Geographic distribution and demographic factors associated with use of a long-acting reversible contraceptive (LARC) in Ethiopia

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Abstract

Increasing access to and utilization of Long-Acting Reversible Contraceptives (LARC) can prevent unintended pregnancies and reduce unmet need for family planning. However, LARC uptake lags behind less effective contraceptive methods. This study, aimed to analyze the geographical distribution and demographic factors associated with LARC uptake, was based on survey data from the 2019 Performance Monitoring for Action (PMA) project in Ethiopia. Spatial autocorrelation was examined using the bivariate versions of Global Moran's *I* and Local Indicators of Spatial Association (LISA), with spatial lag regression analyses performed to assess the spatial correlation and association between LARC uptake and demographic factors. Although there was a general, statistically significant positive spatial autocorrelation for LARC uptake (Moran's $I = 0.308$, $p<0.001$), a negative correlation was observed between LARC uptake and the percentage of Muslims, rural populations, those lacking formal education and the people belonging to a low-wealth quantile. The spatial lag model indicated that zones with Muslim populations and those with higher percentages of people without formal education had a lower LARC uptake. The overall uptake was 8%, with the lowest levels in the Afar and Somali regions. To expand access to LARC, the Ethiopian government, policymakers, and non-governmental organizations should implement programs targeting low-uptake areas (particularly Afar and Somali regions). Muslim religious leaders could play an important role in promoting acceptance of LARC among their members. Tailored health education programs should be developed for Muslim populations and people without formal education to enhance awareness and acceptance of LARC.

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Key words: Long-acting reversible contraceptives, geospatial, Ethiopia.

Conflict of interest: the authors declare no potential conflict of interest, and all authors confirm accuracy.

Ethical considerations: PMA Ethiopia received ethical approval from Addis Ababa University, the College of Health and the JHB-SPH Institutional Review Board (Zimmerman *et al.,* 2020).

Funding: no funding source to report

Availability of data and materials: all data generated or analyzed during this study are included in this published article.

Received: 28 April 2024.
Accepted: 4 December 2024.

Geospatial Health 2025; 20:1302
doi:10.4081/gh.2025.1302

Introduction

The Ethiopian Demographic Health Survey 2016 (EDHS 2016) estimates that 22% of married women in Ethiopia have unmet family planning needs, with one in four pregnancies unintended (Central Statistical Agency - CSA/Ethiopia and ICF, 2017). One strategy to reduce unmet family planning needs would be to increase access and utilization of long-acting reversible contraceptives (LARCs) (Curtis and Peipert, 2017; Jacobstein *et al.*, 2013; Parks and Peipert, 2016; Peipert *et al.*, 2012). However, among married and unmarried, sexually active women, the uptake of LARC in Ethiopia stands at a mere 10% and 12%, respectively (Central Statistical Agency - CSA/Ethiopia and ICF, 2017). LARC methods (implants and intra-uterine devices - IUDs) are one of the most reliable, long-term, highly effective methods in preventing pregnancy after placement of a device (Curtis and Peipert, 2017). A modelling study (Hubacher *et al.*, 2008) shows that 1.8 million unintended pregnancies would be prevented over a five-year period if 20% of African women using short-acting contraceptives (pills and injectables) would switch to LARCs.

One of the factors that could affect LARC uptake is the spatial variation in socio-economic and demographic characteristics. Geographic disparities in healthcare access and use are well documented and closely associated with income and poverty (Cooper *et al.*, 2012). So far, there are only a few studies on geographical distribution and variation of family planning utilization. Some such studies conducted in Africa show clustering in the use of modern contraceptives in urban areas. In addition, regional-level data show association with modern contraceptive use and its spatial variation along with socioeconomic factors, such as education-

al attainment, wealth, employment and marital status (Nyarko, 2020; Yao *et al.*, 2012). A study from Ghana reports spatial variation in the distribution of modern contraceptive use across the country, with low prevalence in the most disadvantaged regions (Nyarko, 2020). It further states that regional differences in age, educational attainment, poverty level, employment, religion, and lack of access to health facilities all affect the use of modern contraceptives (Nyarko, 2020).

