ADDIS ABABA UNIVERSITY COLLEGE OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

DETERMINANTS OF MODERN CONTRACEPTIVE UTILIZATION AMONG MARRIED WOMEN IN ETHIOPIA: A MULTILEVEL MIXED EFFECT ANALYSIS

By: MEKDES SHIMELIS (BSC.)

A THESIS SUBMITTED TO THE DEPARTMENT OF REPRODUCTIVE, FAMILY AND POPULATION HEALTH, SCHOOL OF PUBLIC HEALTH, COLLEGE OF HEALTH SCIENCES, ADDIS ABABA UNIVERSITY FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE MASTERS DEGREE OF PUBLIC HEATH IN REPRODUCTIVE, FAMILY AND POPULATION HEALTH

SEPTEMBER, 2021

ADDIS ABABA, ETHIOPIA

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Examiners' Approval Sheet

We, the undersigned, members of the Board of Examiners for Mekdes Shimelis's final open defense, have read and evaluated her thesis, "***DETERMINANTS OF MODERN CONTRACEPTIVE UTILIZATION AMONG MARRIED WOMEN IN ETHIOPIA: A MULTILEVEL MIXED EFFECT ANALYSIS***" This is to confirm that the thesis was accepted as partial fulfillment of the requirement.

Name of internal examiner: _____

Signature _____

Date: _____

Name of external examiner: _____

Signature _____

Date: _____

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ABBREVIATIONS/ACRONYMS

AAU	Addis Ababa University
CPR	Contraceptive prevalence rate
CSA	Central Statistics Agency
EA	Enumeration area
EDHS	Ethiopian Demographic Health Survey
EMDHS	Ethiopian Mini Demographic Health Survey
HSTP	Health Sector Transformation Plan
HF	Health Facility
IUD	Intra uterine device
OR	Odds Ratio
LAM	Locational amenorrhea method
MCM	Modern contraceptive method
MCU	Modern contraceptive use
MMR	Maternal mortality ratio
PMA	Performance Monitoring and Accountability
SNNP	Southern nations, nationalities, and people
SSA	Sub Saharan Africa
WHO	World health organization
AIC	Akaike Information Criterion
BIC	Bayesian Information Criterion
EA	Enumeration Area
CI	Confidence interval
ICC	Intra-class correlation
HCW	Health care worker
Ref	Reference
UNICEF	United Nations Children's Fund

ABSTRACT

Background: Despite the progress, the prevalence of modern contraceptive use remains low in Ethiopia. There are numerous predictors to use modern contraceptive methods. Attention has been given to individual-level factors on modern contraception while contextual characteristics are equally relevant to increase the utilization. The study implied figuring out barriers related to end-users and the community characteristics that are critical for developing appropriate family planning programs and policies to improve the uptake.

Objective: This study aims to identify individual and community-level factors of modern contraceptive use, using a multilevel analytic approach.

Method: The study utilized the national data collected by Performance Monitoring and Accountability 2018, Ethiopia. Multilevel mixed-effect regression analysis of 3706 married women of reproductive age group nested within 220 clusters was carried out. Results are presented using odds ratios along with their 95% confidence interval.

Result: Respondents who utilize modern contraceptive methods accounted for 42.9% in Ethiopia in 2018. Analysis of the random intercept model evidenced that the between community variance of modern contraception is non-zero. The fixed-effect model showed significantly lower odds of modern contraceptive utilization among older women, women in a polygamous marriage (OR 0.67, 95%CI 0.49-0.92), women living in a community with a higher mean parity (OR 0.67, 95%CI 0.46-0.93), and women living in a community with higher mean household size(OR 0.65, 95%CI 0.46-0.84), while completing secondary level of education (OR 1.65, 95%CI 1.24-2.30), visiting a health facility(OR 1.49, 95%CI 1.25-1.79), and being wealthy(OR 1.76, 95%CI 1.26-3.06) are among the positively predicting variables of modern contraception. The effect of community variations for education implies that there is a considerable difference in modern contraceptive use among communities.

Conclusion: This study revealed that both individual and community-level variables were significant determinants of modern contraceptive use in Ethiopia. The study recommends, improving women's education, wealth status, and community fertility `norms as measures that can be implemented to accelerate modern contraceptive adoption in the country.

Keywords: Modern Contraceptive Use, Community, Multilevel Logistic Regression, Mixed effect model, Ethiopia.

1. INTRODUCTION

1.1. Background

Modern contraceptive methods are products to control birth in the form of drugs, devices, medical processes, or surgical procedures. It has been identified as a prominent component of sustainable global development, accelerating fertility declines and improving nations' economic growth through demographic dividends (1).The World Health Organization (WHO) has identified contraception as a critical health measure required to achieve healthy motherhood (2).

Studies showed that contraceptive users are more prone to utilize other maternal and child health services like antenatal care and safe delivery care. The utilization of contraceptives has not only led to better health outcomes, such as lower maternal and infant mortality but also to better educational and financial outcomes, particularly for girls and women. Generally, studies in the past years have documented the positive impact of contraception on women's health and well-being (3).

Reports indicated that every year 44 % of maternal mortality and around 230 million births can be prevented globally by providing contraceptives (3, 4), and of all pregnancies occurring annually in the world, 38% are unplanned, and another 22% end in abortion (5).

In 2017, 58 % of married or in-union women of reproductive age used modern contraceptive methods globally; accounting for 92 % of all contraceptive users but this proportion was lowest in Africa, at 56 %. Total contraceptive prevalence among married or in-union women of reproductive age is projected to rise between 2017 and 2030, primarily in Sub-Saharan Africa and Oceania (6).

Ethiopia has made significant progress by reducing the maternal mortality ratio by more than 60% and achieving impressive growth in contraceptive prevalence rate (CPR), both of which have a range of positive effects but still face higher maternal and infant mortality rates (7). The current prevalence of modern contraceptive use among currently married women in Ethiopia is 41% (8).

Ethiopian Federal Ministry of Health is aiming to achieve a contraceptive prevalence rate (CPR) of 50% by 2025, then based on this trend, the CPR requires a substantial increase to reach a goal, as stated in the current health sector transformation plan (2020/2025) (HSTP) (9).

Primary barriers for those who do not use modern contraceptive methods are age, education, religion, media exposure about contraception, wealth, parity, work status, place of residence, fears of side effects, health concerns, lack of decision-making power, cultural factors, plus community's support to have large family sizes, male child preference, and misconceptions about methods (10-13).

Multilevel modeling is a statistical method for analyzing hierarchically structured data in which units at one level are clustered within units at the next higher level (14), allowing for the simultaneous examination of community and individual characteristics on outcomes. This approach used by researchers in recent years (15-17).Variations could be explained by a variety of unobserved contextual factors, such as cultural beliefs, the availability of reproductive health services, the physical characteristics of the area, macroeconomic factors, or the presence of a transportation route (18-20). Several contextual factors were associated with modern contraceptive use, access to family planning services, female education, religion, place of residence; proportions of polygamous marriages, media exposure were among the factors mentioned in different studies in Ethiopia (11, 13, 17).

A Malian study on community-level characteristics influenced contraceptive use, using multilevel modeling evidenced by the significant difference in contraceptive use between communities with the consideration of both Individual and community-level variables (21).

In the present study, multilevel modeling is taken to investigate whether and how community contexts predict modern contraceptive use of married women living in Ethiopia during 2018. For this, data from Performance Monitoring and Accountability (PMA 2018) is used. Therefore, this thesis intends to highlight communities as a context for modern contraceptive use.

1.2. Statement of the problem

Despite recent increases in modern contraceptive use, Ethiopia is among the 10 countries that account for 59% of maternal deaths globally. About 11,000 women die each year from complications of pregnancy and childbirth in Ethiopia with multifactorial reasons(22).

The extent of modern contraceptive utilization varies within and among different communities, and factors responsible for the variation are at different hierarchies (individual and contextual levels).Few studies have investigated how factors other than individuals' characteristics can influence modern contraceptive use (MCU), but it is also necessary to assess variations within and between communities that support in better estimation of the effects of factors, which aids in the process of planning and implementing more effective programs(13, 23). Unlike previous studies that looked at factors at the individual and community levels while considering the broader context (region) as level two, our study looked at community-level determinants while keeping the enumeration area/clusters as level two. That is addressed by applying multi-level logistic regression modeling.

1.3. Significance of the study

Ethiopia is implementing maternal, neonatal, and child health programs as a priority health agenda to reduce maternal and infant morbidity and mortality (24).

To achieve this reduction, the adoption of modern contraceptive methods plays an important role (17).Understanding the factors influencing modern contraceptive use is core to planning efforts to increase prevalence in Ethiopia. There has been significant research on the effect of individual characteristics, but it is also important to evaluate the contextual influences for modern contraception using hierarchical data. This approach helps produce credible results and conclusions, helping to implement more effective contraceptive future policies and programs that target the particular unit at various hierarchical levels.

Therefore, the findings from this study explain the individual and community level predictors of modern contraceptive use by married women of the reproductive age group, which will contribute to the development of interventions, programs, and policies that will promote uptake of modern contraceptive use in Ethiopia.

2. LITERATURE REVIEW

The contraceptive prevalence in many developing countries rose from 9% in the 1960 to 60% in 1997 (25). According to the first Ethiopian national survey on fertility and family planning in 1990, fewer than 2.9% of currently married women were using modern contraceptive methods, it has doubled in a decade and is estimated at 6 % (26). In the 2019 mini EDHS, 41% of married women reported use of modern contraceptive methods that were much higher than the 2000's and 2005's Ethiopian Demographic Health Survey that was 8 and 14%, the further increment was seen in 2011's DHS survey around 27.3% and about 34.9% in 2016 (8).

