The Impact of the Navrongo Project on Contraceptive Knowledge and Use, Reproductive Preferences, and Fertility

Cornelius Debpuur, James F. Phillips, Elizabeth F. Jackson, Alex Nazzar, Pierre Ngom, and Fred N. Binka

The Navrongo Community Health and Family Planning Project is a quasi-experimental study designed to test the hypothesis that introducing health and family planning services in a traditional African societal setting will introduce reproductive change. This article presents the impact of the initial three years of project exposure on contraceptive knowledge, awareness of supply sources, reproductive preferences, contraceptive use, and fertility. Findings show that knowledge of methods and supply sources increased as a result of exposure to project activities and that deployment of nurses to communities was associated with the emergence of preferences to limit childbearing. Fertility impact is evident in all treatment cells, most prominently in areas where nurse-outreach activities are combined with strategies for involving traditional leaders and male volunteers in promoting the program. In this combined cell, the initial three years of project exposure reduced the total fertility rate by one birth, comprising a 15 percent fertility decline relative to fertility levels in comparison communities. (STUDIES IN FAMILY PLANNING 2002; 33[2]: 141–164)

High fertility in Sahelian West Africa represents a continuing issue for population policy. Fertility levels in the region are double the levels observed in developing regions of the world. Although some coastal cities have witnessed the onset of fertility transition, the rural hinterland of West Africa has yet to enter the global fertility transition. Moreover, the determinants of reproductive behavior and the prospects for change in the region have been widely debated. Many respected observers have emphasized the resilience of pronatalist social institutions in this region in noting that African religious customs, lineage and descent systems, kinship networks, and family structure reinforce high-fertility social norms, beliefs, and values.[1] In this view, high fertility is a reflection of the desire for children, and improving access to family planning services will have little or no fertility impact.[2]

Despite this climate of skepticism about the demographic role of family planning services, most reproductive health and population programs in the Sahelian region retain a focus on improving the accessibility and quality of family planning services. This emphasis on the importance of the supply of services is supported by research demonstrating that distribution of contraceptives has resulted in significant increases in contraceptive prevalence in experimental studies where programs were well organized and implemented.[3] Analysts who have assessed the implications of successful pilot programs have concluded that existing demand for services is sufficient to bring about a reduction in fertility if services are provided (Simmons 1992; Kennedy 1993). Even if programs can be shown to foster contraceptive use, however, whether this increased contraceptive use translates into fertility decline is unclear. Social research on the dynamics of fertility determinants has demonstrated that births in West Africa are spaced by prolonged postpar-

Cornelius Debpuur is Rockefeller Fellow, Navrongo Health Research Centre, Ministry of Health, Navrongo Upper East Region, Ghana. James F. Phillips is Senior Associate and Elizabeth F. Jackson is Research Coordinator, Policy Research Division, Population Council, One Dag Hammarskjold Plaza, New York, NY 10017. E-mail: jphillips@popcouncil.org. Alex Nazzar is Scientist, Health Research Unit, Ghana Health Service. Pierre Ngom is Senior Fellow, Africa Population and Health Research Centre, Nairobi, Kenya. Fred N. Binka is Associate Professor, University of Ghana, School of Public Health.

2

tum abstinence and that contraceptive adopters often substitute Western methods for abstinence, a process that may have no net fertility impact (Lesthaeghe 1989; Bledsoe 1994). The fertility impact of family planning programs is, therefore, questionable, even in settings where programs are known to have had an impact on contraceptive use.

To address the need for definitive research on the demographic role of family planning in sub-Saharan Africa, the Navrongo Health Research Centre is conducting a multiyear controlled experiment testing the relative impact of different types of program strategies in rural northern Ghana. Navrongo was selected as a site for this initiative because the northern regions of Ghana are widely assumed to be unfavorable settings for family planning success. Successive Demographic and Health Surveys have shown that indicators of knowledge of methods, awareness of services, and motives for adopting contraception portray a context for program success that is less favorable than corresponding indicators for the regions of southern Ghana. The Navrongo experiment represents a test of the hypothesis that reproductive ideational change can be introduced in a traditional African society. This article examines the hypothesis of ideational change by assessing the initial impact of the experiment on the knowledge of contraceptive methods, awareness of service-supply points, and fertility preferences. If an intervention can alter the ideational context for reproductive change, the question of whether reproductive change actually occurs is an appropriate one to address. Therefore, this study assesses the impact of experimental interventions on current use of modern methods and on fertility, and reviews the implications of findings for further research and policy.

Design of the Navrongo Experiment

In 1994, the Navrongo Health Research Centre launched the Navrongo Community Health and Family Planning Project (CHFP). This two-phased program of experimental research was designed to assess the demographic impact of convenient community health and family planning services on fertility and mortality rates by testing the hypothesis that family planning service delivery can induce and sustain reproductive change in a traditional rural African population (Binka et al. 1995). The experiment includes a research system designed to provide a basis for understanding the process of reproductive change. Baseline characteristics of the population of women of reproductive age and their husbands were documented, and follow-up panel surveys and a longitudinal demographic surveillance system monitor changes in contraceptive knowledge, reproductive preferences, reproductive behavior, and fertility.

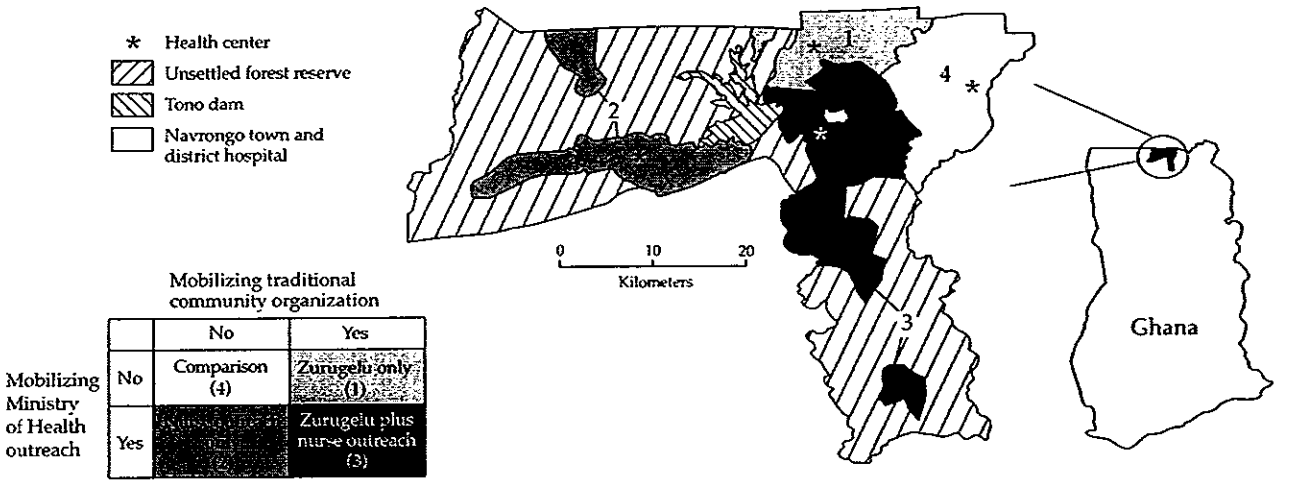
Treatment areas in Kassena-Nankana District are comprised of four cells, in three of which a new basic primary health-care and family planning program were instituted in addition to the standard clinic-based services provided by the Ministry of Health. The fourth cell maintained the standard services only and is used as the comparison area for the project. The four cells were randomly assigned in the typology that is illustrated in Figure 1.

This four-cell design was the outcome of an intensive Ministry of Health review of a relatively simple two-celled protocol specifying the impact of the trial of contraceptive distribution versus fixed-facility services. Frontline workers already trained and available within the health system could be deployed for the project without incremental cost. The feasibility of relocating nurses from subdistrict clinics to villages and the incremental impact of doing so remained the subject of considerable discussion and debate, however. Debate also focused on the role of volunteers. For more than a decade, the Ministry of Health had deployed volunteers to provide basic health services. Volunteerism in rural Ghana has vibrant cultural roots. Results of various volunteer programs had been disappointing, however, and uncertainty remained about the practicality of using volunteers for health care and family planning. The first-generation question to be addressed by the design concerns the impact of each of these experimental operational strategies relative to that of clinic-based care. Sampling and evaluation systems were designed to anticipate second-generation questions regarding the relative impact of each treatment.

The Ministry of Health Dimension: Nurse Outreach

Throughout Africa, public-sector programs provide most preventive health services and curative care. In Ghana, as in many other African countries, staff assigned to community services are posted to clinical service centers, where they often remain idle rather than engaged in community work. Essential resources for travel and transportation are lacking, organizational systems fail to reward community work, supervisory systems are weak, and community accountability is rarely developed. The fixed-service-point focus of the government health-care programs has the unintended effect of isolating public investments in health care from communities that the programs are developed to serve. An operational hypothesis of the Navrongo experiment holds that the existing Ministry of Health primary health-care program can be changed from a passive clinical system

Figure 1 Navrongo Community Health and Family Planning Project cells in the Kassena-Nankana District, Ghana



to an active community-outreach program. Specifically, paramedical workers who are now assigned to underused clinics can be redeployed to villages, equipped with outreach transportation, and instructed to canvass communities and seek clientele for the public program.

Achieving this mobilization of community services required a major administrative and strategic reorientation of Ministry of Health service operations. In the project-development period, paramedics designated as "community health nurses" were trained in community entry and diplomacy, equipped with motorbikes, and provided with a management information system for monitoring doorstep service delivery. The nurses participating in the project were redesignated "community health officers" to signify their new organizational identity and role. Supervisory staff were trained to support this new orientation of the program. Community leaders were invited to convene committees of chiefs and elders for the purpose of fostering the construction of traditional compounds with volunteer labor. These facilities, known within the project as "community health compounds," serve as a residence for the officers and as a village clinic where ambulatory care and family planning services are readily available.

The range of services provided in the Ministry of Health arm of the experimental design is broad. This dimension of the program is designed to improve access to health services that are routinely provided at subdistrict clinics, services that involve doorstep and community-based treatment of minor ailments, treatment of childhood illnesses such as antibiotic therapy for acute respiratory infections, treatment of malaria, and management of diarrheal diseases. Special organizational effort has been directed to improving childhood vaccination coverage. The family planning and reproductive health service components are also designed to be as broad as possible. Supplies of oral contraceptives and condoms are available during household visits. Injectable contraceptive services are also available at the doorstep. The community health officers are requested to visit all of the extended family compounds within a defined area in 90-day cycles. This aspect of the experiment is not strictly regulated, however. Nurses often make alternative arrangements and may ask village residents to report to the health compound for follow-up services. Taken together, the new training, management, and deployment activities of this arm of the experiment test the hypothesis that improved access to health and family planning technology can induce and sustain reproductive change.

The Zurugelu Dimension

The second dimension of the experimental typology concerns the role of social organization and ways in which volunteerism is traditionally managed in the district's communities. In many African societies, traditional systems of village leadership, social networking, and social organization are marshaled to foster volunteerism for self-help, agricultural production, and village governance. Political parties often use traditional communication systems to mobilize votes. Throughout Africa, however, health and family planning programs have directed surprisingly little attention to using these cultural resources for organizing their operations. In the Navrongo project, traditional social cooperation, termed the *zurugelu* approach, is used to mobilize support for community health

4

and family planning services.[4] This approach involves constituting health-care action committees from existing councils of elders, mobilizing traditional peer networks, and implementing supervisory services with extant traditional village self-help schemes. The services are provided through the use of community health volunteers, termed health aides, or *yezura zenna,* who are chosen by the community and trained by the project staff to provide basic health-care services, reproductive health education, outreach to men, and contraceptive supplies.[5] Outreach to men is undertaken by using existing mechanisms for community gatherings, known as "durbars," which are convened by chiefs and elders to mobilize community action. In the zurugelu arm of the experiment, the frequency of durbars is regularized to 90-day intervals, and discussions focus on health and family planning themes to give men an open forum for discussing their reactions to the program. The zurugelu strategy also provides outreach to women's social networks and to activities designed to involve women in durbars and in other means of communication that are traditionally the purview of men only.

The gender strategies and communication activities of the zurugelu arm of the experiment were expected to alter the social context of reproductive change by legitimizing the concept of family planning among men, by opening community dialogue about health and reproductive matters that traditionally were not discussed between spouses, and by involving women in social leadership that previously had been reserved for men. This arm of the experiment was, therefore, designed to test the hypothesis that the social costs of contraception can be reduced through community mobilization.

Cell 1 in Figure 1 tests the zurugelu approach as a stand-alone community-based program, with links to the formal Ministry of Health (MOH) service system established by routine coordination and training meetings every 90 days and to village-outreach systems in which MOH supervisors replenish stocks of primary medication. Each yezura zenna is equipped with a backpack containing a pharmaceutical kit comprised of paracetamol, oral rehydration packets, chloroquin, and condoms. The zurugelu system comprises a field trial of the UNICEF-sponsored Bamako Initiative. With this strategy, communities operate a revolving fund for recovering costs of pharmaceuticals and supplies, and a logistics system is developed to ensure that stocks are replenished as needed. This concept has been widely promoted in West Africa as an approach to community services that is both effective and sustainable.

