Distance, difference in altitude and socioeconomic determinants of utilisation of maternal and child health services in Ethiopia: a geographic and multilevel modelling analysis

Atkure Defar, Yemisrach B. Okwaraji, Zemene Tigabu, Lars Åke Persson, Kassahun Alemu

ABSTRACT

Objective We assessed whether geographic distance and difference in altitude between home to health facility and household socioeconomic status were associated with utilisation of maternal and child health services in rural Ethiopia.

Design Household and health facility surveys were conducted from December 2018 to February 2019.

Setting Forty-six districts in the Ethiopian regions: Amhara, Oromia, Tigray and Southern Nations, Nationalities, and Peoples.

Participants A total of 11 877 women aged 13–49 years and 5786 children aged 2–59 months were included.

Outcome measures The outcomes were four or more antenatal care visits, facility delivery, full child immunisation and utilisation of health services for sick children. A multilevel analysis was carried out with adjustments for potential confounding factors.

Results Overall, 39% (95% CI: 35 to 42) women had attended four or more antenatal care visits, and 55% (95% CI: 51 to 58) women delivered at health facilities. One in three (36%, 95% CI: 33 to 39) of children had received full immunisations and 35% (95% CI: 31 to 39) of sick children used health services. A long distance (adjusted OR = 0.57, 95% CI: 0.34 to 0.96) and larger difference in altitude (AOR = 0.34, 95% CI: 0.19 to 0.59) were associated with fewer facility deliveries. Larger difference in altitude was associated with a lower proportion of antenatal care visits (AOR = 0.46, 95% CI: 0.29 to 0.74). A higher wealth index was associated with a higher proportion of antenatal care visits (AOR = 1.67, 95% CI: 1.02 to 2.75) and health facility deliveries (AOR = 2.11, 95% CI: 2.11 to 6.48). There was no association between distance, difference in altitude or wealth index and children being fully immunised or seeking care when they were sick.

Conclusion Achieving universal access to maternal and child health services will require not only strategies to increase coverage but also targeted efforts to address the geographic and socioeconomic differentials in care utilisation, especially for maternal health.

Trial registration number ISRCTN12040912.

INTRODUCTION

The global goal of universal health coverage is a significant challenge since half of the world’s population does not have access to essential health services. The Sustainable Development Goals stress the need for accelerating the ambitions to reach the targets for improving maternal, newborn and child health. The WHO, with its partners, has developed policies and programmes aiming to promote health equity across and within nations. Utilisation of maternal, newborn and child health services has increased. However, inequities by geographic location and socioeconomic status are challenges in the efforts towards universal health coverage.
Studies from low-income African countries have indicated a strong association between geographic accessibility to health facilities and the use of maternal and child health services. In Ethiopia, reports have described geographical inequality. Distance measured as a straight line and walking time was associated with attendance to antenatal care and facility delivery. The topography of Ethiopia, characterised by difficult steep terrain with high hills, valleys and long distances from home to health facilities, has contributed to inequalities in the use of maternal and child health services. In addition, studies in Ethiopia and other African countries have shown that distance to health facilities was negatively associated with the use of family planning, antenatal care, facility deliveries and care seeking for sick children.

To the best of our knowledge, no previous studies have simultaneously analysed the difference in altitude, the distance between household and health facility as well as socioeconomic characteristics and their possible association with utilisation of a range of maternal and child health services in Ethiopia. Therefore, this study aimed to analyse if the geographic distance from home to the nearest health facility, the difference in altitude between home and health facility and socioeconomic status were associated with the use of antenatal care, facility delivery, full child immunisation and utilisation of primary care services for sick children in rural Ethiopia.

**METHODS**

**Study design and setting**

We conducted a cross-sectional study in 46 districts of the four most populous Ethiopian regions, namely, Amhara, Oromia, Tigray, and Southern Nations, Nationalities, and Peoples (figure 1). The regions have a population scattered in dispersed settlements, and the primary source of income is farming.

In the Ethiopian health delivery system, the primary healthcare unit is comprised of five satellite health posts and one health centre. Each health post serves approximately 5000 people and is staffed by two female health extension workers.

The study was conducted from December 2018 to February 2019. The Ethiopian Public Health Institute, in collaboration with the London School of Hygiene and Tropical Medicine, University of Gondar, Mekelle University, Jimma University and Hawassa University, conducted the survey.

