The Impact of the Navrongo Community Health and Family Planning Project on Child Mortality, 1993-2000

Brian Pence[1]

Philomena Nyarko[2]

Cornelius Debpuur[2]

James F. Phillips[1]

[1] **Policy Research Division, Population Council, One Dag Hammarskjold Plaza, New York, NY 10017, USA**

[2] **Navrongo Health Research Centre, Box 114, Navrongo, Upper East Region, Ghana**

Correspondence: Brian Pence, bpence@aya.yale.edu

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Abstract

This paper reports on the child mortality impact of the Navrongo Community Health and Family Planning Project (CHFP). The CHFP, launched in rural northern Ghana in 1995, is an ongoing four-celled experimental trial of primary health and family planning service delivery strategies. As in much of rural sub-Saharan Africa, high levels of child mortality persist despite investment in primary health care services. In the comparison area, mortality remained fairly constant over the observation period. Offering convenient, village-based paramedical services was associated with a pronounced improvement in child survival. Community involvement and training of a local health volunteer – the "Community-Based Health Worker" model – was associated with increased mortality in early childhood. A combination of both strategies produced no net effect on mortality. Research on cause of death, morbidity, and health-seeking behavior are needed to further elucidate these results.

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Introduction

The goal of "Health for All by the Year 2000", articulated by the World Health Organization at Alma Ata in 1978, has not been achieved in rural Africa. At the end of the millennium, infant mortality remained above 100 deaths per thousand live births in the sub-Saharan region (United Nations 1998). Fully two-thirds of all deaths among children under 5 years, and half of the years of life lost (YLL) in the region, are attributable to measles, malaria, diarrheal diseases, and acute respiratory infections, often acting in synergy with malnutrition (WHO 1999; Murray and Lopez 1996). (Perinatal transmission of HIV is playing an increasingly important role particularly in southern Africa.) Low-cost and effective preventive measures and treatments for averting the major direct causes of child morbidity and mortality have been available for more than three decades, yet the implementation of effective programs for delivering these technologies remains an elusive goal, less because international agencies have failed to commit resources than because the organizational requirements of Health for All remain poorly understood. Since Alma Ata, substantial funds have been committed toward the achievement of Health for All through the World Health Organization's (WHO) Expanded Programme in Immunization (EPI), UNICEF's "GOBI" initiative (growth monitoring, oral rehydration, breastfeeding, and immunization), and other programs funded by agencies such as the World Bank and the United States Agency for International

Development. Despite these investments, such programs have not succeeded in achieving the dramatic gains over infectious disease in the sub-Saharan region that many observers predicted in the 1960s and 1970s (Hill and Pebley 1989; World Bank 1993; Mosley 1984).

In response to evidence that providing technology and resources for programs is an insufficient basis for achieving Health for All, growing attention has been directed to the need for health equity and community involvement in service delivery (UNICEF 1985; Gwatkin 1980, 1999; Berman et al. 1987; Ngom et al. forthcoming). Inequity and inaccessibility are recognized as key constraints to the achievement of Health for All, and international attention has been directed to achieving community-managed and -sustained primary health care. International interest in health equity has led to regional health agendas, such as the UNICEF-sponsored "Bamako Initiative," which promotes the idea that managing health care resources and providing revolving funds for primary health care drugs and services through community volunteers can be a sustainable means of achieving Health for All. In a review of community-based health worker (CHW) programs, Berman et al. (1987) point to a number of studies showing that small, well-managed programs can have a positive impact on health, but the evidence for larger and national-scale CHW initiatives was decidedly more mixed, with little conclusive evidence of a substantial impact of the programs on health outcomes.

To address the need for practical field trials of community health services, the Government of Ghana launched the Navrongo Community Health and Family Planning Project (CHFP) in 1993. The goal of the CHFP is to develop and test feasible strategies for Health for All. The CHFP serves a broader, and international, need for a rigorous, controlled evaluation of organizational strategies for primary health service delivery in a rural, impoverished sub-

Saharan population. The design of the CHFP addresses the observation that there are two broad sets of under-utilized resources for health programs in much of sub-Saharan Africa. The first set of resources consists of trained health providers and supplies in fixed-location clinics that are often inefficiently structured to provide health care in isolated communities. The second dimension is traditional village-based authority structures that can be mobilized to build community support for and involvement in the provision of health services, yet that are often ignored by government agencies and programs.

In keeping with the spirit of Health for All, facilities, staff, and medical supplies utilized in the experiment are resources routinely available throughout the region. Thus, all cells of the Navrongo study district have the same density of health care providers per population, the same level of training, and the same medical supplies. The experiment tests the effectiveness of alternative strategies for utilizing these resources at the community level. The CHFP is premised on the argument that Health for All has failed because existing organizational resources for health care delivery have not been adequately mobilized.

The CHFP has been longitudinally monitoring demographic dynamics in a population of approximately 140,000 since July 1993, with interventions beginning in 1995. This paper investigates the impact of the experiment on under-five mortality in the first five years of project implementation, through April 2000.

Background and Setting

The Navrongo CHFP is being implemented in Kassena-Nankana District, a poor, rural, isolated area in the Upper East Region of Ghana (see Figure 1) that typifies the challenging development circumstances of Ghana's northern regions. Table 1 compares certain demographic, social, and economic indicators between Ghana, the Upper East Region, and the Navrongo study population. Infant mortality and total fertility in Navrongo are high, educational attainment is low, and few households have a toilet or latrine. Measles, malaria, diarrheal disease, and acute respiratory infections are the primary causes of death in childhood (Binka et al. 1994, 1995a, 1995c, 1997a; Shier et al. 1996; Dollimore et al. 1997). Poor harvests due to unpredictable rainfalls produce nutritional adversity (NHRC 1998), which acts in synergy with infectious diseases to elevate child mortality (Mosley 1984; Hill and Pebley 1989). Breastfeeding is nearly universal in the region and usually continues well into the child's third year, but exclusive breastfeeding commonly ends within the first few weeks and three-quarters of children receive solid supplements by age six months (DHS 1993). HIV-1 seroprevalence is low in Ghana relative to other parts of sub-Saharan Africa. It was estimated in 1997 that 2.4 percent of all adults in Ghana and 1.0 percent of adults outside of major cities are HIV-positive (World Bank 2000). The seroprevalence in Kassena-Nankana District is unknown.

