Women’s empowerment, intrahousehold influences, and health system design on modern contraceptive use in rural Mali: a multilevel analysis of cross-sectional survey data

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Abstract

Background: Persistent challenges in meeting reproductive health and family planning goals underscore the value in determining what factors can be leveraged to facilitate modern contraceptive use, especially in poor access settings. In Mali, where only 15% of reproductive-aged women use modern contraception, understanding how women’s realities and health system design influence contraceptive use helps to inform strategies to achieve the nation’s target of 30% by 2023.

Methods: Using household survey data from the baseline round of a cluster-randomized trial, including precise geolocation data from all households and public sector primary health facilities, we used a multilevel model to assess influences at the individual, household, community, and health system levels on women’s modern contraceptive use. In a three-level, mixed-effects logistic regression, we included measures of women's decision-making and mobility, as well as socio-economic sources of empowerment (education, paid labor), intrahousehold influences in the form of a co-residing user, and structural factors related to the health system, including distance to facility.

Results: Less than 5% of the 14,032 women of reproductive age in our study used a modern method of contraception at the time of the survey. Women who played any role in decision-making, who had any formal education and participated in any paid labor, were more likely to use modern contraception. Women had three times the odds of using modern contraception if they lived in a household with another woman, typically a co-wife, who also used a modern method. Compared to women closest to a primary health center, those who lived between 2 and 5 km were half as likely to use modern contraception, and those between 5 and 10 were a third as likely.

Conclusions: Despite chronically poor service availability across our entire study area, some women—even pairings of women in single households—transcended barriers to use modern contraception. When planning and implementing strategies to expand access to contraception, policymakers and practitioners should consider women's...
Plain English Summary
Despite needing methods to avoid unwanted pregnancies and safely space births, many women around the globe are unable to obtain modern contraception (for example, condoms, implants, etc.) particularly in middle and western Africa. In Mali, less than one in six women aged 15 to 49 years use modern contraception. In order to help design strategies to increase use, we need to understand what factors support women to use contraception in settings where access to healthcare is poor. In December 2016 and January 2017, we surveyed 14,032 women in Bankass, rural Mali, and asked them about themselves and their use of reproductive health services, among other topics. Less than five percent used modern contraception at the time of the survey. In a statistical regression analysis, we determined that women who were involved in decisions pertaining to her own health, visiting her relatives, and household spending were more likely to use contraception than those who were not, as were women who had any education and any paid work. Living with another woman in the household who used contraception meant that a woman was three times more likely to use herself. We also found that the further a woman lived from a health center, the less likely she was to use, even within 5 kilometers. When designing and rolling out targeted strategies to expand access to contraception, we ought to consider these elements related to women's empowerment, intimate relationships, and the broader health system.

Background
Ensuring access to contraception and women's family planning needs are met with modern methods is essential to meeting the Sustainable Development Goals related to universal access to reproductive healthcare, gender equality, and the empowerment of women and girls. Among all women of reproductive age globally, the use of modern contraception has increased only marginally.
between 2000 and 2019 from 42.0 to 44.3%, with the greatest unmet need persisting in middle and western Africa [1]. In Mali, only 15% of women aged 15–49 years used modern contraception at the time of the last Demographic and Health Survey (DHS) in 2018 [2].

Mali’s total fertility rate is among the highest in the world. Women have an average of 6.3 children, with women in rural areas having almost two more children than those in urban areas (6.8 versus 4.9 children per woman) [2]. Although fertility has declined in Mali since 1987 when the average was 7.1 children per woman, certain regions today have fertility rates as high as the 30 year old national average [2]. Despite national policy and law promoting sexual and reproductive health and rights, more than one in five reproductive-aged women in Mali report an unmet need for family planning, including one quarter of women in union and over half of sexually active women not in union [2].

A number of structural barriers may inhibit or delay access to contraception and other basic healthcare services within Mali’s decentralized, pluralistic, fee-for-service healthcare system. Family planning services are theoretically integrated into all levels of public sector care in Mali: national, regional, district, health catchment area, and community. In some communities greater than 5 km from a primary health center (PHC), community health workers (CHW) are stationed in fixed community health posts to provide counseling, services and referral, including for family planning, to patients who seek care and pay the fees for service. However, direct and indirect costs to care, including distance, are well-established barriers to timely, appropriate healthcare access across a variety of settings [3–8]. Furthermore, service delivery at all levels of care in Mali suffers from a shortage and inequitable distribution of the health workforce, inadequate clinical mentoring and supervision, and poor infrastructure and frequent stock-outs, which undermine quality of care and patient confidence. Major system-wide reforms in Mali to improve access to care are were announced in February 2019 and expected to take full effect by 2022, including removing user fees for contraceptives and maternal and child health, strengthening the CHW cadre, and increasing national budget allocations to health.

Beyond barriers related to health system design and implementation, women in this context may be further hindered in fulfilling their contraceptive needs due to infringements on their empowerment, defined here as the expansion in people’s ability to make strategic life choices through resources, agency, and achievements [9]. Socio-economic disadvantages such as poor access to formal education and the paid labor force, constraints on physical mobility, limited decision-making power, and gender norms and attitudes have been shown to limit women’s ability to exercise contraceptive choices in settings across sub-Saharan Africa [10–17]. The expansion in women’s ability to make strategic choices related to reproduction in such a prevailing context may be influenced by household composition, familial relationships, and decision-making dynamics. In South Asian settings where extended family ties are strong, intrafamilial influences, such as spousal communications and interactions with mothers-in-law, may play an important role in women’s contraceptive use [18, 19]. In rural Mali, where women in union typically live with their husband’s extended family and 40% are in a polygynous arrangement [2], the role, autonomy, and contraceptive use status of their female household members may expand women’s access to contraceptive choice.