A geospatial study conducted in Ethiopia on unmet family planning needs reports high levels of such needs in the regions of Oromia, Southern Nations; Nationalities and Peoples Region (SNNPR), and Gambella (Azanaw *et al.*, 2022). Another Ethiopia study regarding the distribution of modern contraceptive uptake accounts for a high uptake in Addis Ababa and Amhara regions and a low uptake in Afar and Somalia regions (Tegegne *et al.*, 2020). Using the EDHS, a relatively recent spatial study on the geographical distribution of LARC uptake confirms the presence of unmet family planning needs in the pastoral regions of the country. Indeed, Afar, Gambela, and Somalia, have a low LARC uptake (Ebrahim *et al.*, 2021). Despite these reports, there are still limited spatial studies on LARC uptake, but they do not include variations in socio-demographic characteristics in this regard. The current study aimed to add information on LARC uptake to the body of evidence by exploring its geographical distribution in Ethiopia and assessing the spatial association between uptake of LARC on the one hand, and demographic and socio-economic factors (education, religion, wealth, residence including the existing number of health facilities that provide LARC) on the other. In conclusion, the objective was to assess the distribution of LARC in Ethiopia and understand demographic and socioeconomic factors impacting the uptake.

Research questions

i) Is there spatial variation in the uptake of LARC among reproductive-age women in Ethiopia at the Zone level? ii) Is there an association between demographic and socio-economic factors and LARC uptake in Ethiopia at the Zone level?

Materials and Methods

Study area

The present analysis covered all of Ethiopia, which has nine regions (Amhara; Afar; Benishangul-Gumuz; Gambella; Harari; Oromia; Somali; Southern Nations; Nationalities and Peoples Region (SNNPR); and Tigray) and two self-administrating city administrations (Addis Ababa and Dire-Dawa). These regions are further divided into a total of 74 zones. The spatial analysis was conducted at the zonal level since the Performance Monitoring for Action Ethiopia (PMA 2019) Enumeration Area (EA) data do not include the geographical borders and only includes one centroid coordinate data point confirmed by GPS. The EA-level data are spatial and joined to prepare zonal-level data using the "completely within" matching option (Zimmerman *et al.*, 2020). There are a total number of 74 zones in Ethiopia, but the PMA study did not collect data for eight of them, so these zones were removed from the analysis, leading to a final number of 66 zones in the analysis. Four of the zones excluded were from the Somali region, two from SNNPR, and one each from the Amhara and Oromia regions.

Data source

Data from the 2019 PMA 2019 survey were used. PMA 2019 is a project launched in 2014 and implemented in collaboration with Addis Ababa University, the Ethiopian Federal Ministry of Health, and Johns Hopkins Bloomberg School of Public Health (JHBSPH) in the United States. It conducts a nationally representative survey annually by measuring key reproductive, maternal, and child health indicators, including modern contraceptive prevalence, reproductive empowerment, fertility intention, health facility readiness, and quality of care. PMA 2019 collects data from two levels: household/females and the Service Delivery Points (SDPs) by combining Global Positioning System (GPS) data using the unique EAs assigned to each household/female as centroids. The number of EAs amounted to 265, each including about 200 households. The 2019 Ethiopia population and housing census amounted to 149,093 EAs, from which PMA 2019 randomly selected 35-42 households from each EA. Data collection was conducted between September and December 2019. A total of 8,837 women (98.5% of those selected for inclusion) completed the cross-sectional survey (Shiferaw *et al.*, 2017; Zimmerman *et al.*, 2020).

Variables

All the variables for this study were obtained from PMA 2019. The dependent variable was the proportion of women using LARC as contraception. LARC users included women who reported using implants or an IUD as a contraceptive method in the past 12 months. The proportion of women using LARC was computed for each zone, with the total sample for each zone as the denominator. We used proportions to account for population size differences. The independent variables used in this study were selected based on literature (Lakew *et al.*, 2013; Ebrahim *et al.*, 2021) and included education level, religion, economic level, residential area (urban vs rural), and the number of health facilities providing LARC. The education level was divided into three levels; i) without formal education; ii) having primary education; and iii) having secondary and higher education. Ethiopia's three most common religions were assessed as orthodox Christian, protestant Christian and Muslim. The household economy was categorized into: low, middle, and high level of wealth using the five wealth quintile variables from PMA 2019, with the two lowest grouped into one (low wealth), the middle quintile kept as that, while the two highest were grouped into one (high wealth). The place of residence was given as urban or rural. This study used the percentage of each independent variable for each zone. The percentages of these independent variables were computed for each zone using the total population of each zone as the denominator. The number of health facilities providing LARC for each zone was computed by counting the number of health facilities located in each zone.