**Sampling**

This study used data from an evaluation of the Optimizing of Health Extension Program intervention that was implemented in four regions of Ethiopia. This intervention aimed to improve care utilisation for sick under 5 children. The evaluation included baseline and endline surveys, and this study was a secondary analysis of end-line data.

A two-stage stratified cluster sampling was applied in the selected study districts. The first stage used lists of enumeration areas from the 2007 Ethiopian Housing and Population Census as the sampling frame. Thereafter, 194 enumeration areas were selected with probability proportional to size (sampling from a finite population in which a size measure is available for each population unit before sampling and where the probability of selecting a unit is proportional to its size).

In the second stage, all households within each enumeration area were listed and a sampling interval was calculated. A random start number between 1 and the sampling interval was selected. The households that matched the random start number on the list were chosen as the first household to be included. This process was repeated until the targeted number of 60 households in each cluster was reached. All women aged 13–49 years and children under the age of 5 years, who lived in the selected households, were included in the study. The health posts and the health centres serving the enumeration area were included in the study.

We used a standard sample size formula to calculate the sample size. We estimated a design effect of 1.3, 80% power and the assumption of a ratio of children less than 5 years of age per household was considered, based on sampling reported in the Ethiopia Demographic Health Survey 2011. We used the assumption to detect 15% improved childcare utilisation in two groups (intervention and comparison) between baseline and endline surveys. The sample size was estimated to be 6000 households per group (12000 in total) to have 80% power to detect differences of 15 percentage points for care seeking for 2–59 months children. The protocol for the evaluation study was registered with a trial number ISRCTN12040912 and published.
Data collection tools
We used a modular questionnaire that was based on the demographic and health survey and similar assessment tools. Information on the antenatal care attendance and place of delivery was collected from all women aged 13–49 who had a live birth in the last 12 months before the survey. Caregivers of children aged 2–59 months were asked whether the child had any illness in the previous 2 weeks and if they had sought care from an appropriate provider. Caregivers were invited to show the immunisation cards and asked additional questions on the different vaccinations if the card was not available. Besides, the questionnaire included information on sociodemographic data, assets and geographic coordinates of households and health facilities. The coordinates were measured by geographical positioning system (GPS) dongles (ND-100S).

Definition of variables
Outcome variables
We estimated the overall coverage of four selected maternal and child health services. For women, this included (1) the proportion of women aged 13–49 with a live birth within the last 12 months before the survey who had attended antenatal care four or more times and (2) the proportion of women with a live birth within 12 months before the survey who gave birth in a health facility. For the child health services utilisation, we included: (1) the proportion of children aged 12–23 months who had received full immunisation, which was defined as BCG, three pentavalent vaccinations (diphtheria, tetanus, pertussis, hepatitis B and Haemophilus influenzae), oral polio vaccine and one dose of measles vaccine, and (2) the proportion of children aged 2–59 months with fever, diarrhoea or suspected pneumonia (cough and difficult or fast breathing) in the last 2 weeks for whom care was sought from an appropriate provider, that is, health posts, health centres, hospitals or private clinics.

Explanatory variables
We used the Euclidian distance and the difference in altitude from the participants’ houses to the nearest health facility and household wealth as explanatory variables. Furthermore, we included other sociodemographic variables such as age, sex, parity, region, caregiver’s education level and number of children in the household to adjust for potential confounding in the analyses.

Data management and analysis
Household data on care utilisation were linked with the GPS information of the 142 health centres and 164 health posts that served the households. The linking was done using cluster identification. The Euclidian distance from participants’ houses to the nearest health facility was calculated using the geographical location of health facilities and households. Thus, we calculated the distance to the nearest health post for child health services (full child immunisation and sick child healthcare utilisation) and distance to the nearest health centre for maternal health-care services (antenatal care and facility delivery). These distances were divided into tertiles and labelled as short, medium and long. Similarly, the difference in altitude was estimated using the altitude information of both the households and the health facility and classified as small, medium and large. Corrections of the GPS readings were done whenever the reading erroneously was positioned outside the study areas. If that was the case, we adjusted by considering the nearest GPS reading captured. To estimate household wealth, we constructed wealth index using 15 household assets and characteristics. We used principal component analysis to construct the wealth index and divided it into tertiles.

