Can Community Health Services Offset the Effect of Poverty and Low Maternal Educational Attainment on Childhood Mortality? Evidence from the Navrongo Experiment in Northern Ghana.

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Abstract: The Government of Ghana has instituted a National Poverty Reduction Program with an initiative known as the Community-based Health Planning and Services (CHPS) as its core health development strategy. Originally launched as an experimental project of the Navrongo Health Research Centre, CHPS is currently a national initiative for shifting the focus of primary health care from clinics to communities. Four contrasting strategies of community health care were tested. In response to early evidence that community nursing could impact on survival, CHPS was launched to scale up the Navrongo community health service delivery system. The program currently functions in over 1000 villages dispersed in all 172 districts of Ghana. This paper presents a longitudinal demographic survival histories of 17,967 under age five children who were observed over the July 1993 to December 2010 period. Analysis of trends show that placing nurses in CHPS communities was associated with more pronounced mortality declines than was observed in comparison communities. Differentials show that Navrongo study areas exhibit equity relationships that are often observed elsewhere in Africa: Children whose parents are uneducated and relatively poor experience significantly higher mortality than children of the educated and less poor. Time conditional Weibull regression models estimate the impact of CHPS on health equity by estimating the interaction of equity indicators with duration of household exposure to CHPS service operations. Results show that the association of maternal education and poverty with childhood mortality is offset by community exposure to community health nursing services. This finding lends support to policies that promote community health services as a component of poverty reduction programs.

Introduction:

Evidence across Africa has consistently demonstrated the adverse association between low parental educational attainment and child survival, a relationship that is compounded by the effects of relative poverty (Muhuri 1995; Montgomery et al. 2000; Filmer and Pritchett 2001; Gwatkin 2002a; Bawah and Zuberi 2005; Debpuur et al. 2005; Kahn et al. 2005; Nathan et al. 2005). Scientific research has also revealed the impact of community-based primary health care on effectively reducing childhood morality (Pence, et al. 2007; Haines, et al. 2007; Community Directed Interventions Study Group. 2010; Binka et al. 2007). In recognition of these findings, it has been widely assumed that the adverse child-survival effects of poverty and low parental education may be offset by the provision of convenient and inexpensive community village based services (Wallerstein et al. 2011). Community health service delivery has become a central component of policies aimed at improving health equity, as facilitated by

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the provision of non-differential health services across social groups (Lake 2012; Marmot 2007; Victora 2003). Nonetheless, an examination of the mitigating impact of community-based health services on the association between poverty and child survival requir8ues direct appraisal. Such evidence seldom exists.

Despite increased efforts across sub-Saharan Africa to improve health access through the expansion of primary health care systems, the health conditions of many vulnerable populations, especially children, continue to deteriorate (Timaeus 1997a, 1997b, and 1999; Ahmad et al. 2000; Black et al. 2003; Hill 1993) Although modest improvements have been identified, the region continues to lag behind the rest of the world (United Nations 2012; World Bank 2005). Extrapolations of trends also suggest that the Millennium Development Goals (MDGs) for child survival are not on target, as suggested by the sub-Saharan Africa's continuously slow reduction rates (Murray et al. 2007; Sahn and Stifel 2003). Furthermore, controversy also persists regarding the importance of focusing policies on the promotion of specific health interventions versus a systems approach which integrates packages of essential services. Achieving the child-survival MDG may require simultaneous attention to a range of prevalent sources of childhood morbidity, such as diarrheal diseases, malaria, acute respiratory infections, and malnutrition. The concurrent delivery of interventions relies heavily on the strengthening of the entire health system, which has been deemed as a prerequisite for the achievement of all health-related MDGs (Travis et al. 2004). Some proponents of health- systems reform and sector-wide community health services also argue that policies focused on promoting specific health interventions are tantamount to abandoning global social and economic health-equity goals (Magnussen et al. 2004). The child-survival effects of maternal educational attainment have been demonstrated for nearly three decades (Caldwell 1979), but questions persist about the efficacy of community based health care on counteracting their harmful impact (Desai and Alva 1998).