Geography, ecology, and language isolate the Upper East Region from Ghana's southern coastal areas. The population lives in dispersed settlements that are often inaccessible by road. Few towns, markets, or roads exist to serve as conduits for the exchange of ideas and information. Traditional social structures, centered around chiefs and lineage heads, remain strong and permeate daily village life. Most households practice the rites of traditional religion, although roughly a third of all households also practice Christianity or Islam. The continued importance of traditional religion, social structure, and family institutions reinforces customs of patriarchy that restrain the autonomy and authority of women. These restraints, in turn, are believed to constrain effective health outreach because many women with children are not free to travel and participate in clinic-based health service programs. The nature of the impact of social characteristics on survival remains poorly understood, however, apart from case-control study evidence that educational attainment of men and women dramatically affects the survival of children (Binka et al, 1995a).

Ministry of Health (MOH) staff in the region provide health care primarily through facility-based programs. Despite a twenty-year-old commitment on the part of the MOH to emphasize village-based service delivery in rural areas (NHRC 1998), primary health services generally fail to reach the periphery. The goal of the CHFP is to develop simple and replicable strategies, using pre-existing resources, to re-orient health care service delivery to the village level and to involve traditional leaders in setting priorities and managing services. The CHFP is designed to determine the extent to which these strategies can induce and sustain the health transition from a high to a low infectious disease burden in this disadvantaged rural population.

Study Design

The CHFP is a four-arm community-randomized controlled experiment to assess the mortality impact of three alternative organizational strategies for community health services. Primary health care technology and training do not differ between cells of the CHFP. Rather, the experiment tests the effect of different strategies for organizing services and involving communities in their delivery. The three interventions were designed through extensive consultations with MOH officials and village leaders and groups. The *zurugelu* intervention (literally translated as "togetherness" from the local language; the term more generally connotes community consensus and collective action) seeks to increase community involvement in health decisions by involving traditional village structures and volunteers in planning and delivering health activities and services. The MOH mobilization intervention tests the effectiveness of improving access to health services by relocating service providers from fixed clinics to village residences and assigning them doorstep service delivery responsibilities. The combined intervention uses both approaches and establishes close links between the MOH nurse and the community leaders and volunteers. A comparison area receives services according to standard MOH guidelines. Figure 2 presents the study typology.

The study area was divided into four geographically distinct areas that correspond as closely as possible to locally recognized political and administrative boundaries. The first step in this process involved delineating the areas of influence of the district's paramount chiefs, each of whom has authority over several communities. The paramouncies were then grouped to correspond as closely as possible to the four Ministry of Health catchment areas in Navrongo District. This resulted in the four areas shown in Figure 3. Navrongo Town, the only settlement of any appreciable size in the district (population approximately 14,000) was excluded from the study. The three interventions and the comparison condition were then randomly assigned to the four cells. The MOH mobilization cell to the left in Figure 3 is clearly quite geographically distinct from the other study areas. The combined cell (central and bottom areas, surrounding Navrongo Town) is also well delineated, as forest reserves separate it from intervention areas to the north and east. The physical boundaries between the zurugelu cell (top center) and the comparison area (top right) are less well defined.

Primary health care technologies and community outreach training were upgraded in all four cells. This upgrading conformed to existing MOH plans and did not rely on resources that are unavailable in other parts of Ghana. In all districts of Ghana, the primary service providers for subdistrict and outreach clinics are Community Health Nurses (CHNs) who receive two years of paramedical training for treating common ailments, such as acute respiratory illnesses, diarrheal diseases, and malaria, and preventing major childhood diseases through immunization. At the beginning of the CHFP, all 32 CHNs in the study area received a refresher course on health care delivery, safe delivery, and reproductive health. All CHNs were trained in midwifery and methods of community entry, liaison, and outreach, functions of the CHN that had not been developed in previous training programs.

The zurugelu intervention (Cell 1), which involves traditional social institutions in health delivery and planning, was specifically designed to be an operationalization of the Bamako Initiative. Village health committees, termed *Yezura Nakwa* (YN), were established in collaboration with chiefs, elders, and other key groups. The YN appoints and oversees a cadre of primarily male volunteers called *Yezura Zenna* (YZ), or health aides, who form the backbone of the zurugelu approach. The main purpose of the YZs is to legitimize the CHFP in the communities, particularly among men who make decisions about women's mobility. Young women in particular are generally not free to leave the household; part of the goal of this intervention is to make it acceptable in the community for women to take their children to the YZ and/or the clinic for health care. YZs receive two weeks of initial training and quarterly refresher training sessions. They visit households to talk about hygiene, child immunization, and other health issues, and to make it known that they are available for basic treatments and referrals. They have significant health resources at their disposal, including paracetanol for febrile illnesses, chloroquine for malaria, aludrox for abdominal pains, and multivitamins, but they do not have antibiotics or vaccines. Instead, they provide referrals to the clinics and help maintain records for the district-wide Management Information System (MIS), an MOH database which tracks immunization status and other health information. Another important element of the zurugelu intervention is the *durbars*, or community gatherings, which are traditionally used by chiefs to mobilize community action on some issue of common concern. Durbars have provided an effective means of communicating project messages to communities, establishing the credibility of the project, and building community support for project activities.

