Article

Does the provision of community health services offset the effects of poverty and low maternal educational attainment on childhood mortality? An analysis of the equity effect of the Navrongo experiment in Northern Ghana

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A R T I C L E   I N F O

A B S T R A C T

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. CHPS was derived from a plausibility trial of the Navrongo Health Research Centre testing four contrasting primary health care strategies: i) Training unpaid volunteers to promote health in communities, ii) placing nurses in communities with training and supplies for treating childhood illnesses, iii) combining the nurse and volunteer approaches, and iv) sustaining a comparison condition whereby clinic services were provided without community resident workers. This paper presents an age-conditional proportional hazard analysis of the long term impact of community health worker exposure among 94,599 children who were ever under age five over the January 1, 1995 to December 2010 period, adjusting for age conditional effects of shifts in exposure type as CHPS was scaled up in Navrongo project area over the 1995–2000 period. Results show that children whose parents are uneducated and relatively poor experience significantly higher mortality risks than children of the educated and less poor. Conditional hazard regression models assess the impact of CHPS on health equity by estimating the interaction of equity indicators with household exposure to CHPS service operations, adjusting for age conditional exposure to original Community Health and Family Planning Project (CHFP) service strategies as scale-up progressed. The association of mortality risk among children with uneducated and relatively impoverished mothers is offset by exposure to community health nursing services. If exposure is limited to volunteer-provided services alone, survival benefits arise only among children of relatively advantaged households. Findings lend support to policies that promote the CHPS nurse approach to community-based services as a core health component of poverty reduction programs.

1. 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 (Bawah & Zuberi, 2005; Debpuur, Wontuo, Akazili, & Nyarko, 2005; Filmer & Pritchett, 2001; Gwatkin, 2002; Kahn, Collinson, Hargreaves, Clark, & Tollman, 2005; Montgomery, Gragnolati, Burke, & Paredes, 2000; Muhuri, 1995; Nathan et al., 2005). Scientific research has also established that community-based primary health care can effectively reduce childhood mortality (Baqui et al., 2008; Binka et al., 2007; Community Directed Interventions Study Group, 2010; Freeman, Perry, Gupta, Rassekh, & Rassehk, 2008; Haines et al., 2007; Pence, Nyarko, Phillips, & Debpuur, 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 (Bawah et al., 2010; Wallerstein & Duran, 2006, 2010; Wallerstein, Yen, & Syme, 2011). This is because, when services are taken to the doorsteps of every resident in the community, then the detrimental effect of poverty and education, which may create disparities in both financial and geographic access between the rich and the poor, may be mitigated. Community health service delivery has become a central component of policies aimed at improving health equity, as facilitated by the provision of non-differential health services across social groups (Lake, 2012; Marmot, 2007; Victora et al., 2003). Nonetheless, an examination of the mitigating impact of community-based health services on the association between poverty and child survival requires direct appraisal. Such evidence seldom exists.

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 (GBD, 2016; Wagstaff, 2002; Wagstaff, Bustreo, Bryce, & Claeson, 2004). Children born to impoverished families are more likely to have lower resistance to infectious diseases, higher odds of malnutrition, relatively low birth weights, and elevated risk of micronutrient deficiencies (Kiros & Hogan, 2001). The poor are often unable to afford curative care and unaware of the importance of preventive care, including child immunizations (Gadomski, Black, & Mosley, 1990). Low income is also associated with low education, which only increases the likelihood of exposure to a variety of health risks (Victora et al., 2003). The poor and less-educated are less likely than those who are better off to comply with a medical regimen, enhancing their risk of developing antibiotic resistance (Gwatkin, Bhuiya, & Victora, 2004). Maternal education, in particular, has been identified as critical for increasing child survival and decreasing malnutrition (Lee, Rosenzweig, & Pitt, 1997; Panis & Lillard, 1994; Wolfe & Behrman, 1982, 1987). The synergistic nature of poverty and low education therefore results in a reduction of disease resistance and an increase of potential exposure to multiple risks, which impact differentially on children and vulnerable populations most acutely.

