RESEARCH ARTICLE

The fertility impact of achieving universal health coverage in an impoverished rural region of Northern Ghana [version 1; peer review: 1 approved, 1 approved with reservations]

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Abstract

Background: When a successful Navrongo Health Research Centre service experiment demonstrated means for reducing high fertility and childhood mortality in a traditional societal setting of northern Ghana, the Ministry of Health launched a program of national scaling up known as the Community-based Health Planning and Services (CHPS) initiative. For two decades, CHPS has been Ghana’s flagship program for achieving universal health coverage (UHC). When monitoring during its first decade determined that the pace of CHPS scale-up was unacceptably slow, the Ghana Health Service launched the Ghana Essential Health Interventions Program (GEHIP) in four Upper East Region districts to test means of accelerating to CHPS implementation and improving its quality of care.

Methods: To evaluate GEHIP, a two-round randomized sample survey was fielded with clusters sampled at baseline that were reused in the endline to facilitate difference-in-difference estimation of changes in fertility associated with GEHIP exposure. Monitoring operations assessed the location, timing, and content of CHPS primary health care. Discrete time hazard regression analysis on merged baseline and endline birth history data permit estimation of GEHIP fertility and CHPS access effects, adjusting for hospital and clinical service access and household social and economic confounders.

Results: GEHIP exposure was associated with an immediate acceleration of CHPS implementation and coverage. Women residing in households with CHPS services had only slightly lower fertility than women who lacked convenient access to CHPS. GEHIP impact on contraceptive use was statistically significant but marginal; GEHIP exposure was associated with increasing unmet need.

Conclusion: Results challenge the assumption that achieving UHC will reduce excess fertility. Social mobilization, community-outreach, connection of family planning discussions with male social networks are...
elements of the Navrongo success story that have atrophied with CHPS scale-up. Achieving UHC does not address the need for renewed attention to these family planning focused strategies.

Keywords
Ghana, Primary Health Care, Universal Health Coverage, Fertility impact,

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Introduction
High levels of fertility and unwanted pregnancy are commonplace in Ghana, despite five decades of policies and programs that aim to provide family planning services to its people. Although fertility decline has been noted in the distant past, recent national survey results suggest that reproductive change in Ghana is stalling. This problem is widespread elsewhere in the sub-Saharan African region where unmet need, unplanned pregnancy, and excess fertility persist. In response to the need for strategies for solving this problem, Ghana’s Ministry of Health commissioned a study of the Navrongo Health Research Centre (NHRC) in the 1990s that integrated community-based primary health care and family planning into a regimen of doorstep maternal and child health services.

The Navrongo operational design was more general than the provision of primary health care services, however. The design of Navrongo outreach activities was based on extensive community-based participatory planning. This planning process involved social research to clarify gender stratification customs, religious belief systems, and social institutions that were posited to be constraining women’s reproductive autonomy. Research also focused on clarifying features of the social environment that could provide robust social organizational support to couples who sought family planning information or services. This aspect of Navrongo research was predicated on the notion that social network norms, community leadership systems, and community communication customs were potentially important resources for organizing community outreach. Navrongo functioned as an extension of the Alma Ata primary health care model. Basic curative and preventive care was provided in community facilities, with referral services delivered by paramedics at sub-district level clinics or at district hospitals. Navrongo extended the Alma Ata model by emphasizing community engagement, doorstep care, and participatory planning—elements of health system development that have received renewed emphasis in the health care literature.

The Navrongo project was governed from the onset of project planning and implementation by a Ministry of Health (MOH) convened Steering Committee comprised of project researchers and national and regional directors who were responsible for health systems management and policy. Fertility effects of the Navrongo project were evident from the onset of observation and found to be sustained with time. Child survival effects were also immediate and pronounced with impact that improved health equity as project exposure progressed. Steering Committee deliberations on the implications of these results focused on ways to replicate and scale-up operations. In 1998, implementation replication research in Nkwanta District of the Volta Region was launched to clarify practical milestones and activities for scale-up. Nkwanta activities demonstrated ways in which the Navrongo strategy for reproductive health service development could be adapted to local circumstances in other regions of Ghana. Once this replication process was completed, Nkwanta was utilized as a demonstration district, with a mandate to catalyze the transfer lessons from the Navrongo success story to management teams from districts elsewhere in Ghana. The implementation success of these exchanges soon fostered a policy decision to scale-up core Navrongo strategies. This national program, known as the Community-based Health Planning and Services (CHPS) Initiative was launched in 2000, and has since comprised Ghana’s core program for achieving universal health coverage (UHC).

Although donor support for elements of CHPS implementation has been significant, the cost, organization, and support of the program was mainly managed and financed by the Ghana Health Service. Initial monitoring of the CHPS expansion process showed that exchanges of district health management staff catalyzed the spread of CHPS coverage in the 38 of Ghana’s 132 districts where management teams had participated in direct exchanges with Nkwanta or Navrongo counterparts. However, nearly all progress with scale-up was confined to these districts. Analyses of the national trend suggested that the process of completing national CHPS coverage goals elsewhere in Ghana would require nearly five decades, if the prevailing pace of scale-up were allowed to continue without program reform. In response, the MOH commissioned a 2009 qualitative stakeholder study to assess organizational and policy factors that constrained CHPS scale-up.

Based on recommendations from this study, the Ghana Health Service launched the Ghana Essential Health Interventions Program (GEHIP) in 2010 to develop and test means of accelerating CHPS scale-up. This agenda, with service improvements that it tested aimed to demonstrate ways to achieve UHC. Pursued in conjunction with national health insurance promotion, GEHIP interventions spanned six sets of health systems strengthening strategies: i) introducing means of improving leadership for CHPS implementation, ii) engaging communities in the task of health post construction, iii) extending the range of services to include emergency care and referral, iv) augmenting flexible revenue with incremental funding of $0.85 per capita per year for three years, and v) retraining frontline workers, supervisors, and managers in community engagement. Taken as a package of health system strengthening activities, GEHIP transformed the pace of CHPS scale-up and the quality of the services that it renders.