The MOH mobilization intervention (Cell 2) tests the effectiveness of improving access to primary health care services. To the extent possible, supervisory procedures were modified to develop principles of supervisory leadership and support that had been lacking in the usual clinic-based service system. All 16 CHNs in Cells 2 and 3 were reassigned from sub-district clinics to village residences built by the community and given door-to-door service delivery responsibilities, and redesignated as “Community Health Officers” (CHOs) to emphasize their new role in the intervention. The CHO provides ambulatory care at her residence and visits all compounds in the community in 90-day cycles for health education, follow-up, and diagnosis. She is provided with a motorbike for community liaison work and given responsibility for visiting compound heads, organizing EPI, and maintaining the MIS.

In the combined intervention area (Cell 3), the zurugelu and MOH mobilization approaches are pursued simultaneously. This intervention tests the hypothesis that the zurugelu and

MOH mobilization interventions are complementary and synergistic, combining the implicit accountability and sustainability of the former with the relative advantages of professionalism in the latter. In the combined treatment area, close collaborative links have been established between the YZs and the CHOs.

The experiment thus represents a trial of the impact of mobilizing two sets of under-utilized resources that are generally available for health care throughout the sub-Saharan Africa region. The zurugelu arm tests the mobilization of the social resources that govern village life and which are available to health care systems, but are typically ignored by health planners and administrators. The MOH mobilization arm tests the effectiveness of moving health care resources out of under-utilized sub-district clinics and into communities, where accountability for health care delivery can be assured and accessibility can be achieved. The experiment examines the impact of mobilizing these two resource dimensions both independently and jointly (the combined cell) in comparison to standard MOH operations.

Demographic surveillance of the study population began in July 1993 while the interventions were being designed in collaboration with the communities. Three villages each in the MOH mobilization and combined cells served as pilot intervention sites. The first CHOs were deployed in February 1994 and the first YZs in January 1995. The interventions were scaled up to all study areas during the period from July 1995 to September 1996. Figure 4 depicts the phasing-in of the CHFP interventions from February 1994 through September 1996.

Data and Methodology

The data for this analysis were taken from the Navrongo Demographic Surveillance System (NDSS), which has been monitoring births, deaths, in- and out-migrations, and social relationships for all individuals in the study area since July 1993 (Binka et al. 1997b). Permanent personal identification numbers uniquely identify each individual, allowing the construction of complete residence histories for people who enter and leave the study area multiple times. Interviewers visit each compound in the study area in 90-day cycles to update registers with demographic events that occurred in the previous three months. NDSS data permit the precise calculation of person-days of risk and demographic outcomes for all residents of the study area from July 1993 to the present.

The sample used in this analysis consists of 51,407 children in the study area who were under five years of age between July 1993 and April 2000. This includes 18,314 children under five years who were enumerated with the beginning of surveillance on July 1 1993; 26,124 children born in the study area after the initial enumeration; and 6,969 children under five years who migrated into the study area after the beginning of surveillance.

The data are structured in survival-analysis format. The onset of risk is defined as birth, so that "analysis time" is equivalent to the child's age. Children who were enumerated or migrated into the study area are therefore treated as left-censored, since they were unobserved from birth until their entry into the sample. The outcome variable of interest is death. Children who do not die are treated as right-censored at the point that they out-migrate, turn five years old, or reach the end of the observation period (April 30 2000). Time under observation is measured from time of entry into the sample (birth, enumeration, or in-migration) until death or censoring.

The main covariates of interest are exposure to the three CHFP interventions. Exposure is represented by time-dependent dichotomous and categorical variables that measure exposure to the zurugelu, MOH mobilization, and combined interventions. The categorical variables have the following categories: no exposure, 1 day to 12 months of exposure, 13 to 24 months of exposure, and 25 or more months of exposure. A child starts to accumulate exposure once the intervention has started in his or her village. Thus a child who is living in the study area when the interventions were introduced contributes the part of her observation time prior to the intervention to the denominator in the unexposed group, and the part of her observation time during the intervention to the denominator in the exposed group.

Children who migrate between experimental cells are censored at the time of migration. Children are also censored if they migrate from a village where an intervention has already begun to a village in the same cell where the intervention has not yet started. The truncated part of these children's histories represent a total of 660 person-years of observation, or 0.6% of the total. The remaining sample used for the analysis represents a total of 117,967 person-years of observation (2.3 years per child on average) and 4,870 deaths.

In some villages in the combined cell, CHOs were introduced on a pilot basis before the zurugelu arm began. Children in these villages during this time period are nevertheless classified as receiving the full combined intervention as of the introduction of the MOH mobilization intervention. The relevant portions of these children's records represent 1,471 person-years of observation, or 5.7% of the total time of exposure to the combined intervention. Results of the analysis do not change if these children are treated as exposed only to the MOH mobilization intervention during this time, or if this part of their records is excluded from the analysis altogether.

So as to adjust for possible district-wide mortality trends over time and to facilitate the comparison of results between cells, a control cell "exposure" variable was also defined by randomly assigning "intervention start dates" to control cell villages in such a way that the phasing-in of the control cell "intervention" matches the phasing-in of the interventions in the other three cells (measured by proportion of population covered). Sensitivity analyses indicate that the results presented here do not change whether this approach is used or all observation time in the control cell is used as a single comparison category.

Mortality rates are calculated as number of deaths divided by total person-years of observation in each age group-exposure category and multiplied by 1,000. Rate ratios compare mortality rates between the exposed and the unexposed in each cell. Ninety-five percent confidence intervals for rate ratios are calculated following Kelsey et al. (1996: 137).

Cox proportional hazard models with the time-dependent exposure variables are used to compare mortality risks by exposure status in each cell, controlling for baseline mortality levels and other confounding variables. Separate models are estimated for children ages 0-11, 12-23, 24-59, and 0-59 months. The covariates included in the models are sex of the child; mother's age, education, and residence in the compound; the number of residents in the compound; and distance from the compound to the nearest health facility and to Navrongo Town.