Analysis

Spatial autocorrelation was investigated by Global Moran's *I* (Chen, 2021) and Local Indicators of Spatial Association (LISA) (Kowe *et al.*, 2019). In this study, two weighting methods were used: contiguity edges and corners (Suryowati *et al.*, 2018), and k-nearest neighbours (Zhang and Murayama, 2011) where we used the five nearest neighbours (*i.e.* k=5). The former method was selected for the analysis of neighbours sharing borders, while the latter was used to evaluate whether including all nearest neighbours would yield different results. The bivariate versions of the two statistical methods employed (Lee, 2001) allowed the study of the correlation between one variable and the spatial lag of another. Here

the techniques were performed to assess the spatial correlation between LARC uptake and a set of demographic and socio-economic variables. A spatial regression model was developed to assess the association between LARC uptake and these variables. Due to collinearity among levels of the same characteristic and using the finding from the bivariate Moran's *I*, the variables included in the regression model were the religious variables (Muslim and Protestant), the level of education, place of residence, wealth group and the number of health facilities that provide LARC. Ordinary Least Squares (OLS) and spatial lag model were developed and compared using log-likelihood and Akaike's Information Criterion (AIC) to select the best-fitting model. The spatial lag model was selected for our analysis based on its theoretical alignment with the spatial dynamics of LARC uptake. This model posits that LARC uptake in one location directly influences uptake in neighboring areas, capturing potential diffusion effects. Furthermore, spatial lag models offer the advantage of accounting for both direct and indirect effects of independent variables, enabling us to estimate spillover effects across spatial units (Okunlola *et al.*, 2021). Data cleaning including identifying missing values and recoding variables was done in R version 2023.12.1, while ArcGIS Pro version 3.1.2 and GeoDa version 1.20.0.36 were used to perform the spatial analyses. Statistical significance was assessed using two-sided $\alpha<0.05$. The variation of LARC uptake at the Zone level in Ethiopia was displayed on a map.

Results

The overall average proportion of LARC uptake was 8% among the study population. The mean age of the participants was 28 years, and the majority of the participants were from rural areas, had no formal education, were orthodox Christian followers, and were in the low-wealth group. The LARC uptake map showed the west-country zones of Ethiopia to have a higher LARC uptake compared to the eastern part of the country. Zones in the Afar and Somali regions for found to have a particularly low LARC uptake, whereas Addis Ababa and some zones in the Benishangul-Gumuz region had the highest uptake (Figure 1).

The result from spatial autocorrelation showed that the Global Moran's *I* values for LARC uptake was statistically significant in both weighting methods (contiguity edges and corners and k-nearest neighbours, with both showing a moderate spatial dependence (between 0.25 – 0.75). Moran's *I* value for the other variables were also statistically significant in both methods, except for the low-wealth and high-wealth groups, while the number of health facilities that provide LARC was not statistically significant using either method. All the statistically significant Moran's *I* values indicated a moderate (0.25 – 0.75) spatial autocorrelation except for secondary/higher education level which showed a weak spatial autocorrelation (Table 1). The LISA analysis on LARC uptake indicated clustering of zones with high uptake of LARC surrounded by zones with high uptake (high-high or HH) in the country's western region and zones with low uptake of LARC surrounded by zones with low uptake (low-low or LL) in the eastern region of the county, particularly in the Afar and Somali regions (Figure 2).

The bivariate Moran's *I* analysis of LARC uptake vs demographic and socio-economic variables resulted in statistically significant but weak correlations for the following variables: Muslims, protestant Christians, rural and urban residence, without formal education, secondary/higher education and both the low and high wealth groups. The direction of the correlation for Muslim populations, rural populations, populations with no formal