GEHIP had an immediate impact on the pace of expansion of CHPS coverage. If GEHIP results were extended to the national program, Ghana could achieve UHC within five years if its strategies were to be replicated. Moreover, CHPS coverage effects of GEHIP exposure was associated with improved childhood survival. Its emergency referral strategies were associated with reduced maternal mortality.

This paper examines the fertility and reproductive health implications of GEHIP implementation success. A statistical investigation is pursued to test the hypothesis that the process of pursuing UHC and progress in achieving UHC has had fertility and reproductive health impact.
Methods

Interventions

GEHIP interventions spanned the three organizational levels of Ghana’s district health system (Figure 1) in which clinical service resources are concentrated at the level of District Hospitals and public health services are managed by “District Health Management Teams” (Figure 1C). Interventions designed to develop district leadership and political engagement, and improve financial planning interventions were directed to level C. Basic primary health care services are available in Sub-district Health Centers that vary in staffing and level of service provision but in general provide basic preventive and curative services. Figure 1B supervisory leadership and referral systems interventions were targeted on the paramedical staff who manage clinical operations and supervise community-level workers. At the periphery of the system (Figure 1A), community-based care is integrated into the health system under the CHPS initiative. CHPS frontline workers are based in health posts located in catchment areas termed “zones,” of which about 6,500 have been mapped in rural areas, each with a service population ranging between 3000 and 5000 residents. About two-thirds of all zones are regarded currently “functional,” a term connoting zones where at least one resident community nurse is assigned. These nurses, termed Community Health Officers (CHO), have two years of basic primary health care service delivery training which includes a six-month regimen of peer learning provided by experienced CHO. Detailed content of CHO care has been extensively documented elsewhere. It includes the provision of WHO mandated immunization services, treatment of common ailments of children according to the WHO mandated regimen of “integrated management of childhood illness,” (IMCI) and the provision of contraceptive methods, including outreach provision of oral contraceptives, condoms, and the injectable contraceptive depo-medroxy-pregesterone acetate. Referral services for clinical conditions and contraceptives are also provided by CHOs. Nurses are instructed to provide community outreach and doorstep services, and most CHPS health posts have a motorbike or bicycles to facilitate outreach activities.

Experimental design

GEHIP was a two-celled non-randomized plausibility trial for testing the fertility and mortality impact of a program of health systems strengthening strategies that aimed to accelerate CHPS coverage. Conducted in the Upper East Region over the 2010 to 2016 period, the GEHIP initiative greatly improved the provision of community-based primary health care through CHPS. The mortality impact of GEHIP on neonates was pronounced among neonates. Mortality also declined significantly among children aged 1 to 59 months, but this trend was realized in both treatment and comparison areas owing to the successful improvement in IMCI care in all UER districts.

Difference-in-difference methods are used to assess the hypothesis that this achievement of UHC, with its impact on survival, will also be associated with significant improvements in reproductive health and fertility reduction. Assessing the impact of GEHIP tests the proposition that the process of UHC development will impact on family planning and fertility; testing the
proposition that access to functional CHPS affects fertility tests the hypothesis that achieving UHC in Ghana will address need for contraception and reduce fertility.

Study setting

The GEHIP intervention was located in four districts of Ghana’s Upper East Region (Figure 2). Seven neighboring districts have provided a basis for statistical comparison of fertility and mortality trends. Two Upper East Region districts, Kassena-Nankana West and Municipal Districts, are localities where extensive NHRC research activities had been ongoing for decades and conditions there would not be representative of the region. Since these districts were atypical of the health care environment elsewhere in the region, they were excluded from GEHIP. A program of interventions was launched in treatment districts to expand the range of CHPS services to include emergency referral care, improve the quality and range of primary care services, and develop leadership for sustaining community and political engagement in the CHPS implementation process\textsuperscript{17,32}.

Evaluation procedures

Birth histories were compiled using interviewing instruments published by the Ghana Demographic and Health Survey of 2008\textsuperscript{33} for interviews of all women resident in GEHIP sample households aged 15 to 49. Sample size and power calculations were designed to permit difference-in-difference evaluation of posited child survival effects of GEHIP exposure\textsuperscript{31}. In the baseline survey (available as Extended data)\textsuperscript{34}, 66 clusters in GEHIP intervention and comparison districts were randomly selected based on the enumeration areas of the 2010 census (Ghana Statistical Service 2004). In the second stage, random household selection proceeded within each cluster proportional to enumeration area size by listing all households in sample clusters. The second stage sampling proceeded at a fraction designed to yield a target sample size of 6000 women of reproductive age. At the endline, the baseline survey clusters were reused to establish longitudinal records of GEHIP exposure. However, relisting and repeat stage two resampling was pursued. Therefore, the GEHIP baseline and endline merged data is a panel at the cluster level only. Interviews were conducted in the prevailing local language of sample households. Baseline survey interviews of 5511 women of reproductive age were conducted out of an estimated sample of 6000, yielding an achieved sample of 91.8 percent of the total sample. Correspondingly, 5914 out of a targeted sample of 7588 women were interviewed in the endline, yielding a 76% achieved endline sample. The baseline survey was paper-based and took place in early 2011 prior to the onset of GEHIP implementation. The endline took place in late 2014 and early 2015 utilizing the paperless “Open Data Kit” (ODK) technology to facilitate data editing and correction at the time of interviews\textsuperscript{35}.