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 have not witness the desired level of improvement (Stevens et al., 2012; United Nations, 2015). And, while modest improvements have been identified since the 1990s, the region continues to lag behind the rest of the world (Stevens et al., 2012; The World Bank, 2016; United Nations, 2015). Most countries in sub-Saharan Africa could not achieved the Millennium Development Goals (MDGs) target on child survival owing to the slow pace of mortality reduction in the region (Hawkes & Fanzo, 2017; United Nations, 2015). 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 (Hawkes & Fanzo, 2017). The current Sustainable Development Goals (SDGs) have reiterated targets for achieving childhood mortality reductions (United Nations, 2016). However, achieving this require simultaneous attention to a range of prevalent sources of childhood morbidity, such as diarrheal diseases, malaria, acute respiratory infections, malnutrition and addressing inequalities in access to care (Hawkes & Fanzo, 2017; Liu et al., 2015; Requejo & Bhutta, 2015; United Nations, 2015). 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, Ehiri, & Jolly, 2004). The child-survival effects of low 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 & 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 primary health care services can offset the detrimental effects of poverty and low educational attainment in an impoverished rural setting of northern Ghana. Our research is based on a quasi-experimental study of the Navrongo Health Research Centre that was implemented during the 1996–2003 period which assessed the health and survival effects of community-based primary health care (Binka, Nazzar, & Phillips, 1995; Phillips, Bawah, & Binka, 2006). The program, referred to as the Navrongo Community Health and Family Planning project (CHFP), 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 and fertility reduction (Binka et al., 2007; Debpuur et al., 2002; Phillips, Jackson, Bawah, & Williams, 2012). 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., 2004; Nyonator, Akosa, Awoonor-Williams, Phillips, & Jones, 2008; Nyonator, Awoonor-Williams, & Phillips, 2011; Nyonator, Awoonor-Williams, Phillips, Jones, & Miller, 2005). 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 (Awoonor-Williams et al., 2013). It has often been suggested that the CHPS program is a poverty reduction strategy but until now there is no empirical evidence of this assertion. This paper provides empirical evidence on the contribution CHPS to mitigating the effects of poverty and low parental education on childhood mortality.

2. Materials and methods

2.1. 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 and in Ghana as a whole in recent years (Ghana Statistical Service, 2015). In addition to interventions implemented in the Upper East region aimed at reducing childhood mortality, the decline could also have arisen because of general improvements in socioeconomic conditions in the country. Even in the 1990s and early 2000s, fertility and mortality declines were particularly pronounced in the Kassena-Nankana District (Phillips et al., 2006). Infant mortality declined from 129 deaths per 1000 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; Streatfield et al., 2014).

The social, economic, and geographic circumstances of northern Ghana also constrain the delivery of social and health services. The terrain makes transportation for health services difficult at all times, and impossible seasonally when the dry river beds in the area flood. 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 involving the purchase of 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 than children in the lower four quantiles. These relationships are commonplace elsewhere in Africa. It is evident that 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.

$$hx(t) = h_0(t)e^{[\beta_1 G_i + \sum_{j=1}^{J} \gamma_j M_{ij} + \sum_{k=1}^{3} \delta_k X_{ikt} + \sum_{l=1}^{L} \theta_l P_l + \sum_{m}^{2} \vartheta_m S_m + \sum_{k=1}^{3}\sum_{l=1}^{L} X_{ikt}P_l + \sum_{k=1}^{3}\sum_{m}^{2} X_{ikt}S_m]}$$

(1)

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. Fig. 1 shows that the Navrongo study area achieved MDG4 by 2007, and that infant and neonatal mortality declined dramatically as well, throughout the entire study area. Regression methods are required in order to estimate the additional effect of Navrongo community health worker exposure, relative to trends in childhood mortality produced by health interventions that have had generalized impact in the study population.

2.2. 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 (Oduro et al., 2012). 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. Computer systems developed for this application permit continuous management of data integrity and the computation of daily risk of demographic

Fig. 1. Time trends in neonatal, infant and under-5 mortality rates ($_0q_5$), rural communities of Kassena-Nankana East and West Districts, 1996–2010.

events among all individuals who are registered in the database (Phillips, Macleod, & Pence, 2000).

Although the period of the experiment span 1996–2003, the data for this paper include information from about 94,599 children who were ever under 60 months of age under observation between 1 January 1995 and 31 December 2010. We extended the observation period of analysis to 2010 because it would afford us the opportunity to examine the long-term effects of the program. The analysis presented here is based on the survival status of each child at the time of last observation. Time at risk for a given child is calculated as that child's exact age in days. 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 survival time such that

where:

G_i = 1 if child i is female,

M_{ij} = Dummy variable for the jth maternal age class at the time of birth of child i for J maternal age categories,

X_{ikt} = Time variant exposure to volunteers (k = 1), nurses (k = 2), or both (k = 3) for child i at exact age t,

P_l = Birth cohorts for children ever under age 60 months during the observation years 1995–2010, and

S_m = Maternal socio-economic status is defined as the poorest four quintiles (S_1 = 1) versus the least poor (S_1 = 0) and maternal educational attainment is defined as no education (S_2 = 1) versus those who report any years of education (S_2 = 0).