Various studies in Ethiopia have revealed several relevant socio-economic, demographic, and cultural factors. Yet, most studies used the traditional analysis method to determine the relationship, and most of them were done based on restricted samples, limited data, or inadequate methods. Thus the previous studies on modern contraceptive use may not represent the whole country; because most contraceptive studies in the country have been institution-based plus a large number of population-based studies were small-scale research, focusing on a few communities.

2.1. Determinants of Modern Contraceptive Use

2.1.1 Micro (women) level factors

Women's Age: The findings of the study in Bangladesh provide evidence that contraceptive use decreases with age, indicating older women are more reluctant to use contraceptives than their younger counterparts. This type of relationship between age and contraceptive use has been observed similarly to other existing studies (27-29). Recent evidence found in Ethiopia showed that the odds of using modern contraceptives was significantly lower among adolescent of age 15–19 and older women of age 40–49 compared to women in their 20's(30).Supporting this a Nigerian study identified that married women who belong to 15-24 years were more likely to use modern contraceptive methods compared to married women above 40 years of age (31). Likewise, older married women were found to be less likely than younger married women to use modern contraception methods in studies conducted in Ethiopia, Mali, and Nigeria (10, 21, 32).

Women's education level: Several studies approve that educated women are more likely to use contraceptives than uneducated women in Bangladesh, India, and Ethiopia (28, 33). Educated women are empowered, exercise their reproductive health rights, and are more likely to engage in professional and employment activities and more likely to use contraceptives to limit their desired number of children (28). Modern contraceptive use among currently married women increases with education from 31% for women with no education to 51% for women with secondary education or higher (7). However, after adjusting for selected covariates, a study done in Bangladesh found no significant difference in modern contraceptive use by level of education (34).

Parity: Evidence has shown that parity is positively correlated with both fertility and contraceptive use in several country-based studies (17, 27, 35, 36).

A study done in Nigeria revealed that married women with no children are less likely and those with 1-2 children are as likely to use modern contraceptives as those with 5 children or more respectively (32).On the other hand, a significant negative association was observed in several African countries at the individual level (37, 38).

Religion: Researchers found an association between religion and contraceptive use and revealed Christians are more likely to use contraception than Muslims in some African studies (23, 35, 39). Representative studies were done in Ethiopia and other parts of the world, in which Christian believers were more to use modern contraception than those in other religions. In contrast, Muslim religious believers were more likely to use modern contraception than those in other religions (40).

In general religious women are consistently less likely to use contraceptives overall, and the effect size is more than three times larger for artificial methods (43). Similarly, studies also revealed the effect of religion on modern contraceptive use (10, 27, 41, 42).

Marriage type: Monogamous respondents were more likely to use modern contraceptives than polygamous respondents (31). Findings in Ethiopia reported that women who had polygamous marriages were by half less likely to use modern contraceptive methods than women in monogamous marriages (11, 23).

Visits by health care worker*:* Findings from several studies revealed that women who were visited by health care providers were more likely to use modern contraceptives than their counterparts (23, 43). A study conducted in Ethiopia showed that the use of modern contraception was positively associated with being visited by a health care provider (23). In contrast, an Ethiopian and Nigerian study reported no association between being visited by health care workers and the use of modern contraception (36, 44).

Media exposure: The significance of individual media exposure to family planning messages is a determining factor for the reduced propensity of childbearing and higher odds of contraceptive uptake (21, 38, 45).Some studies in Ethiopia attest to the fact that the media positively influences the use of modern contraceptives among exposed women at least once a week compared to women without media exposure (11, 13, 17).

2.1.2 Macro (Community) level factors

Place of residence

Evidence supports that urban women tend to have higher utilization of modern contraceptives than their rural counterparts (46-49). In Nigeria, remarkable research findings revealed that women in rural areas were more likely than those in urban areas to seek out private contraceptive providers. It explained that due to a lack of healthcare facilities or services, there has been an increase in the number of private and unlicensed healthcare providers offering family planning services (50).

Community parity

According to the results of a Malian study on the multilevel analysis of the role of individual and community factors in the use of modern contraceptives among women in a union, women living in a community with a higher average number of births were less likely to use modern contraceptives. compared to women living in a community with a lower average number of births (21).On the other hand, A Nigerian study discovered no statistically significant association between the odds of using modern contraception and living in high mean parity communities (20).

Community Household size

Previous studies suggest that women living in communities where the large family size is the norm are less likely to use modern contraceptive methods (21, 51).

Community wealth

In Mozambique, South Africa, and Ethiopia community wealth showed a significant positive effect on the use of modern contraceptives (13, 38, 52). Similarly, it was found that women living in poor communities were less likely to report modern contraceptive use than those living in wealthier communities in a study done in ten European and Asian countries (53).Furthermore, the contextual effects of community wealth were greater in rural areas than in urban areas (52). In contrast, results of multilevel logistic regressions performed in two Nigerian studies revealed that community wealth status where a woman resides doesn't have significant relation with her use of modern contraceptives (20, 31).

Community education

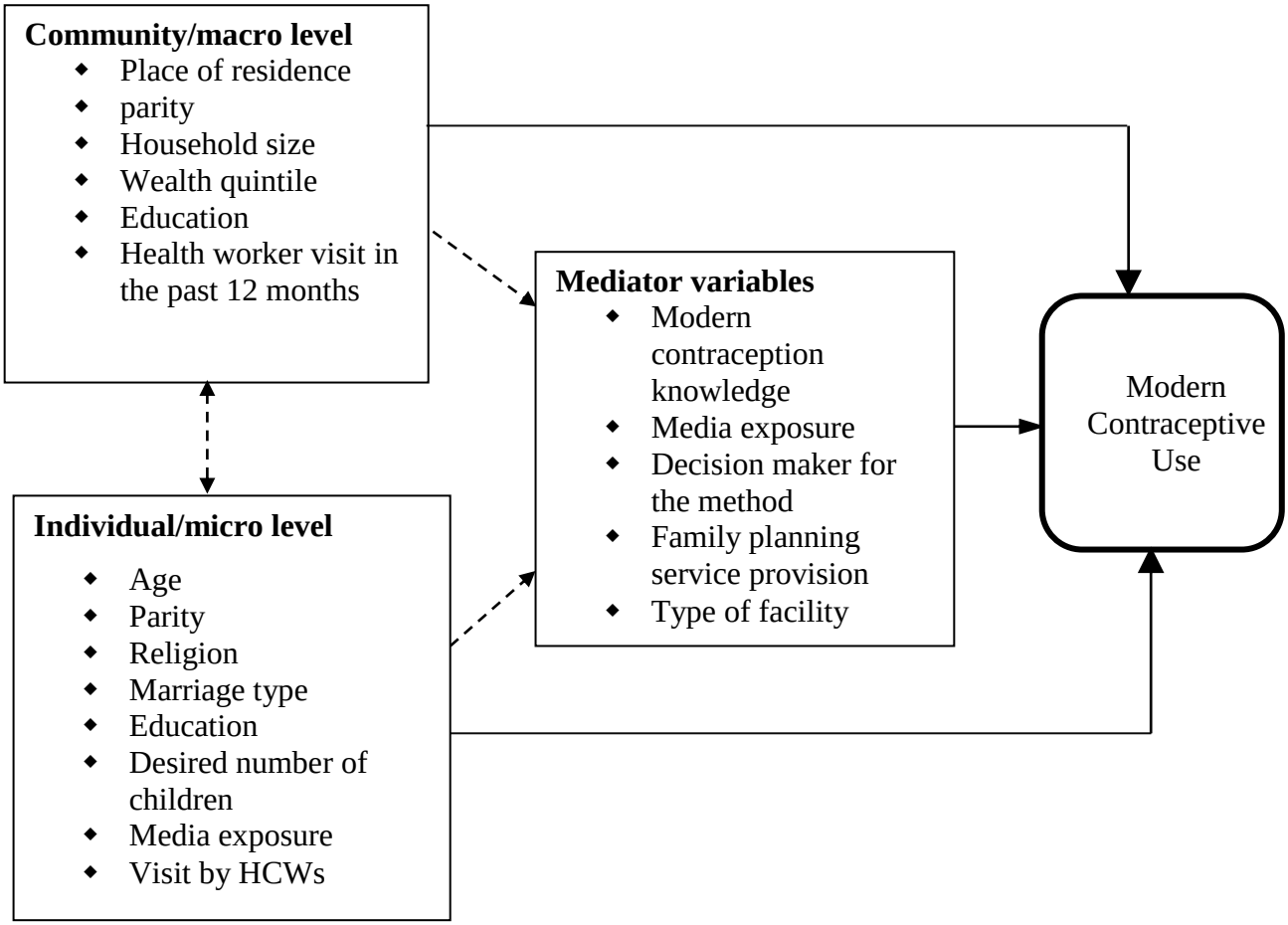
Aggregate education influences other pathways that have an impact on modern contraceptive use. Some countries, including Niger, Namibia, and Senegal, have seen a positive impact from at least primary education at the community level (54, 55). Conversely, community-level education was found to have no influence on modern contraceptive use beyond individual-level education in Zimbabwe and other several Eastern, Northern, Middle, Southern, and Western African countries (38, 47).

Community visit by a health care worker

The likelihood of modern contraceptive use for each woman in the community increased as the percentage of community members who had been visited by CHW concern increased (56).

2.2Conceptual framework

The conceptual framework for this study is organized based on reviewed literature. Factors which determine the use of modern contraceptive are organized into two major categories; community/macro level factors and individual/micro level factors.



- The broken arrows are used to indicate relationships between variables, but will not be evaluated for this study.

Figure 1- Conceptual framework of the individual and community-level factors of modern contraceptive use (19, 32, 36)

3. OBJECTIVES

3.1. General Objective

To identify determinants of modern contraceptive utilization among married women of reproductive age group in Ethiopia

3.2. Specific objectives

1. To assess individual factors associated with modern contraceptive use among married women living in Ethiopia,
2. To assess community factors associated with modern contraceptive use among married women living in Ethiopia,
3. To determine variability in modern contraceptives use among married women within and between communities of Ethiopia,
4. To identify the factors that explains the variability in modern contraceptive use among married women between and within communities.