Baseline and endline household survey data were merged and used to estimate separate Heckman “difference-in-differences” (DiD) models that compared the change in contraception, unmet need, and fertility measures over time in the treatment area with corresponding changes estimated over time for the

![MAP OF GEHIP IMPLEMENTATION AND COMPARATIVE DISTRICTS IN THE UPPER EAST REGION, JUNE 2015](image-url)

**Figure 2.** GEHIP intervention and comparison districts.
comparison area\textsuperscript{30}. Average treatment effects (ATE) were estimated as follows:

\[ ATE = E(Y_{10} - Y_{00}) - E(Y_{11} - Y_{01}) \]  

(1)

In this model, \( Y \) describes a health outcome such as a birth event, the subscript \( t \) refers to measurements of health outcomes at baseline, \( \mathbf{t}^* \) refers to measurements of health outcomes at the end of the point of observation, \( \mathbf{M} \) indexes GEHIP exposed sample cluster areas and \( \mathbf{C} \) indexes comparison sample cluster areas\textsuperscript{30}.

While the Heckman formula is widely applied, it has limitations for health systems research Heckman and others have recommended multivariate extensions of (1) for offsetting confounding effects that are unaddressed in (1)\textsuperscript{37}. To refine the model, adjusting for the potentially confounding effects of social and demographic characteristics of households, regression methods refine the estimation of the net effect of GEHIP, and permit estimation of the conditional effect of GEHIP on segments of maternal age that may represent contrasting responses to UHC access. Moreover, utilization of GEHIP results for interpreting systems effects requires a systems approach to the Heckman procedure\textsuperscript{38,39}. To address the need for a systems approach, monitoring operations during GEHIP assessed the location, timing, and content of community-based primary health care. Census enumeration areas are used for defining areal units of exposure to GEHIP and CHPS services in the statistical analysis.

Discrete time hazard regression analysis was applied to merged baseline and endline health data, with provision for linking exposure to CHPS services at exact ages of mothers as GEHIP implementation and maternal parity progressed. For the analysis of GEHIP impact on fertility, units of observation are maternal months recorded in GEHIP baseline and endline survey pregnancy histories. The model for estimation is a logistic regression model for the age conditional birth event function defining the TFR, given by:

\[
\ln\left(\frac{P_{1t}}{1-P_{0t}}\right) = \alpha_t + \sum_{j}^{J} \theta_j age_{m} + \delta_t treat_{m} + \delta_t period_{m} + \delta_{t \times age} \times period_{m} + \sum_{j}^{J} \gamma_j (age_{m} \times period_{m}) + \sum_{j}^{J} \beta_j X_{jm} \]  

(2)

where,

\( age_{m} \) a dummy variable that defines the five-year age group (\( t \)), from age 15 to age 49, to which each month of observation \( m \) of individual \( i \) belongs, whereby \( t=1 \) (age group 15–19) is the omitted reference age class,

\( treat_{m} \) a dummy variable equal to 1 for each month of observation \( m \) of individual \( i \) that occurs in treatment districts and zero otherwise,

\( period_{m} \) a dummy variable equal to 1 for months of observation \( m \) of individual \( i \) that are recorded in the post intervention period and zero for months of observation \( m \) of individual \( i \) that are recorded prior to the start of the intervention,

\( \text{treat}_{m} \times \text{period}_{m} \) is a dummy variable representing the interaction between treatment and period (the difference-in-differences estimator),

\( age_{m} \times \text{treat}_{m} \) is a set of dummy variables representing the interaction between age group and treatment,

\( age_{m} \times \text{period}_{m} \) is a set of dummy variables representing the interaction between age group and period,

\( period_{m} \) is a dummy variable equal to 1 for months of observation \( m \) of individual \( i \) that are recorded in the post intervention period and zero for months of observation \( m \) of individual \( i \) that are recorded prior to the start of the intervention, and

\( X \) is a vector of \( J \) covariates representing household or personal characteristics of individual \( i \) (literacy, religion, household wealth and distance to nearest health facility).

By setting covariates at sample grand means and summing predicted probabilities of (2) for all five-year age groups from 15 to 49 and the 19 implied interaction terms, this numerical integration of linear combination estimates defines the total fertility rate (TFR). Therefore, linear combinations implied by the parameters of (2) express conditional TFR and treatment or programmatic exposure differences between predicted TFR define expect births averted associated with exposure to program activities. The treatment by time interaction parameters \( \delta \) and \( \gamma \) thus specify regression adjusted estimates simulating Heckman’s Model 1 “Average Treatment Effect.”\textsuperscript{36,37}

GEHIP represents exposure to a process of system improvement rather than an end product of UHC development. Model (2) therefore tests the impact of household exposure to a process of systems strengthening of CHPS that unfolded during the GEHIP implementation period. Model (2) thus tests the proposition that pursuing the process of UHC development at the district level has reproductive health and fertility effects. Assessing direct UHC fertility effects can be represented by estimating the impact of residing in a residence located in a service area where CHPS services are functional, as given by:

\[
\logit f_{ij} = \theta_0 + \sum_{r=2}^{7} \theta_r age_{ir} + \lambda_{CHPS_{ir}} + \lambda_{pYear} + \sum_{k=1}^{K} \xi_k s_{ik} + \sum_{r=2}^{7} \theta_r (age_{ir} \times CHPS_{ir}) \]  

(3)

where, \( \theta_0 + \sum_{r=2}^{7} \theta_r age_{ir} \) defines the contribution of individual \( i \) to the TFR, as in Model (2) and

\( CHPS_{ir} = 1 \) if individual \( i \) resides in a zone where CHPS is functional and 0 otherwise.
pYear = an ordinal scale defining years that pregnancy occurred if a birth occurred in the observation month of the birth history of individual i, 

\[ \sum_{\gamma=2}^{\gamma} \theta_j^{(\text{age}_{\gamma}, \text{CHPS})} \] are interaction indicators that define the age conditionality of CHPS effects.

Since the age parameters of equation 3 define adjusted age specific fertility effects if CHPS is fully operational, parameter estimates for CHPS exposure represent an estimation of the fertility effects of achieving UHC in Ghana.