We first analysed the prevalence of the outcomes variables and graphically displayed the relation between distance, the difference in altitude, household wealth and facility visits for antenatal care, facility delivery, child immunisation and sick child services utilisation. After that, we used two-level mixed-effect logistic regression modelling to examine the associations with individual-level variables (wealth, number of children in the household, sex, age, parity and educational status), group-level variables (region, distance and the difference in altitude) and the interactions between the two. We analysed the crude and adjusted ORs with 95% CIs. As individual observations were grouped within the cluster specifically by geography (region, distance to the health facility and their altitude), the regression models we used accounted for confounding and clustering effects. Considering both the distance as well as the difference in altitude would yield a good estimate of the extent of space between the health facilities and the households. The model quality was assessed using Akaike’s information criterion and intraclass correlation coefficient. The significance level was set at a p value of less than 5%. All analyses were done using STATA V.15 (Stata Corporation, College Station, Texas).

RESULTS
Characteristics of the study participants
Out of 11,877 women aged 13–49, 957 had given birth during 12 months before the survey. Of these, we linked 766 women (80%) with the geographic location data of the 142 nearest health centres, since antenatal and delivery services were provided at the health centre level or above (table 1). We collected information on 5786 children from 2 to 59 months of age. Of these, we linked data on 5285 (91%) children with the geographic location of 164 nearest health posts. We estimated the Euclidian distance (median: 9.7, IQR: 5.2–14.4 km) and the difference in
altitude (median: 54, IQR: 24–1312 m from the participants' houses to the nearest health facility.

**Utilisation of maternal health services**

Of the 766 mothers who had given birth in the previous 12 months before the survey, 39% (95% CI: 35 to 42) had attended antenatal care four or more times. The proportion of women who had delivered at a health facility was 55% (95% CI: 51 to 58). There was an inverse relationship between distance, the difference in attitude and antenatal care or facility delivery (figure 2). There was an increased proportion of prenatal visits and the percentage of facility deliveries with an increasing wealth index.

**Utilisation of child health services**

Among the 912 children in the age group 12–23 months, 36% (95% CI: 33 to 39) were fully immunised. The 2-week morbidity with common childhood illnesses, that is, fever, diarrhoea or suspected pneumonia (cough with fast or difficult breathing), was assessed among 5285 children from 2 to 59 months of age. Of these, 9.4% (95% CI: 8.6 to 10.2) were found to have been sick. The proportion of children who sought care from an appropriate provider, such as health post, health centre, hospital or private clinics, was 35% (95% CI: 31 to 39). There was no clear pattern in the associations between distance, the difference in attitude, wealth index and child immunisations or utilisation of services for sick children (figure 2).

**Determinants of maternal and child health services utilisation**

The multilevel regression analysis, after adjusting for age, parity, education and region, showed that women living with higher difference in altitude were less likely to have attended antenatal care four or more times (adjusted OR (AOR)=0.46; 95% CI: 0.29 to 0.74) and to have delivered at a health facility (AOR=0.33; 95% CI: 0.19 to 0.59) (table 2). Women living at a long distance from health facilities were less likely to have delivered at health facility (AOR=0.57; 95% CI: 0.34 to 0.96). Women from the wealthier household were more likely to have received antenatal care four or more times (AOR=1.67; 95% CI: 1.02 to 2.75) and delivered at a health facility (AOR=3.70; 95% CI: 2.11 to 6.47) than their counterparts in the lower wealth tertiles (table 2).

There was no clear pattern in the associations between distance from home to health post, the difference in altitude or household wealth and child immunisation and sick childcare utilisation (table 3). There was no indication of socioeconomic inequity in coverage of immunisation or utilisation of services for the sick child. The medium distance stratum showed a lower coverage.
We have shown that long distance to the health centre, a more significant difference in altitude between home and facility and a lower socioeconomic group were all associated with a smaller proportion of women delivering at a health facility. Similarly, those living with a considerable difference in altitude and belonging to a lower socioeconomic group were less likely to have attended antenatal care four times or more. However, distance, altitude or socioeconomic status were neither associated with coverage of child immunisation nor with care seeking for sick children.

An estimated, 39% of the pregnant women in the current study had attended antenatal care four or more times. This proportion was higher than the corresponding result reported from the same study areas 2 years earlier, which showed coverage at 30%. It was a bit lower than the national average, based on the Demographic and Health Survey 2019, which was 43%. This increase could reflect the government’s efforts towards universal health coverage. In contrast to the current study, in an analysis of the 2016 Ethiopian Demographic and Health Survey, distance to the health centre was associated with four or more antenatal care visits. Furthermore, in an analysis of data from Demographic and Health Surveys in five East African counties 2010–2014 showed that geographical accessibility of health facilities had a strong influence on maternal healthcare utilisation.