Cell 2 in Figure 1 tests the nurse-outreach approach as a stand-alone system of the MOH. Existing MOH policies for promoting community-based services emphasize the Cell 2 approach. The nurse-outreach and the zurugelu dimensions of the design are combined in cell 3, where the relative advantages of MOH professionalism complement the implicit community accountability and sustainability of the zurugelu approach. Cell 3 of the experiment tests the hypothesis that a combined strategy of improving access and reducing social costs will induce and sustain reproductive change. The bureaucratic and community organizing dimensions thus define three contrasting models for setting up health-care services at the periphery, each to be evaluated in reference to the existing MOH static clinical program: organizing existing community social resources at the periphery (Cell 1), mobilizing existing MOH resources at the periphery (Cell 2), versus a combination of both (Cell 3). The comparison area defined by the existing MOH service system is Cell 4 in Figure 1.[6]

Project Phases

Because little was known about culturally appropriate strategies for providing family planning services in northern Ghana, a pilot phase was launched in three villages in 1994 that involved consulting communities about service strategies, launching pilot operations in response to this advice, and conducting social research to gauge reactions to the services rendered. This procedure led to practical guidelines on how a service program could relate work to communities, explain the program to individuals, mobilize social groups, and involve traditional leaders in organizational activities and supervision. Social research involved putting together consultative groups of village leaders, men, mothers, and health-care service providers over a period of 18 months. This three-village pilot investigation was completed in 1996 and tested strategic details concerning how zurugelu and nurse-outreach services would be planned and implemented (Nazzar et al. 1995).

The second phase, comprised of a district-wide factorial trial, was launched during the period from January to June 1996, using operational strategies developed in phase one. This article presents results for the pilot and large-scale trial through 1999.

The Social and Demographic Context

Navrongo is located in the Kassena-Nankana district, an impoverished rural area in northern Ghana where animist religious practices predominate and traditional forms of village government and social organization per-

sist. The settlement pattern is highly dispersed, lacking towns, modern markets, or industries that would develop centers of modern commerce and communication. Although some exposure to outside ideas and influences arises from trade and migration, the study district remains isolated and remote. The study area lies in the most impoverished region of Ghana, on the Ghana–Burkina Faso border. The semiarid geography and dispersed settlement pattern accentuate social isolation and complicate efforts to organize health and human services in the locality.

As Table 1 baseline data show, 42 percent of all currently married women were in polygynous unions in 1993. Most of the population are Kassim or Nankam speakers, ethnic groups who have historic migratory links with Sahelian people to the north of Ghana. Local languages thus provide only fragmentary communication links to Ghana's southern cultures and restrict exposure of the population to outside ideas more generally. Baseline literacy of currently married women was only 7 percent, further isolating women from the outside world.

The adoption of modern family planning methods is constrained by various cultural traditions that restrict women's autonomy and shape men's perception of the value of children. Taken together, the institution of marriage and the extended family impede the introduction of new ideas about contraceptive technology. The custom of bridewealth transactions reinforces a prevalent belief that marriage is a means to purchase women for the purpose of providing the lineage with children. Focus-group discussions suggest that a woman's decision to adopt contraception is often at odds with perceptions of appropriate female roles, and that the decision may cause contraceptive adopters considerable risk of embarrassment and ostracism from their husbands, cowives, and kin (Adongo et al. 1997 and 1998; Bawah 1999). Despite these constraints to contraceptive use, knowledge of methods was widespread in the baseline period. The ability to name spontaneously a modern contraceptive method ranged between 32 and 52 percent of respondents in the various treatment areas in 1993, although most women knew of a method when prompted and could identify a supply source for a modern method when asked (see Table 2). Baseline prevalence of contraceptive use was low in all treatment areas, especially in the comparison area of the experiment.

Despite the social institutional constraints to contraceptive use, most women expressed a preference for some degree of fertility control. As Table 2 shows, more than one-third of respondents in the 1993 baseline survey expressed fertility preferences for spacing additional births. Between 19 and 37 percent of women expressed a desire to limit additional births. Although traditional reproductive control mechanisms such as prolonged postpartum abstinence are widespread and may reduce fertility substantially, stated reproductive preferences in surveys are consistent with family planning, suggesting that desires for fertility control exist that could be addressed with services. Social research has demonstrated, however, that some of this stated demand may have been an artifact of biases that are associated with the survey-interview paradigm in this setting.[7] Whether demand that is estimated from survey data can be met with services represents an issue for investigation in this study.

The baseline demographic context for the Navrongo experiment was pretransitional (Debpurr et al. 1994). In the area served by the project, infant and childhood mortality were high (124 per thousand live births and 19 per thousand children in the 1994–95 period), and the total

Table 1 Percentage of 2,910 women aged 15–49 who are currently married or in union, by selected background characteristics, experimental cell, Navrongo Project Panel Survey, Kassena-Nankana District, Ghana, 1993

Experimental cell	Zurugelu only	Nurse outreach only	Zurugelu plus nurse outreach	Comparison area	Percent	(n)
Ever attended school	17.7	23.4	29.8	11.7	20.5	(595)
Literate	6.0	8.4	10.0	3.2	6.7	(194)
Polygynous	38.1	46.4	36.9	45.3	41.5	(1,207)
Ethnicity						
Kassim	95.3	81.9	53.0	12.8	49.8	(1,449)
Nankam	2.6	0.7	38.0	86.9	44.1	(1,284)
Bulsa	0.6	15.8	8.3	0.0	5.2	(152)
Other	1.5	1.6	0.7	0.4	0.9	(25)
Religion						
Traditional	59.8	59.6	70.2	86.1	72.6	(2,113)
Christian	27.2	37.4	26.9	13.0	23.5	(685)
Muslim	13.0	2.6	1.3	0.6	3.1	(91)
Other	0.0	0.5	1.5	0.4	0.7	(21)

Table 2 Among currently married women aged 15–49, baseline prevalence of contraceptive knowledge, fertility preferences, and contraceptive use, by experimental exposure area, Navrongo Project Panel Survey, Kassena-Nankana District, Ghana, 1993

Variable	Zurugelu only	Nurse outreach	Zurugelu plus nurse outreach	Comparison area
Spontaneous knowledge of a modern method	52.3	48.5	37.8	32.0
Knowledge of a supply source for a modern method	67.8	66.6	47.6	53.1
Desire to space additional births	37.5	33.2	33.8	36.1
Desire to limit additional births	36.9	23.4	23.6	19.0
Prevalence of modern-method use				
Oral contraceptives	1.6	1.5	1.0	0.2
Injectables	2.0	3.7	1.7	0.7
All modern methods	4.7	5.6	3.5	1.0

b

fertility rate was 5.5 children per woman of reproductive age in 1994 (Binka et al. 1999). Achieving an impact on community health and family planning thus requires that fertility transition be induced rather than that a preexisting trend be accelerated.

Methodology

The central scientific resource of the NHRC is the Navrongo Demographic Surveillance System (NDSS), a longitudinal register of all 139,000 individuals residing in rural villages of the Kassena-Nankana District and of all demographic events, including births, deaths, in- and out-migrations, marriages, pregnancies, and changes in household relationships. The NDSS provides continuous estimates of fertility rates for approximately 43,000 women of reproductive age (Binka et al. 1999).

The NDSS has been augmented with an open-cohort sample of approximately 1,900 compounds in which all married women of reproductive age have been interviewed in annual cycles since early 1993 to assess reproductive behavior and preferences, contraceptive use, and fertility determinants. Since 1995, all spouses of panel respondents have also been interviewed. Panel data from the Navrongo CHFP are used to measure the initial impact of the experiment on respondents' knowledge of contraceptive methods and supply points, fertility preferences, current use of modern methods, intention to use modern contraceptives in the future, and fertility. Experimental services were scaled up during the period from October 1995 to July 1996. The analysis uses six panel data sets compiled in 1993 as a baseline and subsequently through 1999 in order to assess the impact of the experiment on fertility behavior and preferences. The 1994 panel is not used because it did not collect data on the background characteristics that are used as covariates in our analysis.

Study Limitations

Analysis of CHFP results must address the question: What is the net impact of exposure to the two alternative experimental treatments alone and combined with knowledge of contraception, reproductive preferences, contraceptive practice, and fertility? Although tabulation of panel data is informative in addressing this aim, the possibility remains that simple cross-tabulation of data by experimental cell over time can distort estimates of the impact of the experiment. Regression adjustments are required in this analysis because inherent biases may arise from six possible sources.

First, demographic conditions, such as age structure and parity, and social conditions, such as educational attainment, polygamy, religion, and ethnicity, differ by treatment area. The effect of these background characteristics may be associated with baseline cell differentials in the climate of demand for contraception. This point is suggested in Table 1 by the contrasting levels of schooling, literacy, and other social characteristics that may affect demand for contraception and by baseline differences in contraceptive use, knowledge, and fertility preferences by study cell. For example, although the prevalence of contraceptive use in 1993 was low in all four experimental areas, it was especially low in the comparison area. Levels of literacy are two times higher in the zurugelu and combined zurugelu and nurse-outreach cells than in the nurse-outreach and comparison areas. The comparison area has the lowest proportion of currently married women who have ever attended school, 12 percent. Therefore, an adjustment of cell comparisons for background characteristics of the study population is important so that these differences do not contaminate estimates of project impact. Variance in baseline conditions may also reflect the effects of underlying fertility determinants that are not measured by CHFP research systems.

Second, the onset of experimental services varied by village. CHFP services were launched when nurse-outreach communities completed community health compounds or when zurugelu communities convened durbars to celebrate the launching of operations with their yezura zenna health aides. This process of project preparation differed by village in ways that affected exposure to CHFP operations. Estimates of project impact must be adjusted for variation in the timing of project implementation and, therefore, in duration of exposure to project activities.

Third, responses in survey research may be biased in unknown ways. Although longitudinal data provide a valuable resource used in adjusting for other sources of bias, they may be biased by reactions of respondents to the interviewing procedure. This possibility is particularly problematic for measures of contraceptive knowledge, because awareness of contraception in one round of interviewing may be informed by questions asked in previous years. It is, therefore, important to assess relative change in knowledge, awareness, and intention by treatment rather than by levels of indicators at any particular time. Focusing the analysis on relative trends may not compensate completely for biases that arise from deliberate falsification of responses, however. This form of response bias is likely to be particularly problematic in surveys designed to assess levels of contraceptive use in

the Sahelian settings of northern Ghana. The CHFP has employed panel questions on contraceptive use that replicate interviewing procedures used in the Ghana Demographic and Health Survey (DHS). Although DHS questions have been used to monitor contraceptive behavior in the region, assessing actual levels of use may not be possible with survey research methods. This conclusion is suggested by a Navrongo investigation, conducted in the initial year of the study, that matched NDSS identifiers from nurses' register data with corresponding identification information from panel-survey responses. Linked records permitted tabulation of stated use among known contraceptive users. Results of this tabulation suggested that denial of use may be as high as 50 percent among those who are, in fact, practicing contraception. Although research procedures can compensate for the possible underreporting of use by basing inference on relative trends, estimated experimental treatment effects could arise spuriously from differential treatment effects on denial rather than from the true impact of the experiment on use. The CHFP is, therefore, evaluated with fertility endpoints. Reported trends in contraceptive use are examined for consistency with the impact of the project on other indicators of ideational change.

Contamination between cells represents a fourth potential limitation of the study. The geographic configuration of treatments mapped in Figure 1 shows that each cell corresponds to the catchment area of a rural health center. To the extent possible, treatments have been designated in geographically distinct areas separated by natural boundaries. Cell 2, the nurse-outreach cell, is separated from other experimental areas by the backwater of the Tono irrigation project and by forest reserve areas. Cell 3, the area receiving combined zurugelu and nurse-outreach treatment, is separated from other areas by forest reserves to the south and east, but is contiguous to cells 1 and 4 to the north. To minimize diffusion effects between cells, treatments were delineated by entire paramount-chieftaincy areas, so that involvement of traditional leaders in experimental activities would not contaminate the activities in neighboring treatment zones.

Cells may be contaminated by differential access to primary-health-care facilities in subdistricts and in Navrongo town. Moreover, Navrongo town, which borders cell 3, is a relatively developed area, which may affect the inhabitants' reproductive motives in unknown but potentially significant ways. For this reason, respondents residing in Navrongo town are excluded from the analysis. Geographic information coordinates have been included in the regression procedure to permit statistical adjustment for proximity to Navrongo town and for distance to nearest health-care facility.

Finally, the statistical evaluation of the CHFP, like any other randomized four-cell factorial experiment with four areal cells, is intrinsically statistically inefficient. A true experimental study would employ geographic zones as units of observation, with as many zones specified in the design as are needed to permit unambiguous evaluation of hypotheses. This requirement could not be met within Kassena-Nankana District, which contains only four subdistrict health centers and four contiguous catchment areas. Although regression models can be employed to adjust for the potentially confounding effects of cell differentials in baseline characteristics, true sampling errors for measures of experimental exposure effects in four-celled designs with four study areas are unmeasurable. Although the project planners took care to develop the most rigorous possible randomized trial, the design is appropriately characterized as quasi-experimental. Results must, therefore, be interpreted with caution.[8]

The Regression Procedure

To address these problems, estimates of impact must be adjusted for underlying differences between experimental areas in knowledge of family planning, fertility preferences, and contraceptive use and for respondents' differential exposure to project services and background characteristics. A maximum-likelihood logit model that addresses the problem of examining the impact of the experiment on these three variables is presented in Appendix A. This model yields estimates of the impact of exposure to each arm of the experiment relative to the comparison area for each of the dependent variables of interest. Pairwise comparisons assess the relative effectiveness of each cell based on the main effects the zurugelu and nurse-outreach arms of the experiment and their joint effect, bringing into account the possibility of nonlinearity in these effects over time. Results of tests of relative treatment effects at different lengths of exposure duration, controlling for contaminating covariate effects, are presented below in Tables 4, 5, 6, and 8, and the analytical procedure used is described in Appendix A.