Results

Table 1 compares descriptive statistics between cells for the sample used in this analysis. The children in the four cells are comparable on most background characteristics. Children in the zurugelu and combined cells are more likely to have mothers and fathers with some formal education. Children in the comparison area tend to live in compounds with fewer members, and on average they live twice as far from the nearest health facility as children in the other three cells. The difference in the average distance to Navrongo Town reflects the geography of the study area depicted in Figure 3.

Table 2 presents mortality rates among children under five years of age (expressed as number of deaths per 1,000 person-years of observation) for the exposed and the unexposed in each cell. Among the unexposed, mortality is highest in the relatively dispersed and isolated MOH mobilization cell and lowest in the zurugelu and combined cells, which are the closest to Navrongo Town. Mortality is higher among the exposed than the unexposed in the zurugelu (RR = 1.13, 95% CI = [0.97, 1.28]) and combined cells (RR = 1.09, 95% CI = [0.98, 1.19]), although neither of these represents a statistically significant change in mortality. Mortality is significantly lower in the MOH mobilization cell among those exposed to the intervention than among those not exposed (RR = 0.82, 95% CI = [0.67, 0.96]). In the comparison area, mortality decreases slightly during the intervention period, but this change is not statistically significant (RR = 0.96, 95% CI = [0.87, 1.05]).

Table 3 examines the relationship between duration of exposure to the CHFP interventions and mortality in different age ranges. Among children in the first year of life (0-11 months old), mortality is not significantly different in the intervention period compared to the baseline period in any of the cells. Those with some exposure to the zurugelu and combined interventions have slightly higher mortality than those not exposed (RR = 1.02 [0.83, 1.24] and 1.07 [0.93, 1.22], respectively). Infants exposed to the MOH mobilization intervention have lower mortality than those not exposed (RR = 0.88 [0.73, 1.05]). Infants in the comparison area have slightly lower mortality in the intervention period than in the baseline period (RR = 0.93 [0.82, 1.05]).

In early childhood (ages 12-23 months), children exposed to the zurugelu intervention have twice the mortality of those not exposed. This is true both for children who have been exposed to the intervention for less than one year (RR = 2.07 [1.26, 3.37]) and for those who have been exposed for more than one year (RR = 1.94 [1.27, 2.94]). Children exposed to less than one year of the MOH mobilization intervention have significantly higher mortality than those not exposed (RR = 1.50 [1.01, 2.20]), while those exposed to more than one year of the intervention have significantly lower mortality (RR = 0.53 [0.39, 0.85]). Children exposed to less than one year of the combined intervention have higher mortality than those not exposed (RR = 1.35 [1.00, 1/80]), while the mortality of those exposed to more than one year of the intervention differs only slightly from the mortality of the unexposed (RR = 1.04 [0.81, 1.32]). In the comparison area, the mortality of children during the intervention period does not differ significantly from mortality during the baseline period.

In the late childhood period (ages 24-59 months), mortality does not differ significantly between those exposed and unexposed to the zurugelu intervention. Children exposed to the MOH mobilization intervention have lower mortality than those not exposed, but this relationship is only statistically significant for children who have been exposed to more than two years of the intervention, whose mortality is reduced by more than 50 percent (RR = 0.47

[0.28, 0.76]). Children exposed to less than one year of the combined intervention have higher mortality than those not exposed (RR = 1.40 [1.05, 1.86]), while the mortality of children exposed to more than one year does not differ significantly from those not exposed. In the comparison area, the mortality of children during the intervention period does not differ significantly from mortality during the baseline period.

Results from a multivariate analysis show that these conclusions remain largely unchanged after controlling for potentially confounding background characteristics. The models presented in Table 4 control for sex of the child; mother's age, education, and residence in the compound; the number of residents in the compound; and distance from the compound to the nearest health facility and to Navrongo Town. The association of the interventions with mortality is assessed as follows. Indicator variables for cell of residence and level of exposure to any intervention are included, with the omitted categories being the comparison cell and no exposure, respectively. The model also contains interaction terms between the cell and exposure variables. Coefficients on the main-effect cell variables are therefore interpreted as differences in mortality among the unexposed, or baseline mortality differences between the cells. Coefficients on the main-effect exposure variables represent differences in mortality during the intervention period in the comparison area. Coefficients on the interaction terms therefore measure project impact. Specifically, they assess whether mortality in the zurugelu, MOH mobilization, and combined cells among those exposed to the interventions differs from what would be expected given the baseline differences in mortality between cells and the overall changes in mortality over time observed in the comparison area.

After controlling for background characteristics, none of the interventions is associated with any difference in infant mortality (ages 0-11 months). The magnitude of the effects of the interventions on early childhood mortality (12-23 months) is nearly unchanged after adjusting for confounders. However, only the effects of the zurugelu intervention on early childhood mortality remain statistically significant. In late childhood (24-59 months), exposure to two years or more of the MOH mobilization intervention is associated with nearly a 60 percent reduction in mortality, which is statistically significant. The combined intervention is no longer associated with increased mortality in the first year of the intervention, as was suggested by the unadjusted rates in Table 3.

Discussion

Before turning to a discussion of these results, it is appropriate to add a word of caution regarding the limitation of the study design. Since treatments were randomized at the level of cell rather than cluster or individual, it is not possible to adequately statistically adjust for possible differences between the four cells that might explain observed differences in mortality during the intervention period. In general, when randomization occurs at some level of aggregation above the individual (such as the classroom or village), individuals within each group will tend to be similar on various observable and unobservable background characteristics. This "cluster effect" violates the assumptions of independent errors on which individual-level statistical tests are based and causes these procedures to under-estimate standard errors and produce overly narrow confidence intervals (Simpson et al. 1995). Although methods exist to adjust for cluster effects when there are multiple clusters per treatment, no methods are available to address designs such as the CHFP that have only one cluster per treatment. It is not possible through statistical methods to fully assess the probability that unmeasured differences between the four cells rather than project activities account for any observed differences in mortality in project cells during the intervention period. Although this limitation was recognized at the project planning stage, it was deemed impossible from a practical standpoint to divide the study area into more than four clusters, given the logistical need for the clusters to correspond to the MOH catchment areas and the spheres of influence of the paramount chiefs. This problem of cluster effects is difficult to avoid in community-based interventions that for reasons of administration and contamination cannot realistically be randomized at any level below the community or even group of communities.