Mali recently developed a renewed five-year national strategic plan for family planning, with the ambitious goal of increasing female modern contraceptive use to 30% by 2023 [20]. Building on the experiences and lessons learned in implementing the previous 5-year plan (2014–2018), the renewed plan for family planning is based on five strategic pillars: demand generation; availability and access to services; supply chain management; an enabling political environment and financing; and monitoring and supervision. In order to achieve this new goal, Mali must attain a rapid growth rate in contraceptive use comparable only to that achieved by Sierra Leone in the West African region [20]. Further elucidating how health system design and women’s realities influence modern contraceptive use helps to determine how such ambitious plans should be operationalized in order to improve access.

In this study, we aim to: (1) describe modern contraceptive use among women of reproductive age in the under-studied, high fertility, rural Malian context of the Bankass district, including methods and procurement among users; (2) explore descriptively and visually household and village composition of reproductive-aged women and their use of modern contraception; and (3) identify predictors of modern contraceptive use in this context where utilization is exceptionally low. We use a multilevel modeling approach using detailed household survey data, including geolocated measures of distance, to assess influences on women’s modern contraceptive use at the individual, household, community, and health system levels. We include ‘direct’ measures of women’s empowerment (decision-making and mobility in the public domain), as well as indirect socio-economic sources of empowerment (education and paid labor force participation). We explore the role of intimate female social networks by assessing how living in a household with another woman who uses modern contraception influences adoption. Determining what structural barriers to
dismantle and social relationships to leverage in order to expand contraceptive access is key to meeting national and international goals for women’s wellness, health, and survival.

**Methods**

**Study design**

We conducted a cross-sectional household survey in the communities of seven health catchment areas of the rural Bankass district, Mali from December 2016 to January 2017. This survey served as the baseline for an ongoing cluster-randomized controlled trial (trial registration number NCT02694055; N = 137 village-clusters) to assess the effects of a proactive approach to community-based healthcare delivery on child mortality and access to care over three years, including access to modern and long-acting reversible contraception (secondary trial endpoint) [21]. Here, we analyze baseline survey data from women of reproductive age to assess contraceptive use before the launch of intervention activities.

**Study setting**

The Bankass health district is part of the Mopti region in central Mali, approximately 600 km northeast of the nation’s capital, Bamako. The district has a population of approximately 300,000 people and is served by a public, secondary referral hospital located in Bankass, the largest town in the district [22]. It was chosen for the trial in collaboration with the Malian Ministry of Health and Social Affairs based on high under-five mortality and low healthcare utilization in the region, similar to other rural Malian settings [23], as well as few concurrent health interventions in the district and interest from local authorities to collaborate. Within the Bankass health district, the study was conducted in seven (of 22) contiguous, rural health catchment areas: Dimbal, Doundé, Ende, Kani Bozon, Kouloungon, Lessagou, and Soubala, an area with a population of approximately 100,000 people. Each health catchment area is served by a public sector PHC.

**Study participants**

In the context of rural Mali, extended families often live together in family compounds comprised of multiple households. Our survey definition of a household within a family compound was a monogamous or polygynous marital arrangement with or without children and additional relatives, or a single mother with or without additional relatives. All women aged 15 to 49 years permanently residing in the study area with no plans to leave during the trial period and who provided consent or assent were eligible to participate in the women’s questionnaire component of the household survey. From the present analysis we excluded all women who reported being pregnant at the time of the survey (N = 222) or who reported having reached menopause or having had a hysterectomy (N = 299).

**Data sources and measurement**

We adapted our household survey instrument (see Additional File 1) from the Mali DHS and programmed it in Open Data Kit. The survey captured detailed information on household and individual socio-demographic characteristics, utilization of reproductive, maternal and child health services, and recorded household geographic coordinates, among other topics. All surveyors were women who were not members of the villages they surveyed, due to the sensitive nature of questions related to contraception and reproductive health. Respondents participated in French, Bamanankan, Peulh, or the Dogon dialects of Tomokan and Tingu.

**Measures**

**Outcomes**

We evaluated women’s self-reported use of a modern method of contraception at the time of the survey. We defined modern methods according to the World Health Organization (WHO) [24] and Malian guidelines, and included female and male sterilization, female and male condoms, intrauterine device (IUD), implant, injectable contraception, oral contraceptive pill (OCP), diaphragm, foam/spermicidal jelly, the lactational amenorrhea method (LAM), and the standard days method (e.g., cycle beads). Traditional methods included the rhythm/calendal method, withdrawal, herbal, and other methods. For women who reported using multiple methods concurrently (N = 5), the more efficacious method was chosen for analysis (i.e., sterilization > implant > IUD > injectable > other modern method > traditional method).

We descriptively examined length of use and place and cost of last procurement among all contraceptive users. Length of contraceptive use in months was calculated by subtracting the month and year that the woman reported using before the launch of intervention activities. From the present analysis we excluded all women who reported being pregnant at the time of the survey (N = 222) or who reported having reached menopause or having had a hysterectomy (N = 299).
Predictors
We elaborated a list of potential predictors a priori based on existing evidence and contextual knowledge. At the individual level, these included: women’s age (5-year categories); number of living children (none, one or two, three or four, five or six, seven or more); marital status (monogamous, polygynous, not currently married); tolerant attitudes for spousal violence (coded any tolerance versus none, based on whether she believed a husband was justified in hitting or beating a wife under any of the seven circumstances evaluated, including if she used contraception without his consent); education (any formal schooling versus none); participation in paid labor (any versus none); and empowerment measures we adapted from existing scales, including mobility and decision-making power. We coded women’s mobility categorically based on their having ever been to the market place, health center, women’s group, or outside the village (never been to any, been to some or all but never alone, been to at least one alone—with which we capture independent mobility) [25]. Women were coded as having any involvement in decision-making versus none, based on whether they reported making decisions, either independently or jointly with someone else in the family, for any of the three domains asked (i.e., her own healthcare, visiting her relatives, household purchasing) [26].