### Table 2
Determinants of antenatal care four or more times and facility delivery in four regions of Ethiopia, 2019

| Characteristic | Category | Antenatal care four or more visits | | Institutional delivery | |
|---------------|----------|-----------------------------------|---|------------------------|---|
|                |          | OR (95% CI) | AOR (95% CI) | OR (95% CI) | AOR (95% CI) |
| Household and individual-level characteristics | | | | | |
| Wealth tertiles | Low | Ref. | | Ref. | 2.48 (1.54 to 4.01) | 1.61 (0.99 to 2.60) |
| | Middle | 1.40 (0.90 to 2.19) | 1.15 (0.74 to 1.81) | 1.67 (1.02 to 2.75) | 6.85 (3.87 to 12.15) |
| | Upper | 2.50 (1.55 to 4.02) | 1.57 (1.07 to 2.29) | 2.02 (1.23 to 3.30) | 5.79 (3.26 to 10.24) |
| Age | <20 | Ref. | | Ref. | 0.62 (0.34 to 1.17) | 0.72 (0.36 to 1.43) |
| | 21–25 | 1.84 (1.01 to 3.37) | 1.52 (0.80 to 2.89) | 0.81 (0.46 to 1.41) | 0.81 (0.44 to 1.47) |
| | 26–30 | 2.33 (1.29 to 4.22) | 1.74 (0.85 to 3.53) | 1.08 (0.57 to 2.06) | 1.08 (0.56 to 2.11) |
| | 31–35 | 1.99 (1.02 to 3.91) | 1.51 (0.68 to 3.40) | 1.24 (0.63 to 2.44) | 1.24 (0.62 to 2.48) |
| | 36–49 | 1.97 (0.90 to 4.28) | 1.42 (0.56 to 3.61) | 1.12 (0.47 to 2.70) | 1.12 (0.47 to 2.71) |
| Educational level | No school | Ref. | | Ref. | 1.53 (1.02 to 2.29) | 1.26 (0.81 to 1.96) |
| | Schooling | 1.12 (0.79 to 1.60) | 1.18 (0.80 to 1.74) | 1.41 (1.00 to 1.99) | 1.41 (1.00 to 1.99) |
| Parity | One | Ref. | | Ref. | 0.69 (0.34 to 1.41) | 0.94 (0.46 to 1.93) |
| | Two | 0.92 (0.51 to 1.68) | 1.01 (0.55 to 1.87) | 0.55 (0.27 to 1.11) | 0.55 (0.27 to 1.11) |
| | Three | 0.69 (0.37 to 1.30) | 0.77 (0.39 to 1.52) | 0.37 (0.18 to 0.74) | 0.37 (0.18 to 0.74) |
| | Four | 1.35 (0.74 to 2.47) | 1.44 (0.73 to 2.84) | 0.41 (0.20 to 0.84) | 0.41 (0.20 to 0.84) |
| | ≥Five | 0.96 (0.56 to 1.67) | 1.01 (0.56 to 2.15) | 0.38 (0.20 to 0.71) | 0.38 (0.20 to 0.71) |
| Group-level characteristics | Region Tigray | Ref. | | Ref. | 2.13 (0.91 to 5.02) | 1.35 (0.66 to 2.77) |
| | Amhara | 0.93 (0.49 to 1.70) | 0.75 (0.41 to 1.36) | 1.99 (0.91 to 4.39) | 1.35 (0.66 to 2.77) |
| | Oromia | 0.23 (0.13 to 0.45) | 0.22 (0.12 to 0.41) | 0.13 (0.06 to 0.28) | 0.13 (0.06 to 0.28) |
| | SNNP | 1.48 (0.66 to 3.35) | 1.05 (0.49 to 3.34) | 2.32 (0.80 to 6.75) | 1.26 (0.48 to 3.34) |
| Distance to health facility tertiles | Short | Ref. | | Ref. | 0.87 (0.52 to 1.44) | 0.90 (0.56 to 1.47) |
| | Medium | 1.06 (0.69 to 1.64) | 1.01 (0.67 to 1.54) | 0.87 (0.52 to 1.44) | 0.90 (0.56 to 1.47) |
| | Long | 0.75 (0.46 to 1.22) | 0.77 (0.49 to 1.19) | 0.51 (0.29 to 0.90) | 0.57 (0.34 to 0.96) |
| Difference in altitude tertiles* | Small | Ref. | | Ref. | 0.59 (0.34 to 1.02) | 0.60 (0.36 to 1.01) |
| | Medium | 0.78 (0.49 to 1.22) | 0.85 (0.55 to 1.29) | 0.59 (0.34 to 1.02) | 0.60 (0.36 to 1.01) |
| | Great | 0.48 (0.28 to 0.83) | 0.46 (0.29 to 0.74) | 0.39 (0.19 to 0.79) | 0.34 (0.19 to 0.59) |
| ICC for the null model (%) | 27% | | | 49% |
| ICC for the final model (%) | 8% | | | 13% |