4. METHODS AND MATERIALS

4.1. Study Area

Ethiopia is the 12th most populous country in the world and the second-most populous country in Africa after Nigeria, with a current population of around 115 million, according to the most recent estimates by the United Nations. The areal coverage for Ethiopia is currently 1,104,300 km^2. The population of Ethiopia is growing by around 2.7% per year(57).

Ethiopia is now home to ten regional states (including Amhara, Oromia, Southern Nations, Nationalities and Peoples' Region, Tigray, Afar, Somali, Benishangul-Gumuz, Gambella, and Harari) and two administrative cities (Addis Ababa and Dire Dawa). Only twenty percent of the population resides in urban areas. Ethiopia has close connections with the major Abrahamic religions; including Christianity who makes up 63% of the country's population and Muslims account for 34% of the population (4).

Women make up 49.5% and men make up 50.5% of the total Ethiopian population (58). Women of reproductive age between 15 and 49 constitute 23.4% of the total population. Ethiopian women have most of the responsibility for childbearing and managing family affairs. They are underrepresented in socio-economic, educational, leadership, managerial and political roles that are thought to result in poor health outcomes for women in Ethiopia(4, 59).

4.2 Study design

The thesis is based on an analysis of the 2018 Performance Monitoring Accountability (PMA) survey, which is a cross-sectional community-based study.

4.3. Source population

The source populations for particular study are married women aged 15-49 years in Ethiopia.

4.4. Study unit

The study populations are married women aged 15-49 years who were members of conventional households in enumeration areas chosen for the PMA2018 survey.

4.5. Inclusion and Exclusion criteria

4.5.1. Inclusion criteria: - Currently married women between the ages of 15 and 49 years who were usual residents of conventional households or visitors who stayed a night before the survey date in the household (women who slept in the household the night before) were included in this study.

4.5.2. Exclusion criteria:-All women who reported pregnancy during the survey were excluded from the analysis.

4.6. Sampling procedure

The Ethiopian PMA 2020 a sixth round done in 2018 sample survey was stratified and used a two-stage cluster design with urban-rural and major regions as strata. It used the same size of 221 enumeration areas. In each enumeration area, 35 households (HHs) were randomly selected. HHs with eligible women of reproductive age were interviewed from June to JULI 2018. In this study, a total of 3706 eligible women were included after the necessary exclusion criteria were carried out and the selection procedure is schematically presented in Figure 2 below.

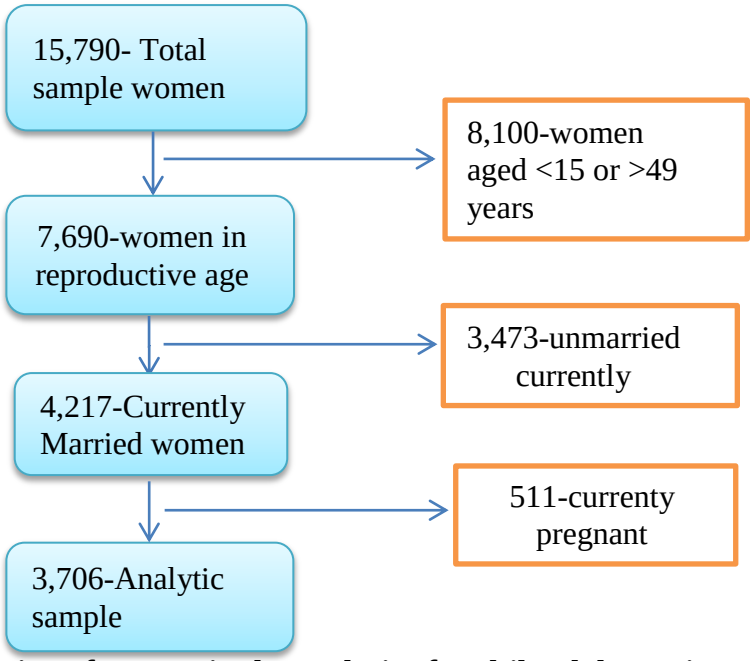


Figure 2- Schematic presentation of women in the analysis of multilevel determinants of MCU among married women in Ethiopia, PMA 2018

4.7. Study Variables

4.7.1. Dependent Variable

The outcome variable of interest in this study is the current use of modern contraceptive methods.

4.7.2. Independent Variables

To explain the variability in the current use of modern contraceptive methods, the following two-levels of independent variables were selected based on previous literature and availability of them in the PMA2018/Ethiopia Round 6 dataset. Variables are broadly classified into two main groups, individual-level and community-level factors aligned for the multilevel analytic approach.

Individual-level variables

These include women's age, education level, religion, region, marriage type, marital frequency, parity, desired number of children, household size, wealth quintile, media exposure, knowledge, health facility visit & being visited by health care workers (HCWs) in the prior 12 months.

Community-level independent variable

The community-level factors were residence (rural and urban), community parity, community household size, community wealth, community education, and community visit by HCWs.

4.8. Operational definition

Modern contraceptive methods: include injectable, intrauterine devices (IUDs), contraceptive pills, implants, female and male condoms, sterilization, standard days method, lactational amenorrhea method, and emergency contraception (7).

Multilevel Analysis: An analytical approach that is appropriate for data with nested sources of variability that is, involving units at a lower level or micro-units (individuals) nested within units at a higher level or macro units (clusters). Multilevel analysis allows the simultaneous examination of the effects of group-level and individual-level variables on individual level outcomes while accounting for the non-independence of observations within groups (60).

In this study the independent variables were grouped into individual level and community-level factors.

Individual-level variables

The independent variables at the individual level are the age of the woman measured at the time of the survey, the level of education of the woman, defined as the highest level of school achievement, religion, region, marital frequency that is grouped into once and more than once, respondents' marriage type, classified into monogamy and polygamy.

The PMA 2018 survey wealth index was calculated by weighing and attributing scores constructed from a principal components analysis of household assets and construction characteristics and then divided into five classes of wealth: lowest, lower, middle, higher and highest. The survey data classified the main source of drinking water into improved and unimproved. Household size was categorized into having less than (<5) or greater than or equal to (>=5) household members.

Parity, or the woman's number of live births, is categorized as 0, 1–2, 3–4, and 5 or more births. Media exposure, defined as exposure to a contraceptive message at least via one of the media (television, radio, newspaper, and phone). A respondent's knowledge is considered if she has ever heard about at least one of modern methods, visiting health facility, being visited by a health care worker in the prior 12 months, partner awareness of contraceptive use, & decision-maker for contraception.

Community-level independent variable

In this study, communities (macro-levels); are defined using clusters/enumeration areas (EA). The community-level factors were residence (rural and urban), community parity, community household size, community wealth, community education, and community visit by HCW.

The mean number of parity in a community was computed by averaging the total number of parity in each cluster then categorized into two groups: community with above the mean parity, which had a value of 2(high), and below the mean parity, which had a value of 1(low). The mean number of household size in the woman's cluster of residence: was computed by averaging the total number of household sizes to women in each cluster, was divided into two categories, communities with the above mean household size which had a value of 2(high) and below the mean household size, which had a value of 1(low).

Community wealth was classified based on the wealth index of the household in each cluster. The median value of the wealth index was 3. Then the aggregated clusters were classified into low if the median value of the community was below 3 (the lower and lowest wealth quintile) and high if the median value of the community was greater than or equal to 3(the middle, the higher, and highest wealth quintile)

For the variable community education, the aggregated clusters were classified into low if the median value of the cluster was below 2, educational attainment below secondary level, and high if the median value of the cluster was greater than or equal to 2 an educational attainment at least secondary level.

Table 1- Definition and categorization of individual and community level independent variables used in the analysis

Variable Name	Levels of measurement	Categorization/ Operational Definition
Individual-level		
Age	Ordinal	15-19, 20-24, 25-29, 30-34, 35-39, 40-44, and 45-49 years
Educational attainment	Ordinal	No education, primary, secondary, technical and higher education
Religion	Categorical	Orthodox, Catholic, Protestant, Muslim, Traditional, and others.
Marital frequency	Categorical	Once/more than once
Marriage type	Categorical	Monogamous/polygamous
Parity	Categorical	0(Null), 1-2, 3-4, 5+
Household size	Categorical	<5, >=5
Wealth status	Categorical	Lowest, Lower, Middle, Higher, Highest quintile
Main source of drinking water	Categorical	Unimproved, Improved
Visited by HCW	Categorical	No, Yes
Visited a HF	Categorical	No, Yes
Media exposure	Categorical	No, Yes
MCM knowledge	Categorical	No, Yes
Community-level		
Place of residence	Categorical	1. Urban 2. Rural
community parity	Categorical	1. Low 2. High
community HH size	Categorical	1. Low 2. High
community wealth	Categorical	1. Low 2. High
community education	Categorical	1. Low 2. High
Community visit by HCW	Categorical	1. Low 2. High

4.9. Data source

PMA2020 surveys use a multi-stage stratified cluster design to draw a probability sample of households and females of childbearing age. They constitute a large-scale, nationally representative survey platform that is currently fielded in eleven geographies across Asia and Africa. Datasets are made publicly available within six months of data collection via www.pma2020.org. The Ethiopian PMA cross-sectional survey of all women ages 15–49 years is a nationally representative household survey, focusing on family planning and reproductive health behaviors. The data from the PMA2018 survey used a two-stage cluster design with urban-rural, major groups as strata. This survey round used the 221 enumeration areas (EAs), with 35 households chosen for each EA. systematic random selection was used to sample households. An individual questionnaire was used to conduct interviews with eligible females of reproductive age from selected households. Final sample included 7,621 households and 7,429 de facto females. Data collection took place over a four-month period from June to July 2018.

4.10. Data processing and analysis

Variables in the data set have been selected, re-categorized, re-coded, and analyzed using STATA version 15.

