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Factors influencing pregnancy care and institutional delivery in rural Mali: a secondary baseline analysis of a cluster-randomised trial

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ABSTRACT

Objective The vast majority of the 300 000 pregnancy-related deaths every year occur in South Asia and sub-Saharan Africa. Increased access to quality antepartum and intrapartum care can reduce pregnancy-related morbidity and mortality worldwide. We used a population-based cross-sectional cohort design to: (1) examine the sociodemographic risk factors and structural barriers associated with pregnancy care-seeking and institutional delivery, and (2) investigate the influence of residential distance to the nearest primary health facility in a rural population in Mali.

Methods A baseline household survey of Malian women aged 15–49 years was conducted between December 2016 and January 2017, and those who delivereda baby in the 5 years preceding the survey were included. This study leverages the baseline survey data from a cluster-randomised controlled trial to conduct a secondary analysis. The outcomes were percentage of women who received any antenatal care (ANC) and institutional delivery; total number of ANC visits; four or more ANC visits; first ANC visit in the first trimester.

Results Of the 8575 women in the study, two-thirds received any ANC in their last pregnancy, one in 10 had four or more ANC visits and among those that received any ANC, about one-quarter received it in the first trimester. For every kilometre increase in distance to the nearest facility, the likelihood of the outcomes reduced by 5 percentage points (0.95; 95% CI 0.91 to 0.98) for any ANC; 4 percentage points (0.96; 95% CI 0.94 to 0.98) for an additional ANC visit; 10 percentage points (0.90; 95% CI 0.86 to 0.95) for four or more ANC visits; 6 percentage points (0.94; 95% CI 0.94 to 0.98) for first ANC in the first trimester. In addition, there was a 35 percentage points (0.65; 95% CI 0.56 to 0.76) decrease in likelihood of institutional delivery if the residence was within 6.5 km to the nearest facility, beyond which there was no association with the place of delivery. We also found evidence of increase in likelihood of receiving any ANC care and its intensity increased with having some education or owning a business.

Conclusion The findings suggest that education, occupation and distance are important determinants of pregnancy and delivery care in a rural Malian context.

Trial registration number NCT02694055.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This was a large study covering over 8500 women of reproductive age and conducted in one of the impoverished regions of rural Mali.
⇒ A key strength of the study is the objective measurement of distance using geospatial techniques.
⇒ There is a possibility of recall bias that might have affected the survey responses and there was no information on the quality of antenatal or delivery care services.

INTRODUCTION

Globally, about 2.6 million stillbirths and 300 000 pregnancy-related deaths occur annually.[1–3] Despite a global decline in the maternal mortality ratio (MMR) by 30% from 1990 to 2015, sub-Saharan Africa still experiences unacceptably high levels of MMR, at 375 per 100 000 livebirths.[4] Often, maternal deaths,[4 5] most of which happen in the first 48 hours after birth,[6] can be prevented with early identification and treatment. Increasing timely access to affordable quality care in resource-poor settings can reduce the vast majority of these deaths, vis-à-vis early identification of high-risk pregnancies and providing quality intrapartum care.[7]

Mali is one of the world's poorest nations,[8] with the majority of its population living in rural areas where availability of emergency obstetric and neonatal care is scarce.[9] In Mali, the stillbirth rate in 2019 was 20 per 1000 total births[10] and the MMR was 562 per 100 000 livebirths,[11] which are among the highest globally. Simultaneously, Mali suffers from a severe health worker shortage.[12] According to Mali's national strategy, access to care including community-based obstetric care among rural populations rests on a system of community health workers (CHW), where

one CHW covers approximately 700 people, although the actual coverage could be much higher.[13] An analysis of Malian Demographic and Health Survey (DHS) data identified lack of qualified birth attendants, transportation facilities and distance as key barriers to seeking pregnancy care.[14]

This study leverages the baseline survey data from a cluster-randomised controlled trial (CRCT) conducted in rural Mali to examine the efficacy of door-to-door proactive case detection by CHWs to reduce under-five mortality and increase utilisation for a host of primary care services including pregnancy.[15] Focusing specifically on the barriers to care that women in such a low-access environment face, our secondary analysis of the baseline data aimed to: (1) examine the sociodemographic risk factors and structural barriers associated with pregnancy care-seeking and institutional delivery, and (2) investigate the influence of residential distance to the nearest primary health facility using the survey's geolocation data. The results will contribute to the understanding of specific structural barriers including distance that affect access to pregnancy and delivery care in rural Malian populations.