Dependent variables measure the time trend in the prevalence of knowledge of contraceptive methods, preferences for limiting or spacing births, modern-contraceptive use, and parity progression. The key independent variable for this analysis, duration of project exposure, is defined in reference to the onset of service coverage in defined work areas. Extended families reside in walled housing compounds consisting of dwelling units sharing a courtyard and joined by a wall. Work areas in the CHFP are delineated by groups of contiguous compounds

8

termed "clusters." Typically, a cluster is covered by an outreach worker in one week or less. Exposure duration is measured at the cluster level because the variation of individual exposure within clusters is, therefore, small, ranging over a few days. Dates of project implementation permit adjustments for varying exposure times at the cluster level. In each case, the independent variable duration of exposure to the experiment is measured at the cluster level of service-delivery implementation to reflect the phasing in of experimental activity over time, whereby some clusters have been exposed to the experiment before others. Because the assignment of workers to communities has been monitored precisely, and because the service rounds for clusters of households are known, exposure to services over time for each woman is defined as the duration of her compound's exposure to CHFP service interventions based on the time that service delivery was implemented in her cluster.

Parameters also adjust for differential effects of educational attainment, age, and other characteristics of individuals that may affect dependent variables and that may differ by cell in ways that could contaminate results. Parameters for squared age and parity are included because diagnostic tests showed that the relationship between these variables and the dependent variables is nonlinear. Owing to the nonlinearity of effects, both the parameters for duration of exposure and duration of exposure squared determine the effect of a given treatment at a specific time. For this reason, combined parameter effects are presented for all possible comparisons of treatments in Tables 4, 5, 6, and 8 for one to four years of exposure to the experiment.

Adjusted predicted values for parameters of the regressions in Table 3 are presented in Figures 3 through 6. Each diagram portrays time trends in the net effects of exposure in each of the experimental cells, adjusting for the effects of age, parity, geographic cell, polygamy, education, religion, ethnicity, and distance to nearest health facility and Navrongo town. The adjusted values are calculated using sample mean values for each of the independent variables and observed values for time and duration of experimental exposure. For 1993, before experimental exposure began, adjusted values are the same for each cell in each diagram. As exposure ensues and exposure duration increases over time, the adjusted prevalence of each dependent variable examined diverges among the four cells according to their relative estimated net impact.

The dependent variables for current modern contraceptive knowledge, use of a modern method, and having a fertility preference for either limiting or spacing are binomial variables coded as 0 or 1 for the maximum-likelihood logistic-regression procedure. Fertility preference for limiting or spacing is coded as a trichotomous variable, with the comparison category being preference for neither limiting nor spacing (women who either want a child now or have no preference). Table 3 shows regression parameters resulting from modeling each dependent variable using these models.

The Sample

The data set consists of information from 8,998 currently married women gathered in an average of 2.4 panel years for each respondent over a maximum of six panel years. Each observation in the data set represents one year of panel responses from one woman. Individual women are identified separately by the Navrongo Demographic Surveillance System, and each woman's set of observations is differentiated by a time variable representing panel survey year.

Data from the CHFP panels define a time series in prevalence for study areas and repeat observations among adult women resident in sampled compounds. A subset of the panel data consisting of currently married women is used in our analysis. Because individuals who leave study compounds are not traced, the observation set represents an open cohort of individuals who may be first observed in a given panel and may or may not be interviewed during successive panel rounds.

Results

The impact of the experiment on contraceptive knowledge was assessed by examining the time trend in the adjusted prevalence of respondents who spontaneously mentioned any modern contraceptive method. The odds ratios in Table 3, column 1, control for time period, age, parity, underlying social characteristics, and baseline differences in levels of knowledge. The odds ratios in column 1 indicate that education and practicing a nontraditional religion are each associated with an increased likelihood of knowing about a modern contraceptive method. Educated women and women who no longer practice traditional religion are similarly significantly more likely to have higher levels of knowledge of a modern-method source, more likely to prefer to limit fertility, and more likely to use a modern method, findings that may indicate that such women are more likely to exhibit nontraditional fertility behavior (see columns 2, 3, and 5).

Educational attainment bears a strong relationship to the survival of children, health-related behavior of

Table 3 Maximum-likelihood logistic-regression model odds ratios, with standard errors adjusted for multiple observations of individuals, measuring the effect of duration of experimental exposure on respondents' modern contraceptive knowledge, reported method use, fertility preferences, and on parity progression of currently married women aged 15–49, Navrongo Project, 1993–99

Covariates	Knows a modern method (1)	Knows a source (2)	Prefers to limit birth[a] (3)	Prefers to space birth[a] (4)	Reports used of a modern method (5)	Parity progression (6)
Time	1.435***	1.563***	1.069***	1.122***	1.109***	0.998
Age	1.325***	1.314***	1.052	0.968	1.307***	1.449***
Age squared	0.995***	0.996***	1.000	0.999*	0.996***	0.992***
Parity	1.375***	1.266***	2.372***	1.942***	1.378***	0.345***
Parity squared	0.982***	0.988**	0.959***	0.952***	0.981***	—
Parity–age interaction	—	—	—	—	—	1.029***
Seasonality effect						
January–March	—	—	—	—	—	0.994
April–June	—	—	—	—	—	0.887***
July–September	—	—	—	—	—	0.861***
Background characteristic						
Polygamous	1.046	0.953	1.016	0.949	0.871	0.911***
Ever attended school	1.813***	1.717***	1.328***	1.036	1.675***	0.925**
Husband attended school	na	na	na	na	na	0.920***
Compound size (people)	na	na	na	na	na	0.998***
Nontraditional religion (Christian, Muslim, other)	1.815***	1.653***	1.324***	1.046	1.986***	na
Ethnicity (Kassena omitted)						
Nankana	0.788***	0.848*	0.853*	0.879*	0.886	na
Bulsa or other	0.759**	1.092	0.871	0.878	0.989	na
Baseline differences in exposure areas						
Zurugelu area (Cells 1 and 3)	1.313*	1.331*	1.336*	0.836	1.881**	1.044
Nurse-outreach area (Cells 2 and 3)	0.992	0.904	0.901	0.891	1.415	0.987
Zurugelu–nurse-outreach interaction (Cell 3)	0.669**	0.590**	0.896	1.050	0.527*	1.002
Location						
Distance to nearest clinic	0.961*	0.993	1.020	1.007	0.877***	1.004
Distance to Navrongo town	0.999	0.994	0.980***	0.999	0.975**	1.007***
Community-level exposure duration in years[b]						
Zurugelu only	1.311***	1.800***	0.859	1.044	1.249	0.959*
Nurse outreach only	1.312***	1.115	1.511***	1.140*	1.050	0.967*
Zurugelu–nurse-outreach interaction	0.958	0.916*	0.971	0.994	1.007	1.005
Squared effects						
Zurugelu only	0.915***	0.842***	1.046*	0.985	0.945*	—
Nurse outreach only	0.931***	0.942**	0.935***	0.957**	0.991	—
Zurugelu–nurse-outreach interaction	1.005***	1.010***	1.000	1.001	1.001	—
Person–years of observation	21,485	21,485	21,485	21,485	21,485	79,843
Individual women observed	8,998	8,998	8,998	8,998	8,998	17,573
Average years observed	2.4	2.4	2.4	2.4	2.4	4.5
Log-likelihood	–11,547.8	–7,766.39	–18,684.87	–5,074.70	–55,436.37	
Wald χ^2 test (6 degrees of freedom) of exposure-duration variable set	83.05 ($p > \chi^2 = 0.00$)	87.65 ($p > \chi^2 = 0.00$)	29.88 ($p > \chi^2 = 0.00$)	22.07 ($p > \chi^2 = 0.00$)	10.26 ($p > \chi^2 = 0.1142$)	22.20 (3 d.f.) ($p > \chi^2 = 0.00$)
Wald χ^2 *degrees of freedom*	2,246.8 *21*	1,885.4 *21*	3,718.4 *42*	735.9 *21*	4,754.62 *20*	
Pseudo R^2	0.1484	0.1580	0.1752	0.1021	0.0402	

*Significant at p<0.05; **p<0.01; ***p<0.001. — = Not applicable. na = Not available. [a]Multinomial logistic regression, comparison "want more now" or "don't know." [b]The comparison area and unexposed treatment area person-rounds of panel interviews comprise the reference category.

women, reproductive behavior, and family planning, although the prevalence of education has historically been very low among women in the study area. The education coefficients shown in Table 3 are another manifestation of the importance of education as a component of human development, which has been demonstrated in many research projects.[9]

Controlling for other covariates in the model, the effects of duration of exposure to either the nurse-outreach or the zurugelu approach are significant, but are offset by significant and negative duration-squared effects. This relationship between experimental exposure and knowledge suggests that the effect of the combined approach on knowledge is initially positive, but decreases with time, implying that independent arms of the experiment have diminishing returns as time progresses and that the pool of women who do not know about a method diminishes. The effect of combining treatment arms is deter-

mined by summing the nurse-only, zurugelu-only, and joint effects of nurse–zurugelu interaction. The odds ratio for the interaction effect is positive, indicating that the effect on knowledge of combining strategies is greater than the independent effect of each strategy considered separately.

Because interpretation of the overall role of treatments is complicated by the significant squared duration of exposure terms, tests have been conducted for the relative impact of treatments that bring into account all parameters in the regression model for one to four years of exposure duration (see Appendix A). These results are presented in the upper panel of Table 4. Odds ratios in the upper panel of column 1 show that the nurse-outreach and the zurugelu strategies each had a significant independent impact on knowledge of contraception relative to gains in knowledge that occurred in the comparison area. When the two interventions operate jointly, in the first year of exposure their combined impact on knowledge is much greater than effects registered by each strategy separately (OR = 1.41 in the combined condition versus 1.22 and 1.20). The impact of one year of the combined treatment relative to one year of either the zurugelu or nurse-outreach strategy is statistically significant (as shown in columns 2 and 3, upper panel). This finding suggests that introducing information and enhancing awareness about contraceptive methods are more effective in the first year when strategies are combined than when CHFP strategies are pursued separately. In subsequent years of exposure, the effect of combining strategies waned, as demonstrated by the significant squared duration of exposure terms. By the fourth year, zurugelu exposure actually decreased the onset of knowledge relative to the comparison area.

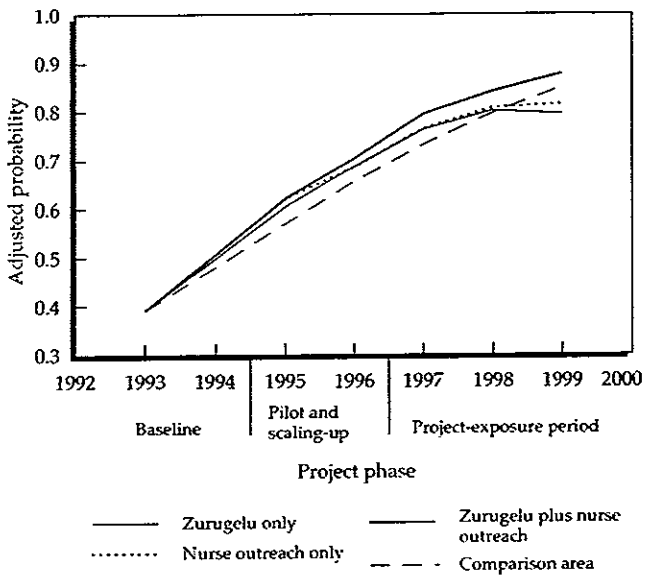
This conclusion is further clarified by the time series in Figure 2 for regression-adjusted levels of knowledge by type of experimental area for each of the experimental cells by year. As the figure shows, the adjusted-probability baseline levels of knowledge in all experimental areas rose from 39 percent in 1993 to between 80 and 90 percent by 1999. Contraceptive-knowledge levels in the three experimental areas initially diverged upward from the comparison area with the onset of exposure, although differences between the exposed and comparison areas decreased over time so that by 1999, prevalence of knowledge in the combined-exposure area was 88 percent, slightly above prevalence in the comparison area at 85 percent. Knowledge levels among women receiving only one arm of exposure fell below that of the comparison area. This trend is a consequence of the significant and negative squared effects for the nurse-outreach-only and zurugelu-only odds ratios in column 1 of Table 3. When these parameters are combined in the estimate of the cell 3 combined-exposure trend, the negative effect of each arm of the experiment also affects the trend in areas where these activities were implemented jointly. Thus, even in cell 3, the impact of the project on knowledge reaches a diminishing return as the pool of women who do not know about methods diminishes and when knowledge about contraception saturates the population. Nonetheless, project activities accelerate the pace at which knowledge is attained.