There were some inconsistencies as a result of the use of this secondary data. Following a review of the data, it was discovered that there were significant missing values in certain variables, and the sample size was insufficient to perform logistic regression analysis without accounting for missing values. The problem of missing data was addressed using the multiple imputation techniques including all analysis variables under the assumption that missing values are missing at random (53). Stata 15's 'mi imputes chained' command generated 20 imputed datasets, and visual inspection of imputation convergence led to the very conservative choice of 15 burn-in iterations (53).

Imputed values compare reasonably to observed values, and results using list-wise deletion are similar to MI, It has been noted that it is effective in dealing with missing data in a large dataset. The reason for using multiple imputation techniques for dealing with missing data is because of its improved performance over alternative approaches. A simple logistic regression model was used in bivariate analysis because the dependent variable was dichotomous and coded as yes or no (54).

The analysis started from simple descriptive statistics such as frequencies and proportions were demonstrated then a bivariate logistic regression was applied at last multi-level logistic regression analysis was done. We utilized sampling weight to minimize bias plus to compensate for the unequal probability of selection. The variables with a p-value of less than or equal to 0.25 at the bivariate logistic regression analysis were included in the multi-level logistic regression model. The odds ratio with 95% confidence intervals was estimated to identify independent variables of modern contraceptive use. P-values less than 0.05 were declared to be statistically significant. The fixed and random effects were calculated to assess the within and between community variations.

LOGISTIC REGRESSION MODEL

Because the dependent variable is binary and coded as 0 and 1 different assumptions are made in logistic regression than are made in OLS regression.

The goal of logistic regression is to estimate the K +1 unknown parameters also called coefficient (β). This is done with maximum likelihood estimation which entails finding the set of parameters for which the probability of the observed data is greatest. The most effective and well-known Newton-Raphson iterative method was used to solve the equations and the estimated coefficients are denoted by $\beta_0, \beta_1 ... \beta_k$ (61).

Then the logit or log-odds of having Y=1 is modeled as a linear function of the explanatory variables. Where β_0 is a constant of the equation and; $\beta_1 \ldots, \beta_k$ are the coefficients of the predictor variables.

The estimated logistic coefficient β (betas) are interpreted as the change in the log-odds for every unit increase/decrease (depending on the variable change in x_i) holding other predictors constant(62). Then the odds ratio was defined as the ratio of the probability that the event will occur to the probability that the event will not occur. That is, the odds of the event E (in this case the odds of currently using modern contraceptive methods, Y_i =1) is given by

$$\text{Odds}(E) = \frac{P(E)}{1 - P(E)}$$

MULTILEVEL MIXED EFFECT REGRESSION MODELS

Multilevel logistic regression is used to predict a binary dependent variable from a set of independent variables. In this thesis, we used a two-level logistic regression model to compare and analyze the effect of socio-economic, demographic, and reproductive health-related variables on modern contraceptive use among women and to estimate any residual correlations across the communities in estimating the current use of modern contraceptive methods. The current modern contraceptive use (MCU) predictors are chosen based on their established theoretical importance in literature and the conceptual framework.

A two-level structure is used in the multilevel analysis, with community/Enumeration area (EA) as the second-level units and respondent women as the first-level units. Based on the 2018 PMA survey data, the data has a hierarchical structure, that individuals (women) were nested in clusters.

The probability of the binary outcome to be one is defined as P_{ij} = Pr (y_{ij}=1) where P_{ij} is modeled using a logit link function. With the standard assumption that Y_{ij} is binary distributed, the multilevel logistic model can be written as

$$\text{Log}\,[P_{ij}/(1-P_{ij})] = \beta_0 + \beta_1 X_{ij} + \ldots.. \beta_n X_{nij} + U_{0j}$$

Where the same assumptions as in the case of multilevel logistic models apply to 'u' the random effect is assumed to be normally distributed, where

✓ P_{ij} -the probability of women who are currently using modern contraceptives

✓ 1 - P_{ij} - the probability of not using modern contraception

✓ β_0 is the intercept coefficient

✓ $\beta_1 \ldots. \beta_n$- the amount of effect by the individual and community level variables

✓ $X_1 \ldots X_n$ - the independent variables at individual and community level, and

✓ U_{0j} - the random error at community level

Fixed effects (measures of association)

The fixed estimates were measured by odds ratios (OR) with 95% confidence interval (CI) for the binary dependent variable, current modern contraceptive use.

Random effects (measures of variation)

The estimated between-community/cluster variance quantified the variability in unobserved influences on MCU of women living in the same community. It examines assumptions about whether the variance of intercept or slopes (or their covariance) is significantly different from zero.

Intra-class correlation coefficient (ICC)

Variations can be interpreted in terms of intra-class correlations in a latent variable, reflecting unobserved factors shared in the same group among women. The ICC is used to measure the extent to which individuals within the same group are more similar to each other than to individuals from different groups.

The intra-class correlation (ICC) was calculated as the proportion of the between community variation in the total variation:

ICC= $\frac{\text{Var (U0j)}}{\text{Var u0j} + \pi^2/_3}$

Where

- Var (U_{0j}) is the community level variance.
- $\pi^2/_3$ is the standard logistic distribution, that is, the assumed community variance component, which is ≈ 3.29

Goodness of Fit Test

1. Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC)

The AIC (Akaike Information Criterion) and the BIC (Bayesian Information Criterion) are two popular measures for comparing maximum likelihood models. AIC and BIC can be viewed as measures that combine fit and complexity. The larger the value, the worse the fit is. Given two models fit on the same data, the model with the smaller value of the information criterion is considered to be better (63, 64).

2. Likelihood Ratio Tests for Multiple Parameters

The likelihood ratio test compares the deviance (-2 log-likelihood) of two models by subtracting the smaller deviance (model with more parameters) from the larger deviance. The difference is a chi-square test with the number of degrees of freedom equal to the number of different parameters in the two models.

Any number of parameters can be compared in the two models. In the case the empty model is compared with the last model, the likelihood ratio test provides information about whether the predictors in the model together account for a significant amount of variance in the dependent variable.

The Random intercept (Empty) Multilevel Logistic Regression Model

For a dichotomous outcome variable empty two-level model refers to a population of groups (level-two units) and specifies the probability distribution for group-dependent probabilities without taking any explanatory variables into account. The model that specifies the transformed probabilities f (p) to have a normal distribution is the focus of this paper. This is expressed, for a general link function f (p), by the formula $f(p) = \beta + U$, where β is the population average of the transformed probabilities and U is the random deviation from this average for group j. If f (p) is the logit function, then f (p) defines the log-odds for group j. Thus, for the logit link function, the log-odds have a normal distribution in the population of groups, which is expressed by:

$\text{Logit}(p) = \beta_0 + U_{0j}$

For the deviations $U_{0j}$are assumed to be independent random variables with a normal distribution with mean zero and variance (65).

The Random Intercept with Fixed Coefficient Multilevel Logistic Regression Model

In this model, the intercept is the only random effect meaning that the groups differ concerning the average value of the response variable. It represents the heterogeneity between groups in the overall response. The logistic random intercept model expresses the log-odds i.e. the logit of Pij, as a sum of a linear function of the explanatory variables and a random group-dependent deviation U0j.

$\text{Log}[P_{ij}/(1-P_{ij})] = \beta_0 + \beta_1 X_{ij} + \ldots. \beta_n X_{nij} + U_{0j}$

Thus, a unit difference between the X_n values of two individuals in the same group is associated with a difference of βn in their log-odds, or equivalently, a ratio of exp (βn) in their odds.

Comparing odds for individuals in the same group; U_{0j} is the effect of being in group j on the log-odds that y = 1 also known as a level 2 residual, the level 2 (residual) variance, or the between-group variance in the log-odds that y = 1 after accounting for x (65).

The Random Coefficient Multilevel Logistic Regression Model

We've let the probability of MCU vary across communities till now, assuming that the effects of the explanatory variables are consistent across communities. This assumption got altered by allowing the difference between explanatory variables within a community to differ across communities. We needed to add a random coefficient to the explanatory variables to account for this effect. So, a random coefficient model represents heterogeneity in the relationship between the response and explanatory variables.

$\text{Log}\,[P_{ij}/\,(1\text{-}P_{ij})] = \beta_0 + \beta_1 X_{ij} + U_{0j} + U_{1j} X_{ij}$

A new term $U_{1j}X_{ij}$is added to the model and a '0' subscript to the intercept residual. Also as before, the random effects U_{0j} and U_{1j} are assumed to follow normal distributions with zero means, variances $\sigma u_{02}$and σu_{12} respectively, and covariance σu_{01}.

The slope of the linear relationship between x and the log-odds that Y = 1 is $\beta 1 + U_{1j}$for group j. The covariance between the random effects, σu_{01}, is the covariance between the group intercepts and slopes.

4.11. Ethical consideration

Ethical approval was obtained from the Research Ethics Committee of the School of Public Health and the Institutional Review Board of the College of Health Sciences of Addis Ababa University to carry out this study. Upon receipt of the approval letter, Permission to use the survey data for this study was obtained from the PMA2020 to be undertaken in this study. The data can be downloaded from the website and are free to be used by researchers for further analysis after the written request form has been submitted and permission has been granted.

The study used the existing data of the PMA survey in Ethiopia. PMA Ethiopia received ethical approvals from Addis Ababa University, the College of Health Sciences (AAU/CHS), and the Johns Hopkins University Bloomberg School of Public Health (JHSPH) Institutional Review Board. The survey follows national and international ethics procedures and protocols for the collection of data from human beings. The objectives of the survey were explained to the participants. The anonymity and confidentiality of the results of the participants have been ensured. Participation in the data collection process was voluntary and the information that led to the identification of individuals was deleted.