METHODS

Study setting

The trial of Proactive Community Case Management to Reduce Child Mortality (ProCCM) aimed to assess the effect of complementing the conventional 'integrated community case management (iCCM) model delivered at a fixed point in the community' with 'door-to-door proactive community-based service delivery by CHWs' on utilisation of primary health services, including for reproductive and maternal health (NCT02694055).[15] The trial was based in Bankass, a rural district in central Mali about 600 km northeast of the national capital Bamako. Reproductive, maternal and child health indicators were particularly poor in this area.[16–18] The study area comprised of seven health catchment areas, each served by one public-sector primary health centre (PHC), with a centralised public-sector secondary referral hospital located outside the study area. In this region, households with extended family ties were often geographically co-located within family compounds. The survey was conducted between December 2016 and January 2017, prior to the launch of the ProCCM intervention. At that time, about 55 CHWs were covering the study area.

Study population

At baseline, 99 576 individuals in 15 839 households were enrolled across 137 village clusters. Village clusters were defined as a geographical grouping of homes at least 1 km away from the nearest grouping of homes and could comprise a single (or several) village(s) and/or hamlet(s). The baseline study population included 16 353 women of reproductive age (15–49 years) who completed a survey module on their health and sociodemographic characteristics. The survey instrument was adapted from the DHS questionnaire, included a household roster and modules on household characteristics, which was administered to the female head of household or another household representative at least 18 years of age. The survey was programmed in Open Data Kit and recorded household geographic coordinates. Eligible women of reproductive age completed modules on contraceptive use, maternal health, lifetime birth history and healthcare utilisation for all co-residing children under 5 years of age.[19] All women who delivered in the 5 years preceding the survey were included in this analysis.

The study used a population-based cross-sectional cohort design.[20] The household survey pertains to a cross-section in time. Although the exposure, outcome and covariate data were collected concurrently during the survey, they relate to events that occurred in the past (ie, retrospective). The residential distance to the nearest primary health facility was estimated separately, using the residential geocodes collected during the survey. The survey was conducted in a well-defined population-based cohort with clear inclusion and exclusion criteria, which served as the baseline for a cluster-randomised trial.[15]

Outcomes, exposures and covariates

Pregnancy care and institutional delivery-related outcomes pertained to the most recent birth. The outcomes (or dependent variables) for this analysis were derived from responses to five separate survey questions about the most recent birth.

1. Any antenatal care (ANC, yes/no)—"Did you see anyone for ANC for this pregnancy?"
2. Number of total ANC visits—"How many times did you receive ANC during this pregnancy?"
3. Four or more total ANC visits (yes/no) as was recommended by WHO in its focused ANC model. WHO revised its guidelines in 2016 and recommended eight or more ANC visits.[21] However, in our dataset 16 women (0.13%) fell into this category, which was insufficient to examine analytically.
4. First ANC visit in the first trimester (yes/no)—"How many months pregnant were you when you first received ANC for this pregnancy?"
5. Institutional delivery (yes/no)—"Where did you give birth?" and "Who assisted with the delivery?" Trained attendant was considered a doctor, nurse, midwife or a matron.

Exposures (or independent variables) represented sociodemographic risk factors and structural barriers to care, including woman's ethnicity (Dogon, Peulh, other minority), educational attainment (any formal schooling or none), occupation (housewife or business owner) and marital status (monogamous, polygamous with first wife, polygamous with second or higher order wife or not in union). We also created covariates for number of lifetime births, a dichotomous indicator

of any recent food insecurity,[22] husband's/partner's occupation and decision-making power from questions in the survey tool. As a measure of household socioeconomic status (SES), we adapted measures from the DHS and created a wealth index based on livestock and durable goods ownership data collected in the household survey, using principal component analysis. The wealth index was then converted into five wealth quintiles, which were used in the final analysis.[23] Household distance to the nearest PHC was determined using orthodromic (great-circle) distance estimates between family compound and PHC Global Positioning System coordinates.

Statistical analysis

The distributions of the key variables were explored using histograms and descriptive statistics. For outcomes that were dichotomous like any ANC care, four or more ANC visits, first ANC in the first trimester and institutional delivery, we used multivariable logistic regression model. Number of total ANC visits was in counts, hence, we used Poisson regression to model this outcome. While the dataset had a three-tier clustered structure—women within households, households within family compounds and family compounds within village/hamlet clusters—we used only two levels (women clustered within villages) because distances between family compounds within a village were relatively short. The final models were multivariable and multilevel, including a random intercept for each cluster to account for geospatial autocorrelation and to estimate appropriate SEs. To focus on distance as a structural risk factor, the associations are presented as per kilometre increase in distance from the nearest PHC. As half of the study population lived at least the median distance (5.7 km) away from the nearest primary health facility, we additionally reported the association per median distance increase to aid contextual interpretation (ie, association$^{\text{median distance}}$). We also examined non-linearities in the relationship between distance and each of the outcomes using a locally weighted scatter plot smoother in exploratory analysis. Only institutional delivery exhibited a non-linear relationship with distance. So, we fit piecewise linear splines, and examined one-knot and two-knot models by placing the knots at different distances. The number and placement of the knots were visually guided by the locally weighted scatter plot smoothing graphs to understand the inflection points. A one-knot model with a knot at 6.5 km had the lowest Akaike information criterion and Bayesian information criterion values, which were used for regression analysis. In other words, the relationship between distance and institutional delivery was different on both sides of 6.5 km.