Time variable effects of X are specified by XP to allow for the possibility that treatment changes over time alter the exposure to service relative to the age of each child at the time of exposure change, owing to scaling up policies or worker deployment changes in the demographic surveillance system (DSS) cluster where a given child resides. Children's birth cohorts are modeled in a total of five three-year groupings (born 1996–1998, born 1999–2001, born 2002–2004, born 2005–2007, and born 2008–2010) relative to a baseline cohort of children born between 1990 and 1995. Thus the risk incurred by a given child at exact age t is defined in reference to the timing of treatment exposure as of that child's age in days (Blackstone, Naftel, & Turner, 1986). Maternal age is included as a categorical variable in order to most accurately model the non-linear relationship between maternal age and child mortality.

Effects of community-based care are assumed to be the presence of a nurse or a volunteer in the locality as each individual child ages through the 60 months of childhood. Each sub-district in the study area is divided into several zones that have four alternate community-based health care delivery strategies. Care strategies include a nurse resident at the community level, a community health volunteer program termed Zurugelu (togetherness) at the community level, both a nurse and volunteer program, and, finally, a comparison strategy offering no community-based services. Residents of all areas are served by health clinics at the sub-district level. Our model tests the proposition that equity effects are associated with treatment exposure by including interaction terms for treatment exposure and maternal education and treatment exposure and wealth status. Quintiles of household wealth were established from an index of assets created using principal components analysis (Filmer & Pritchett, 2001). The assets that form the index include the different kinds of materials used in home construction, the
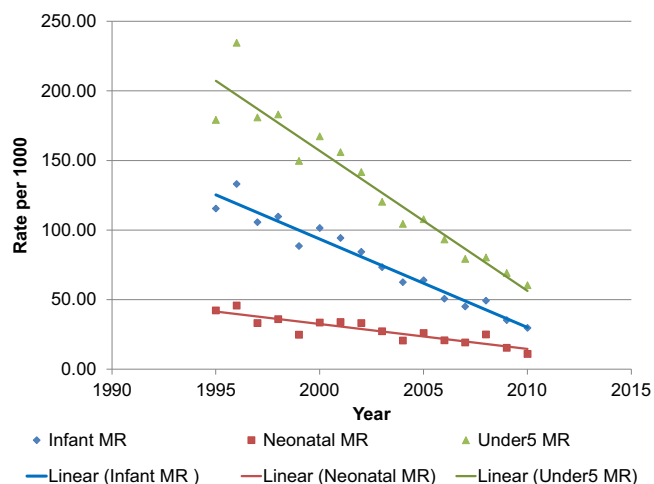
types of animals owned, means of transportation and other household possessions or characteristics that are relevant for identifying relative household wealth. Our model contrasts the four poorest wealth quintiles with the least poor quintile because of wealth homogeneity among the poorest four quintiles.

In this analysis, standard errors are adjusted for the effect of clustering. There are 175 DSS clusters 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 days defining the exact timing of childhood exposure to nurse and volunteer services by cluster.

Owing to the complexity of interactions and their interpretation, we have used model parameters to construct linear combinations of effects and effect measure modifiers to estimate predicted survival rates, their corresponding hazard ratios, and standard errors.

Assessing the long-term equity effects of the Navrongo project is complicated by the scale-up of altered intervention strategies that occurred over time. The comparison area that originally received no community health and family planning services (CHFP) achieved complete coverage with UNICEF volunteers providing integrated management of childhood illness (IMCI) services. These High Impact Rapid Delivery (HIRD) services were also brought to former CHFP nurse-only areas by the year 2003. Nurse services were scaled up in the original volunteer area, and in the original comparison area, without household visitation. Therefore, exposure is measured in our analysis in terms of the original community health and family planning services scaled up between 1995 and 2000. By including interaction terms between child's year of birth and original exposure type in our model, we make it possible to compare mortality effects during the later period from 2000 to 2010 by birth cohort. This allows the analysis to distinguish between the effect of original CHFP services in the original combined cell, original services in other cells, and the contamination with alternative services that began in 2003.