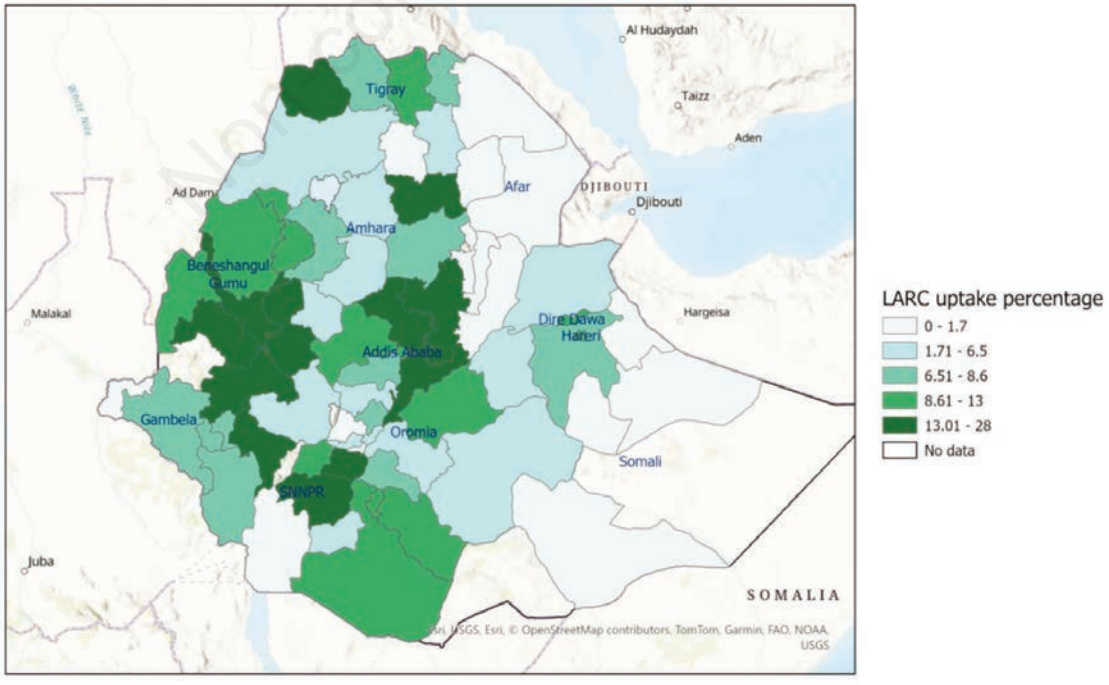

Figure 1. Spatial distribution of LARC Uptake in Ethiopia. Source: PMA 2019.

education, and low-wealth groups with LARC uptake was in the negative direction. The statistically significant correlation of Moran's *I* value was highest for the Muslim population (-0.246), followed by the population with secondary/higher education (0.240) and the population without formal education (-0.204) (Table 2). The BiLISA maps for Muslim populations and LARC uptake (Figure 3) and those with no formal education and LARC uptake (Figure 4) showed a moderate negative, but statistically significant correlation, in eight zones. In contrast, the BiLISA map for populations with secondary/higher education and LARC uptake showed a clear statistically significant positive correlation in nine zones (Figure 5). OLS and the spatial lag model, developed to assess the association between LARC uptake and demographic and socioeconomic variables, gave the Muslim population proportion, and the population without formal education were statistically significantly associated with LARC uptake according to both models. The spatial lag model showed the best fit compared to the OLS model based on log-likelihood and AIC. Moran's *I* for the spatial lag model was not statistically significant indicating that the spatial autocorrelation had been adequately taken into account in the spatial lag model (Anselin, 2020). Based on this model, zones with a higher percentage of the Muslim population (β= -5.39, p=0.01) and no formal education (β=-10.26, p=0.03) were less likely to have a higher LARC uptake of LARC. The proportion of population with no formal education was more strongly associated with LARC uptake than