**Ethical safeguards**

Ethical safeguards for the GEHIP project and its data collection processes were instituted and approved by the ethical review procedures of the Ghana Health Service and Columbia University.

**Results**

**Demographic information**

Baseline results portrayed in Table 1 assess the statistical balance of the survey data (available as Underlying data)\(^*\). In the endline, women in both intervention and comparison areas were

**Table 1. Characteristics of treatment and comparison area respondents, baseline and endline surveys.**

|                              | GEHIP Baseline Survey | GEHIP Endline Survey |
|------------------------------|-----------------------|----------------------|
|                              | Comparison area | Treatment area | p-value  | Comparison area | Treatment area | p-value  |
| N                            | 2,151          | 2,301           | 0.007    | 2,824          | 3,080          | 0.24     |
| Parity at time of interview  |               |                 |          |                |                |          |
| Nulliparous                  | 415 (19.3%)    | 483 (21.0%)    |          | 901 (31.9%)    | 1050 (34.1%)  |          |
| 1–2 births                   | 716 (33.3%)    | 724 (31.5%)    |          | 873 (30.9%)    | 887 (28.8%)   |          |
| 3–4 births                   | 538 (25.0%)    | 510 (22.2%)    |          | 628 (22.2%)    | 663 (21.5%)   |          |
| 5–6 births                   | 349 (16.2%)    | 392 (17.0%)    |          | 329 (11.7%)    | 383 (12.4%)   |          |
| 7 or more births             | 133 (6.2%)     | 192 (8.3%)     |          | 93 (3.3%)      | 97 (3.1%)     |          |
| Age Category                 |                |                 | 0.051    |                |                | 0.083    |
| 15–19                        | 357 (16.6%)    | 444 (19.3%)    |          | 738 (26.1%)    | 820 (26.6%)   |          |
| 20–24                        | 378 (17.6%)    | 339 (14.7%)    |          | 507 (18.0%)    | 499 (16.2%)   |          |
| 25–29                        | 362 (16.8%)    | 393 (17.1%)    |          | 405 (14.3%)    | 401 (13.0%)   |          |
| 30–34                        | 379 (17.6%)    | 377 (16.4%)    |          | 355 (12.6%)    | 376 (12.2%)   |          |
| 35–39                        | 317 (14.7%)    | 334 (14.5%)    |          | 333 (11.8%)    | 383 (12.4%)   |          |
| 40–44                        | 238 (11.1%)    | 282 (12.3%)    |          | 275 (9.9%)     | 363 (11.8%)   |          |
| 45–49                        | 120 (5.6%)     | 132 (5.7%)     |          | 211 (7.5%)     | 238 (7.7%)    |          |
| Marital status               |               |                 | <0.001   |                |                | 0.014    |
| Unmarried                    | 505 (23.5%)    | 661 (28.8%)    |          | 1238 (43.8%)   | 1445 (46.9%)  |          |
| Polygamous                   | 626 (29.2%)    | 624 (27.2%)    |          | 513 (18.2%)    | 575 (18.7%)   |          |
| Monogamous                   | 1016 (47.3%)   | 1013 (44.1%)   |          | 1073 (38.0%)   | 1060 (34.4%)  |          |
| Literacy                     |               |                 | <0.001   |                |                | 0.28     |
| Illiterate                   | 455 (21.2%)    | 656 (28.5%)    |          | 1009 (35.7%)   | 1142 (37.1%)  |          |
| Literate                     | 1696 (78.8%)   | 1645 (71.5%)   |          | 1815 (64.3%)   | 1938 (62.9%)  |          |
| Wealth                       |               |                 | <0.001   |                |                | <0.001   |
| Least poor 4 quintiles       | 1505 (70.0%)   | 1378 (59.9%)   |          | 2397 (84.9%)   | 2377 (77.2%)  |          |
| Poorest quintile             | 646 (30.0%)    | 923 (40.1%)    |          | 427 (15.1%)    | 703 (22.8%)   |          |
| Religion                     |               |                 | <0.001   |                |                | 0.034    |
| Traditional                  | 307 (14.3%)    | 322 (14.0%)    |          | 246 (8.7%)     | 306 (9.9%)    |          |
| Christian                    | 1077 (50.1%)   | 1377 (59.9%)   |          | 1695 (60.1%)   | 1898 (61.6%)  |          |
| Muslim                       | 679 (31.6%)    | 522 (22.7%)    |          | 811 (28.7%)    | 820 (26.6%)   |          |
| Other                        | 86 (4.0%)      | 78 (3.4%)      |          | 70 (2.5%)      | 55 (1.8%)     |          |
| CHPS zone exposure           |               |                 | 0.020    |                |                | <0.001   |
| No CHPS                      | 1388 (64.5%)   | 1407 (61.1%)   |          | 1519 (53.8%)   | 1130 (36.7%)  |          |
| Functional CHPS              | 763 (35.5%)    | 894 (38.9%)    |          | 1305 (46.2%)   | 1950 (63.3%)  |          |
| Nearest health facility (km) | 2.9 (SD 1.8)   | 4.3 (SD 3.0)   | <0.001   | 2.7 (SD 1.7)   | 4.0 (SD 2.5)  | <0.001   |
younger, less likely to have given birth before, and less likely to be married. In terms of religious affiliation, the majority of women were Christian, followed by Muslim and then traditional. The number of women who professed traditional religion declined between the baseline and the end line in both arms of the experiment while those born to women of the Christian faith increased. Both literacy and poverty levels decreased between the baseline and endline periods. The proportion of women living in a functional CHPS zone increased over time in both intervention and comparison areas, though the increase in the treatment area was much greater probably due to the effect of GEHIP on CHPS scale-up.