3. Results

Data for this paper include information from about 94,599 children who were ever under 60 months of age under observation between 1 January 1995 and 31 December 2010. Unadjusted mortality rates are presented in the time series graphs that appear in Fig. 1. Mortality declines were pronounced as the combination of nurse and volunteer services was extended throughout the study area. However, gauging the net effect of each type of worker posting is obviously confounded by the success of scaling up project activities. For this reason, interpretation of the Fig. 1 trends requires multivariate modeling.

Linear combinations of the parameters producing the Table 1 hazard ratios are estimated in Tables 2 and 3. Our model demonstrates significant 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, as indicated by the downward trend in mortality by year-of-birth cohort. These results suggest that generalized impact of Navrongo Health Research Centre interventions has been substantial, even in comparison areas of the Navrongo project. What this suggests is that beyond the effects of the CHPF interventions, other interventions such as vitamin A distribution, insecticide impregnated bednet distribution, and the widespread delivery of other preventive and curative care implemented by NHRC had major effects that are suggested by the trends portrayed in Fig. 1 and captured by the period variable "year of birth" in Table 1. In addition, over the period there have been improvements in general socioeconomic conditions that could also be implicated in the circular decline.

Overall, children are more likely to survive to age five among those born to women who have at least some education or women who reside in households representing the upper socioeconomic quintile. These relationships portrayed by the effects of poverty and maternal education in Navrongo are consistent with findings reported from elsewhere

Table 1
Hazard ratios comparing hazard of mortality among 94,599 children who were ever aged 60 months or less over the 1995 to 2010 period and residing in rural communities of Kassena-Nankana East and West Districts, Upper East Region, Ghana.

Covariate:	Model 1		
	HR	P > |z|	95% CI
Female	**0.925**	0.000	(0.885, 0.966)
Maternal Age at child's birth			
Maternal age 10–19	**1.322**	0.000	(1.237, 1.412)
Maternal aged 35–49	**1.139**	0.000	(1.082, 1.199)
Reference (Maternal age 20–34)	1.000		
Exposure to Original CHFP			
Original Zurugelu Exposure	1.035	0.706	(0.866, 1.237)
Original Nurse Exposure	0.995	0.952	(0.849, 1.166)
Original Combined Exposure	**1.155**	0.024	(1.019, 1.310)
Reference (Original No Exposure)	1.000		
Year of birth			
1996–1998	0.938	0.171	(0.855, 1.028)
1999–2001	**0.848**	0.001	(0.770, 0.933)
2002–2004	**0.636**	0.000	(0.572, 0.707)
2005–2007	**0.487**	0.000	(0.432, 0.549)
2008–2010	**0.367**	0.000	(0.313, 0.430)
Reference (1990–1995)	1.000		
SES and education			
Reference (Least poor)	1.116	0.165	(0.956, 1.305)
Poorest			
Uneducated (reference is any exposure to education)	**1.345**	0.000	(1.188, 1.524)
Interaction between year of birth and exposure:			
Zurugelu × 1996	0.951	0.657	(0.763, 1.185)
Zurugelu × 1999	0.959	0.713	(0.767, 1.199)
Zurugelu × 2002	0.900	0.395	(0.706, 1.147)
Zurugelu × 2005	0.910	0.484	(0.700, 1.184)
Zurugelu × 2008	0.946	0.735	(0.684, 1.308)
Nurse × 1996	1.033	0.754	(0.843, 1.266)
Nurse × 1999	0.874	0.213	(0.707, 1.080)
Nurse × 2002	0.906	0.398	(0.720, 1.140)
Nurse × 2005	**0.739**	0.027	(0.566, 0.966)
Nurse × 2008	1.113	0.495	(0.819, 1.512)
Combined × 1996	**0.749**	0.000	(0.637, 0.880)
Combined × 1999	**0.611**	0.000	(0.516, 0.724)
Combined × 2002	**0.671**	0.000	(0.560, 0.805)
Combined × 2005	**0.659**	0.000	(0.540, 0.805)
Combined × 2008	**0.583**	0.000	(0.448, 0.758)
Interactions between SES/Educational attainment and Exposure:			
Zurugelu × Mother Uneducated	1.012	0.908	(0.829, 1.235)
Nurse × Mother Uneducated	0.834	0.099	(0.673, 1.034)
Combined × Mother Uneducated	**0.812**	0.011	(0.691, 0.954)
Zurugelu × Poorest	1.106	0.353	(0.894, 1.369)
Nurse × Poorest	1.270	0.202	(0.880, 1.832)
Combined × Poorest	0.890	0.256	(0.729, 1.088)
Summary statistics:			
Log likelihood	-87488.216		
Chi square for Likelihood Ratio (dg. freedom)	1218.71 (34)		
p-value for Chi square	p < 0.0000		

Note: Zurugelu refers to volunteerism which literary translates as "togetherness" in the local language.

in Africa. However, there are important differences in mortality by education and wealth status, across the various types of health services offered.

