

**Environmental and Socio-demographic Risk Factors of Childhood Mortality:
Evidence from Longitudinal Surveillance Data**

Kubaje Adazu
CDC/KEMRI Health and Demographic Surveillance System
P. O. Box 1578
Kisumu, Kenya
Kadazu@ke.cdc.gov

Michael J. White
Population Studies and Training Center
Brown University

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Contact information:
Michael J. White
Population Studies and Training Center
Brown University
86 Waterman Street
Providence, RI 02912
Michael.White@brown.edu

ABSTRACT

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In this paper we investigate the determinants of infant and child mortality in a rural sub-Saharan setting, exploiting several years of data from longitudinal demographic surveillance in the area. Our objective is to contribute to knowledge by presenting empirical evidence on the extent to which environmental and socio-demographic risk factors influence child survival outcomes. Our study population lives in the Kassena-Nankana district of northern Ghana, noted for its high infant and child mortality rates. We use multivariate hazard models to help disentangle the effects of these risk factors on infant and child mortality. Our results point clearly to effects of individual and household level covariates, and they further implicate contextual and environmental conditions, such as season, urban residence, and female migration, even in this relatively homogenous population. We find, among other things, that male children, and children of parents with limited education and mothers who are rural-rural migrants are disadvantaged. We conclude that a better understanding of the several forces underlying childhood mortality could help intervention program managers to target children who are most vulnerable, especially in settings with a high incidence of preventable infectious diseases.

Environmental and Socio-demographic Risk Factors of Childhood Mortality: Evidence from Longitudinal Surveillance Data

Introduction:

In the discourse on the subject of childhood mortality, the assumption has been that the majority of children in Sub-Saharan Africa and other parts of the developing world die from preventable infectious diseases, the causes of which can largely be explained by biological, social, and environmental factors. Our objective in this paper is to contribute to this discourse by presenting empirical evidence, derived from longitudinal surveillance data, on the extent to which environmental and socio-demographic risk factors influence child survival outcomes in the Kassena-Nankana district of northern Ghana. In the 1990s triple digit infant and child mortality rates characterized the district. Through the provision of better healthcare services, infant and under-five mortality rates have declined from 129.1 and 147.2 to 84.7 and 82.9 deaths per 1,000 live births, respectively over the decade (Binka et al, 2007). Although the situation is much better than it was a decade ago the level of childhood mortality is still quite high. Therefore disentangling the effects of environmental and socio-demographic risk factors of mortality could lead to a better understanding of the forces underlying childhood mortality and help child survival intervention program managers to prioritize and target children who are at most risk. We also exploit the richness of these data to show the influence of migration and seasonality.

The Navrongo experience took place in a national experience of high, yet declining infant and child mortality. Through the concerted efforts of the national government and support from external governmental and non-governmental donor agencies, the past four decades witnessed considerable decline in infant and child mortality in Ghana. For example infant mortality rates in the period 1984-1988 were estimated from the Demographic and Health Survey to be 83.8 per 1,000 live births (GSS, 1994). By 2003 the DHS-based national estimate of infant mortality was 64.3 per 1,000 live births (GSS, 2004).

Indeed, infant and child mortality rates in the Kassena-Nankana district rank among the highest of any district in Ghana, and life expectancy at birth is far below the national average. For example, life expectancy at birth for this district in 1995 was estimated to be 47.1 years for males and 49.3 years for females (Binka et al, 1999). Estimated life expectancy for the whole country for the same period was 54.2 years for males and 57.8 for females (United Nations, 1997). The population experiences mortality risks that are characteristic of rural populations elsewhere in Sub-Saharan Africa. The major causes of death are malaria, diarrhea, respiratory infections, and measles. The district also experiences periodic outbreaks of meningitis. These major causes of death, particularly among young children, are exacerbated by nutritional and environmental factors that compromise the natural resistance to infectious diseases, and by social and economic factors that diminish affordability and accessibility to modern health care.

The Kassena-Nankana district has a long history of temporary seasonal and permanent out migration to the cities and towns in southern Ghana. The district is characterized by a long dry season. The rainy season is generally concentrated in the period May to October and this has partly contributed to the seasonal migration. Movement out of the district is pronounced after the harvest in November while in-migration is highest in May, just before the onset of the rainy season. Circular migration within the district is also very common. Some migrant parents entrust the care of their children to extended family members while they are away in the cities or in other parts of the district whilst others move with their children.

Studies in Ghana and elsewhere in Sub-Saharan Africa have shown repeatedly that the prevalence of some of the major killer diseases varies considerably by season (Koram et al, 2003; Bairds et al, 2002; Owusu-Agyei et al.; Bouvier et al, 1997). There is also considerable amount of literature on socio-demographic differences in childhood mortality (Brockerhoff and Hewett, 2000; Blakely, et. al., 2003; WHO, 2003;). However, in the context of the Kassena-Nankana district no study has yet attempted to tease out the effects of the environment from the

effects of the socio-demographic risk factors of infant and child mortality. Secondly and more importantly, no study in Ghana has used longitudinal data to investigate the effects of environmental and socio-demographic risks factors on early childhood mortality.

Using longitudinal surveillance data we attempt in this paper to unravel the effects of the environment at both the household and community level from the effects of other risks factors associated with mortality in one of the rural districts in northern Ghana. The main hypothesis of the paper is that in rural settings such as the Kassena-Nankana district, social, demographic and environmental factors all influence infant and child mortality. Therefore teasing out the environmental effects from the social and demographic risk factors would not only lead to a better understanding of the forces underlying childhood mortality, but could immensely help program managers implement more appropriate child survival interventions in high-risk areas. For example, knowledge of social groups that are exposed to high risk in particular communities or seasons could be very useful to managers, who can then direct limited program resources toward social groups that are more vulnerable (INDEPTH, 2005).

Background

The Kassena-Nankana district is in the Upper East region, spanning 1,675 square kilometers of semi-arid grassy land on Ghana's northern border with Burkina Faso, (Figure 1) with a population of about 150,000. The Upper East region is one of the poorest regions of Ghana. The level of economic deprivation has greatly hampered efforts to improve health conditions in the Kssena-Nankana and other districts in this region. Rainfall is limited, restricting cultivation to a single growing season. The main crops cultivated are groundnuts, millet and sorghum. Just before the harvest of the early millet in July food is usually scarce and many families are unable to meet their food requirements. Consequently nutritional adversity,

particularly among children, is prevalent in this district, exacerbating the mortality impact of infectious disease morbidity.