Table 4 Odds ratios for the relative effect of duration of treatment exposure and duration of treatment exposure squared on currently married women's knowledge of modern methods and contraceptive supply sources, adjusted for other parameters of Table 3, Navrongo Project, Kassena-Nankana District, Ghana, 1993–99

	Odds ratio		
		Treatment	
Knowledge of modern methods/sources	Comparison area (1)	Nurse outreach only (2)	Zurugelu only (3)
Spontaneous knowledge of a modern method			
After one year of exposure to			
Nurse outreach only	1.22***	—	—
Zurugelu only	1.20**	0.98	—
Zurugelu plus nurse outreach	1.41***	1.16**	1.18**
After two years of exposure to			
Nurse outreach only	1.29**	—	—
Zurugelu only	1.21	0.93	—
Zurugelu plus nurse outreach	1.43***	1.10	1.18
After three years of exposure to			
Nurse outreach only	1.18	—	—
Zurugelu only	1.02	0.86	—
Zurugelu plus nurse outreach	1.25*	1.05	1.23
After four years of exposure to			
Nurse outreach only	0.94	—	—
Zurugelu only	0.72*	0.76	—
Zurugelu plus nurse outreach	1.28	1.37*	1.79***
Ability to identify a source for a modern contraceptive method			
After one year of exposure to			
Nurse outreach only	1.05	—	—
Zurugelu only	1.52***	1.44**	—
Zurugelu plus nurse outreach	1.47***	1.40***	0.97
After two years of exposure to			
Nurse outreach only	0.98	—	—
Zurugelu only	1.63**	1.66*	—
Zurugelu plus nurse outreach	1.31*	1.34*	0.81
After three years of exposure to			
Nurse outreach only	0.81	—	—
Zurugelu only	1.24	1.53*	—
Zurugelu plus nurse outreach	1.01	1.24	0.81
After four years of exposure to			
Nurse outreach only	0.60**	—	—
Zurugelu only	0.67*	1.13	—
Zurugelu plus nurse outreach	1.19	1.99**	1.77*

*Significant at p<0.05; **p<0.01; ***p<0.001. — = Not applicable.

Figure 2 Among currently married women aged 15–49, maximum-likelihood logistic-regression-adjusted probability of naming one or more modern contraceptive methods spontaneously, by experimental exposure, Navrongo Project, Kassena-Nankana District, Ghana, 1993–99

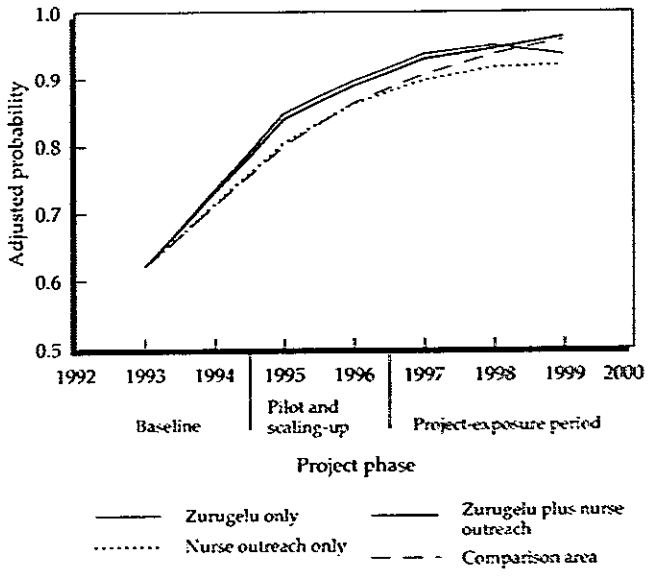


The effect of experimental exposure on knowledge of a modern-method supply source is presented in Table 3, column 2. A respondent is considered to know a modern supply source if she confirms in her interview that she knows where to get any of the modern methods that she previously either listed spontaneously or said she had heard of when prompted by a list of methods. As Table 3 shows, zurugelu duration-of-exposure effects were positive and duration-squared effects were negative, suggesting that initial positive effects were offset by diminishing returns as the project progressed. Nurse outreach, on the other hand, had no apparent effect on knowledge of supply sources.

The contrasting impact of the nurse-outreach and zurugelu strategies may arise because zurugelu activities often involve durbars that emphasize community education about the services provided in clinics. Nurse outreach, on the other hand, emphasizes the provision of doorstep care without community mobilization or education. Respondents may have misinterpreted the question, thinking that it related to awareness of services at some distant place where care is provided rather than to the supply of services they receive in their homes or in the community. This misinterpretation may also explain the pronounced negative joint effect of zurugelu and nurse-outreach activities on knowledge of contraceptive supply sources. Initially, no evidence is found that the combined strategy is more effective than the zurugelu approach in creating awareness of sources of services, as shown by odds ratios in the lower panel of Table 4. As statistical tests in that panel show, however, by the fourth year of exposure, the effects of both nurse-outreach and zurugelu exposure alone are associated with lower levels of knowledge of a supply source than are found in the comparison area, and combined-treatment exposure is the only type of exposure that does not differ significantly from the comparison area.

The impact of the experiment on knowledge of a supply source has been estimated for each of the four experimental areas as regression-adjusted levels of this knowledge and is presented in Figure 3. Among married women of reproductive age experiencing each of the three exposure types, the adjusted probabilities show that prevalence of knowledge of a supply source increased from 1993 to 1999 in all experimental areas from a baseline value of 62 percent to more than 90 percent. An interview effect likely contributed to this dramatic rise, because respondents who are repeatedly questioned about an issue learn from the interviewing process, as discussed above in the case of spontaneous knowledge of a modern method. Nonetheless, the trend shown in Figure 3 indicates that the zurugelu-only and combined-exposure areas had an equivalent initial three-year impact on the pace of change in knowledge of supply sources. The ad-

Figure 3 Among currently married women aged 15–49, maximum-likelihood logistic-regression-adjusted probability of being able to name a supply source for at least one modern contraceptive method, by experimental exposure, Navrongo Project, Kassena-Nankana District, Ghana, 1993–99



12

justed trends illustrate the consequence of significant and negative squared effects in Table 3, column 2. As noted above, the impact of the project on knowledge reached a diminishing return as exposure to the experiment progressed.

Reproductive Preferences

Several analysts have noted that traditional reproductive practices are associated with long durations of postpartum abstinence. Women seeking family planning services often substitute contraception for abstinence, and demand for fertility regulation is typically expressed in terms of need for spacing childbearing rather than as a desire to limit childbearing (Caldwell and Caldwell 1987, 1988, and 1990; Bledsoe et al. 1994). To assess the effect of experimental exposure on preferences, the discrete dependent variable in Model 1 in Appendix A was expanded to accommodate a trichotomous variable assessing preferences for fertility regulation, with the omitted class specified as either wanting more children soon or "not sure." Parameters estimate the effect of each experimental arm on the desire to space or limit childbearing relative to wanting more children soon or not stating a preference.

Table 3, columns 3 and 4, report odds ratios showing that the nurse-outreach arm of the experiment is associated with significantly higher odds of wanting to limit or space fertility, although the presence of a significant and negative squared term indicates that the relationship between the nurse-outreach arm and modified fertility desires is nonlinear and decreases as time progresses. A small but significant zurugelu effect is indicated by a significant and positive association of squared zurugelu exposure duration with desire to limit fertility. Taken together, these effects suggest that the experiment has introduced changes in reproductive preferences.[10] This finding is further confirmed by tests of the combined effect of exposure and exposure squared at one through four years (as shown in Table 5). Contrasts between the upper and lower panel of Table 5 show that the prevalent preference for child spacing was unaffected by the experiment. Where nurses were deployed in communities, however, the desire to limit childbearing remained greater over all four years of exposure duration, suggesting that exchanges between nurses and clientele may have introduced new ideas about childbearing.

Odds ratios in Table 5 show that one year of nurse-outreach activities is associated with 1.4-fold higher odds of desiring to limit fertility relative to the comparison area. One year of zurugelu exposure is associated with significantly lower odds of desiring to limit fertility than is one year of nurse-outreach exposure. The first year of combined zurugelu and nurse-outreach effect, taking into account each experimental-arm estimator and the interaction term, demonstrates that women who have experienced combined exposure are 20 percent more likely to desire to limit fertility, compared with unexposed women (see Table 6). Thus, the combined-exposure condition has less impact on women's desire to limit their fertility than does nurse-outreach exposure alone. Although the combined-exposure effect appears to be entirely a result of the impact of nurse outreach, zuru-

Table 5 Odds ratios evaluating the relationship between linear combinations of estimators for duration of exposure to the zurugelu and nurse-outreach arms of the Navrongo Project and fertility preferences for limiting or spacing among currently married women aged 15–49, Kassena-Nankana District, Ghana, 1993–99

	Odds ratio		
		Treatment	
Desire to avoid or space additional births	Comparison area (1)	Nurse outreach only (2)	Zurugelu exposure only (3)
Avoid births			
After one year of exposure to			
Nurse outreach only	1.41***	—	—
Zurugelu only	0.90	0.64***	—
Zurugelu plus nurse outreach	1.23**	0.87*	1.37***
After two years of exposure to			
Nurse outreach only	1.74***	—	—
Zurugelu only	0.88	0.51***	—
Zurugelu plus nurse outreach	1.37**	0.78*	1.55***
After three years of exposure to			
Nurse outreach only	1.88***	—	—
Zurugelu only	0.95	0.50***	—
Zurugelu plus nnurse outreach	1.36**	0.72*	1.44**
After four years of exposure to			
Nurse outreach only	1.77***	—	—
Zurugelu only	1.11	0.63*	—
Zurugelu plus nurse outreach	1.22	0.69*	1.10
Space births			
After one year of exposure to			
Nurse outreach only	1.09	—	—
Zurugelu only	1.03	0.94	—
Zurugelu plus nurse outreach	1.12	1.02	1.09
After two years of exposure to			
Nurse outreach only	1.09	—	—
Zurugelu only	1.02	0.94	—
Zurugelu plus nurse outreach	1.11	1.02	1.09
After three years of exposure to			
Nurse outreach only	1.00	—	—
Zurugelu only	0.99	0.99	—
Zurugelu plus nurse outreach	1.03	1.03	1.04
After four years of exposure to			
Nurse outreach only	0.83	—	—
Zurugelu only	0.93	1.11	—
Zurugelu plus nurse outreach	0.95	1.14	1.03

*Significant at p<0.05; **p<0.01; ***p<0.001. — = Not applicable.

Table 6 Odds ratios evaluating the relationship between linear combinations of estimators for duration of currently married women's exposure to the Zurugelu and nurse-outreach arms of the Navrongo Project and current use of modern contraceptive methods, Kassena-Nankana District, Ghana, 1993–99

	Odds ratio		
		Treatment	
Use of a modern contraceptive	Comparison area (1)	Nurse outreach only (2)	Zurugelu exposure only (3)
After one year of exposure to			
Nurse outreach only	1.04	—	—
Zurugelu only	1.18	1.14	—
Zurugelu plus nurse outreach	1.24*	1.19*	1.05
After two years of exposure to			
Nurse outreach only	1.06	—	—
Zurugelu only	1.25	1.17	—
Zurugelu plus nurse outreach	1.38*	1.29	1.10
After three years of exposure to			
Nurse outreach only	1.07	—	—
Zurugelu only	1.18	1.10	—
Zurugelu plus nurse outreach	1.40*	1.32	1.19
After four years of exposure to			
Nurse outreach only	1.05	—	—
Zurugelu only	0.99	0.95	—
Zurugelu plus nurse outreach	1.36	1.29	1.37

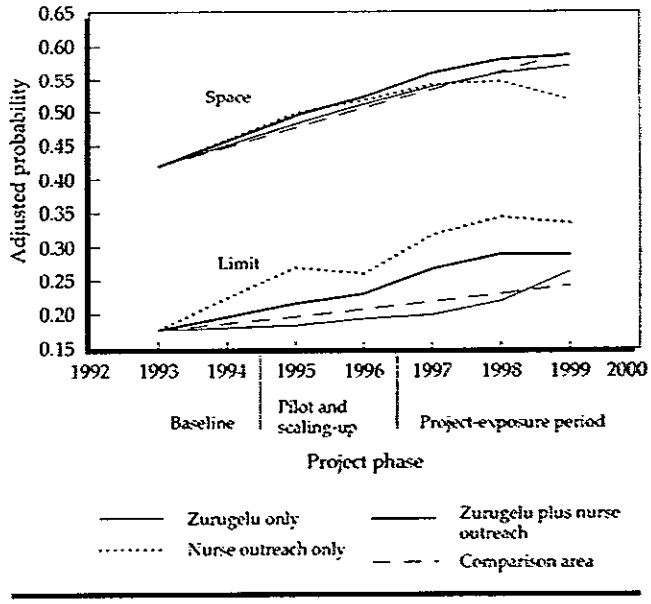
*Significant at $p<0.05$. — = Not applicable.

gelu exposure may actually detract from the impact of nurse outreach on desire to limit fertility.[11] The association of nurse outreach with women's increased preference for limiting childbirth relative to findings for the comparison area, the combined-exposure area, and the zurugelu-only area remains consistent for the next three years of exposure.