Household level predictors included: another woman of reproductive age in the household using modern contraception; household wealth quintiles constructed using principal components analysis of asset indicators; [27] household food insecurity (coded as any versus none, based on whether the respondent affirmed that in the last 30 days, there was no food to eat due to a lack of resources, or someone went to sleep hungry because there was not enough food, or someone went a whole day and night without eating because there was not enough food); [28] and household distance to nearest public sector health facility. Orthodromic (great-circle) distance estimates were based on Geographic Information System (GIS) data for the entrance to the family compound, each PHC, and the district referral hospital. When GIS data for the family compound was missing (N = 560), we approximated household distance using GIS collected at the central gathering place in the village. We included a community level factor for the availability of CHW services at the time of the survey (coded as having a CHW posted in the village or hamlet at a fixed community health site, having a CHW provide services in the village or hamlet but not posted there, or not having any CHW services available), based on documentation from the Ministry of Health and Social Affairs.

Regression analysis
We conducted a multilevel regression analysis to assess factors at multiple levels influencing modern contraceptive use among women of reproductive age. As the percent missing on outcome data and covariates was small, these observations were dropped from the regression analysis. Due to the clustering of female modern contraceptive users within households, family compounds, village-clusters, and health catchment areas, we employed a multilevel modeling approach. We used a three-level, mixed-effects logistic regression with random effects at the family compound and village-cluster levels, and fixed effects for health catchment area in order to adjust for any time-invariant unobserved heterogeneity across catchment areas, such as availability of contraceptive methods or characteristics of provision at the PHCs.
Level 1 : \( \eta_{ijk} = \alpha_{0jk} + \beta_1X_{ijk} + \varepsilon_{ijk} \)

Level 2 : \( \alpha_{0jk} = \delta_{00k} + \gamma_1Z_{0jk} + \mu_{0jk} \)

Level 3 : \( \delta_{00k} = \theta_{000} + \lambda_1C_{00k} + \nu_{00k} \)

The Level 1 equation represents variation at the individual woman level. \( \eta_{ijk} = \log \left( \frac{\pi_{ijk}}{1-\pi_{ijk}} \right) \). \( \pi_{ijk} \) denotes the probability that the \( i \)th woman in the \( j \)th family compound and the \( k \)th village-cluster uses modern contraception. \( X_{ijk} \) denotes a vector of individual woman-level and household-level (e.g., wealth, food insecurity) variables of interest, and \( \beta_1 \) represents the coefficients for this set of covariates. \( \varepsilon_{ijk} \) is the woman-level error term, with variance \( \sigma^2_{\varepsilon_{ijk}} \). The Level 2 equation represents variation at the level of the family compound, where \( \alpha_{0jk} \) is a function of: \( Z_{0jk} \), which denotes family compound-level covariates (i.e., distance to the nearest public sector health facility); \( \delta_{00k} \), which is a systematic component modelled as the compound specific random intercept; and \( \mu_{0jk} \), representing the family compound-level random effect with variance \( \sigma^2_{\mu_{0jk}} \). The Level 3 equation represents variation at the level of the village-cluster. \( \delta_{00k} \) denotes cluster-level covariates (i.e., availability of CHW services), \( \theta_{000} \) represents the village-cluster specific intercept, and \( \nu_{00k} \) is the village-cluster level random effect with variance \( \sigma^2_{\nu_{00k}} \).

We estimated adjusted odds ratios (AORs) and reported 95% confidence intervals (CIs). For all categorical variables, we conducted a likelihood ratio test to assess the evidence of an association between the variable and the outcome.

**Sensitivity analyses**

To assess the extent to which missing outcome data affected the results, we ran the model assuming women with missing contraceptive use data were all not modern contraceptive users, and again assuming they were all modern contraceptive users.

**Results**

**Sample characteristics**

Our sample included 10,872 households within 4987 family compounds, with a median household size of six members (IQR 4, 9) (Table 1). Median household distance to the nearest health center was 5.41 km. These households included 14,032 women of reproductive age (Table 2), with a median age of 30 years. Nine out of ten women (90.4%) were married; 38.6% were in a polygamous marital arrangement and 51.8% in a monogamous arrangement. Women had a median of three living children (IQR 1, 5). Only one in ten women (10.7%) had received any formal education and only slightly more (13.7%) participated in any paid labor. Approximately one quarter (26.9%) participated to any extent in decision-making; this was the same for women in monogamous (26.3%) and polygynous (26.7%) marital arrangements.

Just 49 women (0.4%) were missing main outcome data on contraceptive use at the time of the survey and were therefore excluded from subsequent analyses. A relatively larger proportion of these women were Peulh, young (15 to 19 years), never married, nulliparous, having independent mobility, not involved in decision-making and in wealthier households compared to those with non-missing contraceptive use data (See Supplementary Tables 1 and 2, Additional File 2).

**Descriptive results**

The geographic distribution of female modern contraceptive users across the study area is depicted in Fig. 1. Approximately a third of village-clusters (N = 44/137) had no modern contraceptive users at all (blank circles, Fig. 1) and 51.8% (N = 71/137) had more than one user. More than a quarter of all women who lived with a modern contraceptive user in the same household also used modern contraception (N = 85/324). Put another way, 14% of all female modern contraceptive users lived with another modern contraceptive user in the same household (N = 85/626).

Table 3 represents household composition of reproductive-aged women and their use of modern contraception. Among households that had more than one woman of reproductive age (N = 2640/10,872; column 4, Table 3), less than 2% (N = 42/2640) had more than one woman who used modern contraception (stars, Fig. 1). One household had three users (a mother and her two daughters) and the rest had two users, most commonly first and second co-wives (N = 30/41), followed by other pairings of co-wives in households with three or four wives (7/41) and mother-daughter dyads (4/41). Within multi-woman households in which some but not all women were using modern contraception (N = 195 households containing 446 women; Table 3), those who were not using tended to be younger, unmarried and nulliparous (results not shown). Households with at least one female modern contraceptive user (N = 584 households containing 867 women; Table 3) tended to be richer, closer to the nearest health center, and more inclusive of women in decision-making than households with none (results not shown).