With this caution in mind, certain observations can nevertheless be made. The analysis indicates that in the zurugelu cell, children aged 12-23 months during the intervention period are experiencing twice the mortality in the second year of life compared to children prior to the intervention. The increase in mortality is highly statistically significant ($p = 0.01$ for those exposed to up to one year of the intervention and $p = 0.001$ for those exposed to more than one year) and stands in sharp contrast to the comparison area, in which mortality is fairly stable from the baseline through the intervention period. It should be noted that baseline mortality was low in the zurugelu cell relative to the other cells. However, an examination of deaths in the zurugelu cell in each calendar year (data not shown) shows little variation in mortality among the unexposed from 1993 to 1995, suggesting that the increase in mortality is not simply a “regression to the mean” effect produced by a single year of abnormally low mortality in the zurugelu cell just before the intervention. The year-by-year tabulation of deaths indicates that child mortality in 1996 was unusually high throughout the district compared to other years. If 1996 is excluded from the analysis, children exposed to up to one year of the zurugelu intervention have comparable mortality to the unexposed (RR = 1.15 [0.56, 2.34]), but children exposed to more than one year of the zurugelu intervention still have elevated mortality (RR = 1.78 [1.16, 2.72]).

This is an unexpected result that calls for further investigation and action. One possible explanation for the increased mortality is that mothers in the zurugelu cell may be using the more accessible and less expensive but less well-trained services of the YZ (*yezura zenna*, or health volunteer) in situations where they used to take their children to the subdistrict clinic. In the second year of life, acute respiratory infections (ARI) and diarrheal disease are two of the leading causes of death in the area. It is possible that the YZs are treating ARI with paracetamol when they should be referring such cases to a clinic for antibiotic therapy. If this is the case, the zurugelu intervention needs to be redesigned so that YZs are not responsible for dispensing medications. Their sphere of activities could be limited to health education, outreach coordination, and family planning provision, for which they have been shown to be effective service providers (Debpuur et al. forthcoming; Phillips et al. 2000). Further research is urgently needed on the causes of death among children in this age group (verbal autopsy data has been collected by the project but is not yet ready for analysis) and on health-seeking behavior in the zurugelu cell to understand these results and take appropriate action.

In the multivariate analysis, the MOH mobilization intervention is only significantly associated with a change in mortality among older children who have been exposed to the intervention for more than two years, for whom mortality is reduced by nearly 60 percent. Older children exposed to less than two years of the intervention also have lower mortality than those not exposed, but these reductions do not achieve statistical significance. The unadjusted rates in Table 3 suggest that in early childhood, the intervention is associated with

50 percent elevated mortality among those exposed to up to one year of the intervention and 40 percent reduced mortality among those exposed to more than one year, but these relationships are not significant after controlling for confounding variables.

The year-by-year tabulation of deaths suggests that the elevated mortality among young children exposed to less than one year of the MOH mobilization intervention is heavily influenced by the district-wide elevated mortality in 1996, when the rate was more than twice as high as the rates for most of the other year-exposure categories in the MOH mobilization cell, and 50 percent higher than the highest rate for any year-exposure category. If 1996 is excluded from the analysis, young children exposed to up to one year of the MOH mobilization intervention have comparable mortality to those not exposed (RR = 0.89 [0.52, 1.51]), while young children exposed to more than one year still experience a nearly 50 percent reduction in mortality (RR = 0.55 [0.35, 0.84]).

The reasons for the elevated mortality in 1996 are unknown. Some light on this question may be shed by the verbal autopsy data. The fact that the MOH mobilization intervention has its greatest impact on older children who have been exposed to the intervention for several years, and may also help younger children exposed for more than one year, may reflect the cumulative gains in resilience and survival for children who are consistently treated for ARI, diarrhea, malaria, and other ailments. It may also operate through improved measles vaccination coverage, which is administered in infancy but has been demonstrated to dramatically reduce all-cause mortality in later years both in this population and elsewhere (Nyarko et al. 2000; Koenig et al. 1991; Aaby 1995; Kristensen et al. 2000). Data on immunization coverage are only available starting in 1996, making it impossible to compare pre- and post-intervention coverage rates. Since 1996, coverage with all EPI antigens has been markedly higher in the three intervention cells relative to the comparison cell but has not differed greatly between the three intervention cells. For example, the proportion of twelve-month-olds vaccinated against measles between 1996 and 1999 was 52% in the zurugelu cell, 48% in the MOH mobilization cell, 49% in the combined cell, and 37% in the comparison cell.

The combined intervention is not significantly associated with mortality in any age group or exposure category after adjusting for confounding variables. The unadjusted mortality rates suggest that both younger (ages 12-23 months) and older (ages 24-59 months) children who are exposed to up to one year of the combined intervention have somewhat elevated mortality compared to those not exposed, but mortality for those exposed to more than one year of the intervention is comparable to that of unexposed children. This may represent offsetting effects of the CHO and the YZ in the community: the YZ may divert health-seeking behavior even when the CHO lives in the village and visits households on a regular basis.