This paper examines the empirical basis for a poverty reduction program focused on community-based primary health care by testing the hypothesis that the presence of such services are able to offset the detrimental effects of poverty and low educational attainment in the impoverished rural setting of northern Ghana. Our research is based on a 1996-2003 quasi-experimental study of the Navrongo Health Research Centre which assessed the health and survival effects of community-based primary health care (Binka et al. 1995; Phillips et al. 2006). The program, referred to as the Navrongo Community Health and Family Planning project, served as a field trial of organizational strategies for the delivery of health care in rural and impoverished settings. Assessment of the direct experimental effects indicated that the placement of nurses directly in communities, equipped with the training and equipment to provide basic primary health care services, could accelerate mortality reduction (Binka et al. 2007) and fertility reduction (Debpuur, et al. 2002). Consequently, these findings lead to the Government of Ghana's formal

adoption of the model for national policy and its eventual scale up across Ghana (Awoonor-Williams, et al. 2010; Nyonator, et al. 2005 and 2008). Currently referred to as the Community-based Health Planning and Services (CHPS) initiative, this community health system continues to operate across the country, with the greatest program coverage found near its origin in northern Ghana.

Poverty has been consistently associated with childhood mortality. Several studies have demonstrated that the burden of disease is highest among the poorest segments of populations (Wagstaff 2000; Kiros and Hogan 2001; Gwatkin 2002b). Children born to impoverished families are more likely to have lower resistance to infectious diseases, be malnourished, be born with a low birth weight, and have micronutrient deficiencies (Wagstaff et al. 2004). The poor are often unable to afford curative care and unaware of the importance of preventive care, including child immunizations (Gadomski et al. 2001; Yazbeck, 2002). Low income is also associated with low education, which only increases the likelihood of exposure (Victora et al. 2003). The poor and less-educated are more unlikely than those who are better off to comply with a medical regimen, enhancing their risk of developing antibiotic resistance (Gwatkin et al. 2005). Maternal education, in particular, has been identified has critical for increasing child survival and decreasing malnutrition (Lee et al. 1197; Panis and Lillard, 1994; Wolfe, 1982). The synergistic nature of poverty and low education therefore results in a reduction of disease resistance and an increase of potential exposure, which impacts children and vulnerable populations the most acutely.

THE SETTING

Demographic and health conditions in Kassena-Nankana District reflect the adverse ecological and economic circumstances of northern Ghana. Prior to the health interventions introduced with the development of the Navrongo Health Research Center, the district had one of the highest mortality levels in Ghana (VAST Study Team 1993). Although health conditions remained poor in the early 1990s, results from the most recent Ghana Demographic and Health Survey (GDHS) indicate that both infant and child mortality have declined in the Upper East region in recent years, while conditions have worsened in all other regions of the country (GSS et al. 2004). Fertility and mortality declines are particularly pronounced in the Kassena-Nankana District (Phillips et al. 2006). Infant mortality declined from 129 deaths per 1,000 live births in 1995 to 85 in 2003, representing a 34 percent decrease, while mortality of children younger than five declined from about 147 to 83 deaths, representing a 44 percent decrease over the period (Binka et al. 2007). Although childhood mortality remains high, and infectious diseases are the predominant cause of deaths, all causes of childhood illness have declined, including malaria, diarrheal diseases, acute respiratory infections, and immunizable diseases (Adjuik et al. 2006).

The social, economic, and geographic circumstances of northern Ghana also constrain the delivery of social and health services. The mobility of health services is restricted by the lack of resources

for facilities, supplies, fuel, and equipment. Services at stationary facilities in the district are underused because the cost of travel and of services and medicines at clinics is prohibitive for most rural families. Consequently, parents confronting their children's illnesses resort either to traditional medicine or self-medication, purchasing medicines from untrained village hawkers.

Tabulations of demographic data from the project show that children who are born to mothers with no educational attainment experience higher mortality risks than other children born to mothers who have some education. Moreover, survival improves as educational attainment increases. Relative household economic status has a less pronounced effect, although children born in families who ranked among the top quintile have higher survival odds then children. These relationships are commonplace elsewhere in Africa. Clearly, children of the less educated and relatively less prosperous are less likely to survive. Even in a locality where there is pervasive and nearly uniform poverty, social and economic differentials affect the survival of children.