Figure 1: Map of Ghana



The population is predominantly rural except for those living in the district capital. The rural population lives in dispersed settlements. In the rural settlements the houses, generally referred to as compounds, are built with mud and roofed by mud, thatch or corrugated zinc. The compounds are usually surrounded by farmlands and typically consist of related individuals from several generations. Two distinct ethno-linguistic groups, the Kassem and Nankam speaking groups, make up over 90% of the population. Despite this dual-linguistic identity, the Kassena-Nankana are in most respects a homogenous group with a common culture.

Levels of educational attainment and literacy, particular for women, are low. For example literacy rate among women in the district in the 1990s was about 12% (Binka, et. al. 1995) while the national estimate of female literacy rate for 1995 was 54% (Adlakha, 1996). The low literacy rate among women in the Kassena-Nankana district is partly due to low female enrollment in school and partly due to high early school dropout among women.

Data

The data used for the analysis in this paper came from the Navrongo Demographic Surveillance System (NDSS). The NDSS is a longitudinal population registration system launched by the Navrongo Health Research Centre (NHRC) in July 1993 to support studies of the determinants of morbidity, mortality and fertility in a predominantly rural population in northern Ghana. Professional interviewers do the data collection. The interviewers visit every compound (housing unit) in the study area in a 90-day work cycle, and record basic demographic events such as deaths, pregnancies, births, migrations and marriages in registers, and report the data to the NHRC for computerization, checking, and reporting. The 90 days cycle was chosen as an interval that is short enough to minimize recall lapses, but long enough for all data collected in the field to be processed and reported in the cycle of work of the NHRC. A number of such demographic surveillance systems exist worldwide. Most focus on a district-sized population, involve complete enrolment of that population, regular tracking of key vital events and health outcomes, and 3-4 full interviews per year with more limited data collected for socioeconomic characteristics (INDEPTH, 2002).

In Navrongo the The 90-day cycle system of reporting is supplemented by community key informants. The key informants are residents of the community who are appointed by the Navrongo Health Research Center in consultation with the people of the various communities to register pregnancies, births and deaths of all children under 10 years of age. Each community key informant is provided with a register to record the events of interest as they occur and is paid for each event that he or she correctly reports. Field supervisors visit the community key informants once every two weeks and extract, verify, and pay for events recorded since the last visit and this information is used to update the surveillance data.

The field supervisors also conduct verbal autopsies for all child deaths reported by the community key informants and the professional interviewers. The verbal autopsies are done using a questionnaire designed by the NHRC to elicit answers on the cause of death from the person who took care of the child before it died. The recording of pregnancies by the community key informants and the professional interviewers, combined with the follow up verbal autopsies have significantly improved the reporting of neonatal mortality, particularly the deaths that occur at birth. The NDSS also collects household relations and compound level information. All compounds and individuals are assigned unique identification numbers and this makes it possible to define household relations.

Most of the data on infant and child mortality in Ghana and other African settings come from retrospective cross-sectional surveys. Some infant deaths, particularly neonatal deaths, are often missed in these surveys. Inaccurate reporting of timing of events and age heaping are other problems commonly associated with retrospective survey data (Klerman, 1993). These problems are considerably mitigated in the Navrongo setting through pregnancy surveillance, issuing of birth certificates, close supervision and frequent retraining of interviewers, and data feedback procedures. This carefully designed system of data collection coupled with the continuous surveillance of the study population has resulted in a high level of completeness and accuracy in the recording of births and infant deaths in the NDSS. Although the NDSS generates data of high quality, it has its limitations. To minimize the risk of respondent fatigue, information is collected on a limited number of covariates.

For this analysis, we selected all children in the NDSS born between January 1, 1994 and June 30, 1998¹. We then linked these children to their mothers, fathers, and compounds of

¹ Although the surveillance was inaugurated in mid-1993, field procedures were not fully scaled up and comprehensive until January 1994.

residence using the permanent identification numbers of the parents and the compounds of residence and extracted information on the characteristics of the parents and the compounds.

Analytical Method

Survival and multivariate event history analyses were used to examine the effect of socio-demographic and environmental risk factors on mortality in the Kassena-Nankana District. The survival analysis was employed to investigate the distribution of the survival probabilities by maternal age and level of education. We make use of surveillance data from 1 January 1994 through 30 June 1998. Our sample includes all 18,806 children born in that interval. In this analysis we created a duration variable to capture the period of observation for each child. Duration was computed from the date of birth and date of exit for children who left the district either through death or migration. For those children who died, the duration is date of death minus date of birth. For those children who were still alive and residing in the district as of June 30, 1998, the period of observation was computed using the date of birth and June 30, 1998. For children who migrated out of the district, duration is from birth to date of departure. In addition to the time variable we also created a censoring variable to indicate whether they experienced the event of interest (child mortality) or were censored through out-migration or the end of the observation period. We then used these two variables together with the other covariates to model survival. We use the STATA statistical package for descriptive life tables and multivariate analysis, as described below.

It is well established that causes of death and their determinants change as the child grows older (DaVanzo, 1983; Boland et. al. 1996). Thus we further employed three multivariate event history models to investigate the effects of these risk factors on survival in the first month of life, the first year of life conditioned on surviving the first month, and after the first year

conditioned on survival through the first year. We employed event history models rather than conventional regression models because these models have the capacity to handle censored data. Most of the observations in the data that were used for this analysis are censored. Approximately 14% of the children in the sample migrated out of the study area before the end of the period of observation (June 30, 1998). Hence their survival status after the end of the period of observation was unknown. Simply treating these cases as missing and excluding them from the analysis would bias the parameter estimates. Of those who remained in the district, 86% were alive as at the end of the period of observation, and thus were also censored at the end of the period of observation. With this huge number of censored cases, the data can be best analyzed with event history models.

Specifically the piecewise constant exponential hazard model was used. This model takes into consideration duration and it does not require the hazard of death to be constant nor monotonic through out the whole period as required by some other event history models. With this model the period of observation is divided into smaller intervals. The hazard is allowed to vary across intervals but within an interval the hazard is assumed to be constant. The hazard for an individual i at time t in interval j under the piecewise constant exponential model is usual written as follows: $h_i(t) = \lambda_j(t) \exp\{\beta X_i\}$ for $\alpha_{j-1} \leq t < \alpha_j$. Where, λ_j, β are parameters to be estimated and X_i a set of covariates.