Conclusion

The results of the Navrongo CHFP provide evidence that relocating trained nurses to village residences where they are easily accessible to the community can dramatically reduce child mortality, although this effect takes some time to develop. The impact of the MOH mobilization strategy likely operates through improved treatment of acute respiratory infections, malaria, and diarrhea, or possibly improved childhood vaccination coverage. In contrast, the Navrongo experience with the community health worker strategy raises questions about the efficacy of this approach in reducing child mortality. Indeed, the CHFP provides evidence that the popular CHW model may have the potential to increase child mortality, possibly by diverting mothers' health-seeking behavior from trained paramedical care to the more accessible and less expensive but less thoroughly trained volunteers. Thus, the CHFP demonstrates the scientific and policy value of field trials, even for intuitively appealing health service interventions. Further research on causes of death and health-seeking behavior are needed to fully understand these findings. The results of the CHFP suggest that the Bamako model may have limited or even detrimental effects on health, but making professional primary health care services available in isolated rural communities can produce important gains towards Health for All in Africa.

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Figure 1. Regional map of Ghana

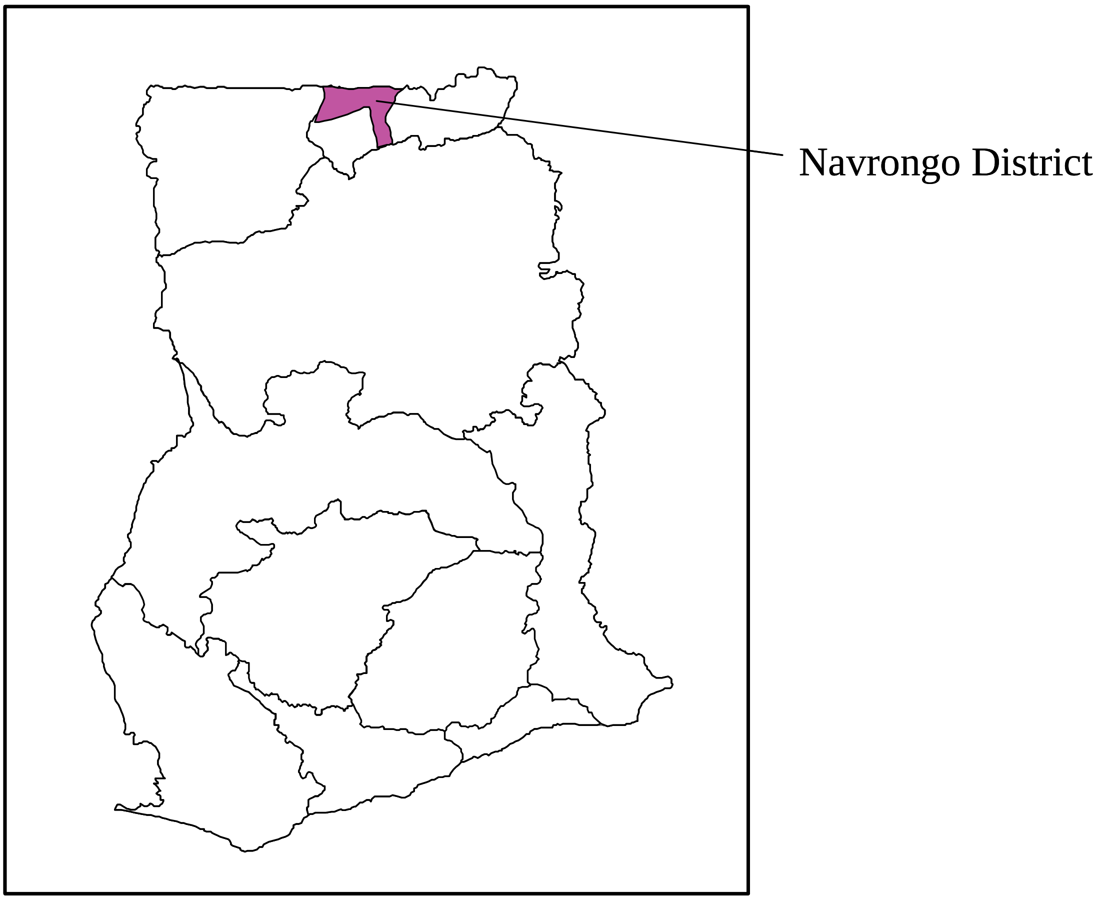

Table 1. Comparison of demographic, social, and economic indicators in Ghana, the Upper East Region, and the Navrongo study area, 1993

Indicator	**Ghana**[a]	**Upper East**[a]	**Navrongo**[b]
Total fertility rate	5.5	6.4	6.0
Infant mortality ($_1q_0$)	74.7	105.0	119.4
Proportion with any formal education:			
Men	74	49	17
Women	62	33	12
Proportion of households with flush toilet or latrine	69	9	2

[a] Source: DHS 1993.
[b] Source: Navrongo Demographic Surveillance System; Navrongo Panel Surveys.

Figure 2. CHFP study design

Mobilizing Ministry of Health outreach	Mobilizing traditional community organization (zurugelu)	
	No	Yes
No	Cell 4 Comparison	Cell 1 Zurugelu only
Yes	Cell 2 MOH mobilization only	Cell 3 Combined

Figure 3. Navrongo study area.

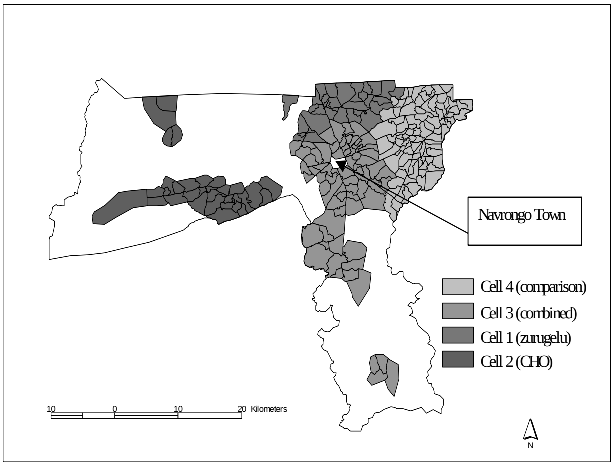

Figure 4. Phase-in of CHFP interventions.