The innovations derived from research conducted at the Navrongo Health Research Centre have improved the health situation in Kassena-Nankana District over the past several years, however. Figure 1 shows that the Navrongo study area achieved MDG4 by 2007, that infant mortality also declined, and neonatal mortality decline dramatically as well. Tabulations attest to the importance of regression methods that can estimate the additional effect of Navrongo community health worker exposure, relative to trends in childhood mortality that have been produced by health interventions that have had generalized impact in the study population.

[Figure 1 about here]

THE MODEL

Data used for the analysis presented in this paper are drawn from the Navrongo Demographic Surveillance System (NDSS), a system of continuous assessment of demographic dynamics in Kassena-Nankana District (Binka et al. 1999). In 1993, the entire district's population was enumerated and registered in a relational database. At quarterly intervals since July 1993, field-workers visit all dwelling units in the district to update the information obtained in previous rounds regarding changes in household relationships, births, deaths, in- and out-migration, and pregnancies occurring in each 90-day period.

Data for this paper include information about all 17,967 children born between 1 January 1998 and 31 December 2004. Models for the analysis presented here are based on the survival status of each child at the time of last observation. The analysis estimates parameters of the proportional hazards model, assuming that the hazard rate for childhood mortality is the product of a baseline failure rate, $h_0(t)$, which is a function of time only, and a positive function $g(x, A)$, independent of time, which incorporates the effects of a vector X comprised of covariates, such as household exposure to community-based services,

mother's characteristics (age and educational attainment), and an index of poverty as estimated by the method of principal components. The conditional hazard is given by

$$h(t/\underline{X}) = h_o(t)^{.} g(\underline{X}, \underline{A}),$$

<div align="right">

(1)

</div>

where
  $\underline{X}$ is a row vector consisting of the covariates

$$\underline{X} = (x_{l,} \mathrm{x}_{2,} \ldots \mathrm{x}_m),$$

  $\underline{A}$ is a column vector consisting of the effects of unknown parameters of the model, compounded over T units of time

$$\underline{A} = (a_{l,} a_{2,} \ldots \mathrm{a}_m)^{\mathrm{T}},$$

and where
  m = the number of covariates that are age of child-independent.

Effects of community based care are assumed to accumulate with the incremental exposure of a village to the presence of a nurse in the locality as infancy progresses. Effects are posited to accumulate with child age t, starting with the baseline failure rate given by the Weibull underlying hazard, with "shape parameter" β:

$$\lambda_0 = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1}$$

and the conditional hazard given by

$$\lambda(t, X) = \beta t^{\beta-1} e^{\sum_{j=0}^{m} a_j \cdot x_j}$$

The estimation of the shape parameter β and the vector of regression effects, $\underline{\alpha}$, obtained by the method of maximum likelihood (Therneau and Grambsch 2000), are appropriate for specifying the familiar nonlinear relationship of survival with the advancing months of age of childhood.

In this analysis, standard errors are adjusted for the effect of clustering. There are 175 DSS groups of households comprising units of observation where the posting of nurses and volunteers are monitored over time. Records of worker deployment have been translated into indices of childhood exposure to nurse and volunteer services by cluster.

RESULTS

Figure 2 reports time trends in under-five mortality by experimental cell of the Navrongo Project. As the figure shows, significant mortality declines were evident, even in comparison areas. However, where nurses were posted to community locations, declines were earlier and more pronounced than in other cells of the project. Mortality trends also vary by time point, as reflected by the downward trend in mortality after community-based care was scaled up throughout the study area, starting in 2001 and accelerating with passing time. Both infant and childhood mortality rates decline monotonically, with the onset of declines most evident during the Navrongo project study period and levels converging after the experiment as nurses and volunteers were assigned to communities that were formerly Cell 1 (volunteer only), Cell 2 (nurse only), or Cell 4 (comparison). Thus, as scaling progressed in the post-experimental period, both infant and under-five mortality rates converged at Cell 3 (combined) levels of mortality. These findings are consistent with expectations. Ending the experiment, by posting nurses to communities, reproduced experimental effects even after the completion of the Navrongo Project. However, gauging the net effect of each type of worker posting is obviously confounded by the success of scaling up project activities.