To portray the implications of these effects for proportions of women desiring to limit or space childbearing, regression-adjusted levels of preferences for limiting and spacing were estimated for each experimental cell and graphed in Figure 4. The regression adjustments generated by this statistical procedure are designed to simulate the conditions of a true experiment, as illustrated by the convergence of preference curves in 1993. As the figure shows, the trend in the proportion of women who state that they desire to space or limit childbearing increased over time in all study areas, including the comparison area. As expected, the adjusted desire to space childbearing is a more prominent component of reproductive preferences than the desire to limit fertility throughout the study period. The desire to space childbearing portrayed in Figure 4 is approximately two times greater than the desire to limit fertility, a finding that is consistent with other research conducted in the Sahelian region.[12]

Adjusted preference trends differ by experimental area, however. The prevalence of the expressed desire to space the next birth rises from 42 percent among all women in 1993 to 59 percent for women receiving combined exposure or no exposure in 1999, and 57 and 52 percent for women receiving zurugelu-only or nurse-only exposure in 1999. Adjusted prevalence of the desire to limit fertility increases from 18 percent among all women in 1993 to between 24 and 33 percent in 1999. As the adjusted probabilities from Figure 4 show, prevalence of the desire to limit fertility diverged among the four experimental areas with the onset of exposure. By 1999, prevalence of the desire to limit in the nurse-outreach-only area was 33 percent, slightly above prevalence in the combined-outreach area of 29 percent. Preferences for limiting fertility among women receiving zurugelu exposure only were not significantly different from comparison-area preferences; both trends increased from 18 percent to approximately 28 percent by 1998. A convergence of adjusted proportions of respondents seeking to limit childbearing is apparent by 1999, as expected from the significant nonlinear effects in column 3 of Table 3. This finding suggests that the introduction of services and activities in nurse-outreach and combined-exposure areas had an impact on the desire to limit childbearing that eventually diminished with time. By 1997, a high

Figure 4 Among currently married women aged 15–49, maximum-likelihood multinomial logistic-regression-adjusted prevalence of the desire to limit or space the next birth, by experimental exposure, Navrongo Project, Kassena-Nankana District, Ghana, 1993–99



proportion of respondents wanted to limit or space births. Although fundamental social, economic, and cultural determinants of preferences may have constrained further programmatic effects, and the upward trend in prevalence of desire to limit in zurugelu areas may indicate the potential of the zurugelu approach to have a gradual impact on preferences over time, further monitoring and analysis of the trend in desired family size is warranted before definitive conclusions can be drawn about the role of treatment exposure in influencing preferences. The nurse-outreach strategy appears to introduce preferences for limiting, whereas the zurugelu strategy may have the opposite effect; these findings may relate to differences between the impact of outreach to groups of men versus that of service provision to individual women. The zurugelu approach, by emphasizing outreach to groups of men, initially may enhance the influence of men's preferences over the preferences of their wives. This type of spousal effect could give rise to the initial diminished prevalence of women's desire to space in the zurugelu-only cell portrayed in Figure 4. By emphasizing exchanges between nurses and individual women, the nurse-outreach approach may introduce new ideas about childbearing among women that do not immediately arise from zurugelu activities in the community. These hypotheses merit investigation.

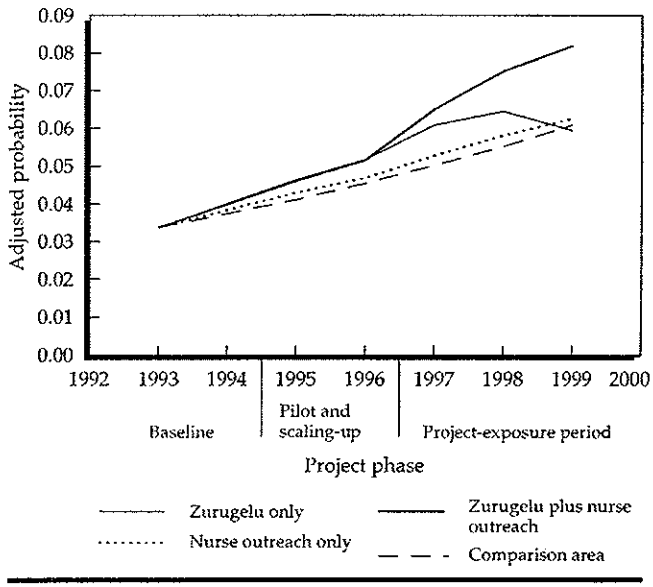
Contraceptive Prevalence

The impact of the experiment on modern contraceptive use was assessed by examining the relationship between the prevalence of modern contraceptive use and the duration of exposure to the experiment. The odds ratios shown in Table 3, column 5 demonstrate that, controlling for time period, age, parity, underlying social characteristics, and baseline differences in contraceptive use, neither the nurse-outreach nor zurugelu strategy alone is associated with a significantly different odds of modern contraceptive use compared with use in the comparison area over the duration of project exposure. A nonlinear relationship between experimental exposure and contraceptive use is evident from the significant and negative squared term for the zurugelu strategy, however. The interaction term for nurse outreach and zurugelu outreach is not significant, indicating that effects are additive for the combined-strategies cell.

The impact of all parameters of the duration and squared-duration cell effects for one, two, three, and four years of exposure to the intervention is presented in Table 6. Tests of combinations of estimators demonstrate that the incremental effect of the two experimental arms and their interaction term amount to a significant overall increase in modern contraceptive use when taken together in the first three years of project exposure. By the fourth year, this effect is no longer significant, as indicated by the significant and negative squared exposure-duration terms in Table 3, column 6. The combined condition of exposure results in a one-and-one-fourth relative odds of contraceptive use compared with the no-exposure condition, and a one-and-one-fifth-fold higher odds of modern contraceptive use relative to nurse-outreach exposure in the first year of the experiment. No significant difference in effect on levels of knowledge is apparent between nurse-outreach and zurugelu exposure, however. This finding demonstrates that when implemented together, the two arms of the experiment have an incremental effect on modern contraceptive use but no apparent effect if implemented independently.

To portray the impact of regression parameters on the prevalence of modern use in each of the four experimental areas, regression-adjusted levels of knowledge were estimated for each of the experimental cells by year and presented in Figure 5. Trends show the adjusted probability that married women of reproductive age exposed to nurse-outreach, zurugelu, and joint nurse–zurugelu outreach strategies currently will be using a modern contraceptive method. Figure 5 shows modern contraceptive use increases in all four areas of the project over time. The adjusted prevalence rate is 3.4 percent in 1993 and rises differentially among the four areas over

Figure 5 Among currently married women aged 15–49, maximum-likelihood logistic-regression-adjusted prevalence of modern contraceptive use, by experimental exposure, Navrongo Project, Kassena-Nankana District, Ghana, 1993–99



15

time. As expected from the model presented in Table 6, the zurugelu and nurse-outreach combined treatment is the only type of experimental exposure associated with consistently higher levels of modern contraceptive prevalence, rising to 8.2 percent in 1999. Thus, the estimated prevalence differential among experimental cells, although statistically significant, is very small in absolute terms. The estimated trends for the comparison area and nurse- and zurugelu-only exposure areas each increase the prevalence of modern use to 6 percent by 1999.

Results indicate, in summary, that the Navrongo Community Health and Family Planning Project has begun to introduce reproductive ideational change in Kassena-Nankana District, although the experimental arms produce contrasting effects for different aspects of the changes investigated. Although both the nurse-outreach and zurugelu arms increase knowledge of contraception, only the nurse-outreach arm has an impact on fertility desires by enhancing women's preference to limit childbearing. The nurse-outreach and zurugelu arms working in combination have an impact on modern contraceptive use, but have no apparent independent effect. The estimated effect of the experiment on reported contraceptive use is statistically significant, but it is too small to induce appreciable fertility differentials.

Evidence of Fertility Impact

The Navrongo Project was fielded as a test of the impact of community health and family planning services on fertility. The unadjusted age-specific fertility rates for the 1995–99 period from the Navrongo Demographic Surveillance System are graphed for each experimental cell in Figure 6 and reported in Table 7. The 1995 age-specific fertility rates represent a baseline assessment, because exposure to the program could not have influenced fertility until services were launched on a pilot basis in 1994 and scaled up over the period from October 1995 to July 1996. When the nine-month gestation period is taken into account, only minor effects of the three-village micropilot activity could arise in 1995.

Although age-specific fertility rates in the comparison area have not changed appreciably over the study period, unadjusted fertility decreased in all three experimental cells. The age pattern of fertility decline suggests that fertility in all age groups has been affected, although notable differences are found in the age regimes of fertility change by treatment. In the zurugelu cell, fertility rates among women in their early twenties decreased most dramatically, suggesting that this treatment had its greatest impact among relatively young women. In the nurse-outreach cell, unadjusted fertility decreased most among women in their late twenties. In the combined zurugelu and nurse-outreach cell, a gradual and uniform decrease occurred among women of all ages. As Figure 6 shows, age-specific fertility patterns in the comparison area closely coincided in the baseline and follow-up periods but diverged in treatment areas in a manner that is consistent with the onset of reproductive change.

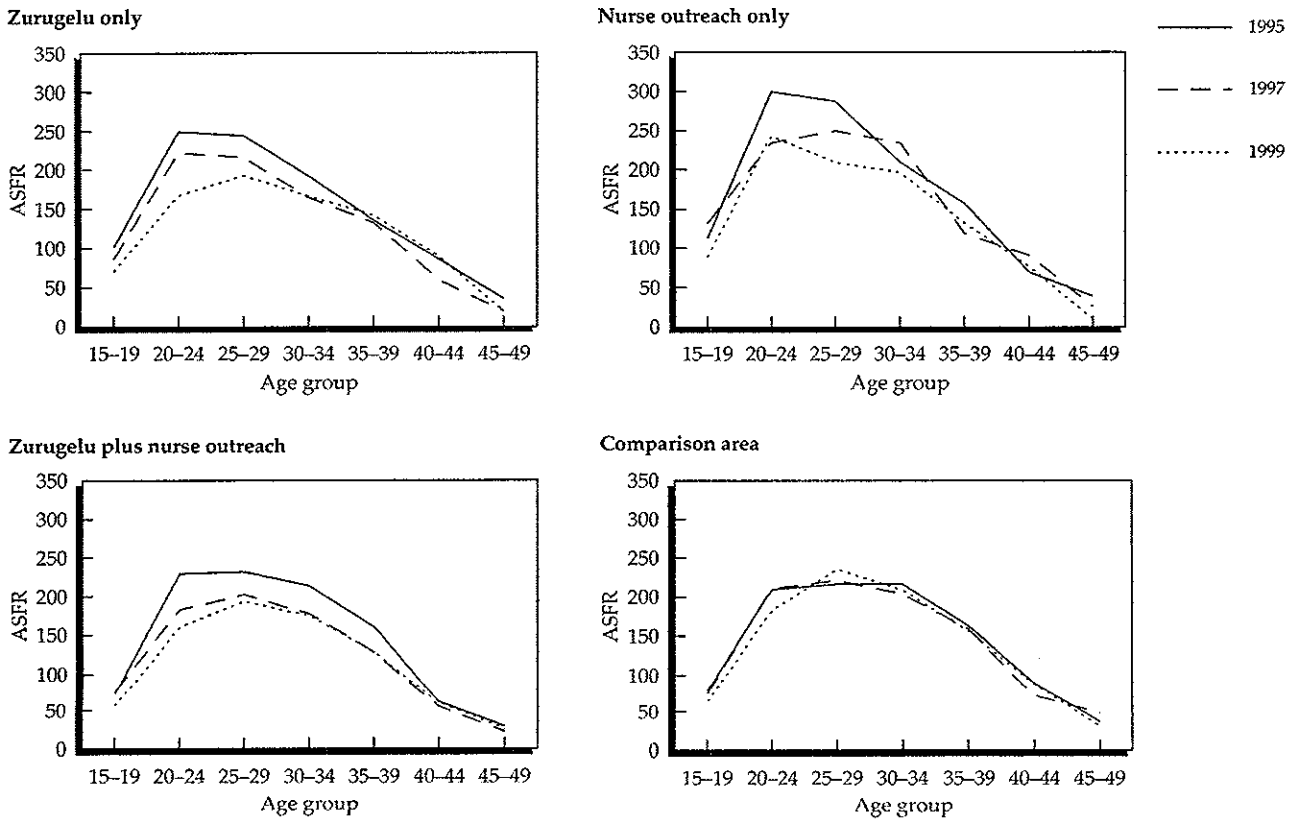
Table 7 Unadjusted total fertility rates and age-specific fertility rates for all women, by experimental cell, Navrongo Project, Kassena-Nankana District, Ghana, 1995, 1997, and 1999

	Fertility rates							
Cell	15–19	20–24	25–29	30–34	35–39	40–44	45–49	TFR
Zurugelu only (cell 1)								
1995	101.4	249.7	245.0	192.3	135.7	86.0	35.7	5.2
1997	85.9	221.5	216.2	164.6	132.9	58.9	19.7	4.5
1999	70.2	167.3	193.0	166.3	142.4	89.4	19.9	4.2
Nurse outreach only (cell 2)								
1995	112.5	299.9	286.8	210.1	156.6	69.5	39.1	5.9
1997	131.2	234.4	250.1	233.9	118.8	90.2	26.1	5.4
1999	89.2	242.9	208.7	196.3	132.7	76.5	10.0	4.8
Zurugelu plus nurse outreach (cell 3)								
1995	74.3	229.8	231.7	213.2	160.3	62.4	28.6	5.0
1997	77.3	182.3	202.1	177.1	128.3	56.2	21.7	4.2
1999	57.2	159.9	193.6	174.9	128.4	61.7	25.8	4.0
Comparison area (cell 4)								
1995	79.8	209.3	216.3	216.8	163.8	91.0	36.9	5.1
1997	75.4	211.3	221.5	203.8	160.0	73.1	48.9	5.0
1999	65.1	182.4	235.6	208.6	156.8	89.1	30.6	4.8

Source: Navrongo Demographic Surveillance System (NDSS).

