) with a one-unit increase (about equivalent to one standard deviation of the vaccination index) associated with about a 5% lower mortality rate. It is important to note that the vaccine impact estimated here is a lower bound estimate since individual level vaccination rates are not available. Having a mother who had heard of oral rehydration therapy is only statistically significant in the model in which the other health policy variables are omitted indicating that it is likely picking up the effects of the other health policy variables with which it is correlated (see footnote 17) when the other controls were not used. The most striking individual result is the large and robust effect of breastfeeding in all regressions with and without other controls. Each additional month of breastfeeding until age 12 months is associated with about a 20% decline in mortality in children 13 -59 months depending on the sample.[22] Such a large and robust effect for what seems like a relatively easy policy to promote warrants further research.

None of the wealth variables is statistically significant in the complete model with or without country dummies. The asset index is associated with a statistically significant lower mortality risk in the restricted regression with only the wealth variables, but is not significant in the complete model. There is likely some correlation between the wealth and health policy

[22] The breastfeeding variable was still statistically significant when I omitted children who had never been breastfed and when I omitted children who had been breastfed for less than 12 months. Results not reported, but available upon request.

variables since the wealth index is statistically significant in the regression in which all but the health policy variables are included (Table VI, column 1) as well. This underscores the importance of using all of the control variables in the model.

While most of the geography variables are not statistically significant in the complete model, both malaria endemicity and the rain variables are statistically significant when the country dummies were omitted (Table VI, column V). Table IV shows substantial differences in these variables across countries making collinearity with the country dummies a possibility. Higher average rainfall is associated with a reduction in mortality risk, but having very high rainfall was associated with higher mortality risk in the regression without the country dummies. A one-standard deviation higher rate of malaria endemicity is associated with about a 20% higher child mortality rate in the regression with the country dummies omitted.

VI. Conclusion

Pritchett and Summers (1996) famously claimed that 'wealthier is healthier'. While this may be true on average when comparing countries at all levels of development, it does not appear to be the case for these four neighboring countries in West Africa. Rankings of these countries with respect to under-five mortality rates do not follow the same pattern as their rankings in terms of income per capita. At the household level, wealth as measured by ownership of assets, does not explain the variation in child mortality across the four countries.

Several economists have argued that tropical countries have fared worse in terms of development because they have been 'cursed' by poor geography. One of the mechanisms through which this is believed to occur is poor health. Differences in geography do not explain the variation in child mortality between Ghana and its other coastal neighbors, but the inclusion of several key geographical variables is able to reduce the mortality gap between Ghana and Burkina Faso by about 40%.

Health policy variables are able to explain the majority of the mortality gap between Ghana and Côte d'Ivoire, its wealthiest neighbor. In addition, health policy variables explain about as much of the gap in child mortality between Ghana and Burkina Faso as do geography variables. The impacts of health policy reported here are likely underestimated since the impacts of vaccinations could only be examined at the cluster level. While these were consistently shown to be important, the impacts of individual vaccinations are almost certainly larger. None of the contenders was able to explain much of the mortality gap between Ghana and Togo, but several of the key health policy variables were missing for the Togo sample.

Ghana's lower child mortality rate seems in part to be the result of superior health policy implementation. This is excellent news with hopeful implications. Even countries that have not been favored geographically by nature and that have relatively low incomes can potentially improve child health outcomes with well implemented health policies.

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Table I: Five Year Average Child and Infant Mortality Rates (number of deaths per 1000 live births)

	under five mortality	infant mortality	ages 1-4 mortality
Burkina Faso (1993-1998)	219	105	127
Burkina Faso(1998-2003)	184	81	111
Côte d'Ivoire (1993-1998)	181	112	77
Togo (1993-1998)	146	80	72
Ghana (1993-1998)	108	57	54
Ghana (1998-2003)	111	64	50

Source: DHS reports for Ghana 2004, Burkina Faso 2004, Ghana 1999, Burkina Faso 1999, Côte d'Ivoire 1999, and Togo 1999.