Since trends are confounded by scale-up activities, we gauge net effects of the experiment, by estimating treatment effects in hazard regression models that bring into account the age of child at the time of first exposure of each household to experimental impact. An exposure variable is defined for children exposed to nursing or volunteer services from birth, or from ages over one month or for children over 12 months of age at the time when exposure first occurred. This arrangement brings into account the shifting pattern of operations as cells of the Navrongo experiment were abandoned by scaling up operations throughout the district to what eventually became a district saturated with community-based primary health care coverage.

[Figure 2 about here].

Three models of (1) are estimated with hazard ratios reported in Table 1. As the parameters show, estimated effect exhibit statistically significant effects of educational attainment on childhood survival. Results thus confirm relationships noted in bivariate tabulations. Women with community-based primary health care exposure on child mortality. Model I examines the effects of relative poverty and maternal educational attainment on the risk of dying among children younger than five, controlling for the effect of maternal age at time of the birth of the index child and gender of the index child. Results show that the upper quintile of relative wealth is associated with diminished mortality risks. Moreover, successively increasing levels of maternal education are associated with reduced relative risk. Clearly, relationships portrayed by the effects of poverty and maternal education in Navrongo are consistent with findings reported from elsewhere in Africa.

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The estimated effects of nurse and volunteer posting are also presented in Table 2 (Model 2). Direct effects estimated for the project confirm the hypothesis that community-based nurses, or "CHO" contribute to the reduction of mortality. The net contribution of volunteers, however, contrasts with the benefits that arise from CHO community posting. This finding was originally noted in the analysis of the impact of the project and has been attributed to the effect of syndromic volunteer services on delay in parental health seeking. While volunteers benefit health when they are posted in conjunction with trained nurses, their independent effect is apparently detrimental to health.

But where nurses are posted, their effect is beneficial to child survival. Moreover, as results show, health care offsets the effect of poverty and low maternal educational attainment on child mortality. Results show that introducing community-based care into the model as a hierarchical effect is associated with the disappearance of relative mortality effects, even for the most prosperous quintile. The relative magnitude of community service effects versus poverty effects indicates that community based care has a much greater impact on survival than relative poverty.

Model 2 also attests to the significance of secular trends in mortality that are unrelated to educational attainment of the mother, SES status of the household, or community health service exposure to resident nurses   Results suggest that generalized impact of Navrongo Health Research Centre interventions has been substantial. These effects, such as vitamin A distribution, insecticide impregnated bednet distribution, and the widespread delivery of other preventive and curative care, are the major effect that has been estimated, attesting to the overall impact interventions that is suggested by the trends portrayed in Figures 1 and 2. .

CONCLUSION

Widespread investment in community-based primary health care is often pursued under the assumption that children will benefit, not only from the direct effects of accessible and affordable care, but also from the equity effects of placing services in convenient locations that differentially benefit the poor. This research has provided a statistically rigorous appraisal of this assumption. Indeed, as expected, trained community health nurses posted to community locations provide significant survival benefits to children. Moreover, these effects offset the detrimental effects of low maternal educational attainment and relative poverty. Results demonstrate that Navrongo Project community-based primary health care has had equity benefits.

Results nonetheless challenge conventional wisdom about the homogeneity of community health worker effects. Fully trained and deployed nurses who can provide comprehensive preventative and IMCI services have major effects; but volunteers who are marginally trained to provide component services are less effective than providing no such care at all. Volunteers have beneficial roles that they

can play, if pursued in tandem with professional nurse delivered care, but placing them in situations where they are the sole provider is not supported by the Navrongo results.

Findings nonetheless attest to the survival benefits of community-based primary health care. If the workers involved are trained to provide a broad range of services, their impact can be pronounced, even in situations of great poverty and adversity, such as the setting where the Navrongo project was based. Results therefore lend strong support to Government of Ghana policies that aim to accelerate the scale-up of CHPS, not only as a means of providing health care, but as a vital component of Ghana's poverty reduction program.