Fertility
All surveyed women were asked to provide information regarding their pregnancy and childbearing experiences, following interviewing procedures routinely conducted by Demographic and Health Surveys. Women were asked to provide information on all live births they have had in their lifetime including the age, sex, and survival status of all live births reported. Based on the birth history data, we computed basic fertility indicators such as the age-specific fertility rates and total fertility rates using children born within the last 12 months for all districts combined and separately for the intervention and non-intervention districts. Based on the birth history data, age-specific fertility rates and the total fertility rates using children born within the 12 months prior to interviews could be assessed, leading to the estimation of Model 2. The GDHS estimated TFR in the Upper East Region was 4.1, roughly one half of one birth lower than the GEHIP baseline TFR in both treatment and comparison areas. This is most probably due to the fact that the urban parts of the region were excluded in the GEHIP activities and districts covered by the Navrongo project were also excluded from GEHIP research.

The difference-in-differences estimate of the net effect of GEHIP on fertility presented in Table 2, Model 2A, indicates that GEHIP had no overall impact on total fertility. Model 2B introduces an age interaction into the difference-in-differences model, with predicted values that estimate regression adjusted age specific fertility rates and the TFR (Figure 3). The regression-adjusted TFR was slightly higher in comparison areas (4.7), relative to the treatment areas (4.5). Each area experienced a small estimated decline in the TFR, ranging from 0.3 to 0.4 births, yielding a null overall fertility impact of GEHIP. GEHIP was associated with reduced fertility at the peak ages for childbearing, ages 25-29, relative to the comparison area (OR = 0.83, p<=0.025, 95% CI 0.71, 0.98). Figure 3 illustrates that the net fertility reduction attributable to GEHIP among women 25–29 is due to a small decrease in fertility for this age group served by GEHIP, in contrast to a larger concomitant increase in fertility among women 25–29 in the comparison area.

The fertility effects associated with exposure to CHPS as estimated by Model 3 are reported in Table 3. Columns labeled Model 3A present results for main effects of CHPS only; whereas Model 3B includes parameter estimates for assessing the possibility that CHPS effects are conditional on age. Results show that exposure to CHPS is associated with an overall fertility reduction of approximately 5%. The Model 3B results is therefore consistent with the proposition that CHPS exposure reduces fertility. While the effect is not pronounced, representing impact of less than 0.3 births off the TFR, CHPS exposure has significant fertility reducing effects. As Figure 4 shows, this impact arises from the significant age conditional effect of CHPS exposure among women under age 20 (OR = 0.86, p=0.022, 95% CI 0.76,0.98), and among women aged 35 to 39 (OR = 0.87, p=0.015, 95% CI 0.78,0.97). There is no evidence of CHPS effects among other age categories.

Modern contraceptive prevalence and unmet need
Difference-in-differences analyses of GEHIP net effects on contraceptive prevalence and unmet need provide useful reproductive behavioral contextual information for understanding the fertility effects of CHPS and GEHIP. The increase in contraceptive prevalence between baseline and endline was significantly higher in the GEHIP study area, with a net difference-in-differences increase in the GEHIP treatment area, relative to the comparison area, of nearly 80% (Figure 5). The adjusted estimate of the net increase in modern contraceptive prevalence due to GEHIP was estimated to be an odds ratio of 1.80 (95% CI 1.32 - 2.44). While results thus show that GEHIP implementation was associated with increased contraceptive use, a concomitant increase in unmet need was ongoing in both treatment and comparison areas (Figure 5).

Discussion
A widely assumed, but seldom tested, proposition holds that progress with instituting UHC will contribute directly to improvements in family planning coverage[40-42]. Moreover, comprehensive integration of health and family planning services is advocated, without question, as a critical element of reproductive health care advancement. UHC, as specified in the Sustainable Development Goals, are assumed to ensure universal family planning access that improves reproductive health and supports the reproductive aspirations of women. Global indicators that are used to monitor progress with UHC include family planning prevalence among the criteria for gauging success[43].