Table II: Gross National Income per capita (in PPP $)

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Côte d'Ivoire	1160	1200	1280	1380	1470	1520	1520	1460	1470	1450	1450
Ghana	700	720	740	770	800	820	850	870	920	950	1000
Burkina Faso	580	580	610	670	710	740	790	790	840	870	930
Togo	500	550	600	650	730	700	690	680	670	700	710

Source: World Development Indicators

Table III: Cox Proportional Hazards Model: ***risk of mortality***

	Under Five (0-59 mo.s)	**Infant (0-12 mo.s)**	**Children (13-59 mo.s)**
Burkina Faso	1.587***	1.147	1.657***
	(11.82)	(1.249)	(12.08)
Côte d'Ivoire	1.658***	1.220	1.704***
	(7.281)	(1.011)	(7.182)
Togo	1.131**	0.946	1.150***
	(2.538)	(-0.400)	(2.694)
svy98	1.083**	1.022	1.096**
	(2.150)	(0.205)	(2.326)

Observations	38,849	8,507	30,342
failures	4254	496	3758
chi2	171.1	3.311	175.2

Hazard ratios reported with z-values in parentheses*** p<0.01, ** p<0.05, * p<0.1

Table IV: Summary Statistics for Key Variables of interest (means with standard deviations in parentheses; asterisks indicate results from t-tests for equality of means across samples)

	Ghana/Burkina Faso	Ghana/Côte d'Ivoire	Ghana/Togo
Avg. Vaccination Index	.43(1.12)/-.44(1.16)***	43(1.12)/.14(1.13)***	-
Months breastfed	11.16(2.74)/11.15(2.81)	11.16(2.74)/10.53(3.58)***	-
Mom heard of ORT	.81(.39)/.64(.48)***	.81(.39)/.59(.49)***	.80(40)/.58(.49)***
Cluster Avg. for delivery in med.facility	.32(.21)/.49(.15)***	.32(.21)/.20(.12)***	-
Wealth Index	2.48(1.60)/2.47(1.37)	2.48(1.60)/3.51(1.68)***	2.48(1.60)/2.20(1.44)***
Piped water	.24(.43)/.14(.34)***	.24(.43)/.58(.49)***	.24(.43)/.11(.31)***
Well water	.44(.50)/.75(.43)***	.44(.50)/.38(.48)***	.44(.50)/.45(.50)
'Natural' water	.32(.47)/.11(.32)	.32(.47)/.05(.21)***	.32(.47)/.31(.46)
Latrine/Toilet	.60(.49)/.25(.43)***	.60(.49)/.74(.44)***	.60(.49)/.20(.40)
No toilet facility	.37(.48)/.75(.43)***	.37(.48)/.26(.44)***	.37(.48)/.80(.40)***
'Good' floor	.77(.42)/.34(.47)***	.77(.42)/.82(.38)***	.77(.42)/.68(.47)***

Mud/earth floor	.23(.42)/.67(.47)***	.23(.42)/.18(.38)***	.23(.42)/.32(.47)***
Avg monthly rainfall (1949-01)	14.59(12.75)/.51(1.07)***	14.59(12.75)/23.18(16.74)***	14.59(12.75)/7.13(7.64)***
Malaria Prevalence	.53(.09)/.61(.06)***	.53(.09)/.63(.06)***	.53(.09)/.61(.08)
Elevation	384.89(201.61)/431.35(92.95)***	381.89(206.16)/324.31(219.61)***	381.78(206.31)/441.80(279.29)***
Acrisols	.36(.48)/0 ***	.36(.48)/.57(.50)***	.36(.48)/0 ***
Luvisols	.33(.47)/.53(.50)***	.33(.47)/.05(.21)***	.33(.47)/.53(.50)***
Nitosols	.05(.21)/.03(.17)***	.05(.21)/0***	.05(.21)/.15(.36)***
Cambisols	.01(.12)/.06(.24)***	01(.12)/0***	01(.12)/0***
Ferralsols	.01(.12)/0***	.01(.12)/.09(.28)***	.01(.12)/0***
Lithisols	.11(.31)/.03(.16)***	.11(.31)/0***	.11(.31)/.16(.37)***
Fluvisols	.01(.08)/0***	.01(.08)/0***	.01(.08)/.07(.25)***
Arenosols	.005(.07)/0***	.005(.07)/.09(.28)***	.005(.07)/0***
Regosols	.01(.09)/0(.04)***	.01(.09)/0***	.01(.09)/.06(.24)***
Vertisols	.06(.23)/.03(.18)***	06(.23)/0***	06(.23)/.02(.15)***
1998 Survey	.63(.48)/.56(.50)***		