Linear combination of estimators demonstrates that in original Zurugelu (volunteer) areas, wealth and education continue to be associated with lower mortality (Table 2 and Fig. 2). The magnitude of the reduction in mortality due to higher wealth and education was greater in the Zurugelu group as depicted by the hazard ratios. This implies that the Zurugelu volunteer program reduces child mortality among the least poor and among the educated, more than it reduces mortality among the disadvantaged. Volunteer services alone therefore have no impact on equity. In original Nurse areas, wealth remains associated with lower mortality, although being uneducated is no longer

Table 2

Hazard ratios for mortality odds by economic and educational attainment category, within each type of original CHFP exposure, using interactions from Model 1.

Exposure	Least Poor versus Poorest (Upper wealth index quintile versus lower 4 wealth index quintiles)	Educated versus Uneducated
Original Comparison	0.90	0.74[*]
Zurugelu	0.81[**]	0.73[***]
Nurse	0.71[*]	0.89
Combined	1.01	0.92

  * Denotes p < 0.05.

  ** Denotes p < 0.01.

  *** Denotes p < 0.001.

significantly associated with higher mortality. The ability of nurses to reduce mortality among the uneducated represents a partial impact on equity. In the original combined areas, we find that neither wealth nor education is associated with mortality. Therefore, the effect of the combination of nurse and volunteer services demonstrates a large and significant equity effect.

Over three quarters of all children in our analysis had uneducated mothers who were in the lower four wealth index quintiles. We assessed mortality among this large disadvantaged group in Fig. 3, over time, using the linear combination of indicators presented in Table 3, for this group. As Fig. 3 shows, the original combination of nurses who provided household outreach, with the original volunteer program focused on social mobilization for health, had pronounced mortality effects that consistently benefitted children from the most disadvantaged households. Mortality decreased in every area over the 1995 to 2010 period and converged in the original comparison, original nurse, and original volunteer (Zurugelu) areas by the end of the period of analysis. We also see that the socioeconomic disparity in mortality increases in magnitude among the volunteer intervention group, as portrayed in Figs. 2 and 3, which suggests that the intervention was more effective for the advantaged compared to the disadvantaged. However, original combined services have continued to be associated with significantly lower child mortality.

4. Discussion and 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. Indeed, the Ghana Shared Growth and Development Agenda (GSGDA) of 2010–2013 was aimed at pursuing
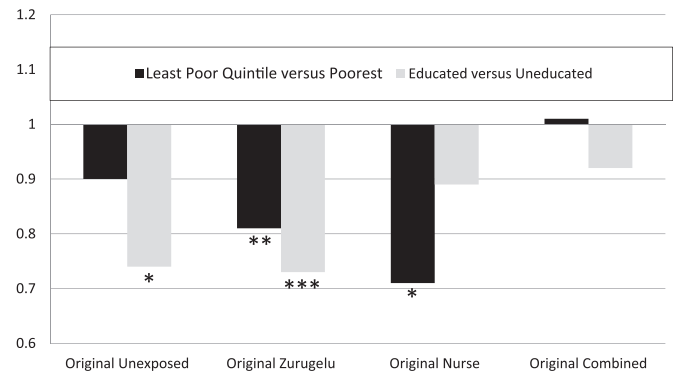

Fig. 2. Hazard ratios comparing mortality among children under 5 by mother's wealth and educational status, within original CHFP exposure categories, 1995 to 2010.

this agenda with the medium-term development policy framework by strengthening community-based health delivery programs among the disadvantaged and most vulnerable rural populations (Republic of Ghana, 2015). The policy posits that putting nurses and volunteers in rural communities to provide convenient health services to women and children addresses the persistently high neonatal, infant and under-five mortality among Ghana's most vulnerable. Relocating nurses from fixed health facilities and deploying them to accessible village locations provides a mechanism for lowering barriers to health care and helps to reduce the gap between the rich and the poor because community-based health care is intended to be provided without regard to social class. (Government of Ghana, 2003).