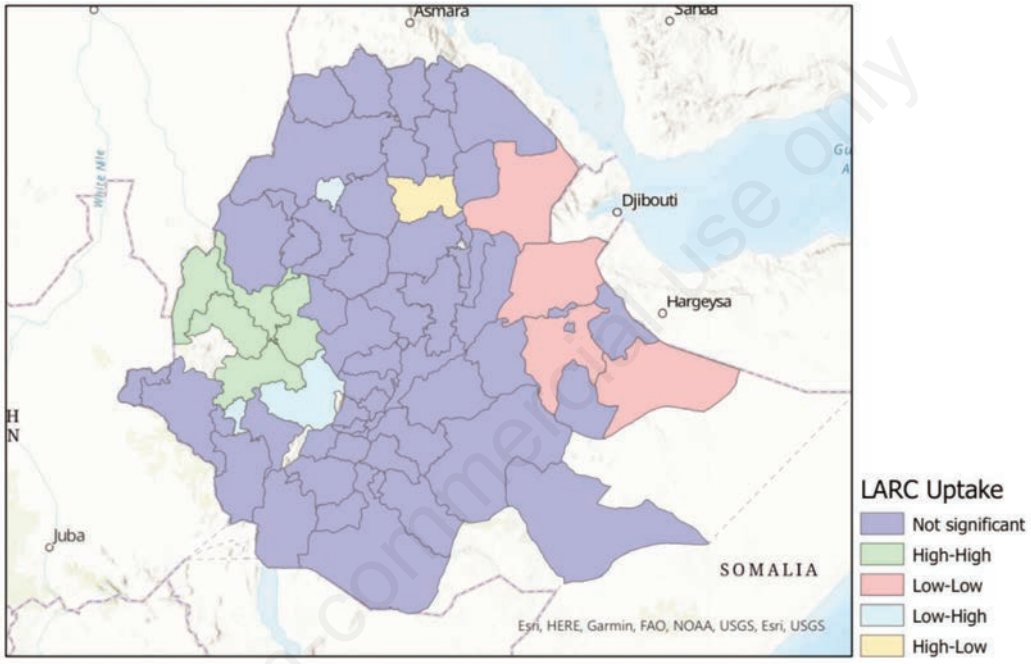

Figure 2. Moran's *I* for LARC uptake in Ethiopia 2019. Produced by Local Indicators of Spatial Association (LISA).

Table 1. Global Moran's *I* for LARC uptake and the study variables in Ethiopia 2019.

Variable	Contiguity[a]	p	KNN[b]	p	Difference
LARC (%)	0.288	0.001	0.242	0.001	0.046
Health facilities providing LARC (no.)	0.035	0.51	0.062	0.25	0.027
Rural	0.131	0.07	0.162	0.03	0.031
Urban	0.131	0.07	0.162	0.03	0.031
Low wealth group	0.028	0.60	-0.013	0.50	0.041
High wealth quantile	0.075	0.31	0.07	0.07	0.005
No formal education	0.301	0.001	0.268	0.001	0.033
Primary education	0.255	0.001	0.278	0.001	0.023
Secondary/higher education	0.19	0.01	0.171	0.001	0.019
Muslim	0.563	0.001	0.525	0.001	0.038
Orthodox Christian	0.55	0.001	0.554	0.001	0.004
Protestant Christian	0.583	0.001	0.591	0.001	0.008

Source: PMA Ethiopia,2019; [a]Edges and Corners; [b]Nearest Neighbours (k=5).

the proportion of Muslim population. In addition, based on the R^2 value, in the spatial lag model, 41% of the variation in the dependent variable was explained by the independent variables compared to 32% in the OLS model (Table 3).

Discussion

This study examined the geographical distribution of LARC uptake in Ethiopia and its association with geographical variations of socio-demographic factors. The study's findings showed clustering of both high and low LARC uptake in different areas of the country. A positive correlation was found with regard to secondary and higher education, protestant Christian religion following, living in urban living areas and belonging to a high wealth group. In contrast, a negative correlation was observed for the Muslims, those without formal education, living in rural areas and belonging to a low wealth group population. The spatial regression analysis confirmed that areas with a high percentage of Muslim population and people without formal education are associated with a lower uptake of LARC.

Despite high LARC uptake observed in the central and western regions (Addis Ababa, Western Oromia and Benishangul-Gumuz), low LARC uptake was generally seen in the country's eastern regions (Afar and Somali), a finding supported by previous studies (Ebrahim *et al.*, 2021; Lakew *et al.*, 2013; Tegegne *et al.*, 2020; Wado *et al.*, 2019). This emphasises the geographic differences and indicates that large areas still lag with respect to utilization of