4.12. Dissemination plan

After submission, and approval of the final document to Addis Ababa University, School of Public Health of the findings of the study will be presented. Furthermore, steps will be taken to present research in various seminars, workshops, and to publish in national or international reputable journals.

5. RESULT

5.1 Background Characteristics

Background characteristics of respondents are presented below at both individual and community levels. The weighted sample of 3655 married and non-pregnant women of reproductive age in 220 clusters were included.

Individual-level socio-demographic characteristics

The majority of the women 1491(40.8 %) were orthodox Christians. Half of whom had no education, one-third of whom, and nearly 43.6% of whom had at least secondary education. 9.6 % of the married women in the sample were in a polygamous marriage. Approximately half of respondents were from poor households, while 37% were well-off (19.3% higher and 17.7% highest quintile). Seventy-five percent of women lived in a house with an improved source of drinking water. Slightly more than half (56%) of respondents were members of a household with <5 members. More than 8 in 10 women lived in rural areas. By region, 40.5% lived in Oromia, followed by about a quarter in Amhara, then about one-fifth in SNNPR.

Table 2-Socio-demographic characteristics of study women of reproductive age in Ethiopia, 2018PMA

Variable	Categories	Weighted (%)	Unweight (%)
Age of women	15-19	219(6.0)	192(5.18)
	20-24	571(15.6)	588(15.87)
	25-29	824(22.5)	865(23.34)
	30-34	687(18.8)	699(18.86)
	35-39	630(17.2)	657(17.73)
	40-44	408(11.2)	404(10.9)
	45-49	316(8.64)	301(8.12)
Religion	Ethiopian orthodox	1491(40.8)	1758(47.45)
	Catholic	27(0.74)	16(0.43)
	Protestant	837(22.9)	720(19.43)
	Muslim	1242(34)	1177(31.77)
	Traditional believers	45(1.2)	24(0.65)
	Other	12(0.3)	10(0.27)
Region	Tigray	197(5.3)	502(13.55)
	Afar	48(1.3)	165(4.45)
	Amhara	941(25.8)	708(19.1)
	Oromia	1483(40.5)	959(25.88)
	Somali	24(0.6)	82(2.21)
	Ben-Gumz	70(1.9)	104(2.81)
	SNNP	738(20.2)	771(20.8)
	Gambella	12(0.33)	31(0.84)
	Harari	9(0.25)	30(0.81)
	Addis Ababa	121(3.33)	319(8.61)
	Dire Dawa	12(0.33)	35(0.94)
Education	No education	1852(50.6)	1571(42.39)
	Primary	1310(35.9)	1251(33.76)
	Secondary	280(7.7)	460(12.41)
	Technical school	135(3.7)	251(6.77)
	Higher education	78(2.1)	173(4.67)
Marital frequency	Once	2996(82)	3093(83.46)
	More than once	659(18)	613(16.54)
Marriage type	Monogamous	3286(89.9)	3346(90.2)
	Polygamous	353(9.65)	343(9.2)
Main source of drinking water	Unimproved	905(24.8)	620(19.73)
	Improved	2750(75.2)	3086(83.27)
Wealth quintile	Lowest quintile	801(22)	594(16.03)
	Lower quintile	770(21)	571(15.41)
	Middle quintile	732(20)	540(14.57)
	Higher quintile	704(19.3)	681(18.38)
	Highest quintile	648(17.7)	1319(35.6)
HH size	<5	2047(56.03)	2269(61.23)
	>=5	1607(43.97)	1437(38.77)

Respondent women's reproductive health characteristics

In this study, 30.2% of the women had low parity (1-2 live children), while 37.2% had a high parity (5 or more live births). About 74% of women reported waiting for years for the next child, while twenty percent wanted their child soon. Meanwhile, 45.4% women in this study reported the use of contraceptives to delay or avoid pregnancy in Ethiopia of which 42.9% reported the use of modern contraceptive methods. Injectable was the most commonly used modern contraception (64.5%). Eighty-five percent of women discussed contraceptive use with their partners, 66% of the respondents reported a joint decision to use modern contraceptives. More than 90 % of women obtained the method they desired to use. Out of the respondents, women who reported exposure to contraceptive messages through media accounted for 61.3%.

Table 3- Reproductive health characteristics of study women of reproductive age, Ethiopia, 2018 PMA

Variable	Categories	Weighted (%)	Unweight (%)
Ever have given birth	No	297(8.13)	330(8.9)
	Yes	3358(91.87)	3376(91.1)
Parity	0	297(8.1)	330(8.9)
	1-2	1104(30.2)	1331(35.91)
	3-4	894(24.5)	913(24.64)
	>=5	1360(37.2)	1132(30.55)
Desire for (more)child	Don't know	233(6.39)	236(6.37)
	Desire for child	2231(61.03)	2435(65.7)
	No desire for child	1095(29.96)	941(25.39)
	Infertile	96(2.62)	94(2.54)
Waiting time to next child	Months	135(3.7)	127(3.43)
	Years	2735(74)	2704(72.96)
	Soon	749(20.5)	836(22.56)
	Infertile	22(0.6)	27(0.73)
	Other	14(0.3)	12(0.32)
Ever have unwanted pregnancy	No	2957(80.9)	3026(81.7)
	Yes	695(19.1)	677(18.3)
Terminated unwanted pregnancy	No	3643(94.8)	3457(93.3)
	Yes and succeeded	95(2.6)	137(3.7)
	Yes and failed	75(2.06)	85(2.3)
MCM knowledge	No	18(0.49)	33(0.89)
	Yes	3637(99.5)	3673(99.11)
Media exposure about contraceptives	No	2241(61.31)	1896(51.16)
	Yes	1414(38.69)	1810(48.84)

Table 3- Reproductive health characteristics of study women of reproductive age, Ethiopia, 2018 PMA (Continued)

Variable	Categories	Weighted (%)	Unweight (%)
Ever used contraceptive	No	1120(30.6)	1038(28.01)
	Yes	2535(69.4)	2668(71.99)
Currently using any contraceptive method	No	1996(54.6)	1991(53..4)
	Yes	1659(45.4)	1704(46.6)
Current MCU	No	2089(57.1)	2059(56.33)
	Yes	1566(42.9)	1596(43.67)
Type of used MCM	Female sterilization	24(1.49)	18(1.11)
	Implants	408(25.8)	424(26.2)
	Intra uterine device	40(2.48)	62(3.83)
	Injectable	1037(64.5)	956(59.1)
	Oral Pill	77(4.79)	122(7.5)
	Emergency pill	3(0.18)	7(0.43)
	Male condom	5(0.31)	12(0.74)
	Standard days	8(0.49)	7(0.43)
	LAM	8(0.49)	7(0.43)
Number of children at first use	0	582(22.4)	714(27.13)
	1-2	1054(40.6)	1157(43.96)
	3-4	502(19.4)	428(16.26)
	>=5	454(17.5)	333(12.65)
Partner aware of contraceptive use	No	334(9.14)	305(8.23)
	Yes	3321(90.86)	3401(91.77)
Discussion with a partner	No	540(14.77)	507(13.68)
	Yes	3115(85.23)	3199(86.32)
Provider told about side effects	No	2044(55.93)	2084(56.23)
	Yes	1611(44.07)	1622(43.77)
Provider gave instructions to side effects	No	856(23.41)	864(23.31)
	Yes	2799(76.59)	2842(76.69)
Decision to use contraceptive	Respondent's	1081(29.57)	1093(29.49)
	Husband	127(3.47)	106(2.86)
	Joint decision	2427(66.41)	2484(67.03)
	Other's	20(0.56)	23(0.62)
Final decision about the method	Respondent's only	1977(54)	2038(54.99)
	Provider	133(3.6)	121(3.26)
	Husband	144(3.9)	149(4.02)
	Respondent and provider	193(5.2)	173(4.67)
	Respondent and partner	1205(33)	1219(32.89)
	Others	3(0.3)	6(0.16)
Visited by HCW in the prior 12 months	No	2962(81.05)	2980(80.41)
	Yes	693(18.95)	724(19.54)
Visit a health facility in the prior 12 months	No	1439(39.4)	1252 (33.8)
	Yes	2216(60.6)	2454(66.2)

Community-level characteristics

The description of the variables at the community-level is presented in Table 4. A total of 220 clusters had married and non-pregnant women of reproductive age-eligible for modern contraceptive utilization, included in this study. More than half of the clusters came from rural areas, communities with parity above the mean accounted for 41.8%. More than 70% of communities live in at least the middle wealth quintile. Compared to the average education level, 75% of the communities had lower educational attainment. More than half of the groups had fewer visits from health professionals.

Table 4- Background characteristics of clusters by community-level variables among study women in Ethiopia, 2018 PMA (n=220)

Variable	Categories	Weighted (%)
Place of residence	Urban	109(49.5)
	Rural	111(50.5)
Community parity	Low	128(58.2)
	High	92(41.8)
Community HH-size	Low	125(56.8)
	High	95(43.2)
Community wealth	Low	63(28.7)
	High	157(71.3)
Community education	Low	165(75)
	High	55(25)
Community visit by HCW	Low	124(56.4)
	High	96(43.6)

5.2Result of Bivariate Logistic Regression Analysis

The effect of each independent variable on women's modern contraceptive use was examined using bivariate logistic regression. Accordingly, a woman's age, educational level, religion, region, type of marriage, wealth status, parity, media exposure, a visit by HCW, and visits to HF became significant predictors of MCU.

Table 5-Bivariate Logistic Regression Analysis of Predictors of Modern Contraceptive Use among married women of reproductive age group in Ethiopia, 2018 PMA.