We conducted sensitivity analyses to examine the robustness of the results by additionally adjusting the final models with the number of births, an indicator of food insecurity and husband's/partner's occupation, as well as decision-making indicators. We also examined whether results are comparable by analysing distance in categories (<2, ≥2 to <5, ≥5 to <7, ≥7 to <10, ≥10 km). Statistical significance tests were two-tailed and fixed at 5%. All analyses were conducted using Stata V.17.1.

Patient and public involvement

The study was designed and implemented in partnership with national, district and local health officials of the Malian Ministry of Health. Bankass health district was chosen in consultation with the Ministry of Health for three reasons: (1) healthcare utilisation (prenatal and curative consultations) was low and under-five mortality was high; (2) there were no overlapping interventions by other non-governmental organisations at the time or intended for the period of the trial and (3) local authorities were highly engaged and interested in collaborating on study implementation. Research questions and outcome measures were also chosen in consultation, to answer questions of key concern to government partners for informing the design of the national strategic plan for iCCM scale-up, including whether the intervention was equitable, cost-effective and affordable at scale. Community consultation and permission were sought prior to trial commencement in meetings with representatives of the village clusters, such as village chiefs and their advisories, politico-administrative authorities, religious leaders and representatives of women's and youth associations. Representatives then communicated with community members via open public meetings. Findings will be disseminated via workshops at all levels of local, regional and national representation.

RESULTS

The study cohort comprised 8575 women between 15 and 49 years who delivered in the 5 years preceding the survey (table 1). About two-third of the women were between 20 and 34 years (65%), over half were in monogamous marriage (55%) and the vast majority were of Dogon ethnicity (94%), had no formal education (93%) and were homemakers (87%). Women had low autonomy; approximately one-third of the women went to the market, to a health facility, to a women's group or to outside the village by herself. The largest number of births occurred in the hot (23%) and cold seasons (37%) (table 1).

The median residential distance to the nearest primary health facility was 5.7 km (range 0.1–12.8). Less than one-fifth (17%) of all women lived within 2 km and a little over one-quarter each lived at distances of 2–5 and 5–7 km, respectively (table 1).

Antenatal care

About two-thirds of women (63%) received any ANC in their last pregnancy. The likelihood of receiving any ANC reduced by 5 percentage points (0.95; 95% CI 0.91 to

Table 1 Descriptive statistics of the study population

Characteristics	Count	%	Characteristics	Count	%
Total study population	8575	100	Household wealth quintile		
Age (years)			Poorest	1694	19.8
15–19	343	4.0	Poor	1745	20.4
20–34	5611	65.4	Middle	1788	20.9
35–49	2621	30.6	Rich	1725	20.1
Marital status			Richest	1623	18.9
Monogamous marriage	4747	55.4	Distance to nearest primary health centre (km)		
Polygamous marriage—first wife	1796	20.9	<2	1476	17.2
Polygamous marriage—second or higher order wife	1885	22.0	2 to <5	2228	26.0
Not in union, widowed, divorced or separated	147	1.7	5 to <7	2168	25.3
Ethnicity			7 to <10	1690	19.7
Dogon	8019	93.5	10 or greater	1013	11.8
Peulh	368	4.3	Season of delivery		
Others	188	2.2	Hot (March–May)	1996	23.3
Education*			June	598	7.0
Any school (madrasah or French)	608	7.1	July	458	5.3
No formal education	7959	92.8	August	565	6.6
Occupation			September	559	6.5
Housewife	7436	86.7	October–November	1236	14.4
Small business or trader	1139	13.3	Cold (December–February)	3163	36.9
Respondent's independent mobility			Year of delivery		
Been to market alone†	3183	37.1	2012	1519	17.7
Been to a health facility alone†	2921	34.1	2013	1815	21.2
Been to a cinema alone†	2661	31.0	2014	1833	21.4
Been to outside the village alone†	2925	34.1	2015	1702	20.0
All four above†	1752	20.4	2016	1669	19.5
			2017	37	0.4

*Eight participants did not have education level reported.
†The totals for these characteristics are 4653, 4536, 3910, 4212 and 2789, respectively. The percentages are reported using the same denominator (8575) for consistency.