Evidence of substantial fertility effects is inconsistent with the conclusion that the experimental impact on contraceptive use has been negligible (Phillips et al. 2001). To address the possibility that comparisons portrayed in Figure 6 are spurious as a result of contaminating social and demographic study-area differences, adjusted marital fertility trends have been estimated in which the quarterly odds of parity progression are regressed on age and parity (to control for underlying fecundability), fertility time trends, and other covariates listed in Table 3 (see Appendix A).[13] Figure 7 presents regression-adjusted marital TFR trends from the regression parameters for predicted parity progression (presented in column 6 of Table 3).[14] All study areas experienced marital fertility decline. As in the case of unadjusted trends, however, regression-adjusted treatment-area marital fertility trends declined to lower levels than were observed in the comparison area. Results indicate that the combined nurse-outreach and zurugelu intervention strategy reduced fertility by approximately 15 percent in the study period. This finding corresponds to

Figure 6 Unadjusted age-specific fertility rates (ASFR), by experimental area, Navrongo Project, Kassena-Nankana District, Ghana, 1995, 1997, and 1999



a fertility reduction of about one birth fewer than the 1999 marital TFR relative to the comparison area.

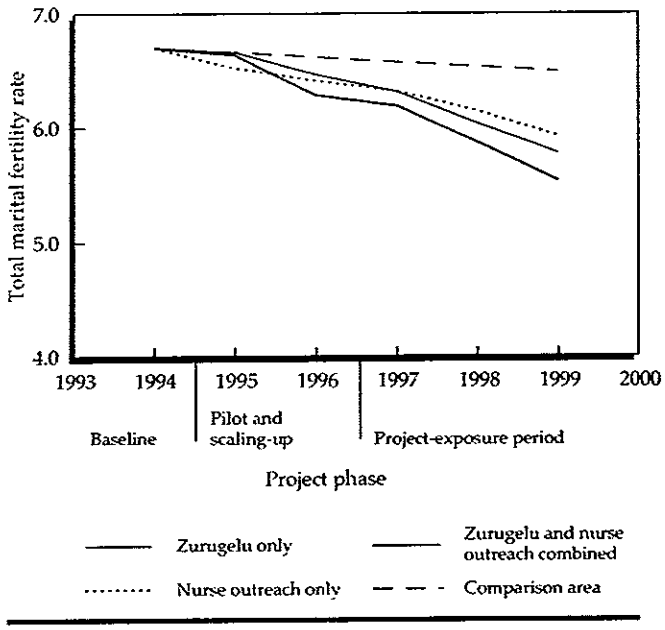
Parameters presented in column 6 of Table 3 show that both the zurugelu and nurse-outreach strategies are associated with significantly lower odds of parity progression relative to parity-progression odds in the comparison area. The combined nurse-outreach and zurugelu interaction term is not significant, indicating that the cell 3 effect arises from adding the independent effects of nurse outreach and zurugelu mobilization, that is, no diminishing return occurs from operating the two strategies jointly, and no acceleration of impact occurs from joint implementation. Thus, regression results substantiate findings for the unadjusted treatment comparisons presented in Figure 6. Cell differentials arise for both arms of the experiment; these effects cannot be attributed to areal differentials in the characteristics of populations served by the experiment.

In order to explore the implications of these effects, statistical tests were conducted for all treatment comparisons and at one-to-five years of exposure duration. The results are presented in Table 8. Odds ratios in column 1 show that the nurse-outreach and the zurugelu strategies each significantly reduced parity progression relative to the comparison area in every year of exposure duration.[15] When the two experimental arms operated jointly, their combined effect was greater than each arm operating separately, demonstrating that each arm has an additive effect on fertility reduction.

Discussion

The initial results lend support to the hypothesis that the Navrongo experiment induced reproductive change in this rural Ghanaian community. Implementation of the project has made contraceptive and family planning services more available than in other rural areas in northern Ghana, and project activities may have fostered reproductive attitudes and behavior that differ from those in communities where clinical services are more remote and community outreach is less developed. Two challenges arise to this conclusion, however. First, the Navrongo experiment has occurred in the context of a regional fer-

Figure 7 Among currently married women aged 15–49, maximum-likelihood logistic-regression-adjusted total marital fertility rate, Navrongo Project, Kassena-Nankana District, Ghana, 1994–99



tility decline; the changes observed may be the result of determinants unrelated to contraception or the project. Second, a marked inconsistency is found between contraceptive effects and fertility effect.

To investigate the first of these challenges, an assessment of the fertility implications of the impact of the Navrongo experiment is appropriate in the context of fertility trends in study areas compared with fertility trends in neighboring regions of Sahelian northern Ghana. Although 1993 and 1998 Demographic and Health Survey (DHS) data are available for the various regions of Ghana, comparing rates is complicated because DHS fertility rates for a survey year represent mean fertility levels for the five years prior to the survey. Because five-year retrospective TFR data for the Upper East region are limited to the five-year period ending in 1998, direct comparisons of DHS and 1994–99 NDSS data are not possible. Moreover, the Navrongo project's experimental exposure began in the middle of this five-year DHS observation period, further constraining prospects for direct comparisons. Nonetheless, general trends in fertility change are evident from the DHS data, providing a basis for inferences about the context of northern Ghana for reproductive change in study areas. Table 9 compares fertility changes that have taken place in Kassena-Nankana District with trends in northern Ghana reported by the DHS for the Upper East, Upper West, and northern regions.

Table 8 Odds ratios evaluating the relationship between linear combinations of estimators for duration of currently married women's exposure to the zurugelu and nurse-outreach arms of the Navrongo Project and parity progression, Kassena-Nankana District, Ghana, 1993–99

	Odds ratio		
		Treatment	
Women with a parity progression	Comparison area (1)	Nurse outreach only (2)	Zurugelu only (3)
After one year of exposure to			
Nurse outreach only	0.97*	—	—
Zurugelu only	0.96*	0.99	—
Zurugelu plus nurse outreach	0.93***	0.96**	0.97*
After two years of exposure to			
Nurse outreach only	0.94*	—	—
Zurugelu only	0.92*	0.98	—
Zurugelu plus nurse outreach	0.87***	0.94*	0.95
After three years of exposure to			
Nurse outreach only	0.90*	—	—
Zurugelu only	0.88*	0.97	—
Zurugelu plus nurse outreach	0.83***	0.92	0.94
After four years of exposure to			
Nurse outreach only	0.87*	—	—
Zurugelu only	0.84*	0.97	—
Zurugelu plus nurse outreach	0.79**	0.91	0.94
After five years of exposure to			
Nurse outreach only	0.85*	—	—
Zurugelu only	0.81*	0.96	—
Zurugelu plus nurse outreach	0.77*	0.91	0.95

*Significant at p<0.05; **p<0.01; ***p<0.0001. — = Not applicable.

The fertility rates shown in the table suggest that reproductive behavior is changing in the two northernmost regions of Ghana, the Upper West region and the Upper East region that includes Kassena-Nankana.

Table 9 Trends in unadjusted five-year total fertility rates and reported current modern contraceptive use in 1993 and 1998 and total fertility rates for the single years 1995 and 1999 among women in rural Ghana, northern Ghana, and Kassena-Nankana District

	TFR				Modern contraceptive use	
Locality	1989–93	1995	1999	1994–98	1993	1998
Upper West region	6.0	na	na	6.1	5.1	9.1
Upper East region	6.4	na	na	5.0	7.2	7.5
Kassena-Nankana District	na	5.1	4.1	4.5	3.1	7.6
Zurugelu only (cell 1)	na	5.2	4.2	4.5	4.7	10.0
Nurse outreach only (cell 2)	na	5.9	4.8	5.2	5.6	6.6
Zurugelu plus nurse outreach (cell 3)	na	5.0	4.0	4.5	3.5	10.5
Comparison area (cell 4)	na	5.1	4.8	4.8	1.0	3.2

na = Not available.
Sources: TFRs are from the 1993 and 1998 Ghana Demographic and Health Surveys and the Navrongo Demographic Surveillance System; contraceptive-use figures are from the Ghana Demographic Health Surveys and Navrongo panel surveys.

Despite evidence that fertility has declined in the northern regions of Ghana, no evidence is found that the family planning program effort explains this development. Modern contraceptive use increased by 4 percentage points in the Upper West between 1993 and 1998, and the TFR in that region remained constant. Modern contraceptive use increased by only 0.3 percentage points in the Upper East region, and yet the TFR for that region declined from 6.4 to five births over the period from 1993 to 1998. TFR trends in Kassena-Nankana District as recorded by the NDSS are consistently 0.5 births lower than corresponding DHS estimates for the Upper East during the 1994–98 period. Annual TFR levels in Kassena-Nankana cells declined by approximately one birth in all experimental areas and by 0.3 births in the comparison area during the period from 1995 to 1999. Just as the fertility decline in the Upper East region cannot be explained by increasing contraceptive use, the fertility impact of the Navrongo project cannot be explained by reported treatment trends and differentials in reported contraceptive-use prevalence.

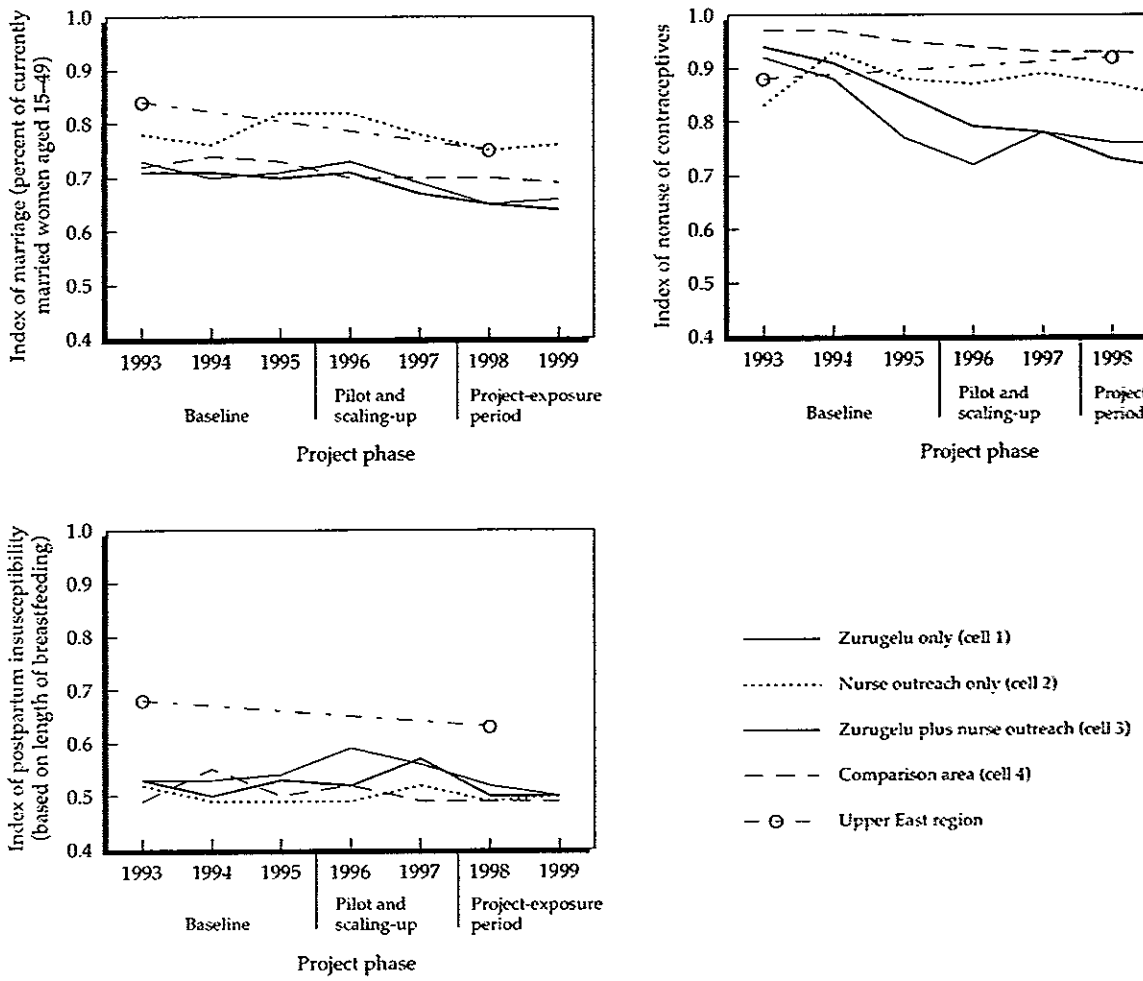
To investigate possible factors explaining the apparent inconsistency between contraceptive trends and fertility trends, proximate fertility indices for Kassena-Nankana District and the Upper East region have been calculated and are presented in Figure 8.[16] Trends in the indices of marriage, adjusted nonuse of contraceptives, and postpartum insusceptibility were the most influential proximate fertility determinants in study areas throughout the study period. Adjustment to the index of nonuse brings into account the possible effect of denial of contraceptive use, which has been shown to comprise as much as half of all reports of contraceptive use from interviews with women (Phillips et al. 1997).[17] Estimates portrayed in Figure 8 depict trends in Kassena-Nankana fertility determinants that differ from corresponding fertility determinants for the Upper East region. According to fertility indices, reproductive change is explained by a 9 percentage-point decrease in the proportion of women who are married or in union and a 5 percentage-point decrease in the index of postpartum infecundability resulting from a lengthened average period of breastfeeding and an increase in postpartum abstinence. Social research on the determinants of these changes indicates that pronounced annual fluctuations in fertility determinants may represent an adjustment to agricultural adversity.[18] Increases in the age of marriage are evident, a trend that is explained in part by bridewealth adjustments to adversity and in part by a gradual but sustained trend in increasing levels of schooling. Although the full range of causes of these trends in fertility determinants is undoubtedly complex, clearly contraceptive use has not explained recent reproductive change in the regions of northern Ghana. The index of nonuse in the Upper East region has, in fact, increased by 4 percentage points over the 1993–98 period, owing to a reported decrease in overall contraceptive use. This change is explained by a 1.3 percentage-point decrease in periodic abstinence that offset slight increases in modern contraceptive use during the period. Apparently, the impact of the Navrongo experiment may have arisen in the context of a more general decline in regional fertility, but this regional trend may be unrelated to changes or trends in modern contraceptive behavior.