We transform the data to multiple records per child. In all, three new data files are generated from the original data corresponding to each major sub-period: one for the neonatal period; one for the first year of life; and one for those who survived the first year). In the analysis of the neonatal period we limit the survival time to the first 28 days of life and transform the data into person-weeks format. Children who survived beyond four weeks are censored on

the 28th day. In this file a child contributes between one and four records, depending on how long the child was observed.

The second file (post neo-natal infancy) is created for the purpose of estimating the impact of the various risk factors on mortality in the first year of life conditioned on survival through the first month. Hence the data is transformed into person-months format. The period of observation starts from the 29th day and ends on the 365th day. All children who died or were taken out of the study area within the first 28 days after birth are therefore excluded. Children who survived beyond the 365th day are censored on the 365th day, while those who migrated out after the 28th day but before the 365th day are censored on the day they exited. The data is then transformed from a single record per child to multiple records per child. A child contributed up to 11 observations depending on whether the child was alive and residing in the study area by the 365th day after birth. In all 17,779 children were selected and from this number 168,692 observations were generated. Observations are again excluded for months after which a death or out-migration occurs. For those children who were temporarily taken out of the district but returned, the time periods lived outside were also excluded.

As in the cases of the two files described above, the file created for the investigation of the impact of the risk factors after the first year of birth also contain multiple records per child. In this file the period of observation begins from the 366th day after birth and it is a person-“half-year” format. In other words the period of observation is broken down into intervals of six months. All children who died or migrated out of the study area before the 366th day after birth were excluded. Children who migrated out of the study area on or after the 366th day were censored and the date of exit and date of birth were used to compute the duration of observation. Children who were alive and still residing in the Kassena-Nankana district as of 30th June 1998

were censored and the duration of observation was computed using the date of birth and 30th June 1998. Depending on the age of the child and the time of exit a child contributed between one and eight observations. Based on the selection criteria outlined above a total of 12,469 cases were selected from the 18,806 births and used to generate 46,230 observations. Observations for months after which a death occurs and time spent outside of the district are excluded from the analysis.

Variables

In the multivariate models the dependent variable is the hazard of death which is modeled as a function of the explanatory variables. Several explanatory variables are included, reflecting both environmental and socioeconomic traits. Some covariates are fixed while others are time-varying. We discuss here these key variables and some of their expected effects.

The season in which a child is born may increase or decrease the risk of death. The study population lives in a malaria endemic area. In the dry season there are few water sources for the breeding of mosquitoes, the vector through which the malaria parasite is transmitted. Thus transmission is lower in the dry season than in the rainy season. An attempt is therefore made to test for the effects of seasonality by including dummy variables in the models to represent the season of birth.

Zinc roof, coal-pot, and the level of education of the father and mother were included in the model as proxies for household socioeconomic status. Zinc roof is a very good measure of socioeconomic status. By Navrongo standards, corrugated roofing sheets are very expensive and those who can afford to roof their houses with corrugated roofing sheets are generally considered to be of higher socioeconomic status. Coal-pots (metal cooking stove for charcoal) are relatively cheap but cooking with a coal-pot is a deviation from the traditional mode of cooking (stone with

firewood). It therefore serves as an indicator for modernization and a proxy for improved hygiene. These indicators of household well-being and modernization are expected to predict lower mortality.

There are very few mothers in the sample that have higher than middle school education, so we created two dummy variables for mothers' education. The dummy variable primary education was coded one for those with less than seven years of schooling (primary education in Ghana is six years), and zero otherwise. The other dummy represented mothers with post-primary education and was coded one for those who had more than six years of schooling and zero otherwise. Fathers' education was also represented by two dummy variables, namely, primary and post primary and defined as in the case of mothers. Higher levels of education among both mothers and fathers are expected to be associated with lower mortality, as more educated individuals have better health awareness and better communication skills with health staff. Recent work in the literature from other data sources would lead one to expect that mother's education should be particularly influential (Blakely, et al., 2003).

The age of the mother is treated as a categorical variable and represented by a dummy coded one if the mother was a teenager at the time she gave birth to the child and zero otherwise. Sex and place of residence are categorical variables and are represented by dummy variables. Sex is coded one if the child is a boy and zero otherwise. Our expectations are uncertain. On the one hand, we expect for biological reasons, males to exhibit higher neonatal mortality (Davanzo et al, 1983). On the other hand local Kassena-Nankana customs might be seen to favor males. In Ghana generally there is no evidence of sex preference linked to differential mortality (GSS, 2004). Place of residence is coded one if the child resides in the district capital (Navrongo town) and zero otherwise. Worldwide, urban residence is generally associated with lower mortality.

Yet the salutary effect of urban residence has been questioned for the case of sub-Saharan Africa (NRC, 2003) Since Navrongo town is a modest-sized locale, it will be of interest to see if an urban effect appears in our data. If so, it would reinforce the view that even a modest level of urbanization could shift morbidity and mortality outcomes.

Migration is treated as a time varying covariate. The duration window is divided into sub-spells with the value set for the migration status of the mother at the beginning of each spell. Migration is represented by two dummy variables, urban-rural-mother and rural-rural-mother. Urban-rural-mother is coded one if the mother migrated out of the district before or at the beginning of a spell, and zero otherwise. The dummy variable rural-rural-mother is coded one if the mother migrated to another part of the district before or at the beginning of a spell but never migrated out of the district, and zero otherwise. A woman is considered to have migrated if she stayed away from the regular compound of residence for 90 consecutive days. The 90 days is based on the NDSS residency requirement.

Empirical Findings

Descriptive Statistics

Summaries of the distribution of deaths in the first year of life by selected covariates are shown in Table 1 below. Between January 1, 1994 and June 30, 1998 we use a total of 18,806 births registered in the NDSS. Data quality is quite high; there were only three cases in the data with inconsistent or blank dates. We excluded 249 cases, (less than 1.5% of the births registered in the NDSS in the five year period), because their mothers were most likely visitors (they had no unique identity numbers and thus had not met the three months continuous residence rule). Of our sample of births used for the analysis 14.2% died before attainment of their fifth birthday. Although the surveillance system was inaugurated in July 2003, registration

was not fully comprehensive in July-Dec 2003 (confirmed by our tabulations), so our observation window opens in 2004.