*Difference in altitude between household and nearest health centre.
AOR, adjusted OR; ICC, intraclass correlation coefficient.
cost–distance analysis based on the health facilities’ position and difficulties in traversing the surface of each 300×300 m cell in the study areas. The analysis included the slopes based on elevation measurements as well as the distance from home to the health facility. These findings imply that efforts climbing up and down the hills were barriers to accessing these services. A similar result was shown regarding the influence of household wealth on antenatal care use and facility delivery in the previous study in the same study area.\textsuperscript{19}

We found that more than half of the study women had delivered at a health facility, which was similar to the coverage (48%) reported by the 2019 Ethiopian Demographic Health Survey.\textsuperscript{20} In line with the current study, there was also a marked wealth-based inequity in the utilisation of antenatal care four or more times and facility delivery in a study performed in the same areas 2 years earlier.\textsuperscript{19} Reviews of similar Ethiopian studies,\textsuperscript{23} research from sub-Saharan Africa countries\textsuperscript{24} and East African countries\textsuperscript{22} as well as from a range of low-income countries\textsuperscript{25} point at considerable regional variation, social inequities in the utilisation of facility delivery services and the importance of topography and distance from home to health centres and hospitals. A study from Kenya which attempted to disentangle distance to facility and quality of care indicated that pregnant women bypassed possible places to deliver, preferring to give birth at a facility that provided better-quality care.\textsuperscript{26} Furthermore, an analysis from 81 low-income and middle-income countries suggested that closing the quality gap would enhance the use of services.\textsuperscript{27} Such evidence suggest that the problem with distance to the health facility may be less important if the services offered maintain a high quality. In some areas, it may be motivated to consider outreach antenatal clinics organised by the health centres. The problems with distance to facilities for delivery services may be managed by schemes to organise transport or manage associated costs or by improving maternal waiting homes.

In terms of utilisation of child health services, 36% of children aged 12–23 months had received all basic immunisations. This low level was similar to the national estimate (38%) from 2019 Ethiopian Mini Demographic and Health Survey.\textsuperscript{18} A study 2 years earlier in the same rural areas as the current study showed an equitable distribution of full child immunisation across different socioeconomic groups.\textsuperscript{19} This relative equity in vaccination coverage