In contrast to the determinants of fertility change in northern Ghana as a whole, the most important factors contributing to fertility decline in Kassena-Nankana District between 1993 and 1999 were changes in the prevalence of marriage and in the index of nonuse of contraceptives. As Figure 8 shows, this index decreased dramatically in the zurugelu and combined nurse-outreach and zurugelu cells by 16 and 23 percentage points, respectively, decreased by only 5 percentage points in the comparison area, and remained unchanged in the nurse-outreach area.[19] The proportion of women married or in union decreased universally, with the largest decreases occurring in the zurugelu and combined nurse-outreach and zurugelu cells. The proportion of women married or in union decreased by 7 percentage points in these two areas between 1993 and 1999. The index of postpartum infecundability decreased only slightly between 1993 and 1999 in the three experimental cells and remained the same for the comparison area.

These trends in proximate fertility determinants are consistent with regression-adjusted estimates showing that use of contraceptives increased significantly more among women exposed to the combined treatment than among women in the comparison area and in the nurse-outreach-only area. The index of nonuse was generally higher in Kassena-Nankana than in the Upper East region in 1993, but by 1998 it had fallen below the Upper East index in all treatment areas. These findings lend support to the hypothesis that contraception was an important determinant of the Kassena-Nankana District fertility level, even though it has not contributed to the fertility decline observed elsewhere in northern Ghana.

Although contraceptive prevalence is a factor in the fertility change in the Kassena-Nankana District from 1993 to 1998, it is not the most important determinant of fertility levels. The fertility effects of the downward trend in exposure to marriage and consistently high prevalence of postpartum insusceptibility are far more pronounced than is the fertility effect of contraceptive use. Lower fertility in the Kassena-Nankana District compared with the

Figure 8 Trends in three proximate fertility determinants in the Upper East region and Kassena-Nankana District, by experimental exposure, Navrongo Project, Ghana, 1993–99



rest of the Upper East region appears to be the result among women in Navrongo of a lower prevalence of marriage and union and a longer period of postpartum insusceptibility resulting from prolonged breastfeeding. Lower fertility is also explained in part, however, by a lower index of nonuse of contraceptives.

Conclusions

Findings from the Navrongo experiment have implications for population policy in West Africa. The impact of services in the initial years of the project is consistent with the hypothesis that reproductive ideational change can be introduced in a traditional African society and that fertility can be reduced with supply-side approaches. This conclusion requires important qualifications, however.

First, contraceptive use is clearly not the only fertility determinant responsible for fertility declines in the district or the region. In 1998, fertility declined markedly in all areas of Kassena-Nankana District, including the comparison area, but the determinants of this change were dominated by abstinence and delayed marriage rather than by increased contraceptive prevalence. Circumstantial evidence indicates that the 1997 harvest was lost to many households and that adversity may explain the absence of a seasonal peak in births in 1998. Thus, in a year when fertility regulation temporarily may have been in a heightened state of demand, means other than contraception caused a reduction in infertility (Appiah-Yeboah et al. 2001). This finding suggests that a contraceptive norm has yet to replace traditional means of fertility control, even in areas of the district where the project has begun to have an impact.

Second, project experience suggests that even minor and temporary lapses in program intensity can lead to widespread discontinuation of contraceptive use. Just as women respond to convenient services when nurses live in villages and conduct home visits, they readily abandon contraception if program support is disrupted. Ideational change has been introduced by the Navrongo experiment, but demand for services is nascent and remains fragile, which suggests that spacing remains the dominant motive for adopting contraception. Impact of the experiment is distributed across all age groups. As a consequence, no evidence is found of the onset of a sustained and expanding fertility transition of the sort that has been observed in experimental studies in Asia.

Third, the effect of the experiment on reported contraceptive use is difficult to interpret because women being interviewed may deny contraceptive practice. This finding challenges the conventional practice of evaluating family planning experiments with data from women's reports of contraceptive use. Only the combination of the two strategies is shown to increase modern contraceptive use significantly, and this estimated effect may be attributable to treatment differentials in women's tendency to deny use rather than to treatment differentials in actual use. Fertility results in this analysis, in contrast with the contraceptive result, suggest that all cells are experiencing an impact from the experiment and that this effect is pronounced in the combined-treatment cell. The discrepancy between contraceptive-impact findings and fertility-impact findings attests to the importance of using fertility as an endpoint for studies of the impact of family planning introduction in Africa.

Fourth, the impact of the Navrongo project cannot be attributed to improving access to family planning alone. The zurugelu program represents a reproductive health action mobilization of chiefs, elders, and male social networks. Women's networks are also involved in the program, but the main focus of communication activities has been on reassuring men that family planning is acceptable to respected leaders. Findings suggest that activities of this nature, which collectively reduce the social costs of contraception, comprise a critical element of community family planning service success. Although the nurse-outreach strategy provided access to improved health care and contraception, zurugelu activities in the program may have empowered women to implement their reproductive preferences. The incremental effect of combining nurse-outreach and zurugelu activities caused the greatest fertility impact. Strategies that resolve social constraints to contraceptive use are more effective when convenient family planning services are available to women on demand. The relative effectiveness of the combined strategies attests to the need for a balanced, gender-sensitive approach to developing male participation. A balanced approach provides women with convenient and private family planning services and communities with open means of communication with men in ways that address their anxieties and concerns. Findings from the Navrongo experiment indicate a need for further research concerning the social costs of contraception and on the ways that these costs can be mitigated by community-action programs.

Finally, findings presented in this article describe initial results that may not be sustained over time. Definitive conclusions require further long-term observation, although early indications are consistent with the hypothesis that Navrongo Community Health and Family Planning Project services are having an impact on fertility.

Despite these important qualifications, the central finding of this analysis, that fertility can be reduced by one birth in three years of program exposure, has important implications for population policy in Africa. Each arm of the experiment has had modest, but significant, fertility effects that compound when strategies are combined into a comprehensive community-mobilization strategy. If current treatment differentials are sustained and amplified, project hypotheses will be upheld. Thus, the preliminary project results provide evidence that a supply-side program can have an impact, even in a rural traditional setting that is widely viewed as being incompatible with family planning program success.

Appendix A

The maximum-likelihood logistic-regression analysis of panel-survey data uses repeat observations of individuals over six panels as the basis for inference. Standard errors are corrected for the effect of correlation within repeated observations of the same individual.[20] Regression methods are designed to provide estimates of the impact of treatment on prevalence of indicators of family planning knowledge, supply-source knowledge, desire for additional children, contraceptive use, and fertility. The model for the effect of duration of treatment exposure on supply-point knowledge, contraceptive use, and binomial fertility preference is

$$logit\ Y_{ij} = \alpha(t) + \sum_{k=1}^{3}\beta_k x_{ijk} + \sum_{k=1}^{3}\gamma_k z_{ijk} + \sum_{k=1}^{3}\delta_k x_{ijk}\cdot z_{ijk} + \sum_{l=1}^{L}\zeta_l w_{li} + u_i + \varepsilon_{ij} \quad (1)$$

where x_{ij1} is a discrete areal dummy variable indicator of the experimental cell to adjust for pre-experimental cell

differentials in nurse outreach for individual i as of observation j; x_{ij2} is a continuous variable representing years of nurse outreach experimental exposure to assess cumulative duration of exposure effects for individual i as of observation j; x_{ij3} is a continuous variable representing years of nurse-outreach experimental-exposure squared effects; z_{ij1} is a discrete areal dummy variable indicator of the experimental cell to adjust for pre-experimental cell differentials in zurugelu outreach for individual i as of observation j; z_{ij2} is a continuous variable representing years of zurugelu-outreach experimental exposure to assess cumulative duration of exposure effects for individual i as of observation j; z_{ij3} is a continuous variable representing years of zurugelu-outreach experimental-exposure squared effects; w_{li} is the lth background characteristic of individual i; parameter $\alpha(t)$ is a function of time in years, β, γ, δ, and ζ are vectors of unknown parameters to be estimated with maximum likelihood, and u_i is the error term for the ith individual; and ε_{ij} is the jth observation error term for the ith individual.

In the analysis of preferences, Model 1 is extended to the polytamous case, where the omitted class of Y_{ij} corresponds to responses "wanting more children soon," or nonresponses, or no stated preference.

Cell comparisons are necessary, which bring into account all parameters for a given cell, including the interaction term δ_k in the case of experimental cell 3, at one to four years of exposure. Tests for linear combinations of estimators are presented in Tables 4, 6, and 8 for one to four years of exposure duration. Where duration-of-exposure effects are nonlinear (in the first five regression models presented in Table 3), treatment impact is determined by combinations of effects of duration, duration squared, and interaction terms at different values of exposure duration.

Diagrams in this article are based on the predicted dependent variables implied by the parameters of equation (1) setting all independent variables other than treatments and time at grand means, multiplying parameters by means and summing, as in equation (1), for each of the four treatment conditions over time.

In the analysis of fertility, a grand mean 90-day predicted parity-progression probability $\hat{q}_x$ is calculated for each age 15–49 by year and experimental exposure. These predicted probability values are adjusted to a central fertility rate for quarterly age interval a by the equation

$$\hat{f}_a = \frac{2\hat{q}_a}{2-\hat{q}_a} \qquad (2)$$

The adjusted predicted value, $\hat{f}_a$, is transformed into a predicted yearly fertility rate for each year and type of experimental exposure by multiplying the predicted $\hat{f}_a$ by four to approximate a single-year fertility rate. These single-year rates for married women aged 15–49 are summed by year of age a:

$$TFR_{tc} = \sum_{a=15}^{49} 4\hat{f}_{atc} \qquad (3)$$

for each calendar year t and experimental cell c to yield an estimated total marital fertility rate.

Notes

1 This point of view, stressing the role of pronatalist social institutions, can be found in much of the demographic literature on fertility determinants in Africa (for example, see Caldwell and Caldwell 1987, 1988, and 1990; Frank 1987; Frank and McNicoll 1987; Lesthaeghe 1989; Goody 1990; van de Walle and Foster 1990; Caldwell et al. 1991; Pritchett 1994; Makinwa-Adebusoye 2001).

2 Scant empirical evidence supports the hypothesis that accessible family planning programs have an impact on contraceptive behavior in rural West Africa; no experimental program evidence exists to support the hypothesis that African fertility is affected by the efforts of family planning programs. A 1998 review of more than 100 operations research projects in Africa concluded that no experimental evidence exists showing that convenient family planning services can induce and sustain fertility decline (Phillips et al. 1998).

3 Demonstration projects in Chogoria, Kenya, in Danfa, Ghana, and in Ishan, Nigeria, demonstrated that contraceptive use increases if services are conveniently available (Goldberg et al. 1989; University of Ghana Medical School 1979; Farooq and Adeokun 1976). However, owing to the absence of statistical controls and other methods for adjusting for potential biases, results have been subject to challenge.

4 *Zurugelu*, in the Kassim language, is translated literally as "togetherness." In the community context, the term connotes cooperation of participants in an initiative for the common good.

5 Of the 42 yezura zenna in the program, ten have been trained and equipped to provide oral contraceptives. This variance in the zurugelu system permits appraisal of the incremental effect of community-based distribution through volunteers. Despite the general availability of the pill through the nurse-outreach system and enhanced accessibility of volunteer-provided pill supplies, the pill is not widely used in the study population. Volunteer pill distribution has had no effect on prevalence. More than 90 percent of all contraceptive use is attributable to adoption of the injectable method, depo-medroxyprogesterone acetate (DMPA), even in communities where the pill is available through volunteer assistance.

6 For ethical reasons, development of training and clinical systems cannot be withheld from the comparison area. Thus, implementation involved upgrading all clinical service-delivery points in the district so that supplies and equipment were adequate for delivering a full range of family planning services and so that clinical personnel could be trained as necessary.

7 Individuals who are interviewed about reproductive preferences sometimes interpret questions as an inquiry about the corporate family. Although preferences are expressed and recorded, respon-

dents believe that preferences are, in fact, owned by the extended family. Under such circumstances, responses may not measure reproductive motives accurately (see Biddlecom et al. 1997).

8 The design of quasi-experimental studies is reviewed in Campbell and Stanley (1966) and Cook and Campbell (1979). The issue of statistical inference in experimental and quasi-experimental studies of health interventions is reviewed in Habicht et al. 1999. As these authors note, statistical inference in true experimental studies is based on units of observation rather than on data from individuals exposed to cells. In the ideal case, the number of areas under observation would be expanded from four to the number required for all possible pairwise cell comparisons. In this instance, however, this requirement of a true experiment could not be met. See also the discussion of strategies for responding to design limitations proposed by Fisher et al. (1985).

9 The important role education plays in development has been recognized by the Government of Ghana and the District Assembly. At present, all of the development budget for the Kassena-Nankana District is being invested in expanding schooling. The proportion of girls aged 15–19 who have ever attended school increased from 60 percent in 1995 to 73 percent in 1999.

10 A binomial regression of the desire to either limit or space fertility (not shown in Table 3) has confirmed that the net effects of the CHFP on the desire to space or limit fertility are significant.