The results in Table 1 suggest a negative relationship between mortality and maternal education. Approximately 12% of the children of mothers with no education or primary education died in the first year compared about 7% of children whose mothers' had at least middle school education. A similar relationship is observed in the case of fathers. Maternal age also appears to be negatively associated with child mortality. The results suggest that children of teenage mothers are at greater risk of death in the first year of life. One other striking result is the difference in mortality by place of residence. Children residing in Navrongo town appear to have about half the first-year mortality as those living in the rural portion the district.

Table 1: Distribution of Deaths in the first year of life by selected covariates

Covariate	No of children	% Dead by year one
Socio-demographic Factors		
Sex of Child		
Male	9,335	14.28
Female	9,471	13.62
Age of Mother		
Teenager	1,704	16.67
Non-teenager	17,102	13.68
Education of Mother		
None	16,111	14.49
Primary	1,435	13.10
Post-primary	1,260	7.94
Migration Status of Mother		
Non-migrant	9,547	14.01
Rural-migrant	5,062	15.25
Urban-migrant	3,197	12.22
Education of Father		
None	13,478	14.88
Primary	1,184	12.67
Post-primary	1,889	8.21
Unknown	2,255	13.88
Household SES		
Zinc roof	7,149	12.37
No zinc roof	11,657	14.92
Coal pot	9,609	12.62
No coal pot	9,197	15.33
Environmental Factors		
Season of Birth		
Nov-Jan	4,053	13.10
Feb-Apr	5,210	12.32
May-Jul	4,724	14.46
Aug-Oct	4,819	15.92
Place of Residence		
Rural Navrongo District	18,090	14.28
Navrongo Town	716	5.45

Seasonality in Births and Under-Five Mortality in KND

The distributions of births and deaths by calendar year and month (Figures 2 and 3) for the period 1994 to 1998 in the Kassena-Nankana District suggest a seasonal pattern in these two events. Births are elevated in April-May and September-October, while deaths show a single peak in October-November. One other striking thing in the mortality graphs is that mortality in the month of March 1997 was exceptionally high compared with the mortality levels for this month in other years. This exceptionally high mortality recorded in March 1997 was probably due to the outbreak of cerebrospinal meningitis in the Upper East region during that period.

Survival Analysis

We first investigated effect of gender on survival (Figure 4). Given the patrilineage and descent customs of the Kassena-Nankana there is the potential for boys to be favored over girls. However the results of this analysis do not show any statistically significant differences in the survival chances between boys and girls; if anything there is slightly higher mortality among males. There is no evidence to suggest selective gender discrimination.

From the survival curves shown in Figures 5 through 7, education, place of residence, and maternal age appear to be good predictors of child survival in the Kassena-Nankana district. Children born to teenage mothers have lower survival chances compared with those whose mothers are not teenagers. As expected, children of mothers with post-primary education have an advantage over those whose mothers have only primary or no education at all. The Kassena-Nankana district is generally considered to be rural. The wide difference in survival between children residing in the district capital (Navrongo), which has some semblance of urban area, underscores the importance of urbanization in child mortality as observed by other studies.

Figure 2: Births by Month in KND (Jan 1994-June 1998)

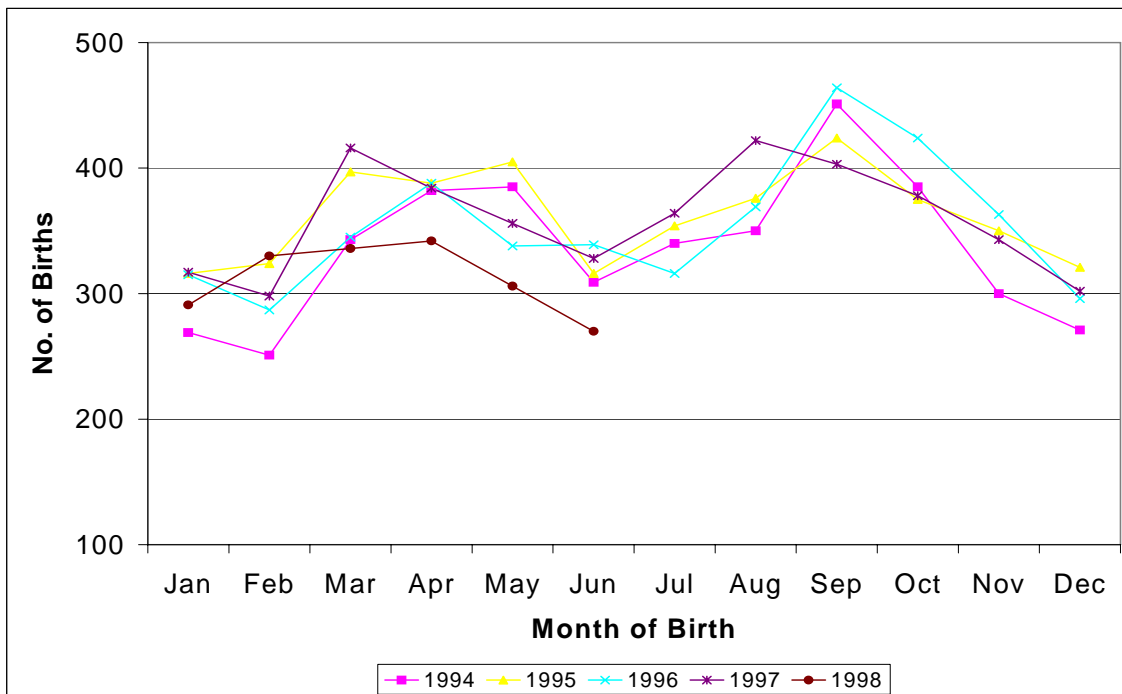


Figure 3: Infant and Child Deaths by Month in KND (Jan 1994-June 1998)