0.98) per kilometre increase in residential distance to the nearest facility (table 2, column 2), which is equivalent to a 26 percentage points reduced likelihood for half of the study population.

Of those who received ANC, the mean number of visits was 3 (SD=1, range 1–10). The likelihood of receiving an additional visit reduced by 4 percentage points (0.96; 95% CI 0.94 to 0.98) per kilometre increase in distance (table 2, column 4), or 21 percentage points for half of the study population. Less than 1 in 10 women had four or more ANC visits and only 16 women (0.13%) had 8 or more ANC visits. The likelihood of four or more ANC visits reduced by 10 percentage points (0.90; 95% CI 0.86 to 0.95), per kilometre increase in distance (table 2, column 6) or a 45 percentage points reduction for half of the study population.

Among those who received ANC, about 26% had their first ANC in the first 3 months of pregnancy. The likelihood of initiating ANC in the first trimester reduced by 6 percentage points (0.94; 95% CI 0.91 to 0.98) per kilometre increase in distance to the nearest facility (table 2, column 8), indicating as much as 30 percentage points reduced likelihood of initiating ANC in the first trimester for half of the study population. None of the ANC indicators showed a non-linear association with distance.

Of the other risk factors, age between 35 and 49 years reduced the likelihood of receiving four or more ANC visits, when compared with 20–34 years (table 2, column 6). Being single, widowed, divorced or separated reduced the likelihood of receiving any ANC care, and if sought, this group had fewer visits, compared with women who were married and monogamous. However, if they received

Table 2 Adjusted* associations for ANC-seeking indicators among those who delivered between 2012 and 2017, per kilometre linear increase in residential distance to the nearest primary health facility in rural Mali

	Any ANC (yes vs no)		Number of total antenatal visits (count)		Four or more total antenatal visits (yes vs no)		First antenatal visit in the first trimester (yes vs no)	
	Yes=5414	63.2%	Mean=3, SD=1§		Yes=750	8.75%	Yes=2202	25.7%†
Characteristics	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**	**OR (95% CI)**	**P value**
Distance (per kilometre)‡	**0.95 (0.91 to 0.98)**	**<0.01**	**0.96 (0.94 to 0.98)**	**<0.01**	**0.90 (0.86 to 0.95)**	**<0.01**	**0.94 (0.91 to 0.98)**	**<0.01**
Age (years)								
20–34	1.00		1.00		1.00		1.00	
15–19	1.09 (0.84 to 1.41)	0.54	0.98 (0.89 to 1.08)	0.66	0.81 (0.54 to 1.22)	0.32	0.86 (0.60 to 1.23)	0.40
35–49	0.96 (0.86 to 1.08)	0.49	1.00 (0.95 to 1.05)	0.97	**0.81 (0.66 to 0.98)**	**0.03**	1.01 (0.91 to 1.14)	0.80
Married and monogamous	1.00		1.00		1.00		1.00	
Polygamous with first wife	1.09 (0.92 to 1.31)	0.32	1.04 (0.98 to 1.10)	0.25	1.16 (0.95 to 1.41)	0.14	1.07 (0.93 to 1.23)	0.32
Polygamous with second or higher order wife	1.02 (0.89 to 1.16)	0.81	1.02 (0.96 to 1.08)	0.48	1.18 (0.99 to 1.42)	0.07	1.05 (0.89 to 1.23)	0.58
Single, widowed, divorced or separated	**0.49 (0.30 to 0.80)**	**<0.01**	**0.76 (0.60 to 0.96)**	**0.02**	0.57 (0.25 to 1.30)	0.19	**1.63 (1.09 to 2.43)**	**0.02**
Ethnicity								
Dogon	1.00		1.00		1.00		1.00	
Peulh	**0.44 (0.33 to 0.59)**	**<0.01**	**0.79 (0.68 to 0.93)**	**<0.01**	1.25 (0.86 to 1.82)	0.24	**1.56 (1.14 to 2.13)**	**<0.01**
Others	1.13 (0.66 to 1.94)	0.65	1.02 (0.86 to 1.20)	0.86	1.16 (0.70 to 1.93)	0.56	0.91 (0.65 to 1.28)	0.60
No formal education	1.00		1.00		1.00		1.00	
Education any school (madrasah or French)	**1.95 (1.48 to 2.57)**	**<0.01**	**1.21 (1.12 to 1.31)**	**<0.01**	**1.39 (1.10 to 1.76)**	**<0.01**	**1.46 (1.23 to 1.74)**	**<0.01**
Occupation								
Housewife	1.00		1.00		1.00		1.00	
Small business or trader	**1.34 (1.12 to 1.61)**	**<0.01**	**1.12 (1.05 to 1.19)**	**<0.01**	**1.41 (1.14 to 1.75)**	**<0.01**	0.95 (0.77 to 1.16)	0.59
Socioeconomic status								
Poorest	1.00		1.00		1.00		1.00	
Poor	0.99 (0.81 to 1.21)	0.95	1.04 (0.97 to 1.12)	0.25	**1.41 (1.08 to 1.84)**	**0.01**	1.04 (0.86 to 1.25)	0.72
Middle	0.99 (0.81 to 1.22)	0.94	1.05 (0.98 to 1.13)	0.16	1.26 (0.99 to 1.620	0.07	0.88 (0.75 to 1.05)	0.15
Rich	0.96 (0.79 to 1.16)	0.66	1.03 (0.96 to 1.11)	0.42	1.23 (0.93 to 1.63)	0.15	0.98 (0.82 to 1.17)	0.79
Richest	1.16 (0.89 to 1.53)	0.27	**1.11 (1.01 to 1.21)**	**0.03**	**1.43 (1.12 to 1.85)**	**<0.01**	0.98 (0.80 to 1.21)	0.86
Season								
Hot (March–May)	1.00		1.00		1.00		1.00	