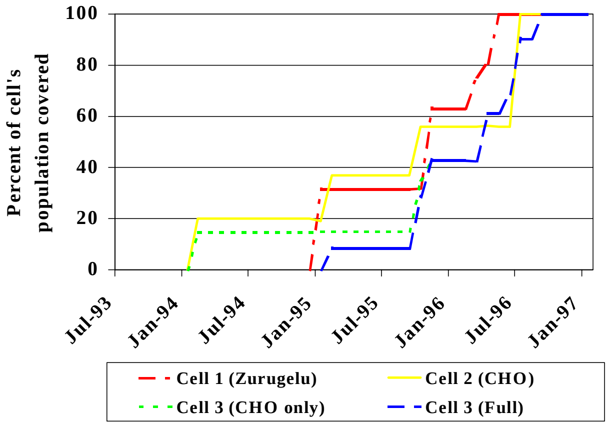

Table 2. Means (standard deviations) and proportions for sample background characteristics, by cell.

Characteristic	Cell: Zurugelu	MOH mobilization	Combined	Comparison	Valid N
Child: Number in analysis	7.965	7,830	17,841	17,771	51,407
Female	50.9%	49.4%	49.9%	49.9%	51,407
Died while under observation	8.9%	10.1%	9.0%	10.0%	51,407
Time under observation (years)	2.3 (1.6)	2.3 (1.6)	2.3 (1.6)	2.3 (1.6)	51,407
Entry into sample:					51,407
Birth	51.2%	51.9%	51.1%	49.8%	
Enumerated at baseline	35.2%	34.9%	36.7%	35.1%	
In-migrant	13.6%	13.2%	12.2%	15.1%	
Mother					
Mother unknown	3.9%	4.0%	3.5%	3.4%	51,407
Age (years)	29.4 (7.8)	29.5 (7.4)	29.5 (7.3)	30.1 (7.5)	49,507
Any formal education	16.8%	10.8%	17.0%	6.4%	49,555
Resident in household with child:					49,555
Never	7.2%	6.6%	7.1%	6.3%	
Sometimes	9.4%	11.3%	10.1%	8.2%	
Always	83.4%	82.1%	82.8%	85.5%	
Father					
Father unknown	19.1%	15.0%	17.8%	18.9%	51,407
Age (years)	43.9 (12.3)	44.2 (13.0)	43.1 (11.5)	44.6 (12.4)	42,161
Any formal education	20.2%	15.9%	20.4%	11.3%	42,187
Resident in household with child:					42,187
Never	10.7%	11.0%	10.0%	15.1%	
Sometimes	13.9%	15.1%	13.0%	19.7%	
Always	75.4%	73.9%	77.0%	65.2%	
Household					
Number of residents*	20.9 (16.3)	19.8 (16.3)	19.6 (17.6)	14.7 (10.8)	51,407
Distance to nearest health facility (km)	2.0 (1.2)	2.1 (3.6)	1.6 (0.8)	4.1 (1.7)	51,063
Distance to Navrongo Town (km)	10.6 (2.3)	22.4 (6.5)	8.5 (8.3)	14.7 (3.4)	51,063

* Mean number of household residents during observation of child.

Table 2. Under-five mortality rates (deaths/person-years of observation) for exposed and unexposed, and rate ratios (95% confidence intervals) by cell

Cell	Unexposed	Exposed	RR (95% CI)
Zurugelu	34.94 (232/6639)	39.51 (475/12021)	1.13 (0.96, 1.32)
MOH mobilization	50.57 (297/5872)	41.78 (493/11797)	0.82 (0.71, 0.94)
Combined	36.27 (564/15547)	39.89 (1034/25918)	1.09 (0.98, 1.20)
Comparison*	45.36 (682/15033)	43.65 (1093/25037)	0.96 (0.87, 1.05)

* See text for an explanation of the definition of “exposure” in the comparison cell.

Table 3. Mortality rates and rate ratios (95% confidence intervals) by age range and duration of exposure to intervention.

Cell / Duration of Exposure	Age Range					
	0-11 months old		12-23 months old		24-59 months old	
	Rate*	RR (95% CI)	Rate*	RR (95% CI)	Rate*	RR (95% CI)
Zurugelu						
Baseline	106.2	–	23.3	–	13.5	–
1-12 mo.	108.7	1.02 (0.83, 1.24)	48.4	2.07 (1.26, 3.37)	10.6	0.78 (0.47, 1.29)
13-24 mo.			45.4	1.94 (1.27, 2.94)	15.3	1.12 (0.70, 1.78)
25+ mo.					11.9	0.87 (0.57, 1.31)
MOH mobilization						
Baseline	148.7	–	47.9	–	14.8	–
1-12 mo.	131.32	0.88 (0.73, 1.05)	71.9	1.50 (1.01, 2.20)	11.0	0.74 (0.44, 1.24)
13-24 mo.			27.8	0.58 (0.39, 0.85)	11.8	0.79 (0.47, 1.32)
25+ mo.					7.1	0.47 (0.28, 0.76)
Combined						
Baseline	103.4	–	37.6	–	12.8	–
1-12 mo.	110.6	1.07 (0.93, 1.22)	51.1	1.35 (1.00, 1.80)	18.0	1.40 (1.05, 1.86)
13-24 mo.			39.2	1.04 (0.81, 1.32)	15.3	1.19 (0.87, 1.62)
25+ mo.					10.8	0.84 (0.63, 1.11)
Comparison**						
Baseline	139.8	–	46.4	–	14.4	–
1-12 mo.	121.9	0.93 (0.82, 1.05)	46.1	0.99 (0.74, 1.31)	18.0	1.25 (0.94, 1.65)
13-24 mo.			41.1	0.88 (0.69, 1.11)	13.8	0.96 (0.69, 1.32)
25+ mo.					15.2	1.05 (0.80, 1.36)

* Expressed as number of deaths per 1,000 person-years of observation.