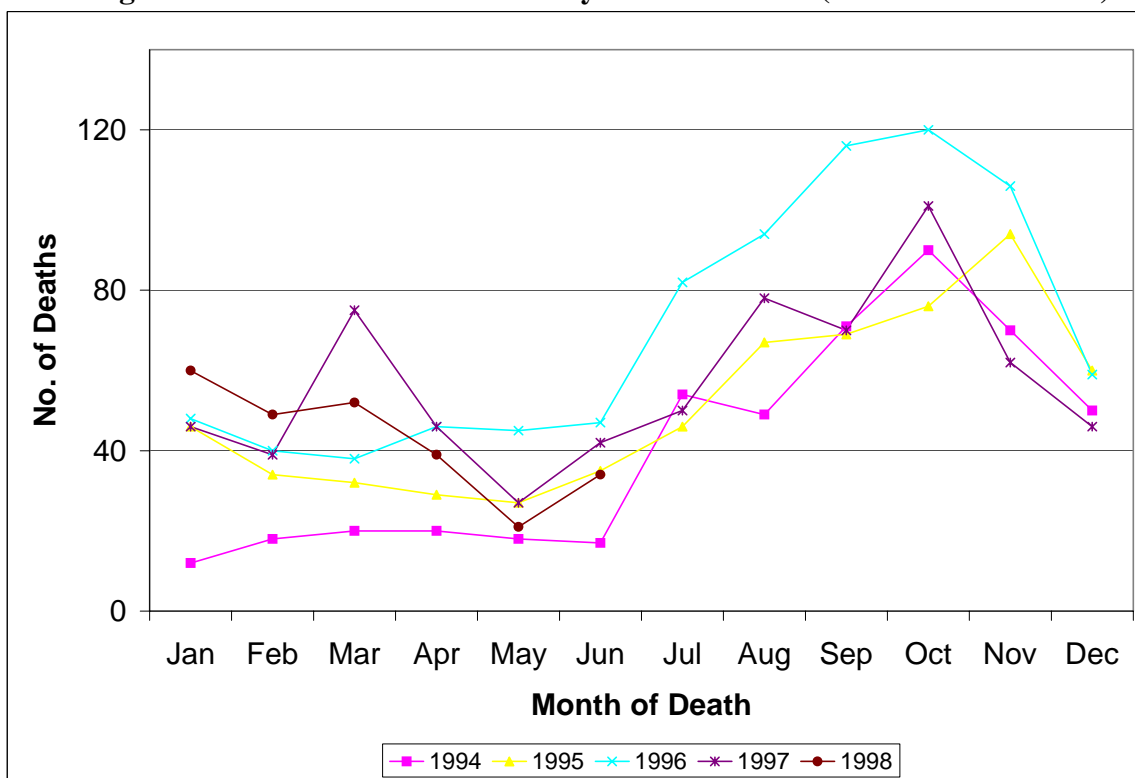


Figure 4: Survival Probabilities by Gender

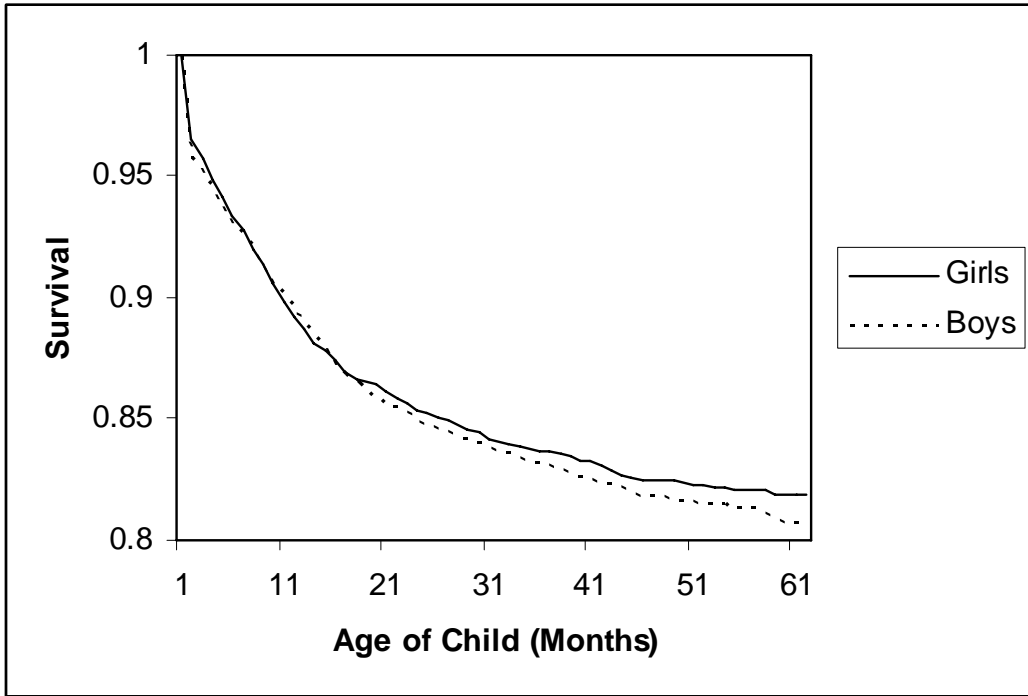


Figure 5: Survival Probabilities by Age of Mother

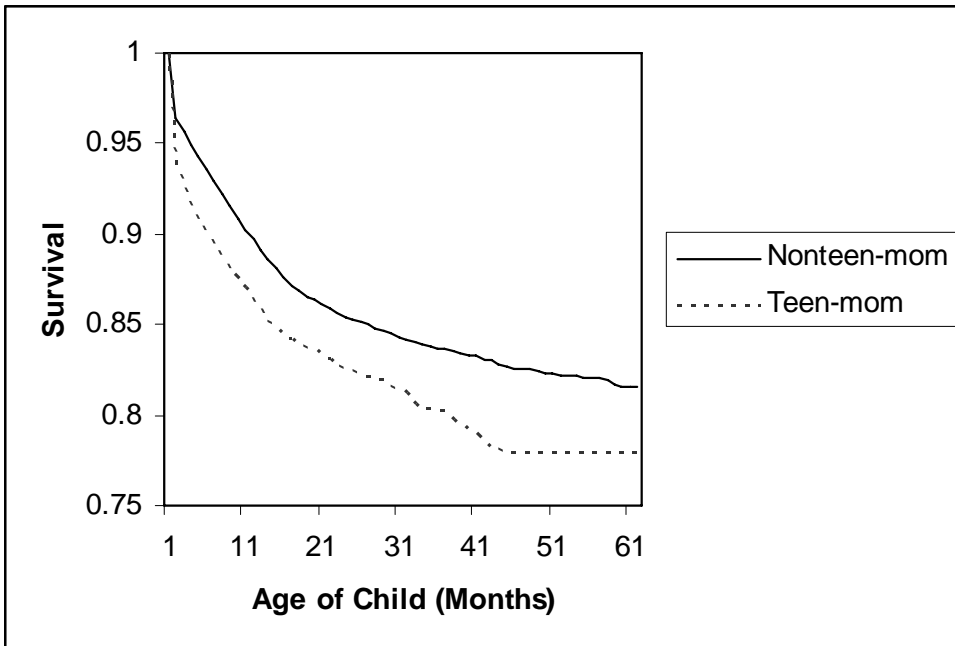


Figure 6: Survival Probabilities by Education of Mother

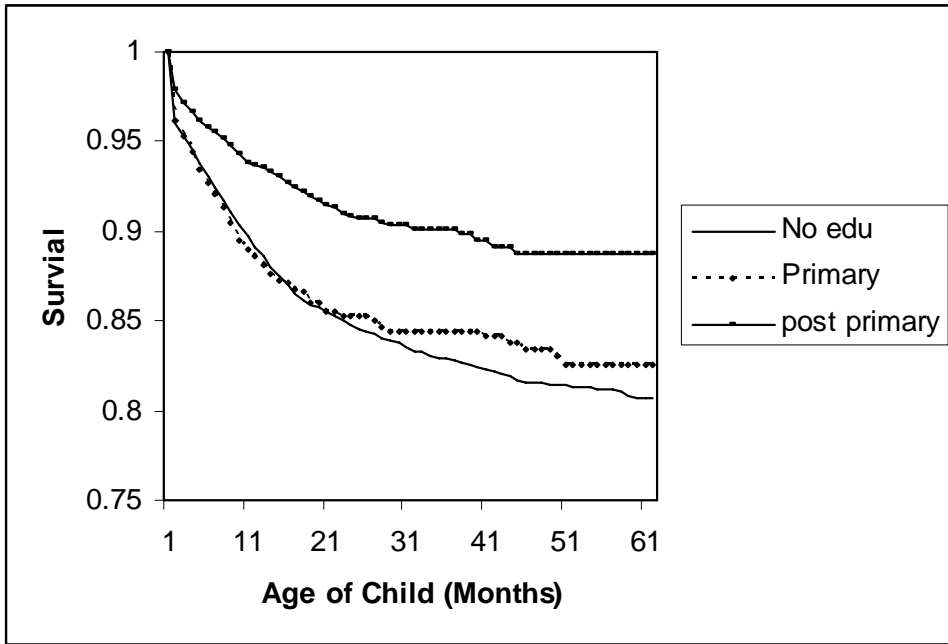
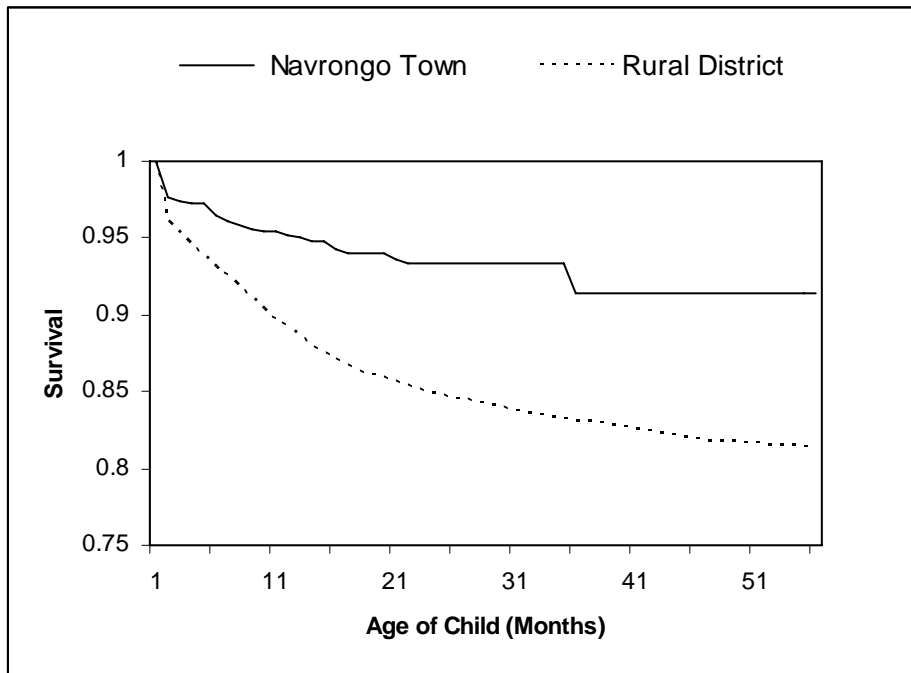


Figure 7: Survival Probabilities by Place of Residence



Multivariate Analysis

We now include the entire set of covariates in the discrete time logit model. We present these multivariate analysis for all three childhood periods (neonatal, post-neonatal infancy, child 1-4) in Table 2. Recall that population of children at risk is conditional on survival to the start of the duration indicated for each period of childhood.

Table 2: Effect of Socio-demographic and Environmental Factors on Mortality in the Kassena-Nankana District of Ghana, 1994-1998

Covariate	<i>Neonatal Mortality</i>		<i>Post-Neonatal Mortality</i>		<i>Childhood Mortality</i>	
	H. R	S.E	H. R	S.E	H. R	S.E