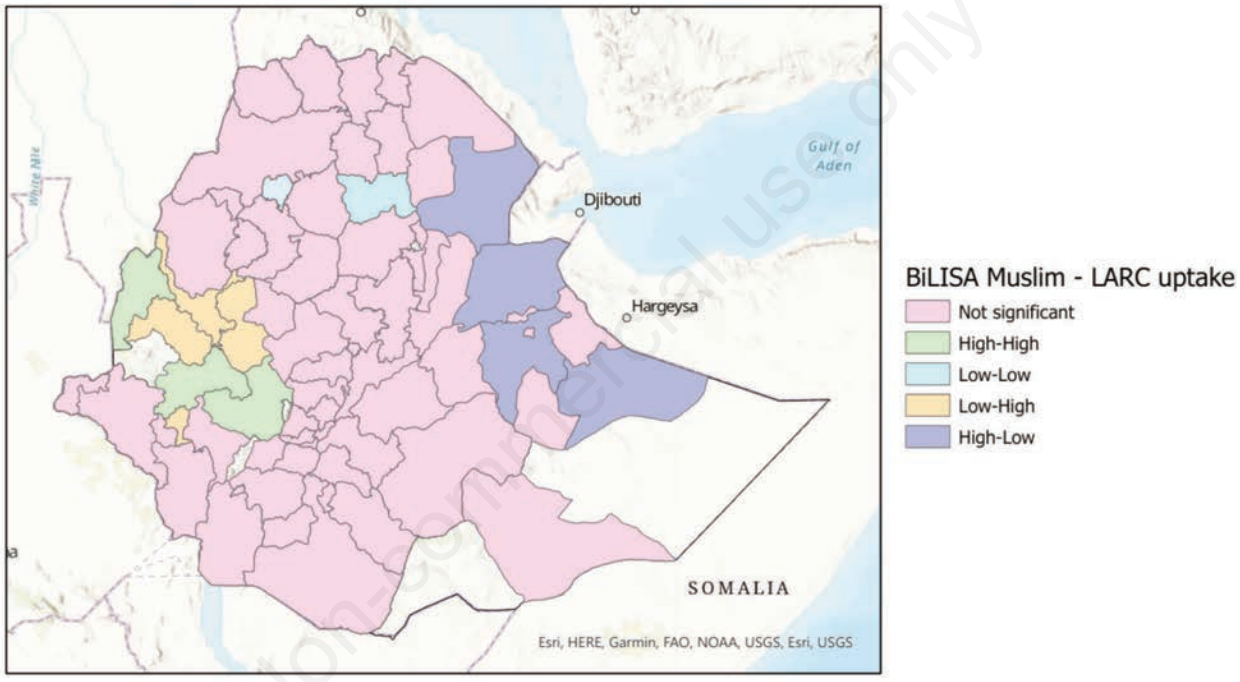

Figure 3. Correlation between Muslims and LARC uptake for Ethiopia 2019. Produced by Bivariate Local Indicators of Spatial Association (BiLISA).

Table 2. Global Bivariate Moran's *I* for LARC uptake and the study variables in Ethiopia 2019.

Independent variables	Moran's *I*	p
Health facilities providing LARC (no.)	0.035	0.257
Rural	-0.185	0.002
Urban	0.185	0.002
Low wealth group	-0.134	0.016
High wealth group	0.135	0.013
No formal education	-0.204	0.002
Primary education	0.043	0.210
Secondary/ higher education	0.240	0.001
Muslim	-0.246	0.001
Orthodox Christian	0.08	0.103
Protestant Christian	0.195	0.002

family planning services including LARC even though the positive effort by the government of Ethiopia to expand access to family planning services in the past decade (Olson and Piller, 2013; Ethiopia Ministry of Health, 2015), abound with. One possible explanation for lower uptake in these regions is a shortage of family planning services providing health facilities nearby (Shiferaw *et al.*, 2017). Although the number of health facilities was not statistically associated with LARC uptake as shown by the current study, zones located in the Afar and Somali regions have the lowest number of health facilities that actually provide LARC and family planning services (Woldemichael *et al.*, 2019). In addition, Afar and Somali regions have the highest proportion of Muslim population and people without formal education shown here to be associated with low LARC uptake. Further efforts are needed to increase