### Table 3 Determinants of child immunisation and sick child services utilisation in four regions of Ethiopia, 2019

| Variable Category                              | Full immunisation 12–23 months | Sick child care utilisation 2–59 months |
|-----------------------------------------------|---------------------------------|----------------------------------------|
| **OR (95% CI)**                               | AOR (95% CI)                    | OR (95% CI)                            |
| Wealth tertiles                              | Ref.                            | 0.73 (0.39 to 1.37)                    |
| Low                                           | Ref.                            | 0.71 (0.38 to 1.33)                    |
| Middle                                        | 0.91 (0.52 to 1.62)             | 1.02 (0.55 to 1.91)                    |
| Upper                                         | 1.58 (0.91 to 2.77)             | 0.89 (0.42 to 1.88)                    |
| Sex                                           | Ref.                            | 1.15 (0.73 to 1.66)                    |
| Girl                                          | Ref.                            | 1.02 (0.67 to 1.55)                    |
| Boy                                           | 1.15 (0.84 to 1.57)             | 1.11 (0.73 to 1.66)                    |
| Number of under 5 children in the household   | Ref.                            | 1.15 (0.74 to 1.80)                    |
| One child                                     | 1.10 (0.79 to 1.54)             | 1.33 (0.83 to 2.14)                    |
| ≥Two children                                 | 1.21 (0.86 to 1.72)             |                                        |
| Region                                        | Ref.                            | 2.07 (1.03 to 4.13)                    |
| Tigray                                        | Ref.                            | 2.26 (1.02 to 5.03)                    |
| Amhara                                        | 1.32 (0.72 to 2.42)             | 2.07 (1.03 to 4.13)                    |
| Oromia                                        | 0.49 (0.25 to 0.94)             | 2.87 (1.42 to 5.86)                    |
| SNNP                                          | 0.68 (0.30 to 1.52)             | 2.04 (0.90 to 4.62)                    |
| Distance to health facility tertiles           | Ref.                            | 0.49 (0.29 to 0.82)                    |
| Short                                         | 0.69 (0.46 to 1.04)             | 0.50 (0.29 to 0.85)                    |
| Medium                                        | 1.23 (0.62 to 2.45)             | 0.50 (0.29 to 0.85)                    |
| Long                                           | 0.64 (0.41 to 0.98)             |                                        |
| Great                                          | 0.55 (2.33 to 1.34)             |                                        |
| Difference in altitude tertiles*             | Ref.                            | 0.76 (0.44 to 1.29)                    |
| Small                                          | 1.00 (0.66 to 1.47)             | 1.02 (0.61 to 1.70)                    |
| Medium                                        | 0.99 (0.65 to 1.51)             | 1.02 (0.61 to 1.70)                    |
| Great                                          | 0.89 (0.55 to 1.42)             | 0.59 (0.34 to 1.01)                    |
| ICC for the null model (%)                    | 24%                             | 18%                                   |
| ICC for the final model (%)                   | 19%                             | 8%                                    |

*Difference in altitude between household and nearest health facility. AOR, adjusted OR; ICC, intraclass correlation coefficient.
could be explained by the rural outreach services, organised from the health posts, where eligible children were summoned to vaccination days in their local villages. Our analysis showed that the medium tertile of distance to health post was linked to lower immunisation coverage and sick child healthcare utilisation. This may be a random error, given the lack of consistency across distance strata. If true, it may be a reflection of the geographic distribution of outreach services. A study in Ethiopia’s hard-to-reach areas, distance to the health facility influenced full child immunisation coverage in addition to the mother’s education, utilisation antenatal delivery services and child delivered at the health facility. However, in an analysis of the 2016 Demographic and Health Survey, full child immunisation showed significant variation between groups characterised by geographic, socioeconomic and maternal factors with proadvantaged bias. The immunisations are given at the health post and partly through outreach services in the villages. This combination of facility-based and outreach services may theoretically not only increase coverage but also enhance equity.

One-third of the children 2–59 months, who had been sick in the 2 weeks before the survey, had sought care from health posts, health centres, hospitals or private clinics, which is in line with the national estimates of the utilisation of health services for sick children. Our results showed no association between care seeking for sick children and distance to the nearest health centre, difference in altitude and socioeconomic status. During the last decade, Ethiopia has scaled up the integrated community case management of common childhood illnesses provided by salaried health extension workers at the health posts. The availability of community-level primary care services at health posts close to home, offering child health services, could partly explain the relative equity in utilisation. Contrary to this, the 2016 nationally representative Demographic Health Survey showed inequities in care seeking for common childhood illnesses between groups defined by geographic region, mother’s education or household wealth. The Ethiopian government has expanded maternal, neonatal and child health services in the country. Further efforts are needed not only to expand these services but also to increase the quality of care to reach the goal of universal health coverage.

The difference in the influence of distance and difference in altitude between maternal and child health service may be related to the differences in service provision. The child health services, mainly managed by the health posts, include outreach activities with immunisation and home-based care. Women had to reach the more distant health centre for care seeking. Given the relative imprecision of the included determinants, we categorised these data into tertiles.

We assessed altitude by GPS data that may not always be accurate. However, the error is usually of little importance, in the range from 10 to 20 m. The socioeconomic status was based on assets and characteristics of the household in the way that is practised in the demographic and health surveys. This characterisation represents accumulated wealth and resources but does not directly represent the economic strength of the household to cover costs for care seeking. Given the relative imprecision of the included determinants, we categorised these data into tertiles.

We used multilevel regression modelling that included the determinants, the outcome and potential confounding factors at the cluster, household and individual levels. The regression models accounted for confounding and clustering effects.