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Table 1: Weibull Regression Hazard Ratios for the Effect of Maternal Educational Attainment, Relative Economic Status, and Community Health Worker on Childhood Mortality, Kassena-Nankana 1996-2009				
	Model 1: The equity effect		**Model 2: The treatment effect**	
Variable	**Hazard ratio**	**Z**	**Hazard ratio**	**z**
Gender of child= male	1.062	+2.10*	1.032	+1.10
Maternal age at birth of child	0.996	-10.52**	1.027	+18.67
Maternal educational attainment:				
No education	Omitted		omitted	
Primary only	0.858	-4.05**	-0.954	-1.17
Some secondary	0.780	-4.06**	-0.924	-1.26
Secondary and over	0.677	-3.83**	-00.804	-2.15
Socio-economic status (SES):				
SES, Lowest quintile	Omitted		omitted	
SES, next Lowest quintile	1.060	+1.00	1.052	+0.93
SES, Mid-status quintile	1.038	+0.60	1.031	+0.52
SES, Near highest quintile	1.009	+0.15	1.004	+0.95
SES, Highest quintile	0.858	-1.99*	0.873	-1.81
Never exposed to the experiment	Omitted		Omitted	
First exposed to volunteers after infancy	--	-	1.116	+1.63
First exposed to volunteers after first 28 days	--	-	1.278	+2.92**
First exposed to CHOs at birth or during first 28 days of life	--	-	1.321	+3.82***
First exposed to CHOs after infancy	--	-	0.996	-0.07
First exposed to CHOs after neonatal period	--	-	0.723	-2.55*
First exposed to volunteers at birth or during first 28 days of life	-	-	0.886	-2.35*
Ordinal year of birth, index child	-	-	0.661	-23.98**
Summary statistics:				
Wald chi square (d.f.)	217.92	(9)**	1010.82	(16)**
Number of subjects	45,383		45,383	
Time at risk	49,383,022		49,383,022	
Log pseudo-likelihood	-17230.2	***	-16845	***
*p<0.05 **p<0.01 ***p<0.001				

Figure 1: Time trends in neonatal, infant and under-5 mortality rates (q_5), rural communities of Kassena-Nankana East and West Districts, 1996- 2010
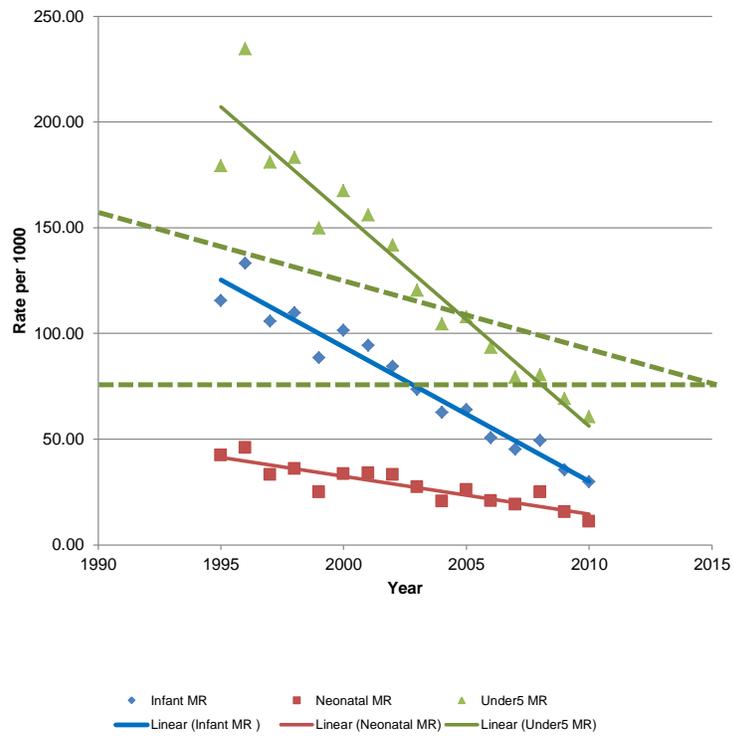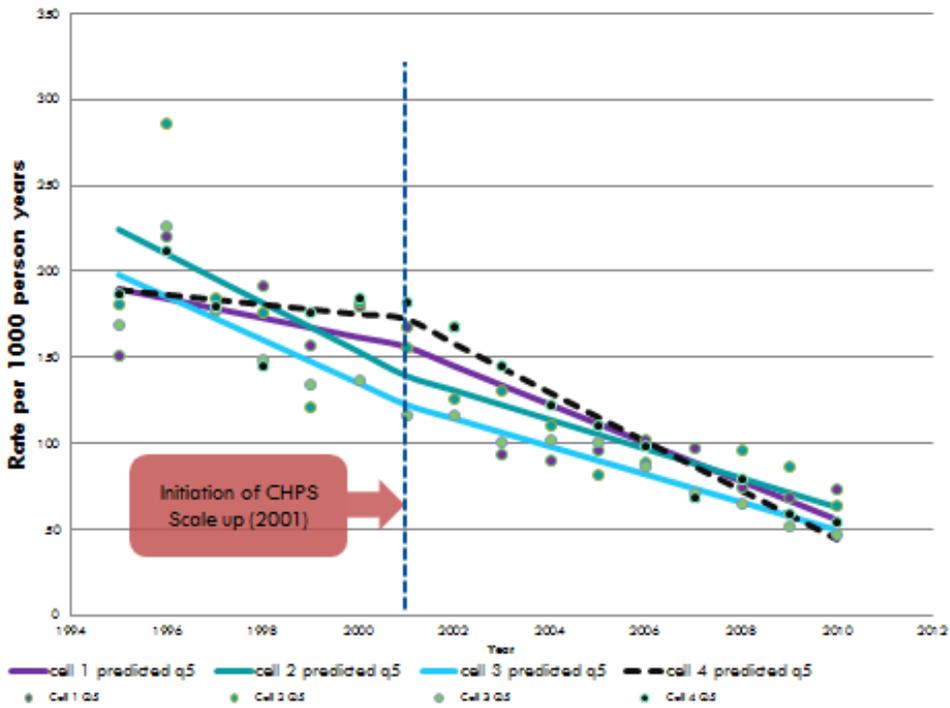
Figure 2: Infant and Childhood Mortality Trends by Navrongo Project Cell, 1995 -2010