Less than 5% of women (4.5%) reported using any method of contraception at the time of the survey, ranging from 1.5 to 12.2% across health catchment areas, the vast majority (98.6%) of whom used a modern method (Table 4). Among women who used modern methods, half used the injectable contraceptive (49.7%), one quarter used the implant (26.2%), 15.3% the OCP, and 5.1%...
Table 1  Household level sample characteristics for women of reproductive age by modern contraceptive use status

| Household level characteristic              | Modern users N = 626 | Non modern users N = 13,357 | All women N = 14,032 |
|--------------------------------------------|----------------------|-----------------------------|-----------------------|
|                                            | n        | %     | n        | %     | n        | %     |
| Household size                             |          |       |          |       |          |       |
| Median/IQR                                 | 6        | 4.9   | 6        | 4.9   | 6        | 4.9   |
| Missing                                    | 1        | 0.2   | 27       | 0.2   | 28       | 0.2   |
| Distance to health center                  |          |       |          |       |          |       |
| < 2 km                                     | 243      | 38.8  | 2455     | 18.4  | 2708     | 19.3  |
| 2–4.99 km                                  | 149      | 23.8  | 3327     | 24.9  | 3489     | 24.9  |
| 5–6.99 km                                  | 104      | 16.6  | 3159     | 23.7  | 3273     | 23.3  |
| 7–9.99 km                                  | 52       | 8.3   | 2527     | 18.9  | 2584     | 18.4  |
| ≥ 10                                       | 61       | 9.7   | 1426     | 10.7  | 1494     | 10.7  |
| Missing                                    | 17       | 2.7   | 463      | 3.5   | 484      | 3.5   |
| Household wealth quintile<sup>a</sup>      |          |       |          |       |          |       |
| Poorest                                    | 85       | 13.6  | 2294     | 17.2  | 2382     | 17.0  |
| Poor                                       | 108      | 17.3  | 2479     | 18.6  | 2591     | 18.5  |
| Middle                                     | 111      | 17.7  | 2589     | 19.4  | 2709     | 19.3  |
| Rich                                       | 139      | 22.2  | 2844     | 21.3  | 2996     | 21.4  |
| Richest                                    | 175      | 28.0  | 2983     | 22.3  | 3178     | 22.7  |
| Missing                                    | 8        | 1.3   | 168      | 1.3   | 176      | 1.3   |
| Water and sanitation<sup>b</sup>           |          |       |          |       |          |       |
| Unimproved toilet facilities               | 235      | 37.5  | 6869     | 51.4  | 7127     | 50.8  |
| Improved toilet facilities                 | 388      | 62.0  | 6437     | 48.2  | 6851     | 48.8  |
| Missing                                    | 3        | 0.5   | 51       | 0.4   | 54       | 0.4   |
| Unimproved water source                    | 150      | 24.0  | 6118     | 45.8  | 6284     | 44.8  |
| Improved water source                      | 476      | 76.0  | 7237     | 54.2  | 7746     | 55.2  |
| Missing                                    | 0        | 0.0   | 2        | 0.0   | 2        | 0.0   |
| Food insecurity in past 30 days            |          |       |          |       |          |       |
| Little to no hunger in the household       | 554      | 88.5  | 11,685   | 87.5  | 12,280   | 87.5  |
| Moderate hunger in the household           | 45       | 7.2   | 932      | 7.0   | 980      | 7.0   |
| Severe hunger in the household             | 25       | 4.0   | 725      | 5.4   | 755      | 5.4   |
| Missing                                    | 2        | 0.3   | 15       | 0.1   | 17       | 0.1   |
| CHW services available                     |          |       |          |       |          |       |
| None                                       | 469      | 74.9  | 9148     | 68.5  | 9649     | 68.8  |
| Satellite villages<sup>c</sup>             | 33       | 5.3   | 1868     | 14.0  | 1908     | 13.6  |
| Posted village                             | 124      | 19.8  | 2341     | 17.5  | 2475     | 17.6  |
| Health catchment area                      |          |       |          |       |          |       |
| Dimbal                                     | 89       | 14.2  | 3051     | 22.8  | 3145     | 22.4  |
| Lessagou                                   | 111      | 17.7  | 2083     | 15.6  | 2195     | 15.6  |
| Doundé                                     | 68       | 10.9  | 1684     | 12.6  | 1756     | 12.5  |
| Ende                                       | 89       | 14.2  | 639      | 4.8   | 728      | 5.2   |
| Soubala                                    | 35       | 5.6   | 2371     | 17.8  | 2407     | 17.2  |
| Kanibozon                                  | 128      | 20.5  | 1302     | 9.8   | 1448     | 10.3  |
| Koulongon                                  | 106      | 16.9  | 2227     | 16.7  | 2353     | 16.8  |

<sup>a</sup> Household wealth quintile here excludes water, sanitation, and hygiene measures, which are reported separately

<sup>b</sup> We used the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation harmonized survey questions and definitions to define improved drinking water and improved sanitation [39]

<sup>c</sup> Satellite villages are within the CHW’s catchment area, 5 km or less of the village where the CHW has a fixed site (posted village)
Table 2  Individual level sample characteristics for women of reproductive age by modern contraceptive use status