**CONCLUSION**

The topography, that is, the distance and difference in altitude of the areas and socioeconomic status of the household affected the utilisation of maternal health services. We did not find such inequities in the utilisation of child health services, although coverage was on a low level. The strive for universal health coverage in Ethiopia...
will require not only increased coverage but also target efforts to address the geographic and social differentials in care utilisation.

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**REFERENCES**

1. World Health Organization., The World Bank. Tracking Universal Health Coverage – First Global Monitoring Report. Geneva, WHO 2015.
2. Countdown to 2030 Collaboration. Countdown to 2030: tracking progress towards universal coverage for reproductive, maternal, newborn, and child health. *Lancet* 2018;391:1538–48. doi:10.1016/S0140-6736(18)30104–1
3. Schaaf H, Hesse G. Schwindelkrankeiten im kindesalter: Erweiterte diagnosemöglichkeiten der vestibulären komponente. *Pediatrische Praxis*, 2012;79:253–65.
4. Memirie ST, Verguet S, Norheim OF. Inequalities in utilization of maternal and child health services in Ethiopia: the role of primary healthcare systems and services in low and middle income settings. *BMJ Health Serv Res* 2016;16:51.
5. Kassie T, Lokina R, Mujinja P, et al. Determinants of delay in care seeking among children under five with fever in Dodoma region, central Tanzania: a cross-sectional study. *Malar J* 2014;13:348.
6. Lohera TJ, Campbell OMRF, Gabrysch S. Distance to care, facility delivery and early neonatal mortality in Malawi and Zambia. *PLoS One* 2012;7:e52110.
7. Tegegne TK, Chojenta C, Getachew T, et al. Antenatal care use in Ethiopia: a spatial and multilevel analysis. *BMJ Pregnancy Childbirth* 2019;19:399.
8. Tadele N, Lamaro T. Utilization of institutional delivery service and associated factors in bench Maji zone, Southwest Ethiopia: community based, cross sectional study. *BMJ Health Serv Res* 2017;17:1–10.
9. Jimma R, District H, Zegeye K. Primary Health Care : Open Access The Role of Geographical Access in the Utilization of Institutional Delivery. *Prim Health Care* 2014;4:1–6.
10. Defar A, Okwaraji YB, Tigabu Z, et al. Geographic differences in maternal and child health care utilization in four Ethiopian regions; a cross-sectional study. *Int J Equity Health* 2019;18:173.
11. Shiferaw S, Spigt M, Seme A, et al. Does proximity of women to facilities with better choice of contraceptives affect their contraceptive utilization in rural Ethiopia? *PLoS One* 2012;17:e0187311.
12. Tanou M, Kamiya Y. Assessing the impact of geographical access to health facilities on maternal healthcare utilization: evidence from the Burkina Faso demographic and health survey 2010. *BMJ Public Health* 2019;19:1–8.
13. Nesbitt RC, Loihela TJ, Soremekun S, et al. The influence of distance and quality of care on place of delivery in rural Ghana. *Sci Rep* 2016;6:30291–8. doi:10.1038/srep30291
14. Sarrassat S, Meda N, Badolo H, et al. Distance to care, care seeking and child mortality in rural Burkina Faso: findings from a population-based cross-sectional survey. *Trop Med Int Health* 2019;24:31–42.
15. Berhanu D, Okwaraji YB, Belayneh AB, et al. Protocol for the evaluation of a complex intervention aiming at increased utilisation of primary child health services in Ethiopia: a before and after study in intervention and comparison areas. *BMJ Health Serv Res* 2020;20:339–12.
16. CSA. Population Census Commission II [Internet]. Mortality, 2007. Available: http://www.csa.gov.et/surveys/Population and Housing census/ETH-pop-2007/survey0/data/Doc/Reports/National_Statistical.pdf
17. Central Statistical Agency and ICF International, Findings K. Ethiopia Demographic and Health Survey, 2011 [Internet]. Addis Ababa, Ethiopia, 2011.
18. Tamirat KS, Sisay MM. Full immunization coverage and its associated factors among children aged 12–23 months in Ethiopia: further analysis from the 2016 Ethiopia demographic and health survey. *BMJ Public Health* 2019;19:1–7.
19. Wunhe AD, Medanyiae AA, Bezabih AM, et al. Wealth-based equity in maternal, neonatal, and child health services utilization: a cross-sectional study from Ethiopia. *Int J Equity Health* 2019;18:1–9.
20. Ethiopian Public Health Institute (EPHI) and ICF. *Mini demographic and health survey 2019: key indicators*. Rockville, Maryland, USA: EPHI and ICF, 2019.
21. Alegabech A, Hatt L, Kukla M. Monitoring and evaluating progress towards universal health coverage in Ethiopia. *PLoS Med* 2014;11:e1001696.
22. Ruktanonchial CW, Ruktanonchial NW, Nove A, et al. Equality in maternal and newborn health: modelling geographic disparities in utilisation of care in five East African countries. *PLoS One* 2016;11:e0162006.
23. Kebede A, Hassen K, Nigussie Teklehaymanot A. Factors associated with institutional delivery service utilization in Ethiopia. *Int J Womens Health* 2016;8:463–75.
24. Moyer CA, Mustafa A. Drivers and deterrents of facility delivery in sub-Saharan Africa: a systematic review. *Reprod Health* 2013;10:40.
25. Karra M, Fink G, Canning D. Facility distance and child mortality: a multi-country study of health facility access, service utilization, and child health outcomes. *Int J Epidemiol* 2017;46:817–26.
26. Escamilla V, Calhoun L, Winston J, et al. The role of distance and quality on facility selection for maternal and child health services in urban Kenya. *J Urban Health* 2018;95:1–12.
27. Chou VB, Walker N, Kanyangara M. Estimating the global impact of poor quality of care on maternal and neonatal outcomes in 81 low- and middle-income countries: a modelling study. *PLoS Med* 2019;16:e1002990.
28 Girmay A, Dadi AF. Full immunization coverage and associated factors among children aged 12-23 months in a hard-to-reach areas of Ethiopia. *Int J Pediatr* 2019;2019:1–8.