Socio-demographic Factors						
Sex of child (Male)	1.29 ***	0.10	0.87 **	0.05	1.20 **	0.09
Age of mother (Teenager)	1.81 ***	0.20	1.10	0.11	1.08	0.16
Mother with P. edu.	0.93	0.13	1.23 *	0.13	0.72 *	0.14
Mother with post p. edu	0.59 **	0.12	0.78	0.12	0.74	0.15
Coal pot	0.87 *	0.07	0.91 **	0.06	0.92 *	0.08
Father with p. edu	0.82	0.13	0.96	0.11	0.86	0.15
Father with post p. edu	0.74 **	0.11	0.66***	0.08	0.49 ***	0.09
Rural migrant mother	1.16 **	0.10	1.02	0.08	1.14	0.12
Urban migrant mother	0.88	0.09	0.91	0.07	0.90	0.11
Environmental Factors						
Zinc Roof	0.91	0.08	0.87 ***	0.06	1.08	0.09
Urban residence	0.83	0.22	0.49 **	0.12	-----	-----
Nov-jan	1.24 *	0.13	1.04	0.09	0.83	0.10
May-july	0.97	0.11	1.28 ***	0.10	1.15	0.12
Aug-oct	1.39 **	0.14	1.24 ***	0.10	1.00	0.11
N of subjects (births)	18806		17779		12469	
Person-time units of obs.	72974		168692		46230	
LL	-3895.2		-5231.4		-2770.4	

* p<0.10; **p<0.05; ***p<0.01

Note: Not shown are year-specific dummy variables for 1995-1998 in all equations and age dummies (24-36 mos; 37-60mos.) for childhood mortality.