| Individual level characteristic | Modern users       | Non modern users  | All women        |
|---------------------------------|--------------------|-------------------|-----------------|
|                                 | N = 626            | N = 13,357        | N = 14,032      |
|                                 | n                  | %                 | n               | %               | n               | %               |
| Age                             |                    |                   |                 |                 |                 |                 |
| 15–19                           | 49                 | 7.8               | 1770            | 13.3             | 1839            | 13.1             |
| 20–24                           | 138                | 22.0              | 2232            | 16.7             | 2377            | 16.9             |
| 25–29                           | 120                | 19.2              | 2620            | 19.6             | 2746            | 19.6             |
| 30–34                           | 135                | 21.6              | 2308            | 17.3             | 2447            | 17.4             |
| 35–39                           | 99                 | 15.8              | 1894            | 14.2             | 2998            | 14.2             |
| 40–44                           | 58                 | 9.3               | 1440            | 10.8             | 1499            | 10.7             |
| 45–49                           | 27                 | 4.3               | 1093            | 8.2              | 1126            | 8.0              |
| Number of living children       |                    |                   |                 |                 |                 |                 |
| Median/IQR                      | 3                  | 1.5               | 3               | 1.5              | 3               | 1.5              |
| None                            | 76                 | 12.1              | 2284            | 17.1             | 2376            | 16.9             |
| 1–2                             | 184                | 29.4              | 3656            | 27.4             | 3858            | 27.5             |
| 3–4                             | 157                | 25.1              | 3513            | 26.3             | 3674            | 26.2             |
| 5–6                             | 128                | 20.5              | 2555            | 19.1             | 2688            | 19.2             |
| 7+                              | 79                 | 12.6              | 1331            | 10.0             | 1416            | 10.1             |
| Missing                         | 2                  | 0.3               | 18              | 0.1              | 20              | 0.1              |
| Ethnicity                       |                    |                   |                 |                 |                 |                 |
| Dogon                           | 585                | 93.5              | 12,024          | 90.0             | 12,646          | 90.1             |
| Peulh                           | 14                 | 2.2               | 1012            | 7.6              | 1036            | 7.4              |
| Other                           | 27                 | 4.3               | 320             | 2.4              | 350             | 2.5              |
| Religion                        |                    |                   |                 |                 |                 |                 |
| Muslim                          | 597                | 95.4              | 13,087          | 98.0             | 13,732          | 97.9             |
| Catholic                        | 19                 | 3.0               | 162             | 1.2              | 181             | 1.3              |
| Other                           | 10                 | 1.6               | 108             | 0.8              | 119             | 0.9              |
| Marital status                  |                    |                   |                 |                 |                 |                 |
| Never married                   | 36                 | 5.8               | 1131            | 8.5              | 1179            | 8.4              |
| Divorced/widowed                | 4                  | 0.6               | 158             | 1.2              | 162             | 1.2              |
| Polygynous marriage             | 246                | 39.3              | 5141            | 38.5             | 5409            | 38.6             |
| Monogamous marriage             | 340                | 54.3              | 6917            | 51.8             | 7272            | 51.8             |
| Married, arrangement unspecified| 0                  | 0.0               | 10              | 0.1              | 10              | 0.1              |
| Education                       |                    |                   |                 |                 |                 |                 |
| None                            | 457                | 73.0              | 12,016          | 90.0             | 12,515          | 89.2             |
| Primary                         | 120                | 19.2              | 1191            | 8.9              | 1318            | 9.4              |
| Secondary or higher             | 47                 | 7.5               | 134             | 1.0              | 181             | 1.3              |
| Missing                         | 2                  | 0.3               | 16              | 0.1              | 18              | 0.1              |
| Participates in paid labor      |                    |                   |                 |                 |                 |                 |
| No                              | 458                | 73.2              | 11,608          | 86.9             | 12,111          | 86.3             |
| Yes                             | 168                | 26.8              | 1746            | 13.1             | 1917            | 13.7             |
| Missing                         | 0                  | 0.0               | 3               | 0.0              | 4               | 0.0              |
| Mobility                        |                    |                   |                 |                 |                 |                 |
| Been to no place                | 241                | 38.5              | 4517            | 33.8             | 4767            | 34.0             |
| Been to some/all places but none alone | 90         | 14.4              | 2404            | 18.0             | 2498            | 17.8             |
| Been to some places alone       | 196                | 31.3              | 3870            | 29.0             | 4094            | 29.2             |
| Been to all places alone        | 97                 | 15.5              | 2532            | 19.0             | 2634            | 18.8             |
| Missing                         | 2                  | 0.3               | 34              | 0.3              | 39              | 0.3              |
| Tolerant attitudes for spousal violence |          |                   |                 |                 |                 |                 |
| Never tolerated                 | 168                | 26.8              | 3677            | 27.5             | 3853            | 27.5             |
Five women used two options concurrently: four used the injectable with another method (two with implant, one with OCP, one with rhythm/calendar method) and one used the OCP with jelly. Over three quarters of all contraceptive users (78.4%) most recently acquired their method at the PHC. The method most commonly procured outside the health sector was the OCP (19.8% of all OCP users; 52.6% of whom procured from black market vendors). The median cost of the most recent procurement was 0.81 USD (IQR 0.32, 1.61). The
least expensive method was the OCP (0.16 USD) and among the most expensive was the implant (1.21 USD).

**Regression results**

Ninety-five percent of observations (N = 13,376 complete cases) were retained in the regression analysis (Table 5). Women had more than three times the odds of using...
Table 5 Three-level mixed-effects logistic regression modeling associations between individual, household, and community level factors and women’s modern contraceptive use