Table V: Cox proportional hazards regression results for risk of child mortality (Hazard ratios reported with z-values in parentheses; standard errors corrected for clustering at the village/town level)

	(1) Just country	(2) Health Policy A	(3) Health Policy B	(4) Wealth	(5) Geography
Côte d'Ivoire	1.797***	1.223*	1.727***	2.127***	1.886***
	(5.624)	(1.819)	(5.377)	(7.140)	(4.867)
Burkina Faso	1.755***	1.585***	1.665***	1.617***	1.416***
	(8.684)	(6.697)	(7.909)	(6.688)	(3.908)
Togo	1.376***		1.315***	1.247***	1.307***
	(3.990)		(3.462)	(2.710)	(2.864)
Health Policy					
Vaccine Index		0.913***			
		(-3.999)			
Months breastfed		0.785***			
		(-46.91)			
Mom heard of ORT		0.968	0.799***		
		(-0.594)	(-5.002)		

Clinic Delivery		0.803			
		(-1.230)			
Wealth					
Wealth Index				0.960**	
				(-2.328)	
Piped water				0.750***	
				(-3.024)	
Well				0.913	
				(-1.488)	
Latrine/toilet				0.871**	
				(-2.205)	
'Good' floor				0.932	
				(-1.249)	
Geography					
Malaria					1.108
					(0.285)
Rain					0.986
					(-1.541)
Rain squared					1.000
					(0.826)
Elevation					1.000**
					(-1.965)
Acrisols					0.875
					(-1.129)
Nitosols					0.792*
					(-1.941)
Planosols					1.008
					(0.0706)
Cambisols					0.971
					(-0.212)
Ferralsols					0.795
					(-0.677)
Lithosols					0.769**
					(-2.546)
Fluvisols					0.870
					(-0.950)
Arenosol					0.618
					(-1.407)
Regosol					0.655**
					(-2.147)
Vertisol					0.611***
					(-3.405)
svy98	1.090	1.000	1.055	1.073	1.076
	(1.643)	(-0.00284)	(1.009)	(1.342)	(1.415)
Observations	27,082	22,403	27,082	27,082	27,082
chi2	83.65	2477	106.4	140.4	131.7
N_fail	3242	2633	3242	3242	3242

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table VI: Cox proportional hazards regression results for risk of child mortality with all control variables (Hazard ratios reported with z-values in parentheses; standard errors corrected for clustering at the village/town level)

	(1) No Health Policy	(2) No Wealth A	(3) No Geography A	(4) All A	(5) No country dummy	(6) No HP B	(7) No Wealth B	(8) No Geography B	(9) All B
Côte d'Ivoire	1.748***	1.125	1.297**	1.195		1.871***	1.789***	1.863***	1.847***
	(3.936)	(0.748)	(2.063)	(1.094)		(4.719)	(4.579)	(5.783)	(4.634)
Burkina Faso	1.399***	1.281**	1.416***	1.288**		1.404***	1.387***	1.495***	1.393***
	(3.037)	(2.414)	(3.932)	(2.328)		(3.463)	(3.614)	(5.179)	(3.391)
Togo						1.278**	1.277***	1.263***	1.274**
						(2.574)	(2.589)	(2.757)	(2.553)
Health Policy									
Vaccine Index		0.964	0.964	0.964	0.951**				
		(-1.467)	(-1.475)	(-1.442)	(-2.066)				
Months breastfed		0.797***	0.797***	0.796***	0.796***				
		(-37.89)	(-38.59)	(-38.37)	(-38.36)				
Clinic Delivery		0.906	0.914	0.903	1.046				
		(-0.527)	(-0.481)	(-0.542)	(0.768)				
Mom heard of ORT		1.057	1.059	1.060	0.980		0.940	0.953	0.951
		(0.952)	(0.971)	(0.993)	(-0.117)		(-1.289)	(-1.018)	(-1.048)
Wealth									
Wealth Index	0.964*		0.977	0.975	0.983	0.976		0.975	0.977