GEHIP has exemplified practical means of surmounting the challenges and prospects for implementing the global UHC agenda for reproductive health service development in Ghana. At the onset of the GEHIP initiative, WHO guidelines for reproductive health service system development called for strengthening and maintaining valuable human resources by improving worker education at all career phases and ensuring integration into the curriculum, developing supportive supervision, and improving service delivery by managing and integrating services. Guidelines also appealed for developing and implementing innovative community outreach programs, expanding family planning, integrating reproductive and child health services and adopting the latest available family planning technologies. Moreover, recommendations emphasized the need to offer emergency contraception and to enhance the quality of services especially by ensuring the use of evidence-based recommendations and clinical guidelines[44].
| Covariates                                                                 | Model 2A                  | Model 2B                  |
|---------------------------------------------------------------------------|---------------------------|---------------------------|
|                                                                           | Odds Ratio | 95% CI   | Odds Ratio | 95% CI   |
| GEHIP treatment area (ref = comparison area)                              |         0.95*    | (0.91 - 0.99) |         0.93    | (0.81 - 1.06) |
| Post period (ref = pre period)                                            |         1.00    | (0.94 - 1.06) |         0.93    | (0.79 - 1.11) |
| DiD term: treatment * period                                              |         0.99    | (0.92 - 1.07) |         0.88    | (0.69 - 1.14) |
| Mother's Age Group (ref = 15–19)                                          |         2.26***   | (2.11 - 2.42) |         2.14***   | (1.92 - 2.39) |
| 20–24                                                                     |         2.17***   | (2.03 - 2.33) |         2.00***   | (1.79 - 2.23) |
| 25–29                                                                     |         1.91***   | (1.78 - 2.06) |         1.69***   | (1.51 - 1.90) |
| 30–34                                                                     |         1.40***   | (1.29 - 1.52) |         1.42***   | (1.25 - 1.61) |
| 40–44                                                                     |         0.79***   | (0.71 - 0.88) |         0.84*    | (0.70 - 1.00) |
| 45–49                                                                     |         0.29***   | (0.22 - 0.39) |         0.34***   | (0.20 - 0.57) |
| Unable to read (ref = literate)                                           |         1.55***   | (1.47 - 1.64) |         1.56***   | (1.47 - 1.64) |
| Poorest household wealth quintile (ref = 4 highest wealth quintiles)      |         1.03    | (0.99 - 1.06) |         1.03    | (0.99 - 1.07) |
| Christian (ref = other)                                                   |         0.92***   | (0.89 - 0.96) |         0.92***   | (0.89 - 0.96) |
| Nearest Health Facility (km)                                              |         1.01**   | (1.00 - 1.02) |         1.01**   | (1.00 - 1.02) |
| Age, treatment, period, DiD interaction terms                             |                       |           |                       |           |
| Treatment * age 20–24                                                     |         0.99    | (0.84 - 1.16) |                       |           |
| Period * age 20–24                                                        |         1.07    | (0.87 - 1.32) |                       |           |
| DiD * age 20–24                                                           |         1.27    | (0.94 - 1.73) |                       |           |
| Treatment * age 25–29                                                     |         1.03    | (0.88 - 1.20) |                       |           |
| Period * age 25–29                                                        |         1.29*    | (1.06 - 1.58) |                       |           |
| DiD * age 25–29                                                           |         0.94    | (0.70 - 1.27) |                       |           |
| Treatment * age 30–34                                                     |         1.14    | (0.97 - 1.34) |                       |           |
| Period * age 30–34                                                        |         1.13    | (0.91 - 1.40) |                       |           |
| DiD * age 30–34                                                           |         1.12    | (0.82 - 1.53) |                       |           |
| Treatment * age 35–39                                                     |         0.97    | (0.81 - 1.16) |                       |           |
| Period * age 35–39                                                        |         0.91    | (0.71 - 1.17) |                       |           |
| DiD * age 35–39                                                           |         1.22    | (0.85 - 1.74) |                       |           |
| Treatment * age 40–44                                                     |         0.95    | (0.74 - 1.22) |                       |           |
| Period * age 40–44                                                        |         0.72    | (0.51 - 1.02) |                       |           |
| DiD * age 40–44                                                           |         1.52    | (0.94 - 2.45) |                       |           |
| Treatment * age 45–49                                                     |         1.45    | (0.73 - 2.88) |                       |           |
| Period * age 45–49                                                        |         0.28*    | (0.09 - 0.85) |                       |           |
| DiD * age 45–49                                                           |         2.08    | (0.54 - 8.05) |                       |           |
| Person months of observation                                              | 554,173     |           | 554,173     |           |
| Log likelihood                                                            | -40318.8    |           | -40296.4    |           |
| chi2                                                                      | 1988.9      |           | 2012.2      |           |
| degrees of freedom                                                        | 13          |           | 31          |           |
| Clusters                                                                  | 10,356      |           | 10,356      |           |
**Table 3. Regression estimation of the impact of CHPS exposure on the total fertility rate.**

| Covariates                        | Model 3A |            | Model 3B |            |
|-----------------------------------|----------|------------|----------|------------|
|                                   | Odds Ratio | 95% CI     | Odds Ratio | 95% CI     |
| Year of onset of pregnancy        | 1.00      | (0.99 - 1.00) | 1.00      | (0.99 - 1.00) |
| Functional CHPS (ref = no CHPS)   | 0.95*     | (0.91 - 0.99) | 0.86*     | (0.75 - 0.97) |
| Mother’s Age Group (ref = 15–19)  |           |            |           |            |
| 20–24                             | 2.26***   | (2.10 - 2.42) | 2.17***   | (2.00 - 2.35) |
| 25–29                             | 2.17***   | (2.02 - 2.33) | 2.03***   | (1.87 - 2.20) |
| 30–34                             | 1.91***   | (1.77 - 2.06) | 1.84***   | (1.69 - 2.00) |
| 35–39                             | 1.40***   | (1.29 - 1.52) | 1.40***   | (1.28 - 1.55) |
| 40–44                             | 0.79***   | (0.71 - 0.89) | 0.79***   | (0.69 - 0.90) |
| 45–49                             | 0.29***   | (0.22 - 0.39) | 0.34***   | (0.23 - 0.49) |
| Unable to read (ref = literate)   | 1.55***   | (1.47 - 1.64) | 1.55***   | (1.47 - 1.64) |
| Poorest household wealth quintile (ref = 4 highest wealth quintiles) | 1.02      | (0.98 - 1.06) | 1.02      | (0.98 - 1.06) |
| Christian (ref = other)           | 0.93***   | (0.89 - 0.96) | 0.93***   | (0.89 - 0.96) |
| Nearest Health Facility (km)      | 1.01**    | (1.00 - 1.02) | 1.01**    | (1.00 - 1.02) |
| Age and CHPS interaction terms    |           |            |           |            |
| CHPS * age 20–24                  | 1.13      | (0.98 - 1.31) |           |            |
| CHPS * age 25–29                  | 1.23**    | (1.06 - 1.42) |           |            |
| CHPS * age 30–34                  | 1.13      | (0.97 - 1.31) |           |            |
| CHPS * age 35–39                  | 1.01      | (0.85 - 1.19) |           |            |
| CHPS * age 40–44                  | 1.04      | (0.83 - 1.31) |           |            |
| CHPS * age 45–49                  | 0.74      | (0.42 - 1.31) |           |            |
| Person months of observation      | 554,173   | 554,173    |           |            |
| Log likelihood                    | -40318.4  | -40312.8   |           |            |
| chi2                              | 2000.5    | 1997.3     |           |            |
| degrees of freedom                | 12        | 18         |           |            |
| Clusters                          | 10,356    | 10,356     |           |            |