| Variables                                      | n    | %    | Adjusted OR (95% CI) | p value   |
|-----------------------------------------------|------|------|----------------------|-----------|
| **Individual level**                          |      |      |                      |           |
| Age in years                                  |      |      |                      |           |
| 15–19                                         | 1839 | 13.1 | 1.0 (Ref)            | <0.0001   |
| 20–24                                         | 2377 | 16.9 | 2.37 (1.52, 3.68)    | <0.001    |
| 25–29                                         | 2746 | 19.6 | 1.89 (1.18, 3.04)    | 0.008     |
| 30–34                                         | 2447 | 17.4 | 2.29 (1.39, 3.77)    | 0.001     |
| 35–39                                         | 2998 | 14.2 | 1.97 (1.17, 3.32)    | 0.010     |
| 40–44                                         | 1499 | 10.7 | 1.31 (0.75, 2.27)    | 0.342     |
| 45–49                                         | 1126 | 8.0  | 0.80 (0.43, 1.49)    | 0.485     |
| Number of living children                     |      |      |                      |           |
| None                                          | 2376 | 17.0 | 1.0 (Ref)            |           |
| 1–2                                           | 3858 | 27.5 | 1.52 (1.05, 2.20)    | 0.028     |
| 3–4                                           | 3674 | 26.2 | 1.42 (0.95, 2.13)    | 0.084     |
| 5–6                                           | 2688 | 19.2 | 1.60 (1.04, 2.46)    | 0.031     |
| 7+                                            | 1416 | 10.1 | 2.39 (1.49, 3.83)    | <0.001    |
| Marital status                                |      |      |                      |           |
| Not currently married                         | 1341 | 9.6  | 1.0 (Ref)            |           |
| Polygynous                                     | 5409 | 38.6 | 1.61 (0.97, 2.67)    | 0.067     |
| Monogamous                                     | 7272 | 52.9 | 1.79 (1.09, 2.92)    | 0.020     |
| Education                                     |      |      |                      |           |
| None                                          | 12,515 | 89.3 | 1.0 (Ref)           |           |
| Any                                           | 1499  | 10.7 | 3.28 (2.52, 4.27)    | <0.001    |
| Participates in paid labor                    |      |      |                      |           |
| No                                            | 12,111 | 86.3 | 1.0 (Ref)           |           |
| Yes                                           | 1917  | 13.7 | 1.71 (1.35, 2.17)    | <0.0001   |
| Mobility                                      |      |      |                      |           |
| Been to no place                              | 4767 | 34.1 | 1.0 (Ref)           |           |
| Been to any place but none alone              | 2498 | 17.9 | 0.58 (0.42, 0.79)    | 0.001     |
| Been to any place alone                       | 6728 | 48.1 | 0.82 (0.64, 1.03)    | 0.093     |
| Spousal violence                              |      |      |                      |           |
| Not tolerated                                  | 3853 | 28.1 | 1.0 (Ref)           |           |
| Tolerated                                     | 9872 | 71.9 | 1.00 (0.80, 1.25)    | 0.978     |
| Decision-making                               |      |      |                      |           |
| None                                          | 10,210 | 73.0 | 1.0 (Ref)           |           |
| Any                                           | 3769  | 27.0 | 1.29 (1.04, 1.60)    | 0.019     |
| Household level                               |      |      |                      |           |
| Someone else in the household using modern contraception |      |      |                      |           |
| No                                            | 13,682 | 97.7 | 1.0 (Ref)           |           |
| Yes                                           | 324   | 2.3  | 3.04 (1.95, 4.73)    | <0.001    |
| Distance to health center^2                   |      |      |                      |           |
| < 2 km                                        | 2859 | 20.4 | 1.0 (Ref)           |           |
| 2–4.99 km                                     | 3586 | 25.6 | 0.50 (0.33, 0.75)    | 0.001     |
| 5–6.99 km                                     | 3329 | 23.7 | 0.33 (0.20, 0.53)    | <0.001    |
| 7–9.99 km                                     | 2677 | 19.1 | 0.33 (0.19, 0.55)    | <0.001    |
| ≥ 10                                          | 1581 | 11.3 | 0.70 (0.38, 1.31)    | 0.266     |
| Food insecurity                               |      |      |                      |           |
| None                                          | 11,931 | 85.1 | 1.0 (Ref)           |           |
| Any                                           | 2084  | 14.9 | 1.05 (0.78, 1.41)    | 0.745     |
modern contraception if they had any formal education (AOR 3.28; 95% CI 2.52, 4.27), and were 71% more likely to use modern contraception if they participated in any paid labor (AOR 1.71; 95% CI 1.35, 2.17). Living in the same household as another woman who used modern contraception was the strongest factor influencing modern contraceptive use after education (AOR 3.04; 95% CI 1.95, 4.73). Women were 29% more likely to use modern contraception if they exerted any, even shared, power over decision-making (AOR 1.29; 95% CI 1.04, 1.60); this was after controlling for all covariates, including women’s education and paid labor force participation. Women who reported some mobility but none independently were 42% less likely to use modern contraception compared to women who reported no mobility at all (AOR 0.58; 95% CI 0.42, 0.79). There was no evidence of an association between women’s independent mobility or tolerant attitudes for spousal violence and modern contraceptive use.

There was very strong evidence (p < 0.0001) that greater distance to a public sector health facility reduced the odds of modern contraceptive use. Compared to women who lived less than 2 km from a health center, those who lived between 2 and 5 km were 50% less likely to use modern contraception (AOR 0.50; 95% CI 0.33, 0.75); those who lived between 5 and 10 km were 67% less likely (AOR 0.33; 95% CI 0.19, 0.55); and those who lived 10 km or more were 30% less likely (AOR 0.70; 95% CI 0.38, 1.31). The strength of the evidence declined in the group farthest away, where approximately 70% were serviced by a CHW compared to 45% for those between 5 and 10 km. Controlling for distance to health center and all other covariates, there was no evidence (p = 0.2920) that having CHW services available in the community as a base or satellite site was associated with modern contraceptive use. The intracluster correlation coefficient (ICC) at the village-cluster level was 0.05 (95% CI 0.02, 0.10) and the