Variable	Categories	OR	P-value	95%C.I. Lower-Upper
Age of women	15-19 (ref)			
	20-24	1.26	0.16	0.9-1.7
	25-29	1.41	0.03	1.02-1.94
	30-34	1.19	0.27	0.86-1.6
	35-39	0.86	0.375	0.61-1.19
	40-44	0.57	0.003	0.40-0.82
	45-49	0.21	0.001	0.14-0.33
Education	No education (ref)			
	Primary	1.92	0.001	1.64-2.24
	Secondary	3.25	0.001	2.62-4.03
	Technical school	2.81	0.001	2.13-3.69
	Higher level	2.06	0.001	1.49-2.84
Religion	Orthodox (ref)			
	Catholic	1.58	0.37	0.57-4.3
	Protestant	1.04	0.59	0.88-1.24
	Muslim	0.35	0.001	0.3-0.41
	Traditional believer	0.13	0.001	0.04-0.45
	Other	0.27	0.104	0.05-1.3
Region	Tigray (ref)			
	Afar	0.13	0.001	0.07-0.23
	Amhara	1.51	0.001	1.20-1.91
	Oromia	0.77	0.024	0.62-0.96
	Somali	0.23	0.001	0.12-0.43
	Ben-Gumz	0.86	0.49	0.55-1.32
	SNNP	1.55	0.001	1.23-1.95
	Gambella	1.44	0.32	0.69-2.98
	Harari	0.57	0.193	0.24-1.32
	Addis Ababa	1.49	0.006	1.12-1.97
	Dire Dawa	0.81	0.583	0.38-1.7
Marital frequency	Once (ref)			
	More than once	0.762	0.003	0.637-0.91
Marriage type	Monogamous (ref)			
	Polygamous	0.47	0.001	0.37-0.60
Wealth quintile	Lowest quintile (ref)			
	Lower quintile	1.18	0.183	0.92-1.51
	Middle quintile	1.24	0.085	0.96-1.59
	Higher quintile	2.16	0.001	1.71-2.72
	Highest quintile	2.53	0.001	2.05-3.11
Main source of drinking water	Unimproved (ref)			
	Improved	2.33	0.001	1.93-2.82
HH size	<5 (ref)			
	>=5	0.65	0.001	0.56-0.74

Table 5-Bivariate Logistic Regression Analysis of Predictors of Modern Contraceptive Use among married women of reproductive age group in Ethiopia, 2018 PMA. (Continued)

Variable	Categories	OR	P-value	95%C.I. Lower-Upper
Parity	0 (ref)			
	1-2	1.94	0.001	1.51-2.49
	3-4	1.35	0.023	1.04-1.75
	>=5	0.78	0.065	0.60-1.01
Visit by HCW	No(ref)			
	Yes	1.25	0.007	1.06-1.47
Visited health facility	No (ref)			
	Yes	1.88	0.001	1.63-2.17
Waiting time to next birth	Months(ref)			
	Years	3.47	0.001	2.14-5.61
	Soon	0.31	0.001	0.18-0.54
	Infertile	1.0	-	-
	Other	0.64	0.59	0.125-3.26
Media exposure	No (ref)			
	Yes	1.45	0.001	1.27-1.65

5.3 Result of Multilevel Mixed Effect Logistic Regression Analysis

5.3.1 Model building for multilevel logistic regression analysis

The model series started with an empty model with a random effect and no covariates, we then modeled random effect and a fixed coefficient covariate. Lastly, a random coefficient multilevel logistic regression model with the random effects was analyzed.

5.3.2 Multilevel logistic regression model comparison

The study employed AIC, BIC and deviance based chi square to compare the fitted multilevel logistic regression models. The AIC value of the empty model with random intercept (AIC = 4685.88) is larger than the random intercept and fixed coefficient model (AIC = 4251.16), which implies that random intercept and fixed coefficient model is better than the empty model with random intercept in predicting modern contraceptive use across communities. The AIC value of the random coefficient model (AIC = 4255.04) is smaller than the random intercept and fixed coefficient model implying that random coefficient model is better compared to the random intercept and fixed coefficient model in describing modern contraceptive utilization status (see Table 6).

Furthermore, the significant deviance-based chi-square value for random coefficient model indicates that the random coefficient model is better regression models in explaining modern contraceptive use.

Table 6-Multilevel logistic regression models and their deviance-based chi-square test for modern contraceptive use among married women of reproductive age group in Ethiopia, 2018 PMA

Fitted Model	Multilevel Empty Model	Multilevel Random Intercept Model	Multilevel Random Coefficient Model
Deviance-Based Chi Squared Value	326.21	77.85	87.62
P-Value	<0.001	<0.001	<0.001
Model Fit Diagnostics			
AIC	4685.88	4251.16	4255.04
BIC	4698.3	4555.13	4583.83

AIC-Akaike Information Criterion, BIC-Bayesian Information Criterion

5.3.3 Multilevel Empty/ random intercept Logistic regression model analysis

The empty model is thought to be a parametric version of assessing community heterogeneity for modern contraceptive use. According to the result shown in the table below, the estimate of the fixed part of the model is -0.268 with a z-value of -3.67 and a P-value of <0.001 which implies that the odds of MCU is significantly different from zero. The odds of using modern contraceptive methods for an 'average' community (with $U_j = 0$) are estimated as exp (-0.26) = 0.77.

The variance estimate of random effects at the community level, 0.926 with SE of 0.066, (p-value=0.0226). Which implies that the between community variance of MCU is 0.926. The intra-class correlation coefficient (ICC) calculated for this model is 0.2068.The deviance-based Chi-square (x^2 = 326.21, d.f =1, p-value<0.001).

Table 7-Empty/ random intercept logistic regression model analysis for parameter estimates and effects on modern contraceptive use among married women of reproductive age group in Ethiopia, 2018 PMA.

Fixed part	Coefficient	S.E.	Z value	P value	OR	[95% CI]
β_0 = intercept	-0.268	0.073	-3.67	<0.001	0.76	0.66-0.88
Random part	Estimation	S.E.	Z value	P value		95% CI
Level2 variance, $\sigma^2_0=Var(U_{0j})$	0.926	0.066				0.80-1.06
Model fit diagnostics						
Deviance based Chi-square	326.21			<0.001		
AIC	4685.8					
BIC	4698.3					
ICC	20.6					

The intercept (β_0), also known as the grand mean, is common to all communities, whereas the random effect of level two residual (U_{0j}) is unique to community j.

5.3.4 Multilevel random intercept and fixed coefficient logistic regression model analysis

The random intercept with fixed coefficient logistic regression model includes individual-level explanatory variables and the aggregated community-level variables to account for their effects on modern contraceptive use. Among the individual-level variables women's age, educational level, religion, region, marital frequency, marriage type, parity, main source of drinking water, visit of health facility and wealth quintile were included, and all the six aggregate community-level variables were included in this model.

The fixed effect analysis showed that the age of a woman, women's educational status, religion, region, marriage type, wealth quintile, drinking water source, parity, media exposure and visiting a health facility were found to be significant individual level determinants of MCU in all communities. Among the community level variables community parity and community household size significantly predicted women's use of modern contraception with respect to the corresponding reference categories (see Table 8).

The model revealed that the likelihood of married women using modern contraceptives was significantly lowest in the older age groups 35-39 (OR=0.37; 95%CI: 0.23-0.60), 40-44(OR=0.22; 95%CI: 0.13-0.38) and 45-49 (OR=0.07; 95 % CI: 0.03-0.12) compared to the age group 15-19. When compared to uneducated women, married women with primary education were 30 percent more likely to use modern contraception (OR=1.30; 95 %CI: 1.05-1.60), and women with secondary education were 65 percent more likely than uneducated women to use modern contraception (OR=1.65; 95%CI: 1.24-2.30). Married women who were followers of Muslim religion and traditional believes were less likely to use modern contraceptives than those who were followers of orthodox religion with the (OR= 0.42; 95% CI: 0.33-0.54), (OR=0.1; 95% CI: 0.016-0.38) respectively.

Compared to married women in Tigray, married women in Amhara and Addis Ababa are 2.41and 1.66times more likely to use modern contraception (OR=2.41; (95% CI: 1.48-3.32), (OR=1.66; (95% CI: 1.04-2.71) respectively. Conversely, married women who lived in Afar are less likely to use modern contraceptives compared to women in Tigray (OR=0.25; 95% CI: 0.08-0.48) which was significant. Those women who are living in a polygamous marriage were 32 percent less likely to use modern contraceptives compared to women who are in a monogamous marriage. Women who had access to an improved source for drinking water were 57 percent more likely to use modern contraceptives than those who had not access (OR=1.57; 95% CI:1.08-1.96). Likewise, women in the higher and highest wealth quintiles are more likely to use modern methods compared with the women in the lowest (OR=1.57; 95% CI: 1.20-2.46), (OR=1.76; 95% CI: 1.26-3.04) respectively.

Parity was positively associated with MCU, having 5 or more live births were more likely to use modern contraceptives (OR=3.95; 95% CI: 2.55-6.11). The odds of using modern contraceptive methods were high among married women who visited a health facility compared with those who did not visit a health facility (OR=1.49; 95% CI: 1.25-1.79).

At the community level, compared to those who live in the urban community, women in a rural community (OR 1.83; 95% CI 1.17–2.85) had a higher likelihood of utilizing modern contraception. Women from a community with a higher mean parity were associated with lower odds of modern contraceptive use than women in communities with lower mean parity (OR: 0.67, 95% CI: 0.46-0.93). Women from communities with a higher mean HH size were less likely to use modern methods of contraception compared to those from communities with a lower mean HH size (OR: 0.65, 95%CI: 0.47–0.85).

The random intercept and fixed coefficient model revealed that the random effect's intercept variance was 0.59(SE= 0.061), whereas the variance of the intercept for the empty model was 0.926(SE= 0.066).

The variance of the intercept for the empty multilevel model decreased to the random effect of the intercept and fixed coefficient model, implying that the inclusion of fixed explanatory variables resulted in this reduction. Taking the fixed independent variables into account, then, can provide additional predictive value on modern contraceptive use in each community.

The significance of random effect intercept variance which is larger than its standard error indicates that there is significant community random effect variation on modern contraceptive use among women (see Table 8). This implies that there is still unexplained variation in modern contraceptive use across communities.