Results portrayed in Fig. 3 lend statistical support to this policy framework by showing that putting nurses in communities working in
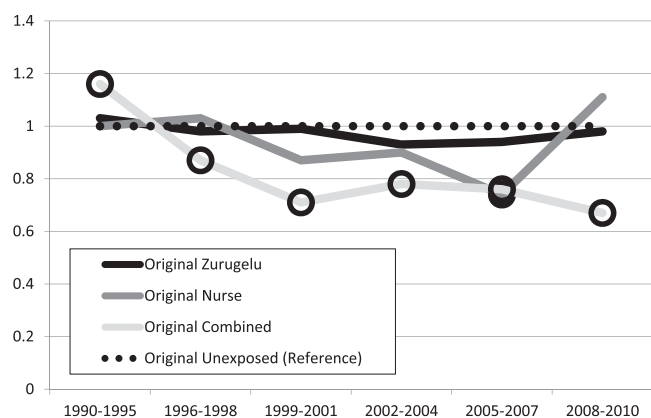
Table 3

Hazard ratios comparing the hazard of mortality from birth to age 5 among those with original CHFP treatment exposure, with mortality among those in the original comparison area, by birth cohort and type of original CHFP exposure, using interactions from Model 1.

Year of birth:	1990–1995	1996–1998	1999–2001	2002–2004	2005–2007	2008–2010
Uneducated, regardless of wealth status						
Zurugelu	0.94	0.89	0.90	0.84	0.85	0.88
Nurse	0.78	0.81	0.68	0.71	0.58[*]	0.87
Combined	1.30[*]	0.97	0.79[*]	0.87	0.86	0.76
Unexposed	1.00	1.00	1.00	1.00	1.00	1.00
Poorest (lowest 4 wealth quintiles), regardless of educational status						
Zurugelu	1.02	0.97	0.98	0.92	0.93	0.97
Nurse	1.19	1.23	1.04	1.08	0.88	1.33
Combined	1.42[***]	1.07	0.87	0.96	0.94	0.83
Unexposed	1.00	1.00	1.00	1.00	1.00	1.00
Least advantaged (poorest 4 wealth quintiles) and uneducated						
Zurugelu	1.03	0.98	0.99	0.93	0.94	0.98
Nurse	1.00	1.03	0.87	0.90	0.74[**]	1.11
Combined	1.16[*]	0.87[**]	0.71[***]	0.78[***]	0.76[**]	0.67[**]
Unexposed	1.00	1.00	1.00	1.00	1.00	1.00

  * Denotes p < 0.05.

  ** Denotes p < 0.01.

  *** Denotes p < 0.001.

Fig. 3. Hazard ratios comparing mortality among children under 5 exposed to original CHFP treatment with mortality among children originally unexposed, among 72,817 children in the poorest 4 wealth quintiles whose mothers are uneducated, by birth cohort.

combination with volunteers to provides services that focus on social mobilization for health results in pronounced mortality effects that differentially benefit children from disadvantaged households. Results are consistent with policies promoting community-based primary health care programs as a means of developing equity in health. Results suggest that children exposed to accessible community-based health care would otherwise have been disadvantaged by the relatively low educational attainment of their parents or low household socio-economic status. Indeed, as expected, trained community health nurses posted to community locations in combination with social mobilization through community volunteers 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.

However, it must be emphasized that the program implemented in Navrongo is not intended to replace improvements in access to education and wealth. Disparities in education and wealth need to be addressed to maximize population health. However, the CHPS program may supplement efforts in advancing education and economic well-being and help to reduce the health effects of these disparities, especially where the socioeconomic disparities already exist.

Results nonetheless challenge perspectives that promote deployment of community health workers irrespective of their clinical capabilities (Singh & Sachs, 2013). Results show that equity effects arise only if workers are trained and equipped to provide a full range of essential primary health care preventive and curative care functions. The combination of fully trained and deployed nurses who can provide comprehensive preventative and IMCI services and volunteers can have major equity effects; but volunteers who are marginally trained to provide component services only reduce mortality among children of the educated and the most prosperous household wealth quintile. Volunteers may have marginally beneficial organizational benefits to primary service delivery, but such benefits arise only if their deployment is pursued in tandem with the provision of professional nurse delivered care. Placing them in situations where they are the sole provider is not supported by the Navrongo results.

Findings 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 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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