Table 5 (continued)

| Variables                     | n      | %     | Adjusted OR (95% CI) | p value \(^b\) |
|-------------------------------|--------|-------|----------------------|---------------|
| **Wealth quintile**           |        |       |                      |               |
| Richest                       | 2385   | 17.2  | 1.0                  | 0.4582        |
| Rich                          | 2592   | 18.7  | 1.04 (0.79, 1.37)    | 0.788         |
| Middle                        | 2689   | 19.4  | 0.91 (0.68, 1.23)    | 0.554         |
| Poor                          | 2997   | 21.6  | 0.86 (0.64, 1.18)    | 0.354         |
| Poorest                       | 3193   | 23.0  | 0.78 (0.55, 1.09)    | 0.140         |
| **Community level**           |        |       |                      |               |
| CHW services available        |        |       |                      | 0.2920        |
| None                          | 9649   | 68.8  | 1.0                  |               |
| Satellite village             | 1908   | 13.6  | 0.81 (0.48, 1.39)    | 0.452         |
| Posted village                | 2475   | 17.6  | 1.27 (0.82, 1.97)    | 0.291         |
| Health catchment area \(^c\) |        |       |                      | <0.0001       |
| Dimbal                        | 3145   | 22.4  | 1.0                  |               |
| Lessagou                      | 2195   | 15.6  | 1.90 (1.14, 3.17)    | 0.014         |
| Doundé                        | 1756   | 12.5  | 1.75 (1.00, 3.07)    | 0.051         |
| Ende                          | 728    | 5.2   | 3.28 (1.67, 6.44)    | 0.001         |
| Soubala                       | 2407   | 17.2  | 0.56 (0.30, 1.03)    | 0.063         |
| Kanibozon                     | 1448   | 10.3  | 4.05 (2.36, 6.97)    | <0.001        |
| Kouloung                      | 2353   | 16.8  | 1.86 (1.10, 3.14)    | 0.020         |

Random effects
- Village-cluster level (level three) variance (SD) 0.22 (0.09)
- Compound-within-cluster level (level two) variance (SD) 0.98 (0.29)
- Level three ICC (95% CI) 0.05 (0.02, 0.10)
- Level two ICC (95% CI) 0.27 (0.18, 0.38)
- Log likelihood −2081.39

\(^a\) N = 13,376 complete cases, or 95% of all women in the analytic sample
\(^b\) Value provided in line with the categorical variable name is the result of the likelihood ratio test
\(^c\) Village distance to health center substituted if household distance to health center was missing (N = 560)
\(^d\) Household wealth quintile in the regression models includes water, sanitation, and hygiene measures, as these are not explored separately
\(^e\) Largest health catchment area in terms of sample population is used as the reference category
family compound-within-cluster ICC was 0.27 (95% CI 0.18, 0.38).

The odds of using a modern method of contraception were greater if the woman was in a polygynous (AOR 1.61; 95% CI 0.97, 2.67) or monogamous (AOR 1.79; 95% CI 1.09, 2.92) marital arrangement than if she was not currently married. Both age (p < 0.0001) and number of living children (p = 0.0053) were also significant predictors in the model. Regression results were consistent in sensitivity analyses (results not shown).

**Discussion**

Our study in seven health catchment areas of the Bankass district in the Mopti region of Mali found a modern contraceptive prevalence below 5%. This is similar to, but even lower than the 8.7% regional average in 2018 (an increase from 2.7% in 2012–2013 [23]), despite over a third of all women in Mopti desiring family planning [2]. Another study in the Youwarou district of Mopti found 8.8% of non-pregnant, reproductive-aged women visiting PHCs used modern contraception [29]. The injectable contraceptive was the most common method used in our study population, followed by the implant, which were also the two most common in the 2018 DHS (34% and 44%, respectively) [2]. Anecdotally, there is a preference for these methods in our context due to their long-acting and discrete nature. We may have had underreporting of traditional methods, although the DHS also reports that less than 1% of all contraceptive users used traditional methods [2].

Such low modern contraceptive prevalence may be partly explained by the services available. Within a global context of shortages and inequitable distribution of human resources for health, approximately 37% of doctors, nurses, and midwives in Mali work in rural areas where three quarters of the population resides [20]. Where healthcare workers are available in Mali’s rural areas, distance, quality, and cost create barriers to basic health services [8]; contraceptive options can be limited and stock-outs frequent. Yet, despite chronically poor service availability and accessibility across our entire study area, some women—and even some pairings of women within single households—used modern contraception. Distilling individual, household, community, and health system level factors associated with contraceptive use in this context helps to inform the design of strategies to reduce unmet need for contraception where access is at its absolute worst.

We found that women who played any role in decision-making, who had any formal education, and participated in any paid labor, were more likely to use modern contraception. In addition, a greater percentage of households that had at least one modern contraceptive user included any reproductive-aged woman in decision-making, compared to households that had no users (37% versus 29%). We found unexpected results related to women’s mobility, where women with some mobility were less likely to use modern contraception than those who had none. Our findings on the association between women’s education and contraceptive use are consistent with other studies from sub-Saharan Africa [10–12, 17]. The evidence base for the role of women’s empowerment, as measured by decision-making and mobility, on contraceptive use is mixed and dominated by research conducted in South Asia [17, 18, 26, 30]. Our results suggest that having any involvement in decision-making related to healthcare, visiting relatives, or household purchasing more adequately captured women’s capabilities to make strategic choices related to contraceptive use in this context than having freedom of movement to the marketplace, health center, women’s group, or outside the village. It may be that having ever been or been alone to these places does not reflect a woman’s physical autonomy in this context, but rather their availability or distribution. Alternatively, it may be that having recently (rather than ever) been to these places—as mobility is so dependent on age or phase of life [30]—would be a more appropriate predictor of current contraceptive use.

Living in the same household as another woman who used modern contraception was strongly associated with an individual’s uptake in our study. Our findings contribute to the broader healthcare utilization literature on the importance of engaging social networks including in Mali [31, 32], by illustrating the power of intimate intra-household female relations—among cowives, and among mothers and their daughters—in influencing contraceptive use. One woman’s ‘functioning achievement’ [9] in accessing modern contraception that she desires may transform the intrahousehold context in which another woman makes a strategic life choice to use. These findings, taken together with education, paid labor, and decision-making, suggest that utilizing contraceptive services in this poor access, low use context may have required considerable assertiveness on the part of women. Strategies to expand women’s ability to make contraceptive choices might engage direct axes of empowerment, sources of empowerment, and the settings for empowerment [33]—decision-making, education and paid labor, and intrahousehold female relations, in this context.