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	(-1.811)		(-1.153)	(-1.236)	(-0.853)	(-1.318)		(-1.451)	(-1.298)
Piped water	0.893		0.882	0.875	0.924	0.879		0.887	0.882
	(-0.962)		(-0.975)	(-1.024)	(-0.615)	(-1.245)		(-1.158)	(-1.208)
Well	0.998		1.057	1.042	1.079	0.966		0.977	0.969
	(-0.0346)		(0.793)	(0.609)	(1.125)	0.976		(-0.400)	(-0.541)
Latrine/toilet	0.983		1.034	1.075	1.077	0.983		0.940	0.986
	(-0.228)		(0.434)	(0.853)	(0.874)	(-0.262)		(-0.975)	(-0.216)
'Good' floor	0.937		0.982	0.995	0.948	0.940		0.945	0.945
	(-0.989)		(-0.249)	(-0.0734)	(-0.754)	(-1.116)		(-1.031)	(-1.018)
Geography									
Rain	0.992	0.980		0.979*	0.972**	0.993	0.991		0.992
	(-0.714)	(-1.592)		(-1.651)	(-2.534)	(-0.817)	(-0.967)		(-0.860)
Rain squared	1.000	1.000		1.000	1.001**	1.000	1.000		1.000
	(0.701)	(1.562)		(1.560)	(2.241)	(0.634)	(0.741)		(0.672)
Malaria Prevalence	2.119*	1.695		1.627	2.174*	1.360	1.323		1.363
	(1.774)	(1.205)		(1.081)	(1.931)	(0.811)	(0.755)		(0.819)
Elevation	1.000	1.000		1.000	1.000	1.000	1.000		1.000
	(-0.492)	(-0.228)		(-0.373)	(0.250)	(-1.393)	(-1.365)		(-1.377)
Acrisols	0.961	1.105		1.081	0.954**	0.915	0.898		0.919
	(-0.319)	(0.812)		(0.618)	(-2.253)	(-0.763)	(-0.936)		(-0.726)
Nitosols	0.800	0.900		0.891	1.103	0.884	0.872		0.882
	(-1.348)	(-0.662)		(-0.727)	(0.818)	(-1.045)	(-1.168)		(-1.059)
Planosols	1.030	1.093		1.093	0.903	1.050	1.050		1.053
	(0.250)	(0.689)		(0.683)	(-0.635)	(0.425)	(0.427)		(0.447)
Cambisols	0.993	1.049		1.044	1.125	0.972	0.992		0.975
	(-0.0514)	(0.366)		(0.328)	(0.904)	(-0.203)	(-0.0595)		(-0.183)
Ferralsols	1.064	1.279		1.321	1.073	1.015	0.999		1.020
	(0.203)	(0.699)		(0.801)	(0.548)	(0.0475)	(-0.00253)		(0.0651)
Lithosols	0.732**	0.885		0.887	1.317	0.788**	0.785***		0.789**
	(-2.312)	(-0.841)		(-0.827)	(0.810)	(-2.539)	(-2.588)		(-2.530)
Fluvisols	0.905	0.790		0.803	0.866	0.897	0.910		0.897
	(-0.931)	(-0.907)		(-0.865)	(-0.994)	(-1.015)	(-0.955)		(-1.040)
Arenosol	0.707	1.039		1.063	0.718	0.704	0.698		0.706
	(-0.979)	(0.121)		(0.187)	(-1.298)	(-1.082)	(-1.128)		(-1.069)
Regosol	1.125	1.361		1.342	1.099	0.855	0.863		0.856
	(0.336)	(0.662)		(0.642)	(0.291)	(-0.506)	(-0.499)		(-0.505)
Vertisol	0.653***	0.664**		0.672**	1.392	0.681***	0.678***		0.682***
	(-2.893)	(-2.121)		(-2.077)	(0.707)	(-2.837)	(-2.900)		(-2.828)
svy98	0.998	1.009	1.011	1.001	0.662**	0.989	0.985	0.992	0.982
	(-0.0468)	(0.154)	(0.182)	(0.00945)	(-2.222)	(-0.217)	(-0.295)	(-0.153)	(-0.353)
Other Characteristics[23]	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	22,721	22,403	22,403	22,403		27,130	27,082	27,082	27,082
chi2	1067	2735	2811	2847		1196	1131	1161	1187
N_fail	2681	2633	2633	2633		-29569	3242	3242	3242