11 One hypothesis for explaining this effect concerns possible unintended effects of the zurugelu emphasis on outreach to male chiefs, lineage heads, and male groups. Mobilizing male participation in fertility regulation without concomitant activities designed to foster the reproductive empowerment of women could explain the observed effect. If husbands' preferences are more pronatalist than the preferences of their wives, and the zurugelu approach enables these male motivational effects to become manifest, exposure to the zurugelu program could reduce the odds of women's wanting to limit or space their children. (See the critique of the zurugelu approach by Schuler [1999].) Findings suggest, nevertheless, that such unintended effects do not arise when the nurse-outreach strategy is in use.

12 Among Sahelian populations in particular, spacing is the predominant family planning concern; the number of fecund women who wanted to space was twice that of those who wanted to limit their fertility in Ghana, Mali, and Togo from 1985–89 (see Westoff and Ochoa [1991], Table 4.1).

13 The regression method substitutes a fertility function for the intercept in Model 1 and estimates experimental effects as deviations from this function. Underlying fertility levels and trends are represented by parameters for ordinal time since the onset of surveillance in 1993, the exact age of women, age squared, parity, and parity squared. Estimated parameters imply corresponding regression-adjusted parity-progression probabilities that are transformed to yearly central fertility rates and summed over all ages to produce an adjusted TFR for each treatment at each calendar period in Figure 8.

14 Fertility levels in Figure 8 are for married women and, consequently, are higher than the TFRs for all women reported in Table 7.

15 The finding that the zurugelu-only and nurse-outreach-only treatments have a significant fertility effect is inconsistent with the observation that each tye of activity alone did not have a significant effect on modern contraceptive use, if contraceptive use is responsible for the decline in fertility in these areas. The determinants of this inconsistency are unknown, but may relate to cell differentials in respondents' denials of contraceptive use. The nurse-outreach and zurugelu strategies may combine to diminish the social stigma associated with discussion of acceptance of modern contraceptive methods, thereby diminishing the tendency of women to deny that they are currently using a modern contraceptive method in interviews, relative to denial rates in the nurse-only and zurugelu-only cells of the experiment. This conjecture merits investigation, however. Factors that explain response bias in sociodemographic surveys in traditional Sahelian settings are unknown. The problem of denial-response biases is not associated with demographic surveillance data.

16 The indices of Bongaarts' proximate determinants of fertility were calculated using the method described in Bongaarts 1978 and 1982, in Bongaarts et al. 1984, and in Stover 1998.

17 The effect of data for denial of contraceptive use can be estimated for cells 2 and 3 of the Navrongo experiment where nurses are assigned to village locations. Nurses maintain registers that are printed from the demographic surveillance data base. Links between the identification of interview data with service registers permit tabulation of response distributions among known contraceptive users. Although confidentiality rules prohibit field verification of tabulations, estimates based on aggregate data tabulations indicate that about half of all users deny practicing contraception in the course of interviews.

18 Severe agricultural adversity documented in the Kassena-Nankana district in 1997 and 1998 has been linked to a drop in fertility in 1998 and early 1999 in all experimental and comparison areas (Appiah-Yeboah et al. 2001). Fertility throughout northern Ghana probably has been affected also by agricultural adversity, which may lower fertility in these regions even when contraceptive prevalence shows no change. Appiah-Yeboah and her colleagues found that the period of agricultural adversity in Navrongo was associated with increases in abstinence and contraceptive use as well as with a lack of energy for or interest in sex during the time of severe hunger.

19 The index of nonuse is based on denial-adjusted estimates of contraceptive prevalence.

20 This correction approach is based on Rogers (1993), after Huber (1967).

References

Adongo, Philip B., James F. Phillips, Beverly Kajihara, Cornelius Debpuur, and Fred N. Binka. 1997. "Cultural factors constraining the introduction of family planning among the Kassena-Nankana of northern Ghana." *Social Science & Medicine* 45(12): 1,789–1,804.

Adongo, Philip B., James F. Phillips, and Fred N. Binka. 1998. "The influence of traditional religion on fertility regulation among the Kassena-Nankana of northern Ghana." *Studies in Family Planning* 29(1): 23–40.

Appiah-Yeboah, Shirley, Elizabeth F. Jackson, James F. Phillips, and Patricia Akweongo. 2001. "The impact of agricultural adversity on fertility among the Kassena-Nankana of northern Ghana." Paper presented at the annual meeting of the Population Association of America, Washington, DC, 29–31 March.

Bawah, Ayaga Agula, Patricia Akweongo, James F. Phillips, and Ruth Simmons. 1999. "Women's fears and men's anxieties: The social impact of family planning in northern Ghana." *Studies in Family Planning* 30(1): 54–66.

Biddlecom, Ann, Eva Tagoe, and Frank Kubaje Adazu. 1997. "Unmet need for contraception among the Kassena-Nankana of northern Ghana." Paper presented at the annual meeting of the Population Association of America, Washington, DC, 27–29 March.

Binka, Fred, Alex Nazzar, and James F. Phillips. 1995. "The Navrongo Community Health and Family Planning Project." *Studies in Family Planning* 26(3): 121–139.

Binka, Fred, Pierre Ngom, James F. Phillips, Kubaje Adazu, and Bruce MacLeod. 1999. "Assessing population dynamics in a rural African society: The Navrongo Demographic Surveillance System." *Journal of Biosocial Science* 31(3): 375–391.

Bledsoe, Caroline H., Allan G. Hill, Umberto D'Alessandro, and Patricia Langerock. 1994. "Constructing natural fertility: The use of Western contraceptive technologies in rural Gambia." *Population and Development Review* 20(1): 81–113.

Bongaarts, John. 1978. "A framework for analyzing the proximate determinants of fertility." *Population and Development Review* 4(1): 105–132.

———. 1982. "The fertility-inhibiting effects of the intermediate fertility variables." *Studies in Family Planning* 13(6/7): 179–189.

Bongaarts, John, Odile Frank, and Ron Lesthaeghe. 1984. "The proximate determinants of fertility in sub-Saharan Africa." *Population and Development Review* 10(3): 511–537.

Caldwell, John C. and Pat Caldwell. 1987. "The cultural context of high fertility in sub-Saharan Africa." *Population and Development Review* 13(3): 409–437.

———. 1988. "Is the Asian family planning program model suited to Africa?" *Studies in Family Planning* 19(1): 19–28.

———. 1990. "Cultural forces tending to sustain high fertility." In *Population Growth and Reproduction in Sub-Saharan Africa*. Eds. George Acsadi, Gwendolyn Johnson-Acsadi, and Randy Bulatao. Washington, DC: The World Bank. Pp. 199–214

Caldwell, John C., I. Olatunji Orubuloye, and Pat Caldwell. 1991. "The destabilization of the traditional Yoruba sexual system." *Population and Development Review* 17(2): 229–262.

Campbell, Donald T. and Julian C. Stanley. 1966. *Experimental and Quasi-experimental Designs for Research*. Chicago: Rand McNally.

Cook, Thomas D. and Donald T. Campbell. 1979. *Quasi-experimentation: Design and Analysis Issues for Field Settings*. Chicago: Rand McNally.

Debpuur, Cornelius, Alex Nazzar, James F. Phillips, and Fred N. Binka. 1994. "Baseline survey on contraceptive knowledge and use, reproductive preferences and study population characteristics: A report of key findings." *Community Health and Family Planning Project Documentation Note* No. 7. Navrongo, Ghana: Navrongo Health Research Centre.

Farooq, Ghazi M. and Lawrence A. Adeokun. 1976. "Impact of a rural family planning program in Ishan, Nigeria, 1969–72." *Studies in Family Planning* 7(6): 158–169.

Fisher, Andrew A., John E. Laing, and John C. Stoeckel. 1985. "Guidelines for overcoming design problems in family planning operations research." *Studies in Family Planning* 16(2):100–105.

Frank, Odile. 1987. "The demand for fertility control in sub-Saharan Africa." *Studies in Family Planning* 18(4): 181–201.

Frank, Odile and Geoffrey McNicoll. 1987. "An interpretation of fertility and population policy in Kenya." *Population and Development Review* 13(2): 209–143.

Ghana Statistical Service (GSS) and Macro International (MI). 1994. *Ghana Demographic and Health Survey 1993*: Preliminary Report. Calverton, MD: GSS and MI.

———. 1999. *Ghana Demographic and Health Survey 1998: Preliminary Report*. Calverton, MD: GSS and MI.

Goldberg, Howard I., Malcolm McNeil, and Alison Spitz. 1989. "Contraceptive use and fertility decline in Chogoria, Kenya." *Studies in Family Planning* 20(1): 17–25.

Goody, Jack. 1990. "Futures of the family in rural Africa." *Population and Development Review* 15 (supplement): *Rural Development and Population: Institutions and Policy*. Eds. Geoffrey McNicoll and Mead Cain. New York: Population Council. Pp. 119–144.

Government of Ghana. 1999. "Situation analysis of children in Ghana." ISSER. Legon: University of Ghana. Unpublished.

Habicht, Jean Pierre; C.G. Victora, and J. Patrick Vaughan. 1999. "Evaluation designs for adequacy, plausibility and probability of public health programme performance and impact." *International Journal of Epidemiology* 28: 10–18.

Huber, P.J. 1967. "The behavior of maximum likelihood estimates under non-standard conditions." In *Proceedings of the Fifth Berkeley Symposium in Mathematical Statistics and Probability*. Berkeley: University of California Press. Pp. 221–233.

Kennedy, Paul. 1993. *Preparing for the 21st Century*. New York: Random House.

Lesthaeghe, Ron. 1989. "Production and reproduction in sub-Saharan Africa: An overview of organizing principles." In *Reproduction and Social Organization in Sub-Saharan Africa*. Ed. Ron Lesthaeghe. Berkeley: University of California Press. Pp. 13–59.

Makinwa-Adebusoye, Paulina. 2001. "Sociocultural factors affecting fertility in sub-Saharan Africa." Paper presented at the United Nations Workshop on Prospects for Fertility Decline in High-fertility Countries, New York, 9–11 July.

Nazzar, Alex, Philip. B. Adongo, Fred N. Binka, James F. Phillips, and Cornelius Debpuur. 1995. "Developing a culturally appropriate family planning program for the Navrongo experiment." *Studies in Family Planning* 26(6): 307–324.

Phillips, James F., Frank Kubaje Adazu, Martin Adjuik, and Alex Nazzar. 1997. "Denial of contraceptive use among known contraceptive adopters in a rural area of northern Ghana." Paper presented at the annual meeting of the Population Association of America, San Francisco.

Phillips, James F., Wendy L. Greene, and Elizabeth F. Jackson. 1998. "Lessons from Community-based Distribution of Family Planning in Africa." *Policy Research Division Working Paper* No. 121. New York: Population Council.

Phillips, James F., Cornelius Debpuur, and Elizabeth F. Jackson. 2001. "Can family planning services induce reproductive change? Evidence from the Navrongo Community Health and Family Planning Project in Northern Ghana." Paper presented at the annual meeting of the International Union for the Scientific Study of Population, Salvador, Brazil. 2001.

Pritchett, Lant H. 1994. "Desired fertility and the impact of population policy." *Population and Development Review* 20(1): 1–55.

Rogers, W.H. 1993. "Regression Standard Errors in Clustered Samples." *Stata Technical Bulletin* No. 13: 19–23.

Schuler, Sidney Ruth. 1999. "Gender and community participation in reproductive health projects: Contrasting models from Peru and Ghana." *Reproductive Health Matters* 7(14): 144–157.

Simmons, George B. 1992. "Supply and demand, not supply vs. demand: Appropriate theory for the study of effects of family planning programmes on fertility." In *Family Planning Programmes and Fertility*. Eds. James F. Phillips and John A. Ross. Oxford: Clarendon Press. Pp. 59–77.

Stover, John. 1998. "Revising the proximate determinants of fertility framework: What have we learned in the past 20 years?" *Studies in Family Planning* 29(3): 255–267.

University of Ghana Medical School. 1979. "The Danfa Comprehensive Rural Health and Family Planning Project: Summary, conclusions, and recommendations from the final report." Accra, Ghana: University of Ghana Medical School.

Van de Walle, Etienne and Andrew Foster. 1990. "Fertility Decline in Africa: Assessment and Prospects." *World Bank Technical Paper* No. 125. Africa Technical Department Series. Washington, DC: World Bank.

Westoff, Charles F. and Luis Hernando Ochoa. 1991. "Unmet Need and the Demand for Family Planning." *Demographic and Health Surveys Comparative Studies* No. 5. Columbia, MD: Institute for Resource Development/Macro International.

Acknowledgments

The Navrongo Health Research Centre (NHRC) Community Health and Family Planning Project (CHFP) was funded by grants to the NHRC by the Rockefeller Foundation and the Population Council Africa Operations Research and Technical Assistance Project (OR/TA) during the 1994 to 1999 period. The OR/TA project was a regional research contract funded by the United States Agency for International Development (USAID). From 1999, the project has been funded by a subaward of the Population Council USAID Cooperative Agreement. The Finnish International Development Agency (FINNIDA), the Andrew W. Mellon Foundation, and the Gates Foundation have provided support for technical assistance, resident fellowships, and communications activities, respectively. Evaluation of the CHFP has been funded by grants from the Rockefeller Foundation to the NHRC that support the Navrongo Demographic Surveillance System. The authors gratefully acknowledge the helpful comments of John Casterline on an earlier draft of this paper.