Health systems must be designed to meet women most of the way. Distance to nearest public sector health facility, where 85% of contraceptive users procured their method, was a strong predictor of modern contraceptive use. Compared to women closest to a health center, those who lived between 2 and 5 km were half as likely to use modern contraception, and those between 5 and
10 km were a third as likely. A growing body of literature suggests that even relatively short distances from health facilities are associated with adverse health outcomes [34]; however, the 5 km cut-off continues to dominate research, policy, and practice [7]. Although CHWs offered family planning counseling and services in some villages 5 km or more from a PHC at the time of the survey, only condoms and the OCP were offered and women were referred to the more distant health centers for other methods. CHW capabilities to deliver a range of specific health interventions and contribute to health outcomes, including contraceptive use, is well established [35]—when CHW programmes are appropriately designed and implemented, and supported by health system enablers [36]. In our study setting, CHWs services were accessible only to patients who initiated their own care-seeking from the fixed community health post, and who paid a fee for service—a practice known to hinder utilization across settings and interventions. Our findings suggest that this conventional approach to CHW service delivery is insufficient to increase contraceptive use. Home visits by CHWs have shown particular promise as an alternative approach to community-based contraceptive service delivery [37, 38].

Finally, variation in modern contraceptive prevalence and methods between PHC catchment areas and the parameter estimates for PHC catchment areas in the regression model suggest that the availability and quality of contraceptive services differed in important ways between the seven neighboring PHCs in the Bankass district. The intracluster correlation coefficients (ICC) in the multilevel model indicated that the local village-cluster environment and the family compound environment within a given village-cluster played a role in contraceptive use in addition to the individual, household, and health catchment area fixed effects. We note that the two catchment areas with the highest prevalence of modern contraceptive use were the smallest in terms of population and tended to be wealthier, and anecdotally, are better connected to societal resources through tourism.

Our study was subject to some important limitations. First, we were unable to measure unmet need for contraception and thus analyzed use among all women of reproductive age. We were unable to exclude women intending to become pregnant at the time of the survey, as respondents did not report this data. Furthermore, while we used the current WHO definition of a modern contraceptive method, we note that women may not encounter the same barriers to using fertility awareness based methods, such as LAM and the standard days methods, as they do for methods procured at a health facility e.g., distance. Given the small number of users in the sample population, we were unable to perform subgroup analyses on users of specific methods or method types. We did not have geolocation data for contraceptive procurement sites other than the PHCs and district referral hospital, and were therefore unable to measure distance to these other locations. Although we assessed relative poverty on contraceptive use, wealth quintiles may be less meaningful in a context where absolute poverty is so widespread. Over three quarters (77.4%) of our sample fell in the poorest wealth quintile relative to a nationally representative sample, and only 5.5% were in Mali’s top two quintiles [2]. Furthermore, small holder wealth in a context like West Africa is difficult to measure as it is accumulated through shifting and diversifying sources (e.g., productive assets, land, labor, remittances, social networks, etc.). Due to seasonality and social desirability bias, we may have underestimated the prevalence of food insecurity. Finally, although we consider the inclusion of empowerment measures a strength of our study on contraceptive use in sub-Saharan Africa, we acknowledge that these measures are “simple windows into complex realities” and thus inherently limited [9]. However, it is likely that our measure of decision-making would underestimate the actual agency women exercise over resources and choice, which may also be exerted through informal or subtle negotiation.

Our multilevel modeling technique allowed us to appropriately model the nested structure of individuals within households within family compounds within communities, and to assess the influences of higher level factors on individual level outcomes. Although women with missing outcome data were different in some observable characteristics, the percentage of missing data was very low (0.4%) and our complete case regression analysis included 95% of women in the sample; therefore, this should not have impacted our results. Finally, by using precise geolocation data at the household and facility levels, our study was able to examine household distance to health center as a predictor of modern contraceptive use and to explore how users were grouped together at the community level. This sets our research apart from much of the multilevel research on the use of reproductive health services that relies on DHS data.

**Conclusion**

Women’s decision-making, education, and paid labor force participation, as well as living in a household nearer to a health center and with another woman who used modern contraception, were associated with use in this poor access environment. In designing and implementing strategies to expand access to contraception, policymakers and practitioners should consider these axes, sources, and settings for underlying female empowerment.
Relevant to the design of accessible and effective community health systems more broadly, our findings suggest that distance to facility is an important barrier to care even within a 5 km radius, and that care available from a fixed community health post on a fee-for-service basis is insufficient to increase utilization.

Supplementary Information
The online version contains supplementary material available at https://doi.org/10.1186/s12978-020-01061-z.

Additional File 1: Household survey instrument
Additional File 2: Supplementary tables 1 and 2

Abbreviations
AOR: Adjusted odds ratio; CHW: Community health worker; CI: Confidence interval; DHS: Demographic and Health Survey; GIS: Geographic information system; ICC: Intracluster correlation coefficient; IQR: Interquartile Range; IUD: Intrauterine device; LAM: Lactational amenorrhea method; OCP: Oral contraceptive pill; PHC: Primary Health Center; WHO: World Health Organization.

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Authors’ contributions
CW conceived of and designed this study with intellectual and scientific contributions from AJ, ET, JB, JL and KK. CW conducted the analysis, with support from ET and JL. ACT and YK provided substantial contributions to the interpretation and contextualization of results. CW wrote the manuscript, with direct input from ET, JB, JL and YK. All authors provided critical intellectual feedback on manuscript drafts. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets generated and/or analysed during the current study are not yet publicly available due to the ongoing nature of the cluster-randomized controlled trial, but are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
The larger cluster-randomized control trial (NCT026940550) received ethical approval from the Ethics Committee of the Faculty of Medicine, Pharmacy and Odonto-Stomatology at the University of Sciences Techniques and Technologies of Bamako (Ref: 2016/03/CE/FMPOS). Secondary analysis of trial data was approved by the Observational/Interventions Research Ethics Committee at the London School of Hygiene & Tropical Medicine (Ref: 13832), and was excepted by the University of California, San Francisco (Ref: 154824).

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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