**Figure 3.** Predicted age specific fertility rates from GEHIP difference in differences Model 2.
All elements of these recommendations were embraced by GEHIP, along with the axiomatic UHC focus on making health care affordable and ensuring that family planning would be provided as a component of accessible integrated health services45. Upon implementation of the GEHIP health systems strengthening interventions, CHPS implementation accelerated, shifting coverage from 20 percent of the population served by the program to 100 percent in a period of four years. Comparison area CHPS coverage also improved, but at a much lower rate that achieved an end of project population coverage rate of half that of the treatment area. As a mechanism for improving health care equity, access, and effectiveness, GEHIP was shown to have had an impact on neonatal mortality29. And assessment of referral volume can maternal mortality ratios showed that emergency referral and facility based care strategies of the program saved maternal lives29. Yet, despite these indicators of GEHIP success, the impact on family planning and fertility has been less impressive than Navrongo. Whereas the total multi-year effect of CHPS zone implementation exposure is approximately 0.3 births, the equivalent Navrongo effect, in the same cultural zone, was approximately a one-birth reduction in the TFR14. This modest GEHIP impact on family planning improvement and fertility reduction is statistically significant but unimpressive.

There are, nonetheless, important parallels to the Navrongo experimental results. Initial unmet need impact of the Navrongo project was also counter-intuitive and positive46. And, when the Ghana Health Service scaled-up Navrongo activities into project comparison areas, replication of the experiment within the original study district failed to replicate original project fertility effects15. Yet, in the CHPS formative era, when replication was pursued as a research project, observed levels of Navrongo experiment fertility impact were replicated without fail19. But, when replication of the family planning components of CHPS is pursued as a routine operation of district managers, results differ from results that emerge from research projects. Whenever operational management has been thoroughly embedded in routine management functioning47,48, GEHIP exemplifies the fidelity challenge: Its successful compliance with the global reproductive health service development agenda, has yet to fully replicate the Navrongo family planning and fertility experimental impact success story. Fidelity problems have been widely encountered.
with scaling up initiative elsewhere: Innovation is often diluted by implementation challenges when operations go to scale\textsuperscript{49,50}. What then, did the Navrongo project implement as an experiment that CHPS and GEHIP has lacked?

Contrasting implementation strategies of the current CHPS program, the original Navrongo project, and GEHIP are portrayed in Figure 6. While national scale-up of CHPS has successfully expanded access to primary health care, its expanded operations have had no discernable impact on fertility. Figure 6 illustrates the possible operational causes of this problem: CHPS has become a “Type 1” program. Navrongo implemented strategies for offsetting social costs arising from gender stratification, male ambivalence about family planning and limitations on the reproductive autonomy of women are not being addressed by the CHPS program. Diagnostic research, focusing on this problem, has found that the original social engagement focus of Navrongo research, as replicated in Nkwanta, has atrophied with CHPS scale-up.

GEHIP has successfully implemented the UHC agenda by improving access, reducing costs, developing service quality and content, and improving the climate of leadership that this agenda entails, transitioning CHPS to the Type 2 program shown by the upper right quadrant, Figure 6. This has contributed to demand for care, contributing to mounting unmet need for family planning, increase in contraceptive use, and modest fertility decline.

Yet, this Type 2 approach, while faithful to the UHC goal, is insufficient for Ghana to achieve its reproductive health development goals. Navrongo also pursued that “Type 2” agenda, but far more attention was directed to social engagement for family planning than was the case in GEHIP\textsuperscript{10,11}. Represented by the Type 3 quadrant of Figure 6, the active doorstep provision of care for a range of methods was supported by community communication activities, social network engagement, gender development activities, and other components of social outreach that embedded program activities in the societal setting. The result was a people-centered program that expanded both demand for family planning and socially engaged supply of services.

GEHIP results attest to the need to augment UHC policies with strategies that mitigate the social costs of family planning, yielding the “UHC+” approach to program development portrayed in the lower right quadrant of Figure 6.

Conclusion

A mother with a child who is ill may be willing to walk for hours to seek care. Demand for health care is well served by constructing convenient health posts, assigning skilled workers to these locations to provide care on demand, and focusing resources on expanding the range, quality, and affordability of services that such a program can provide. But, in rural Ghana, where extensive social costs of family planning are distinct from the relatively marginal social costs that seeking health services incur,
women who seek to space or limit childbearing face social constraints that even the most fully developed UHC can fail to address. Results of the GEHIP trial suggest that successful implementation of UHC can fail to successfully address family planning need. While UHC is essential to achieving access to family planning, UHC will have an impact on fertility only if its implementation is augmented with ancillary strategies for family planning focused social engagement.

Data availability
Underlying data
Data Archiving and Networked Services: GEHIP PLAUSIBILITY TRIAL _FERTILITY. https://doi.org/10.17026/dans-xph-vte94.

This project contains the following underlying data:
- Phillips_GEHIP_fertility_data (data are available in DTA, POR and SAV formats).
- Phillips GEHIP fertility Code Book.pdf

Extended data
Data Archiving and Networked Services: GEHIP PLAUSIBILITY TRIAL _FERTILITY. https://doi.org/10.17026/dans-xph-vte94.

This project contains the following extended data:
- GEHIP Baseline questionnaire.pdf

Please note that free, unrestricted registration with Data Archiving and Networked Services is required prior to data access.

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

Acknowledgements
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Ann Biddlecom
Guttmacher Institute, New York City, NY, USA

This study examines a relevant and uniquely situated research question of the impact on reproductive outcomes of policy and programmatic investments in essential health services. The following points should be addressed to make the article scientifically sound:

1. The overarching outcomes the authors initially seek to address are unplanned pregnancy and unwanted fertility - where women’s reproductive preferences are explicitly accounted for - but the analytical outcomes are overall fertility (both intended and unintended). Either the authors should revise the purpose of the study and explain why overall fertility reductions are valuable to examine (though this would go against the concluding points around people-centered programs), or re-orient the fertility analysis to examine reductions in unintended fertility (too soon/not wanted at all; possible to do given data are of births in the last 12 months and if question about birth intendedness asked) and/or unwanted fertility (e.g., wanted TFR).