The outcome of this model ensures that the better the random intercept and fixed coefficient model is because of the lower the AIC and BIC values. The values of deviance based chi-square lead to a conclusion that the random effect at community level is significantly different from zero.

Table 8-Random intercept and fixed coefficients logistic regression model analysis for effects on modern contraceptive use among married women of reproductive age group in Ethiopia, 2018 PMA.

Fixed effect	Categories	OR	S.E.	P-value	95% C.I. Lower-Upper
Age of women	15-19 (ref)				
	20-24	0.80	0.17	0.31	0.53-1.22
	25-29	0.73	0.15	0.13	0.47-1.11
	30-34	0.61	0.14	0.03	0.38-0.98
	35-39	0.38	0.09	0.001	0.23-0.60
	40-44	0.23	0.06	0.001	0.13-0.38
	45-49	0.07	0.02	0.001	0.04-0.12
Education	No education (ref)				
	Primary	1.29	0.13	0.015	1.05-1.60
	Secondary	1.65	0.26	0.002	1.24-2.30
	Technical school	1.25	0.24	0.27	0.86-1.83
	Higher education	1.01	0.22	0.94	0.67-1.60
Religion	Orthodox (ref)				
	Catholic	1.64	1.09	0.38	0.5-6.0
	Protestant	0.96	0.13	0.82	0.73-1.27
	Muslim	0.42	0.05	0.001	0.33-0.55
	Traditional believer	0.10	0.06	0.005	0.02-0.38
	Other	0.23	0.2	0.11	0.03-1.31
Region	Tigray (ref)				
	Afar	0.25	0.09	0.002	0.08-0.48
	Amhara	2.41	0.45	0.001	1.48-3.32
	Oromia	1.52	0.31	0.04	0.99-2.24
	Somali	0.60	0.28	0.30	0.23-1.53
	Ben-Gumz	1.31	0.53	0.51	0.58-2.91
	SNNP	2.22	0.46	0.001	1.42-3.30
	Gambella	1.39	0.91	0.51	0.45-4.95
	Harari	1.21	0.88	0.77	0.37-4.88
	Addis Ababa	1.68	0.41	0.04	1.04-2.71
	Dire Dawa	1.71	0.79	0.38	0.37-4.31
Marital frequency	Once (ref)				
	More than once	0.82	0.096	0.10	0.65-1.03
Marriage type	Monogamous (ref)				
	Polygamous	0.67	0.10	0.01	0.49-0.92
Wealth quintile	Lowest quintile (ref)				
	Lower quintile	1.22	0.19	0.20	0.93-1.72
	Middle quintile	0.96	0.17	0.82	0.75-1.45
	Higher quintile	1.57	0.31	0.01	1.20-2.46
	Highest quintile	1.76	0.44	0.01	1.26-3.06

Table 8-Random intercept and fixed coefficients logistic regression model analysis for effects on modern contraceptive use among married women of reproductive age group in Ethiopia, 2018 PMA (Continued)

Fixed effect	Categories	OR	S.E.	P-value	95% C.I. Lower-Upper
Main source of drinking water	Unimproved (ref)				
	Improved	1.57	0.22	0.002	1.08-1.99
HH size	<5 (ref)				
	>=5	0.91	0.098	0.42	0.74-1.31
Parity	0 (ref)				
	1-2	2.4	0.37	0.001	1.75-3.26
	3-4	2.81	0.52	0.001	1.93-4.06
	>=5	3.95	0.86	0.001	2.55-6.11
Visit by HCW	No(ref)				
	Yes	1.11	0.12	0.32	0.90-1.38
Visited a health facility	No (ref)				
	Yes	1.49	0.13	0.001	1.25-1.79
Media exposure	N0 (ref)				
	Yes	1.17	0.11	0.09	0.98-1.44
Place of residence	Urban (ref)				
	Rural	1.82	0.35	0.007	0.89-2.32
Community parity	Low (ref)				
	High	0.67	0.11	0.03	0.46-0.93
Community HH size	Low(ref)				
	High	0.65	0.096	0.007	0.46-0.84
Community wealth	Low (ref)				
	High	1.26	0.24	0.22	0.86-1.84
Community education	Low (ref)				
	High	0.88	0.16	0.51	0.61-1.27
Community visit by HCW	Low (ref)				
	High	1.09	0.11	0.42	0.69-1.16
Random effect parameters	Variance component	Std. Err.	95% C.I. Lower-Upper		
EA: Identity	0.62	0.061	0.51-0.75		
ICC	15.8				

OR- Odds ratio, CI-Confidence internal, SE-Standard error

5.3.5 Multilevel Random Coefficient Logistic Regression model analysis

The study examined the impact of women's level covariates by allowing them to diverge randomly across communities. The estimated variances and covariances of the random effects are shown in table 9. Random effects can employ random intercepts at a community level and random coefficients (level-one covariates effect). This section investigates whether the specified individual level variables have random or consistent effects across the community.

We considered that the effects of individual educational attainment and HCW visits are the same in each community, implying that the coefficients of both explanatory variables are constant across communities and regarded as random.

We will now expand the random intercept model by allowing the intercept, educational, and HCW visits to vary randomly among communities. The random coefficient estimates for intercepts and coefficients differ considerably at a 5% significance level as depicted in Table 9, implying that the effects of educational status and visits by HCW variables varied considerably across communities.

The random effect of the coefficient of education varies significantly at 5 percent levels of significance across communities. The variance component corresponding to the coefficient of visits by HCW workers is insignificant. Hence the random effects visits by HCW workers have no variation across communities.

The estimate of between-community variance in the effect of education was 0.08, which is significant. And this result showed that there is a significant education variation across communities in explaining modern contraceptive use.

Communities with higher intercepts have higher average coefficients due to the positive connection between intercepts and coefficients. In contrast, the negative correlation between intercepts and coefficients suggests that communities with higher intercepts have lower coefficients on related predictors on average. The negative intercept-education covariance estimate (σ_{01} = -0.99, S.E=0.23) suggests that communities with above-average use of modern contraceptives (intercept residual $\hat{U}_0 > 0$) also have below-average effects of education (coefficient residual $\hat{U} < 0$).

According to the intra-class correlation coefficient (ICC), fixed variables account for around 18% of differences in modern contraceptive usage. Around 2.4 % of differences in modern contraceptive use are related to the random component of education (level two factor), whereas 21%of differences in modern contraceptive method usage are related to the influence of an HCW visit. This implies that considering the effect of education and HCW visits as fixed will affect the estimates while modeling contraceptive uses.

Table 9- Random coefficients logistic regression model analysis for effects on modern contraceptive use among married women of reproductive age group in Ethiopia, 2018 PMA.

Random part	Variance components		
	Estimation	S.E.	95% CI
σ^2_0= var (U_{0j})	0.73	0.089	0.58-0.93
σ^2_1= var (U_{1j})	0.08	0.054	0.02-0.29
σ^2_2= var (U_2j)	0.81	0.194	0.51-1.29
σ_{01}= cov (U_{0j},U_{1j})	-0.99	0.09	-1.0 -0.99
σ_{02}= cov (U_{0j},U_{2j})	-0.42	0.23	-0.75-0.09
σ_{12}= cov (U_{1j},U_{2j})	0.30	0.81	-0.89-0.96
Deviance based chi-square	87.6***		
ICC	18.1		

In the above table the value of Var (u0j) - estimated variance of intercept, Var (u1j) - estimated variance of coefficient of education, and Var (u2j) - estimated variance of coefficient of visited by HCW.

6. DISCUSION

This study examined the determinants of modern contraceptive use among married women in Ethiopia using a multilevel modeling technique applied to hierarchical data from the 2018 PMA survey data. We found that modern contraceptive use is related to women's individual demographic, socioeconomic, and reproductive health-related characteristics, as well as community-level predictors. Age, education, religion, region, wealth status, marriage type, parity, and visits to a health facility are among the factors strongly associated with modern contraceptive use. Among the community-level determinants, community fertility norms (community parity and community HH size) significantly predict the utilization of modern contraceptive methods.

We find that there is substantial variation between communities in the utilization of modern contraceptive methods, and the estimate of this variation remains significant even when adjustment is made for the individual and community level characteristics. The results of this analysis demonstrate that the significant between-community variation in the effects of women's educational attainment resulted in the variation in modern contraception.

The study indicated clustering with an ICC of 0.206 in the random intercept model, inferring that 20.68% of the variation in the MCU can be explained by clustering women, which means that the dependence on the MCU between women in the same community was 20.6%. This variability identified in this study seems to be more similar to the 21.51% identified by a study done in Ethiopia (66). The finding was also in line with a study done in Nigeria in 2018 (44).

The higher the ICC value the greater the importance of community characteristics in predicting modern contraceptive use. Various studies have also suggested that a woman's environment influences whether or not she uses modern contraceptive methods (13, 18, 21).

Our random intercept and fixed coefficient model revealed that women in the age group of 40-49 were less likely to use modern contraception than women aged 15-19, which agrees with prior studies (17, 35, 36). The most likely explanation for this is that women in their late reproductive years believe that they are not at risk of becoming pregnant, that they are more likely to have casual sex or want children at an older age. One possible implication of this is that attitudes towards fertility change among women in the later reproductive years.

The model also showed a statistically significant relationship between modern contraceptive use and women's educational level; it is consistent with several studies conducted in developing countries (21, 23, 56, 67). Women with secondary and primary education were more likely to use modern contraception than women who had no education. Education, especially beyond the primary level, influences many broad aspects of women's lifestyle choices that can increase women's propensity to use contraceptives, such as the acquisition of skills, knowledge, and interaction with the environment, which can also improve their autonomy and participation in the decision-making process, and positively modify health-seeking behaviors and build social capital through the expansion of social networks (21, 28). This evidence suggests that there is still a need to educate and empower them on their reproductive health.