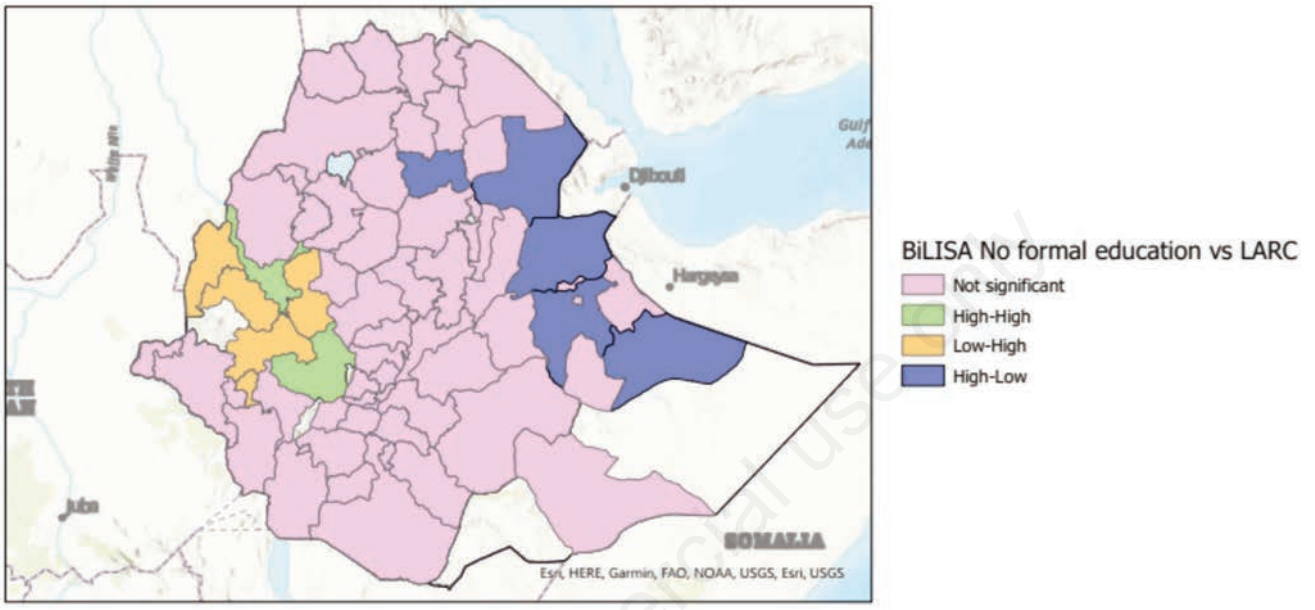

Figure 4. Correlation between absence formal education and LARC uptake for Ethiopia 2019. Produced by Bivariate Local Indicators of Spatial Association (BiLISA).

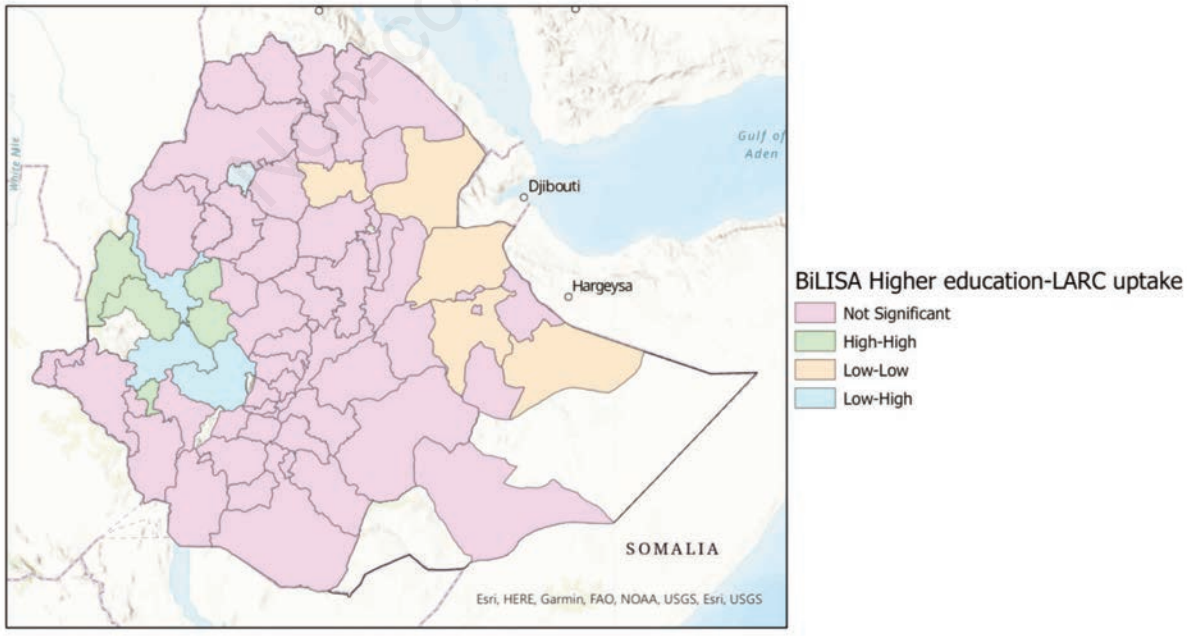

Figure 5. Correlation between population with secondary and higher education and LARC uptake for Ethiopia 2019. Produced by bivariate local indicators of spatial association (BiLISA).

the number of health facilities providing family planning services, including LARC, by changing traditional thinking and increase acceptance of LARC through collaboration with religious leaders. In addition, access to schools and higher education must be improved for the populations in these regions. In contrast to the situation in the eastern regions, the zones in the Benishangul-Gumuz have one of the highest uptakes of LARC despite the region being underdeveloped comprising mostly rural areas with many previously lacking higher education. That this can be changed for the better has been pointed out more than 10 years ago by Daie (2012), which supports our finding of the association between education and LARC uptake. Education can be one possible explanation for the high rate of LARC uptake in the Benishangul-Gumuz region. However, further studies are needed to understand the high LARC uptake in the Benishangul-Gumuz region and perhaps use it as a benchmark to increase LARC uptake in other regions with low uptake.