On the latter point, it is relevant to bring in points from earlier, published analyses in this context that showed that contraceptive services met a demand for child spacing rather than fertility limitation, and that fertility declines were distributed across age groups rather than a limitation pattern where reductions are steepest at older ages (higher parities).

2. The history of the scale up is useful context and is concisely described. That said, elements of the CHPS that atrophied with scale up are not made clear or evident in the analysis. E.g., (page 3) GEHIP involved retraining health workers in “community engagement” or (page 5) “political engagement in the CHPS implementation process”. But it is not clear what this means and the degree to which this does or does not align with social mobilization components carefully detailed in prior fertility impact assessments:

   a. (Para 2): Community-based activities were crucial to the NHRC experiment (community engagement, doorstep care, participatory planning).

   b. Three-year assessment (Debpuur et al., 2002): “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."

c. Longer-term assessment (Phillips et al., 2012): “When project strategies were scaled up, social mobilization components were neglected. As a consequence, the long-term impact of scaled-up operations was negligible.”

3. Figure 6 is not that intuitive regarding “mobilizing demand” since the Navrongo agenda also, in some aspects, seemed to mobilize demand by, in part, reducing social costs (to contraceptive use; how gender relations worked) through the community engagement activities listed in cell 3.

4. (Page 5, para 3): What was behind the large decrease in the achieved sample in the endline survey (76%)?

5. (Title and throughout (page 4 para 3)): Universal health coverage includes not only means increased use of essential services by those in need but also that use does not expose people to financial hardship. The manuscript should describe what was implemented regarding financial hardship protections (e.g., health insurance scheme) during the GEHIP phase.

6. (Page 6, para 3): How much overlap is there between census EAs and catchment areas of services (or “zones”)?

Minor points:

1. (Page 4): What is the difference between “CHPS: Resident nurse with health post” and “CHPS”? Is it that one is fully functional and the other is not?

2. (Page 4, para 2): “on neonates” repetitive in sentence.

3. (Page 4-5): unclear sentence “…testing the proposition that access to functional CHPS affects fertility tests the hypothesis that achieving UHC in Ghana…”.

4. (Page 6, 2nd col text): unclear sentence “…conditional TFR and treatment or programmatic exposure differences between predicted TFR define expect births averted associated with exposure to program activities.”

5. (Page 11, para 1): unclear sentence “And assessment of referral volume can maternal mortality ratios showed…”.

6. (Page 13): remove reference 34 from the data hyperlink.
Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Demography, sexual and reproductive health

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

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Overall assessment: this is a very well written paper on an important topic.

- Ghana is a model for health (including reproductive health) interventions in SSA. Their approach was based first on a high-quality pilot project, then once found to be successful, scaling up and then expanding again.

- Like several other SSA countries, Ghana is experiencing fertility stalls that are of great policy importance with regard to reproductive health, health equity, the demographic dividend and the long-term population-environment balance.
The authors – leading researchers in this area with much experience working in Navrongo and more generally in Ghana – make use of natural experiment data to examine the effects of the scaled-up program on fertility after a 3.5 year interval. Their findings show that the program had only a small effect – much smaller than anticipated given the success of the pilot program. They provide plausible explanations for the overall lack of effect, grounded in their deep knowledge of the Navrongo pilot project and of how the program was scaled up. The results are of considerable importance both within Ghana and more generally for the SSA context.

I would strongly be in favor of indexing this article. Having said that, I would encourage them to make some relatively minor changes to make the paper stronger (the most important are points 1 and especially 3, below):

1. I would have liked somewhat more information on why the program occurred in some areas and not in others, and if this potentially “endogenous program placement” might have an effect on the findings. Having said that, the controls in their regressions for several important covariates (religion, distance to services, literacy and wealth) should largely take care of confounding differences across the zones.

2. Are data available for the post-intervention (scaled up program, not the baseline data)? I didn’t notice that said in the paper.

3. Their model is well justified and fairly classic for this type of analysis. The effects of the intervention are estimated via a simple interaction term (models 2A and 3A) and then by looking on the effects of the scaled up program on the age pattern of fertility (models 3A and 3B). The results are presented in the form of odds ratios, which is standard in public health. That said, for interpreting the results, it is easy to misinterpret the estimated coefficients (or odds ratios) for non-linear regressions with interaction terms (models B). The authors do briefly present predicted outcomes and graph those (figures 3 and 4), but I’d strongly encourage them to go much farther in that direction. Specifically, for the analysis of age patterns of fertility, it would be better to compute the marginal effects and also their statistical levels (Stata as I recall can do this via the margins command or the older inteff command.) Thus for example, the estimated differential fertility of women aged 25-29 in a CHPS (or GEHIP) area versus other areas would surely fall considerably and I suspect become statistically insignificant, if the overall effect of living in the area is simultaneously taken into account (the treatment area dummy variable).

4. The strong and intriguing result of the study is that, while the scaled up programs had the anticipated effects on neonatal and maternal health and survival, its effects on fertility were much lower than expected. The authors carefully compared the programs and outcomes with those of the Navrongo pilot project (where strong fertility results were found), and offer quite plausible explanations for this finding. A question for the authors: might part of the lack of an effect also be due to a weaker provision of family planning services in the scaled-up areas? In my experience (mostly in Francophone sub-Saharan Africa), the public health field – both research and interventions - in Africa is dominated by the medical profession and tends to focus on health services provided by clinics, hospitals, etc. Too often, this approach leads to family planning services being perceived as of lesser priority than more direct health services (vaccinations…). If this is also the case in Ghana, might it be possible that the overall lack of effect of the scaled-up program on fertility be in part caused by a general lack of emphasis by the health services staff on FP/RH services per se?

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Yes

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Demography, RH/FP, adolescent transitions to adulthood, linkages between child mortality and fertility, data and empirical methods.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.