** Comparison cell "exposure" is defined as beginning in November 1995.

Table 4. Hazard ratios (95% confidence intervals) from Cox proportional hazard models of the association between CHFP interventions and mortality in age groups 0-11 months, 12-23 months, 24-59 months, and 0-59 months, controlling for background characteristics.

	Age range			
Variable	0-11 months	12-23 months	24-59 months	0-59 months
Baseline differences between cells				
Zurugelu	0.94 (0.77, 1.14)	0.48 (0.32, 0.72)	0.95 (0.68, 1.34)	0.84 (0.72, 0.98)
MOH mobilization	1.25 (1.04, 1.51)	1.07 (0.76, 1.50)	1.02 (0.72, 1.45)	1.17 (1.01, 1.35)
Combined	0.96 (0.82, 1.14)	0.80 (0.60, 1.07)	1.05 (0.78, 1.40)	0.94 (0.82, 1.07)
Comparison*	1.00 –	1.00 –	1.00 –	1.00 –
Exposure†				
None*	1.00 –	1.00 –	1.00 –	1.00 –
1-12 months	0.95 (0.83, 1.07)	1.05 (0.79, 1.40)	1.28 (0.96, 1.71)	1.00 (0.90, 1.11)
13-24 months	–	0.91 (0.72, 1.15)	0.99 (0.71, 1.38)	0.89 (0.75, 1.05)
25+ months	–	–	1.08 (0.83, 1.41)	0.97 (0.77, 1.21)
Interaction terms†				
Zurugelu × 1-12 mo. exposure	1.08 (0.86, 1.37)	2.13 (1.20, 3.77)	0.62 (0.34, 1.14)	1.14 (0.94, 1.39)
Zurugelu × 13-24 mo. exposure	–	2.31 (1.42, 3.75)	1.20 (0.67, 2.14)	1.44 (1.08, 1.91)
Zurugelu × 24+ mo. exposure	–	–	0.87 (0.53, 1.43)	1.03 (0.69, 1.54)
MOH mob. × 1-12 mo. exposure	0.96 (0.77, 1.19)	1.48 (0.91, 2.40)	0.56 (0.31, 1.02)	0.97 (0.81, 1.17)
MOH mob. × 13-24 mo. exposure	–	0.65 (0.41, 1.04)	0.79 (0.43, 1.46)	0.66 (0.48, 0.89)
MOH mob. × 24+ mo. exposure	–	–	0.41 (0.24, 0.73)	0.41 (0.26, 0.67)
Combined × 1-12 mo. exposure	1.12 (0.93, 1.35)	1.36 (0.90, 2.05)	1.01 (0.67, 1.53)	1.11 (0.95, 1.29)
Combined × 13-24 mo. exposure	–	1.18 (0.84, 1.67)	1.12 (0.70, 1.77)	1.18 (0.94, 1.48)
Combined × 24+ mo. exposure	–	–	0.73 (0.49, 1.09)	0.87 (0.63, 1.19)
Background characteristics				
Sex of child				
Female*	1.00 –	1.00 –	1.00 –	1.00 –
Male	1.03 (0.96, 1.11)	1.13 (1.00, 1.29)	1.14 (1.00, 1.30)	1.07 (1.01, 1.13)
Mother:				
Age‡	1.01 (0.96, 1.06)	1.08 (1.00, 1.18)	1.02 (0.93, 1.12)	1.02 (0.98, 1.06)
Age squared	1.21 (1.15, 1.27)	1.13 (1.03, 1.23)	1.00 (0.90, 1.11)	1.16 (1.11, 1.20)
Any formal education	0.82 (0.72, 0.92)	0.67 (0.53, 0.84)	0.82 (0.65, 1.03)	0.78 (0.71, 0.86)
Resident in compound	0.93 (0.81, 1.06)	0.56 (0.46, 0.69)	0.70 (0.58, 0.85)	0.78 (0.71, 0.86)
Number of residents in compound				
2-8*	1.00 –	1.00 –	1.00 –	1.00 –
9-13	1.07 (0.97, 1.20)	1.16 (0.96, 1.39)	1.00 (0.83, 1.21)	1.08 (0.99, 1.17)
14-22	1.21 (1.09, 1.34)	1.06 (0.88, 1.27)	1.05 (0.87, 1.26)	1.15 (1.06, 1.25)
23+	1.07 (0.96, 1.19)	1.39 (1.16, 1.66)	1.13 (0.94, 1.36)	1.14 (1.05, 1.24)
Distance to nearest health facility§	1.15 (1.09, 1.22)	1.03 (0.93, 1.14)	1.01 (0.91, 1.12)	1.10 (1.05, 1.15)
Distance to Navrongo Town§§	1.02 (0.97, 1.07)	0.96 (0.89, 1.05)	1.08 (0.99, 1.17)	1.02 (0.98, 1.06)
Subjects	31,059	27,928	36,266	49,204
Deaths	2,920	968	912	4800
Person-years of observation	24,610	22,940	67,072	114,622
–2 log likelihood ratio $\aleph^2$ (d.f.) ††	140.30 (17)	114.50 (21)	58.29 (25)	213.78 (25)
P-value	< 0.0001	< 0.0001	0.0002	< 0.0001

* Reference category.

† Due to the presence of interaction terms in the model, the main effect "exposure" variables are interpreted as the difference in mortality in the comparison area during the intervention period. The interaction terms are interpreted as the effect of the interventions on mortality, controlling for baseline differences between cells and for trends in mortality in the comparison area. See text for an explanation of the definition of "exposure" in the comparison area.

‡ Mother's age scaled so that 1 unit = 10 years and centered at age = 30 years.

§ Measured in kilometers; natural logarithm transformation.

§§ Measured in kilometers; square-root transformation.

†† Tests model fit; i.e. tests the null hypothesis that the full set of explanatory variables does not contribute to the fit of the model.