This study found a moderate spatial autocorrelation for LARC uptake in both global and local analyses, *i.e.* high uptake areas surround areas with high LARC uptake, and low uptake areas surround low uptake areas at moderate levels. Similar results have previously been reported in studies on the distribution and uptake of modern long-acting contraceptive devices (Ebrahim *et al.*, 2021; Tegegne *et al.*, 2020). This has also been seen in published, spatial studies on the distribution of modern contraceptives in other sub-Saharan African countries (Bolarinwa *et al.*, 2021; Nyarko, 2020). Clustering of the utilization of modern contraceptive methods, including LARC, could be due to a lack of access to healthcare providers for some geographic regions or the concentration of family planning providers in big cities and nearby areas, which deprives access to family planning services for people living outside these places. In line with previous studies (Schenker, 2000; Stonehill *et al.*, 2020), our research results show that areas with larger Muslim populations and populations without formal education have lower LARC uptake. This finding is particularly important for Ethiopia because Muslims constitute one-third of the population (United States Department of State, 2019), and any effort to enhance LARC uptake in the country needs to involve this population. In Islam, as in most other religions, fertility is highly prized and the use of contraception is therefore seen as negative (Schenker, 2000) Further studies are required to assess why LARC uptake is lower among the Muslim population compared to other religious followers in Ethiopia. This study's finding regarding the association between lacking education and low LARC uptake is similar to findings from individual-level studies from Ethiopia, which report that a higher education is associated with a higher uptake of LARC (Melka *et al.*, 2015; Stonehill *et al.*, 2020; Zenebe *et al.*, 2017).

Limitations and strengths

A causal inference between LARC and covariates is difficult to prove due to the cross-sectional nature of the data used. First, there might be some potential factors not included in the spatial regression that might impact the association between LARC uptake and demographic factors, such as distance to health facilities, transportation availability, and health service availability. Second, PMA 2019 left out data for eight zone from its collection, leading to a partial loss of the country-wide analysis. Most of the excluded zones are from the Somali region, where people lead a pastoral lifestyle, making it difficult to collect reliable data. Third, as only female samples were used to compute the zone-level demographic variables, the results cannot be applied to the general population.

Although the data used in this study were not directly collected, but available from the PMA 2019, we added to the information gathered by applying advanced statistics making it one of the few studies to use a spatial study design to examine LARC uptake in Ethiopia. while PMA 2019 utilized a nationally representative sample, we aggregated the EA-level data to the zone level. As a result, we cannot guarantee that the zone-level data is representative. One of the advantages is that the study findings can be used by policymakers to focus their programs on areas with low LARC uptake and tailor their interventions to populations with low LARC uptake.

Table 3. Regression model showing the LARC uptake and the study variables in Ethiopia 2019.

Variable	OLS model			Spatial lag model		
	β	SE	p	β	SE	p
Muslim (%)	-6.15*	2.33	0.01	-5.39*	2.15	0.01
Protestant (%)	-0.86	2.74	0.76	-1.72	2.39	0.47
No formal education (%)	-11.01*	5.33	0.04	-10.26*	4.68	0.03
Age	0.63	0.57	0.28	0.61	0.50	0.23
Rural (%)	2.37	3.17	0.46	3.36	2.77	0.23
Low wealth group (%)	0.89	3.79	0.82	1.09	3.32	0.74
Health facilities providing LARC (no.)	-0.04	0.11	0.69	-0.02	0.09	0.82
Rho				0.39	0.13	0.00
Goodness of fit	OLS	Spatial lag				
Degree of freedom	58	57				
R^2	0.32	0.41				
Log Likelihood	-200.87	-197.42				
AIC	417.74	412.84				
Moran's I	0.267*	0.093				

*SE, standard error; OLS, ordinary least squares; , regression coefficient; Rho, spatial lag factor; *p<0.05.*

Conclusions

The main variables associations with low uptake of LARC included populations without formal education and those with Muslim beliefs. Stakeholders concerned with increasing LARC uptake could benefit from focusing more on these population groups. The government, policymakers, and non-governmental organizations should develop interventions targeting these areas to improve access to LARC. Religious leaders of the Muslim population could play a significant role in increasing the acceptance of LARC among their followers within the guidelines of their religious beliefs. Other stakeholders could develop health education regarding contraceptive methods tailored to the Muslim population to increase their knowledge of LARC. As the Benishangul-Gumuz region has one of the highest LARC uptake, policymakers and other stakeholders can use this region's story to develop interventions and policies. Future studies assessing LARC uptake at the lower geographical administrative levels are recommended to develop an effective policy and intervention to increase the uptake of LARC.

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