[23] These include: multiple birth dummy, female dummy, whether mother perceived child as small or very small at birth (for cols 1-5), first in birth order (BO), second BO, third BO, fourth BO, fifth BO, sixth BO, seventh BO, eighth BO, short preceding birth interval (BI), long preceding BI, very long preceding BI, no succeeding BI, short succeeding BI, long succeeding BI, very long succeeding BI, mother's height for age, mother's BMI, mother's age at birth, age at birth squared, mother's education, rural, Catholic, Muslim, Protestant, log population density, log distance to road.

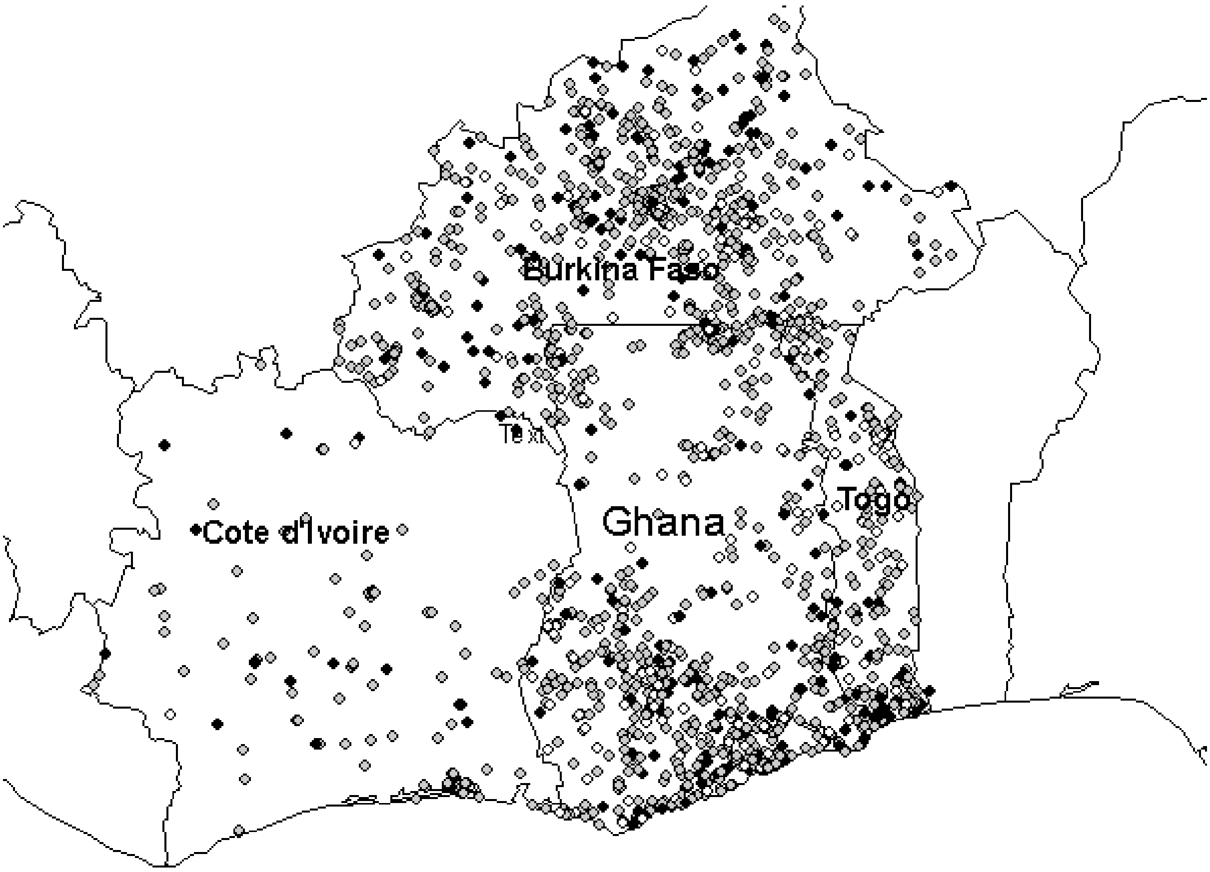
Figure 1: Cluster level under-five mortality