Sex of the child emerged as a strong predictor of mortality. There is ample evidence in the biomedical literature suggesting that, except where there is gender discrimination in favor of boys, the risk of death in infancy is generally higher for boys (WHO, 2003). Consistent with this general finding, the results of this analysis show that in the first month and after the first year of life, the risk of death among boys in the Kassena-Nankana is much higher than that for girls. Surprisingly, among children who survived the first month of life the hazard of death before the first birthday for girls is much higher than that for boys. One plausible explanation for the significant gender differential in the post-neonatal stage is a selection effect: frail boys die in the neonatal period whereas leaving behind more robust males.

Once other factors are controlled the age of the mother matters only for neonatal mortality. For instance, being the child of a teenage mother versus being the child of a non-teenage mother is associated with 80% increase in the hazard of death in the first month of life, whereas in the post-neonatal and childhood stages being the child of a teenage mother is associated with 10% and 8% increase in the hazard of death respectively. Several possible factors might be responsible for the relative higher risk of death among babies of teenage mothers. First, teenage mothers are likely to be inexperienced in child-care, and where family support is not readily available the children of teenage mothers are likely to be exposed to a greater risk of death. Second, teenagers have a higher propensity to give birth to pre-term (Hamisu et al, 2006) or low birth weight babies (Golding and Shenton, 1990), which in turn lowers survival chances. Further more, first births are known to have a higher mortality rate than subsequent births and most teenage births are first births. Finally, malaria could be another contributory factor to the high mortality among children of teenage mothers. Malaria is endemic in this district (Binka, et al. 1996), and malaria attacks during pregnancy, particularly in first

pregnancies, are known to have significant impact on the development of the fetus with negative consequences for the survival of the baby (Cite).

In the Kassena-Nankana district, as in many other places, education (particularly maternal education) significantly reduces the risk of death in infancy. As expected, the children of educated mothers have better chances to survive the first five years of life, the most critical period in the life of a child. However, the effect of education depends on the level attained by the mother. For example, compared with children whose mothers have never been to school and holding constant the migration status of the parents, the age of the mother, and sex of the child, the hazard of death in the first month of life for children whose mothers had at least middle school (post-primary) education is reduced by about 41% whereas the hazard for those whose mothers have only primary education is reduced by 7%. Among those who survived the first month, the hazard of death before the first birthday for children born to mothers with at least middle school education is reduced by 22% and that for children of mothers with only primary education is increased by 23%. The hazard of death for children whose mothers have at least middle school is not only lower than that of children whose mothers have no education at all but the differences are statistically significant. Fathers' education is also negatively associated with mortality and varies by the level attained. Children of fathers with post- primary education have a much better chance of surviving in all three childhood periods than those whose fathers have only primary education or no education at all. Specifically, children of educated fathers have a 26% reduced chance of neonatal mortality; a 34% reduced hazard of post-neonate mortality; and a 51% reduced hazard of later childhood mortality, all of which are highly significant.

The better survival chances of children of educated parents might be a result of better knowledge of prenatal and post-natal care and easy access to and utilization of modern health

care facilities. Education might also influence child health outcomes through increasing skills, knowledge and the ability to deal with new ideas (Caldwell, 1979). Literacy enables parents to easily gather information about causes and ways to prevent illnesses from written sources thereby increasing their repertoire of knowledge about child health. Literate parents can read written instructions from medical personnel for treating childhood illnesses. Hence they can easily follow any written prescribed treatment regimen for their children. Education also empowers parents, particularly women, to demand better health services for their children from medical and health personnel.

Seasonality is clearly influential in determining life chances of children. The Kassena-Nankana district is characterized by two contrasting seasons, a dry season from November to April and rainy season from May to October. The period from mid-August to early September is usually the season of heavy torrential rainfall. Consequently we divide the wet season (May-October) into two intervals to coincide with the period before the heavy rains (May-July) and the period during and shortly after the heavy rains (August-October). The dry season (November-April) was also divided into two intervals (November-January and February-April) to coincide with the cold and hot months of the dry season. Children born between February and April, the hottest period in the district, were used as the reference group.

Table 2 indicates that children born in August-October or in November-January (the cold period of the dry season) experience higher mortality in the first month of life. The seasonal effects are most pronounced in the post neonatal period, with elevated mortality in May-July and August-October. This is consistent with elevated risk following rainfall and the increased presence of vectors. One plausible explanation for the weaker seasonal effects in the neonatal stage is that in the first month babies are kept in doors and therefore have least interaction with

the environmental factors associated with season. In years 1-4 of life, we find no appreciable seasonal effect.

Place of residence is well known to be a good predictor of childhood mortality. For instance, the reports of the Ghana Demographic and Health Surveys (GDHS 1998, GDHS 2003)) showed substantial rural-urban differentials in infant and child mortality. Although the Kassena-Nankana district is generally referred to as rural, Navrongo town, the district capital has some semblance of an urban area. Thus in this study an attempt is made to test for the effect of place of residence. As expected, the results of the analysis (Table 2) show that residing in the district capital decreases the risk of death in the first month of life. For instance, urban residence (residing in the district capital, Navrongo) is associated with 17% reduction in neonatal mortality. But despite the magnitude of the effect of place of residence, it is not statistically significant. Effects of urban residence on post-neonatal residence are quite large, lowering expected hazard rates but about 50%. We cannot estimate urban effects for ages 1-4 because Navrongo town was only enrolled in the surveillance system in 1995.