Continued

Table 2 Continued

Characteristics	Any ANC (yes vs no)		Number of total antenatal visits (count)		Four or more total antenatal visits (yes vs no)		First antenatal visit in the first trimester (yes vs no)	
	Yes=5414	63.2%	Mean=3, SD=1§		Yes=750	8.75%	Yes=2202	25.7%†
	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P value
June	**1.20 (1.01 to 1.42)**	**0.04**	1.06 (0.99 to 1.13)	0.09	0.90 (0.65 to 1.25)	0.52	1.16 (0.92 to 1.46)	0.21
July	1.02 (0.80 to 1.30)	0.87	0.98 (0.91 to 1.05)	0.55	0.88 (0.63 to 1.21)	0.42	0.95 (0.73 to 1.24)	0.71
August	0.99 (0.81 to 1.23)	0.96	0.95 (0.88 to 1.03)	0.19	**0.71 (0.50 to 1.01)**	**0.06**	0.87 (0.69 to 1.09)	0.24
September	1.08 (0.87 to 1.34)	0.48	0.98 (0.90 to 1.06)	0.64	0.74 (0.53 to 1.03)	0.08	0.95 (0.72 to 1.25)	0.73
October–November	1.02 (0.87 to 1.20)	0.81	1.00 (0.94 to 1.06)	0.95	0.90 (0.73 to 1.11)	0.33	0.99 (0.81 to 1.21)	0.89
Cold (December–February)	**0.86 (0.76 to 0.98)**	**0.03**	**0.93 (0.88 to 0.98)**	**<0.01**	**0.74 (0.59 to 0.92)**	**<0.01**	0.94 (0.79 to 1.12)	0.48
Birth year								
2012	1.00		1.00		1.00		1.00	
2013	0.95 (0.82 to 1.09)	0.47	0.98 (0.93 to 1.04)	0.58	0.86 (0.67 to 1.09)	0.21	1.06 (0.89 to 1.26)	0.51
2014	0.96 (0.82 to 1.11)	0.55	0.96 (0.91 to 1.03)	0.26	0.78 (0.58 to 1.04)	0.09	**1.20 (1.02 to 1.42)**	**0.03**
2015	1.05 (0.88 to 1.24)	0.61	1.03 (0.96 to 1.09)	0.42	1.05 (0.83 to 1.35)	0.67	1.19 (1.00 to 1.42)	0.05
2016	0.98 (0.84 to 1.13)	0.74	0.98 (0.92 to 1.03)	0.40	0.82 (0.64 to 1.03)	0.09	1.16 (0.98 to 1.38)	0.09
2017	1.00 (0.51 to 1.96)	1.00	1.01 (0.78 to 1.30)	0.95	0.73 (0.13 to 4.15)	0.72	1.46 (0.40 to 5.35)	0.57

Association shown in bold is statistically significant and the confidence interval exclude 1.
*Adjusted for year of delivery, season of delivery, maternal age, marital status, ethnicity, maternal education, maternal occupation, wealth index and clustering of women in villages.
†41% of those who received any ANC (ie, denominator of 5373) and 26% if the denominator is all women in the study population (ie, with or without ANC).
‡In the main text of the results, we reported the ORs after transforming them to the median distance (5.7 km) increase, as half of the study population lived beyond that distance. Those are in addition to the per kilometre increase.
§SD refers to standard deviation of the mean.
ANC, antenatal care.