Legend:

◆ high

◆ medium

◇ low



Appendix: Summary Statistics for 'Other Characteristics' (means with standard deviations in parentheses; asterisks indicate results from t-tests for equality of means across countries)

	Ghana/Burkina Faso	Ghana/Côte d'Ivoire	Ghana/Togo
Multiple birth	.025(.15)/.019(.14)***	.025(.15)/.021(.14)	.025(.19)/.027(.16)
Female child	.50(.50)/.49(.50)	.50(.50)/.50(.50)	.50(.50)/.50(.50)
'small' at birth	.16(.37)/.16(.37)	.16(.37)/.16(.37)	.16(.37).20(.40)***
Birth order – 1st	.23(.42)/.18(.39)***	.23(.42)/.25(.43)	.23(.42)/.18(.38)***
2nd	.19(.39)/.16(.37)***	.19(.39)/.19(.39)	.19(.40)/.16(.37)***
3rd	.15(.36)/.14(.35)	.15(.36)/.15(.35)	.15(.36)/.15(.36)
4th	.13(.33)/.13(.33)	.13(.33)/.11(.32)	.13(.33)/.13(.34)
5th	.10(.30)/.10(.30)	.10(.30)/.10(.30)	.10(.30)/.12(.32)**
6th	.08(.27)/.09(.29)***	.08(.27)/.07(.26)	.08(.27)/.09(.29)**
7th	.06(.23)/.07(.26)***	.06(.23)/.05(.21)	.06(.23)/.07(.25)***
8th	.04(.19)/.05(.22)***	.04(.19)/.04(.19)	.04(.19)/.04(.20)
Higher	.04(.19)/.07(.25)***	.04(.19)/.05(.22)	.04(.19)/.05(.23)***
Mother's HtA	2803(2567)/4010(2789)***	2803(2567)/3150(2697)***	2803(2567)/2807(2750)
Mother's BMI	21.94(3.62)/20.86(2.85)***	21.94(3.62)/22.91(3.91)***	21.94(3.62)/21.59(3.15)***
Mother's age at birth	19.89(3.75)/18.74(2.92)***	19.89(3.75)/18.53(3.60)***	19.89(3.75)/19.27(3.74)***
'some' education for mother	.38(.48)/.07(.25)***	.39(.48)/.25(.43)***	.39(.48)/.07(.26)***
Rural	.75(.43)/.84(.36)***	.78(.41)/.43(.49)***	.78(.41)/.79(.41)
Catholic	.14(.35)/.21(.41)***	.15(.35)/.21(.40)***	.15(.35)/.19(.40)***
Protestant	.13(.34)/.05(.22)***	.13(.34)/.13(.34)	.13(.34)/.05(.22)***
Other Christian	.39(.49)/0(0)***	.39(.49)/0(0.00)***	.39(.49)/.10(.30)***
Muslim	.17(.38)/.57(.50)***	.14(.35)/.44(.50)***	.14(.35)/.16(.37)***
Traditional	.08(.26)/.14(.34)***	.10(.30)/.22(.41)***	.10(.30)/.39(.49)***
No religion	.09(.28)/.03(.16)***	.10(.30)/n/a	.10(.30)/.10(.30)
Ln population density	4.93(1.47)/4.09(.90)***	4.99(1.40)/5.05(1.81)**	4.99(1.40)/4.65(1.27)***
Ln distance to road	.78(1.47)/.60(1.37)***	.79(1.50)/-.36(1.65)***	.79(1.50)/.63(1.38)***