In terms of religion, the study found that women who followed the Muslim religion were less likely to use modern contraceptives than women who followed the Orthodox Christian religion; Similar studies have shown less contraceptive use among Muslims (23, 67). In further research, the use of the qualitative research method could be a means of better understand the reason for the non-use of modern contraceptives among women who are Muslim religion followers and the need to develop innovative and appropriate strategies to increase the demand for modern contraception among this population in Ethiopia.

In this study, we observed that there were significant regional differences in the use of contraceptives. Women from Amhara, SNNPR, Oromia, and Addis Ababa were more likely to use modern contraceptives than Tigray, and the lowest likelihood of contraceptive use was seen in the Afar region, this is probably due to physicians' attitudes towards minorities, language barriers, transport costs, low level of education, illiteracy, poverty and low socioeconomic status, familiarity with the healthcare services delivery system, as well as the degree and type of family support (23, 55). These have important policy implications, as interventions to expand modern contraceptive utilization in the country will need to be comprehensive in their approach.

Consistent with findings from prior studies (13, 19, 23, 35), the household wealth index positively affects modern contraceptive utilization in the current study. The odds of using modern contraceptives were higher among women from wealthier households than the lower. Higher levels of economic development may also provide environments conducive to improving the increased availability of employment outside the home, which may increase access to and utilization of health services. The wealthy families abstain from higher fertility to accumulate more wealth for the next generations and better their social status or mobility.

The positive relationship between wealth and MCU is cause for concern because it may indicate access inequity. These disparities can be caused by a variety of factors, each of which has a different solution. Due to financial barriers, poor women may be less likely to use modern contraception, which could be addressed by public programs that subsidize the costs of services. Similarly, contracting out through non-governmental organizations (NGOs) could improve access to these methods, allowing women to avoid paying the full price through private providers and facilities. Poor women may also face geographical barriers that are more difficult to overcome, this may require more concerted efforts to provide modern contraceptives through high-quality, mobile outreach services.

This study showed that women in polygamous marriage were less likely to use modern contraceptives than women in monogamous marriages. This finding is consistent with several studies (11, 19, 67). This could be due to their exposure to longer reproductive life to have children due to the nature of relationships, where women with the same husband can compete for more children, plus the wide age difference between spouses, which may inhibit husband-wife interactions and maintain male dominance within marriage. Together with women in monogamous marriages, advocacies should target women in polygamous marriages. Moreover, research is needed to address the co-wives and other related issues concerning modern contraception in areas where polygamy is prevalent.

Women who had five or more live births were more likely to use modern contraception than women who had no children. Many women with a greater number of live children were either at or near their desired family size. As a result, these women are more likely to abandon pregnancy, indicating a desire for greater adoption of modern contraceptives, backed by the findings of a Nigerian study (16, 32, 67).

The current study found that women who visited a health facility 12 months before the survey were more likely to use modern contraception. Several studies have yielded similar results (13, 17). Information, education, and communication (IEC) provided with an available provision of the methods by professional health workers at a time, which possibly will encourage woman's decision-making process to use modern contraceptive methods.

Furthermore, even with controlled individual-level variables, high community parity and community HH size as a contextual variable significantly lower the odds of modern contraceptive utilization across communities. In line with our finding, previous research indicates that women who live in communities where large family sizes are the norm were less likely to use modern contraceptive methods (21, 51).

This finding highlights the utilization shaped by the peer, which describes how behaviors to adopt MCM are learned by observing people (friends and neighbors). The behavior plus large household size is still desirable in Ethiopian families, suggesting that enabling women to make their own decisions about contraceptive use is critical.

Surprisingly the study showed that rural residents had significantly higher odds of modern contraceptive use than urban dwellers, which is contrary to much of previous studies (13, 27, 48), however, remarkable similar research findings are observed in recent studies (39, 56) could be explained by increased family planning and contraception programs specifically promote in the rural areas than urban areas, by non-profit and non-governmental organizations (NGOs). There is a higher prevalence of early marriage with early initiation of sexual doubt in rural areas than in urban areas. So women who marry later in life may want to have children as soon as possible and may not want to use any contraceptive methods (68).

In this study, modern contraceptive use is not significantly associated with community wealth and community visit by HCW. It is an unexpected result and not consistent with other researches (32, 38, 56).

The technique used to create the aggregation of individual variables is likely to have resulted in discrepant contextual inference or the absence of relevant variables of the availability of family planning services. To put the assumption to the test more aggregate or qualitative data is required. The weakness of the relationship between community visits and modern contraceptive use is probably due to the difference in skill and support of health care workers have on the service provided to their community members to diminish cultural/traditional norms that structurally oppose FP.

Even though the relationship was not statistically significant, the results showed the negative effect of community education on modern contraception. A study conducted in Zimbabwe has yielded a similar finding (47). It is unclear why aggregated community education has a negative association among Ethiopian women in our sample. Fertility norms may be so firm in most parts of the country that even educated women do not see the value of using modern methods of contraception before achieving their desired family size.

The findings further disclosed that the random coefficient estimates for intercepts and the slopes vary significantly at a 5% significance level, implying that random effects of education vary across communities in explaining the utilization of modern contraceptives.

The deviance-based chi-square test for random effects is higher in the random intercept model than in the random intercept and fixed coefficient model, indicating that the random intercept model with a fixed coefficient outperforms the random intercept (empty) model. The within-community variation further implies that the use of modern contraceptives within a community is less likely (or heterogeneous) than between communities.

This study demonstrated multilevel modeling has the advantage of accounting for the hierarchical nature of data. It was feasible to show that modern contraceptive utilization varies by community and that this variation may be explained by community-level characteristics whose impact would be overlooked using the standard logistic regression method.

Methods that account for the correlation in outcome among married women in the same community are required. The intra-class correlation obtained from the analysis indicates similarity in modern contraceptive use among married women in the same community, may also be used to validate the adoption of the multi-level logistic regression model in this analysis.

6.1. Strength

One of the key strengths is that we collected data from the PMA survey data, which has a large sample size, and many indicators. Since the data was hierarchical, we were able to investigate and analyze factors beyond the individual level. Using multilevel analysis the study illustrated factors that could explain Ethiopia's low prevalence of modern contraceptive use plus importance in the design of public health programs and future research. The study lies in the novelty of its findings, which add to the existing body of evidence in the research area examined in improving modern contraceptive utilization in Ethiopia.

6.2. Limitation

However, there are limitations to this study. First, the study did not include all of the factors that have been described in different literature to have an association with modern contraceptive use such as women's employment status, husband education, and quality of family planning service due to the absence of these variables in the PMA 2018 survey data.

Second, except for a variable place of residence, all macro-level variables were aggregated micro level variables at the primary sampling unit (enumeration area/cluster) level; this has noted that its effect may still tell us little about the impact. This is a common practice in the literature, and some researchers have also suggested using censuses data or community data collected through surveys (47). Lastly, our study was based on cross-sectional data, which limited our ability to draw causal inferences between the exposure variables and the outcome variable, the current use of modern contraceptives. Furthermore, because these analyses were based on data obtained in 2018 G.C., but the survey was repeated in 2019, it would be useful to see if the observed connections have altered and if the policy aimed to enhance married women's modern conceptions.

7. CONCLUSION AND RECOMMENDATION

7.1 Conclusion

The study revealed that both individual and community-level factors predict the use of modern contraception in Ethiopia. Individual-level factors including women's age, education level, number of live births, religion, wealth, region, and visit to the health facility, and community-level factors: Membership in a community with high fertility norms was significantly associated with the use of modern contraception among married women of reproductive age in Ethiopia.

The results of multilevel logistic regression also confirm that the use of modern contraceptive methods varied due to a significant variation in the effect of educational level between communities, while the effect of other covariates for modern contraception remained fixed across clusters.

The study contributed to the lack of consistent empirical findings. The results also contribute to a better understanding of the community-level factors that shape modern contraceptive use and confirm the importance of investigating community-level influences in addition to individual-level determinants. The study has important implications from a public health stance; the presence of community-level effects indicates that changes in community characteristics can influence the use of modern contraception for entire communities.

Moreover, the study findings gave baseline information for future researchers and contributed new insight to family planning research. In addition to strengthening the health-systems level response to less utilization for contraceptives, programs need to be sensitive to prevailing fertility norms operating at the community level and programmatic efforts to maximize impact on women’s empowerment.

7.2 Recommendations

Future family planning policies and programs in Ethiopia is recommended to take into account community characteristics in the design, implementation, and evaluation of their intervention. As well as being context-specific and culturally acceptable; to increase acceptance in various contexts, and improve information and communication activities targeting the improvement of contraceptive coverage among women within high-risk groups such as; women in the late reproductive age group (40-49), uneducated, Muslim and traditional religious believer, married more than once, who live in the poorest households and residents of the community with high fertility norms.

Ethiopian government, through its policymakers on family planning should take into account factors at both the individual and community levels of the target population. It is also critical to implement strategies that combine individual education, service improvement, and community outreach/mobilization to educate communities about the importance of child spacing and increase the acceptability and utilization of modern contraceptive methods. The government should also continue to prioritize female education; thus, government and non-government organizations focus on educating women which contributes in improving decision-making knowledge, skill, and role and in unlocking women's potential and transform their lives, families, communities, and society.

We also suggest that health workers influence community fertility norms by incorporating family planning issues into community dialogues and providing opportunities for women to discuss and decide more openly.

Researchers need to explore the impact of contextual-level factors to reveal more underlying cultural features and provide a more complete picture. Furthermore, because this study only included married women, similar researches with sexually active and unmarried women, is recommended.

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ASSURANCE OF PRINCIPAL INVESTIGATOR

I, the undersigned MPH student declare that this thesis is my original work in fulfillment of requirement for the master of public health in Reproductive, family and population health.

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Approval of the primary Advisor

This thesis work has been submitted with our approval as the university advisor.

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