29 Geweniger A, Abbas KM. Childhood vaccination coverage and equity impact in Ethiopia by socioeconomic, geographic, maternal, and child characteristics. *Vaccine* 2020;38:3627–38. doi:10.1016/j.vaccine.2020.03.040

30 Oyo-Ita A, Wisonge CS, Oringanje C, et al. Interventions for improving coverage of childhood immunisation in low- and middle-income countries. *Cochrane Database Syst Rev* 2016;7:CD008145.

31 Utazi CE, Thorley J, Alegana VA, et al. Mapping vaccination coverage to explore the effects of delivery mechanisms and inform vaccination strategies. *Nat Commun* 2019;10:1633–10. doi:10.1038/s41467-019-09611-1

32 Central Statistical Agency (CSA) [Ethiopia], ICF.. *Ethiopia demographic and health survey 2016*. Addis Ababa, Ethiopia, and Rockville, Maryland, USA, 2016.

33 Miller NP, Amouzou A, Tafesse M, et al. Integrated community case management of childhood illness in Ethiopia: implementation strength and quality of care. *Am J Trop Med Hyg* 2014;91:424–34.

34 Byrne A, Hodge A, Jimenez-Soto E, et al. What works? Strategies to increase reproductive, maternal and child health in difficult to access mountainous locations: a systematic literature review.. *PLoS One* 2014;9:e87683.

35 Karim AM, Tamire A, Medhanyie AA, et al. Changes in equity of maternal, newborn, and child health care practices in 115 districts of rural Ethiopia: implications for the health extension program. *BMJ Pregnancy Childbirth* 2015;15:238–11. doi:10.1186/s12884-015-0668-z

36 Allen E, Schellenberg J, Berhanu D, et al. Associations between increased intervention coverage for mothers and newborns and the number and quality of contacts between families and health workers: an analysis of cluster level repeat cross sectional survey data in Ethiopia. *PLoS One* 2018;13:e0199937.

37 Defar A, Getachew T, Taye G, et al. Quality antenatal care services delivery at health facilities of Ethiopia, assessment of the structure/ input of care setting. *BMJ Health Serv Res* 2020;20:485.

38 Ayalneh AA, Fetene DM, Lee TJ. Inequalities in health care utilization for common childhood illnesses in Ethiopia: evidence from the 2011 Ethiopian demographic and health survey. *Int J Equity Health* 2017;16:67. doi:10.1186/s12939-017-0561-7

39 Alene M, Yirmaw L, Berelle Y, et al. Health care utilization for common childhood illnesses in rural parts of Ethiopia: evidence from the 2016 Ethiopian demographic and health survey. *BMC Public Health* 2019;19:1–12.