ANC, their first visit was more likely to be in the first trimester (table 2, column 8). Results for Peulh ethnic women mirrored those in the single, widowed, divorced or separated groups. Women with some education had between 21% and 46% increased likelihood of receiving ANC care, compared with those with no formal education (table 2, columns 2-8). Small business owners had between 12% and 41% of increased likelihood of receiving ANC, compared with those whose primary occupation was homemaker (table 2, columns 2-6). Likewise, women from households in the richest wealth quintile were 11%–43% more likely to seek ANC compared with those in the poorest quintile. There was no consistent relation between the season of birth and ANC-seeking behaviour. However, women who gave birth between December and February were less likely to seek ANC (table 2, columns 2-6). The distribution of the outcome variables by categories of the explanatory variables are presented in online supplemental table 1.

Institutional delivery

In the study population, 61% delivered at home and 39% delivered in a facility. Of those who delivered at home, 93% were assisted by someone other than a doctor, nurse, midwife, CHW or a matron (also known as an auxiliary midwife), while 94% of the institutional deliveries had a skilled attendant. Unlike the ANC indicators, we found an inverse association between distance and place of delivery up to 6.5 km, beyond which there was no statistically significant association (figure 1). Among women who resided within 6.5 km of a facility, 49% had institutional delivery, while among those who lived beyond 6.5 km, 23% had institutional delivery (table 3). Furthermore, among those who resided within 6.5 km of a facility, the likelihood of an institutional delivery was reduced by 35 percentage points (0.65; 95% CI 0.56 to 0.76) per kilometre increase in distance. In comparison, if the residence was beyond 6.5 km, there was no significant association between distance and institutional delivery (OR 1.04, 95% CI 0.93 to 1.16). In sensitivity analyses, exclusion of matrons from skilled attendants marginally altered these associations to 41 percentage points (95% CI 0.30 to 0.50) and 1.07 (95% CI 0.90 to 1.26), respectively (data not shown). To compare our results with studies that examined distance as a linear predictor, we note that in our study population the likelihood of an institutional delivery was reduced by 22 percentage points (95% CI 14 to 29) per kilometre increase in distance. Additionally, we presented the results in categories of distance in online supplemental table 2.

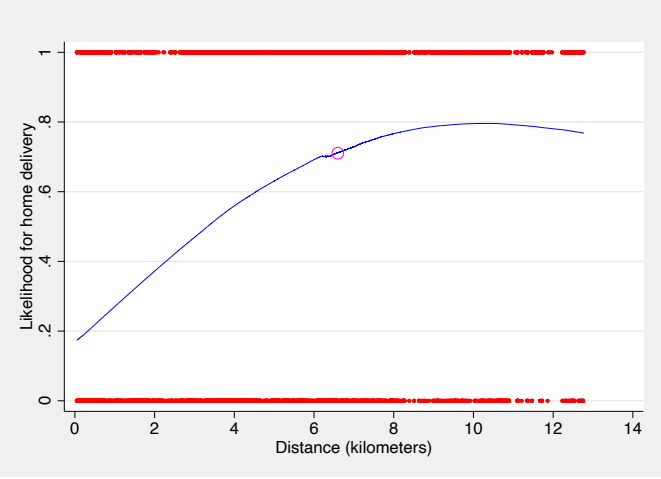

Figure 1 Locally weighted scatter plot smoother graph demonstrating non-linear relationship between place of delivery and distance to the nearest primary care facility. The position of the single knot for the piecewise linear spline model is shown by the hollow circle on the plot. The red dots represent two groups, those who delivered in a facility and those who delivered at home.

Women aged 15–19 years, with some education and small business owners had an increased likelihood, whereas those who were single, widowed, divorced or separated had a decreased likelihood of institutional delivery, compared with their respective reference groups (table 3). Sensitivity analyses demonstrated that additional adjustment of the final models with the number of births, food insecurity indicators, husband's/partner's occupation as well as decision-making indicators neither changed the associations with proximity nor were they individually associated with the outcomes of interest (data not reported).