The impact of female migration on childhood mortality in the Kassena-Nankana district depends on the type of migration. The risk of death in the first month of life among children of urban migrant mothers was less than that of children of non-migrant mothers, although this differential was not significant. The risk of death in the first month of life was significantly higher (16%) for children of rural-rural migrant mothers compared with children whose mothers have not migrated at all. The mortality pattern observed in the first month persists as the children grow older. For example, amongst the children who survived the first month, children of rural-rural migrant mothers continue to experience higher mortality (although not significant) children of urban migrant mothers continue to experience about 10% lower mortality (although

again not significant) in the first year and after the first year of life. These differences are suggestive of residential history effects (and associated social changes) on child health outcomes

Urban exposure of women could bring about behavioral changes that may either increase or reduce the risk of death in infancy amongst children of migrant mothers. For instance exposing women to urban settings through migration could lead to changes in child-raising practices that may contribute to improving the survival chances of children. On the contrary, urban exposure could result in the abandoning of traditional practices such as prolonged breast-feeding which are beneficial for the health and survival of children. From some studies it is known that urban exposure of women is associated with lower infant and child mortality. For example, using data from the Demographic and Health Surveys, Brockerhoff (1989) found that children of rural non-migrant mothers are more likely to die than children of rural-urban migrant mothers resident in urban areas. Brockerhoff attributed the rural-urban migrant versus rural non-migrant mortality differentials to migrant selectivity. In other words rural women who had lower child mortality had a greater propensity to migrate.

The empirical evidence from this analysis does not show any significant differences in the level of mortality amongst children of mothers who have ever migrated to an urban area and children of mothers who have never been to an urban area, although the risk of death for the children of the migrant mothers is slightly lower. One important distinction between this study and Brockerhoff's is that in this study the comparison is between children of rural non-migrant mothers and children of rural-urban migrant mothers resident in the rural place of origin. In other words, this study is comparing the survival outcomes of children of returned rural-urban migrant mothers with children whose mothers have never migrated at all.

In contrast to rural-urban migration, female rural-rural migration is positively associated with infant and child mortality. The mortality differentials observed between children of rural-rural migrant and rural non-migrant mothers may be explained in terms of social integration. It is probably that because these women are not well integrated socially that is why they are so mobile. This therefore suggests a selection process. One other probable explanation of the high mortality among children of rural-rural migrant mothers is that female rural-rural migration might be tapping into the negative consequences of domestic conflicts on children.

Anecdotal evidence from the field shows that conflict between husband and wife or the wife and the parents of the husband is one of the reasons why some women move back and forth between the marital and natal homes. In the event of conflict, some mothers leave their children behind while others move with their children back to the natal home. Such instability may compromise child care and produce negative health consequences for children. In any case marriage migration and other rural-rural migration may weaken social networks that may indirectly benefit the mother's ability to care for her children. From other studies elsewhere in Africa (Kiros and White, 2003) it is known that children of rural-rural migrant mothers had inferior health outcomes compared with children of rural non-migrant mothers. The results of this analysis therefore conform to what has been documented in the literature on migration and child mortality

Part of the variation in mortality in infancy is due to variation in household socioeconomic status (INDEPTH, 2005). Hence in addition to testing for the effect of place of residence we also tested for the effects of household socioeconomic status on mortality. Though our measures for household socioeconomic status (zinc roof and coal-pot) are not very refined, the results are quite illuminating. Children born in compounds that use coal pot to cook are less

likely to die in infancy compared with those born in households that do not have coal pot. The inclusion of Zinc roof produces mixed results. The effect of zinc roof is significantly associated with lower mortality in the post neonatal stage but it is not significant in the neonatal and childhood stages.

Conclusion

This paper has sought to investigate the impact of socio-demographic and environmental factors on childhood mortality in a rural district of northern Ghana, using data from an ongoing longitudinal surveillance survey. This approach has several advantages. The surveillance data we employ has complete coverage of the community and close monitoring (and therefore presumed accurate) of vital events. Surveillance data are superior for identifying temporal sequences and timing of infant and child mortality. In turn this allows us to capture seasonality in health outcomes; in fact, we find a strong seasonal pattern in the Kassena-Nanakana district.

We also find education, place of residence and the age of the mother at the time of birth of the child to be very strong predictors of early childhood mortality. Notably this finding occurs even in a setting often seen to be relatively homogeneous. Being the child of educated parents versus being the child of uneducated parents significantly reduces the risk of death in infancy. Children of teenage mothers have an exceptionally high risk of dying in the first month of life. Although the whole district is generally regarded as a rural area, children residing in Navrongo town have far better chances of surviving to adulthood than children residing in the villages in the outskirts of the district. The fact that socioeconomic factors show through in a rural somewhat homogeneous setting underscores the potential influence of social traits in a broader more diverse setting (INDEPTH, 2005).

The results of the analysis also revealed that rural-rural migration of mothers was associated with higher early childhood mortality whilst urban migration of mothers was associated with lower mortality. This may be linked to the fact that such migrant mothers are removed from some of their natal community networks for information and social support. Our finding parallels that of Kiros and White, who find that children of rural-rural migrant Ethiopian women are less likely to receive immunization in (Kiros & White, 2004).

Estimating the effect of the various risk factors of early childhood mortality in the Kassena-Nankana district using surveillance data posed some methodological challenges because surveillance data gathered from a population as mobile as that of the Kassena-Nankana district is inevitably beset with censored cases. Given the fact that migrants are a self-selected group and some of the factors that select the migrants may be unobservable poses yet another methodological challenge when one is contemplating investigating the impact of migration on childhood mortality. These methodological problems were overcome by employing event history models.

This paper has demonstrated the value of collecting longitudinal surveillance data and the value of such data for exploring and testing the underlying forces driving childhood mortality in rural settings, such as the Kassena-Nankana district. The findings of this paper have also underscored the value of extending surveillance data collection to include more socioeconomic traits. At the same time we have demonstrated that, even in a single rural district under surveillance – often presumed to be a rather homogenous setting – such socioeconomic traits can help predict health outcomes. Thus, the collection of a wider array of socioeconomic data in surveillance settings, combined with the intrinsic temporal richness of the data, holds great promise for deepening our understanding of the factors influencing child health and survival.

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