Trends in infant mortality rates:
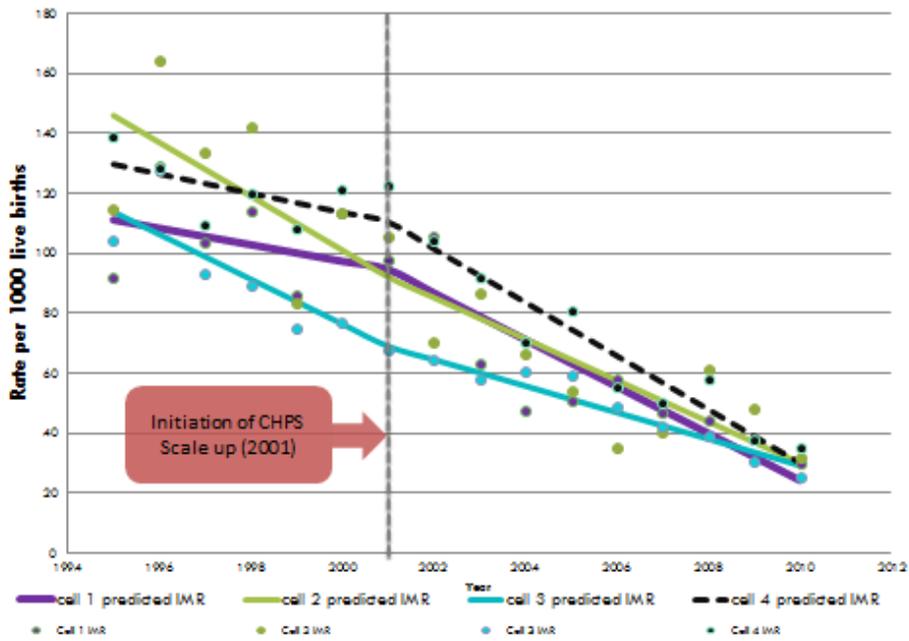
Trends in the probability of death among under-5 children:

Legend: Cell 1 (volunteer only): Cell 2 (nurse only):

Cell 3 (combined): Cell 4 (comparison):

Attainment on Childhood Mortality? Evidence from the Navrongo Experiment in Northern Ghana.

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Abstract: The Government of Ghana has instituted a National Poverty Reduction Program with an. mortality is offset by community exposure to community health nursing services. This finding lends support. to policies that promote community health services as a component of poverty reduction programs. motherâ€™s characteristics (age and educational attainment), and an index of poverty as estimated by the method of principal components. The conditional hazard is given by.

$$h(t/X) = h_o(t) \cdot g(X, A), \quad (1).$$