DISCUSSION

This secondary analysis examined a range of sociodemographic factors as well as structural barriers with respect to pregnancy care and institutional delivery in rural Mali, a setting with high maternal morbidity and mortality. Using several metrics to assess pregnancy care including any ANC visit, number of total ANC visits, four or more ANC visits and timing of the first ANC visit, we found consistent evidence that the likelihood of receiving any care and its intensity increases with having some education, owning a business and decreases with increasing distance to the nearest facility. Results also show that while about two-thirds of all women who delivered in the 5 years preceding the survey, received any ANC for their last pregnancy, <1 in 10 had four or more ANC visits, just 1 in 1000 had 8 ANC visits, as currently recommended by WHO.[21] Sporadic associations were also observed between some categories of maternal age, marital status and ethnicity with a few of the outcomes.

SES and accessibility to healthcare services are among some of the key factors that influence pregnancy care. Our findings related to various measures of SES including woman's occupation are consistent with other studies from the region.[24 25] The occupation-specific results suggest that having an income may give a woman a voice in making a choice and decision about pregnancy care. However, we recognise that it is a complex dynamic, driven by many factors like social and gender norms, family structure and intrahousehold decision-making, among others. Findings related to proximity to a health

Table 3 Adjusted* associations of place of delivery with residential distance to the nearest primary health facility, among those who delivered between 2012 and 2017 in rural Mali

Institutional delivery (yes vs no)*†	OR (95% CI)	P value
Residence within 6.5 km of a facility‡	**0.65 (0.56 to 0.76)**	**<0.01**
Residence beyond 6.5 km of a facility‡	1.04 (0.93 to 1.16)	0.47
Age (years)		
20–34	1.00	
15–19	**1.39 (1.04 to 1.87)**	**0.03**
35–49	0.92 (0.81 to 1.05)	0.21
Married and monogamous	1.00	
Polygamous with first wife	1.03 (0.87 to 1.23)	0.71
Polygamous with second or higher order wife	0.98 (0.82 to 1.16)	0.80
Single, widowed, divorced or separated	**0.58 (0.36 to 0.95)**	**0.03**
Ethnicity		
Dogon	1.00	
Peulh	0.71 (0.46 to 1.09)	0.12
Others	0.85 (0.50 to 1.47)	0.57
No formal education	1.00	
Education any school (madrasah or French)	**1.43 (1.15 to 1.77)**	**<0.01**
Occupation		
Housewife	1.00	
Small business or trader	**1.37 (1.12 to 1.68)**	**<0.01**
Socioeconomic status		
Poorest	1.00	
Poor	0.95 (0.76 to 1.17)	0.61
Middle	1.06 (0.84 to 1.33)	0.63
Rich	1.01 (0.82 to 1.24)	0.94
Richest	1.03 (0.82 to 1.29)	0.79
Season		
Hot (March–May)	1.00	
June	1.25 (0.99 to 1.57)	0.06
July	1.46 (1.12 to 1.90)	0.01
August	1.09 (0.91 to 1.30)	0.37
September	1.04 (0.82 to 1.30)	0.76
October–November	1.11 (0.94 to 1.32)	0.21
Cold (December–February)	1.12 (0.95 to 1.32)	0.18
Birth year		
2012	1.00	
2013	1.00 (0.85 to 1.19)	0.96
2014	1.11 (0.93 to 1.33)	0.25
2015	1.11 (0.93 to 1.33)	0.24
2016	1.17 (0.99 to 1.39)	0.07
2017	0.60 (0.18 to 2.02)	0.41

Continued

Table 3 Continued

Institutional delivery (yes vs no)*†	OR (95% CI)	P value

Association shown in bold is statistically significant and the confidence interval exclude 1.
*Non-linear relationship modelled using one-knot linear spline with a knot at 6.5 km. The OR is for facility delivery with trained attendant compared with home birth with untrained attendant as the reference group.
†Adjusted for year of delivery, season of delivery, maternal age, marital status, ethnicity, maternal education, maternal occupation, wealth index and clustering of women in villages.
‡Percentage of facility deliveries out of all deliveries is 38.7 (=3062/7922). In the two distance categories <6.5 km and ≥6.5 km these percentages are 49.3 and 22.7, respectively.

facility and ANC are also consistent with other studies. Analysis of Ethiopian DHS data showed a reduced likelihood of four or more ANC per kilometre increase in distance.[26] A Malawian study reported a decrease in at least three ANC visits, per kilometre increase in distance[27] and similar associations between distance and ANC were also reported from Zambia.[28] Differences in the magnitude of the associations between previous studies and this study could be due to several reasons including different analytical approaches, outcome definitions, characteristics of the local population and study settings. Most importantly, several studies were based on sampled data, while this study is population-based. Measurement error in assessing distance is equally important because even non-differential misclassification may lead to bias towards null.[29] For example, the Malawian study acknowledged measurement error in assessing distance[27] and we know that DHS geolocations are randomly displaced to protect the confidentiality of participants.[30] Misclassification error is likely to be minimal in this study because every family compound and the closest health facility were precisely geolocated. Findings from this study reaffirms that distance is an important determinant of pregnancy care and even within the African context there lies heterogeneity where local factors and settings likely interplay.

We found about two-fifths of deliveries were in an institution and residential distance to the nearest facility showed a threshold relationship with institutional delivery. When the distance was within 6.5 km, the likelihood of an institutional delivery decreased with increasing distance. As transportation options in this study setting are limited, it appears that when a facility is within a walkable distance, an increase in distance considerably decreased the likelihood of an institutional delivery. If the nearest facility is beyond walkable distance and an alternative mode of transportation is imperative, availability and affordability of an alternative mode are seemingly more decisive factors. Note, our determination of 6.5 km was data-driven and indicative rather than absolute. It alludes to the broader point that distance is an important factor, but it should be viewed along with the general perception of distance to the nearest facility and the other available alternatives of transportation. The relationship between distance and institutional delivery in this study was similar to a study from Ghana that reported 44 percentage points reduction in odds of institutional birth per kilometre increase in distance.[31] Our results are consistent with a meta-analysis of 15 studies that reported increased odds (pooled OR 2.3) of institutional birth if a facility is within 5 km of residence.[26] An analysis of DHS data from Malawi using births between 1980 and 1998 reported 1.2 percentage point decrease in skilled assistance at birth per kilometre increase in distance.[27] In Kenya, living within 5 km of a health facility was reported to increase the likelihood of giving birth in the presence of a skilled birth attendant compared with those who lived 6 km or beyond[32] and a dose-response relationship with distance was reported.[33] Comparable results were also reported from rural Zambia,[34] Malawi[27] and Burkina Faso.[35 36] The totality of the evidence is broadly consistent with our findings, which suggests that where walking is a predominant mode of travel and when there is a facility within 5–6 km, distance is a critical factor that influences the choice of place of delivery.

When compared with a nationally representative sample in Mali, more than three-quarters of this study population fell in the poorest wealth quintile.[17] Thus, wealth inequities between the nation and the study area are large, reflecting pervasive poverty, likely compounding the problem of access to pregnancy care. This analysis using wealth quintiles may be underestimating the effects of poverty and wealth, because a large proportion of the study population falls into the nation's poorest wealth quintile. In other words, even those classified in the more 'wealthy' quintiles in Bankass would be classified as relatively poor nationally. However, the reported associations were adjusted using several indicators of wealth and SES. To the extent that these indicators capture the SES of the study population, our results may be independent of SES. Additionally, the results were also robust to adjustment for parity, food insecurity, husband's/partner's occupation and decision-making power, suggesting these characteristics may not explain the observed associations.

The results should be considered in light of the strengths and limitations of the study. This is a population-based cross-sectional cohort,[20] thus reducing the possibility of selection bias, and potentially increasing generalisability of the results to comparable impoverished populations and settings. A key strength of our study is that distance was objectively assessed using geospatial techniques. Each family compound in the study area was mapped and geolocated. Moreover, the distance to the nearest primary care facility was assessed independent of the outcomes, reducing the possibility of differential

exposure misclassification, if any. In other words, misclassification in the distance metric will have to differentially affect any one group (eg, institutional deliveries only), relative to others, for the results to be systematically biased. We have a relatively large study population increasing power to detect relatively small associations. Our data are based on a comprehensive survey, enabling examination of a range of covariates. The study has some limitations, key among which is the availability of the data at only one time point. Despite one time point, temporality of the examined relationships, especially distance should not pose a threat, which is unlikely to change over a short period of time. Inaccurate recall of the number of ANC visits or when the first ANC occurred is a real possibility. Furthermore, the possibility of recall bias is higher for deliveries where the gap between pregnancy and the survey is longer. We have no information on the quality of antenatal or delivery care services, which is as important as the number of ANC visits. Moreover, misclassification in the reporting of other predictors such as education, occupation, etc remains a possibility. Given the observational nature of the study, we cannot completely rule out residual confounding. Also, we cannot rule out chance finding, which is likely to be low given the low p values.

In conclusion, the findings of this study reinforce what has been observed in many populations that distance is an important determinant of pregnancy and delivery care in a rural population in Mali where transportation is often not readily available. In addition, financial and socioeconomic barriers also appear to play an important role in reducing access to pregnancy and delivery care in the study population. Coverage of ANC and institutional delivery is suboptimal in the study population and requires impetus to attain the Sustainable Development Goals. Interventions to increase accessibility will benefit these populations to identify high-risk pregnancies and minimise adverse maternal and child health outcomes.

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