

PEER REVIEW HISTORY

BMJ Open publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form (<http://bmjopen.bmj.com/site/about/resources/checklist.pdf>) and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below.

ARTICLE DETAILS

TITLE (PROVISIONAL)	Spatial variations and associated factors of modern contraceptive use in Ethiopia: a spatial and multilevel analysis
AUTHORS	Tegegne, Teketo; Chojenta, Catherine; Forder, Peta; Getachew, Theodros; Smith, Roger; Loxton, Deborah

VERSION 1 – REVIEW

REVIEWER	Lukman Solanke Obafemi Awolowo University, Nigeria
REVIEW RETURNED	25-Feb-2020

GENERAL COMMENTS	<p>The manuscript is well-written and addresses an important public health issue. Authors need to fix the following:</p> <ol style="list-style-type: none">1. The Methods section of the main text should include a sub section on the outcome and explanatory variables.2. Authors should explain how occupation was derived particularly what constitute 'professional work' and 'others'3. Authors should delete the use of 'about' and 'only' in result presentation. the actual figure should be reported.4. Include sample size in Table 15. Women who had no children ever born ought to be excluded from the analysis6. In the Discussion section, authors should strictly discuss the key findings and not re-present results or review literature
-------------------------	--

REVIEWER	Lyle McKinnon, Assistant Professor University of Manitoba, Canada
REVIEW RETURNED	24-Mar-2020

GENERAL COMMENTS	<p>Review of Tegegne et al BMJ Open</p> <p>This is an interesting paper on an important topic. An important strength of the paper is that the authors were able to look at supply and demand side variables in a joint analysis, and with a large nationally representative sample. A few queries/suggestions for improvement:</p> <ol style="list-style-type: none">1. Why focus on only married women? This is not provided anywhere in the rationale of the paper. In particular this matters in the younger age groups -- the 15-19 year old married group is nowhere near representative of this age group and contraception at this phase of life may be more critical for single adolescents/young women.2. Sample size 8000 in 1000 facilities seems like an odd ratio. Some facilities must have hardly been sampled?
-------------------------	---

	<p>3. Preparedness to offer contraception and uptake seems a bit obvious-hard to decipher what the reported effect size (1 unit in facility score = 20-fold increase) means. The facility score that is used throughout the paper should be better explained.</p> <p>4. Study is based on combining 2 large 2014 and 2016 surveys: What was the sample size of these and what was the inclusion criteria for this analysis?</p> <p>5. Page 8- % in each quintile and contraception use. Is this based on national data? Otherwise wouldn't it be 20% by definition? Not much discussion given to explanations for why the richest AND poorest quintiles use more contraceptives.</p> <p>6. The exposure to contraceptive message variable is not well defined. This is based on what question(s) capturing which exposure(s)? Many more women seem to know about contraception than have been "exposed" to messages, so they must be learning about it somewhere.</p> <p>7. In table 2 the biggest missing variable is pregnancy desire. That is where the gap is, e.g. where the government needs to roll out contraceptives more effectively. Hard to know what differences in rates mean if this isn't available. Stating the obvious - many women might not be using contraception simply because they don't want to.</p> <p>8. Table 3- would be useful to know the populations of each region in this table (using whatever is closest to 2016 stats)</p> <p>9. Several of the correlates of contraceptive use are themselves correlated- wealth, urban/rural, readiness to provide, distance from facility, etc. It would be worth doing some further analysis – stratification/interaction/mediation etc to determine which of the correlated variables drive the effects that are seen.</p> <p>10. Wealth in particular might not be a direct effect, e.g. not money to travel but instead education, privilege, overall health etc.</p> <p>11. The fact that contraception increases with parity but decreases with age is counter-intuitive- would be worth looking for interactions/stratified analysis here as well.</p> <p>12. Conclusion- not just contraceptives offered but also the mix/choice might be important for uptake.</p> <p>Minor</p> <ul style="list-style-type: none"> • Page 5 line 27- the 44% statistic is unclear. Is that the % of pregnancies that were unintended? • The overall point of the last results paragraph (page 15 line 15-29) could be better explained • Page 17, line 48: the discussion in this paragraph is a bit repetitive • Page e18 lines 5-9 are unclear
--	---

VERSION 1 – AUTHOR RESPONSE

S.No	Reviewer 1 comment	Authors Response
1	The Methods section of the main text should include a sub section on the outcome and explanatory variables.	We have added outcome and explanatory variables sub-headings on page 7.

2	<p>Authors should explain how occupation was derived particularly what constitute 'professional work' and 'others'</p>	<p>The DHS questionnaire for occupation is open-ended. Respondents were asked the following question regarding occupation:</p> <ul style="list-style-type: none"> • What is your occupation? That is, what kind of work do you mainly do? • What is your (husband's/partner's) occupation? That is, what kind of work does he mainly do? <p>The DHS then categorised individual responses into several groups. We used the DHS occupation grouping – the obtained EDHS dataset had occupation groups. Respondents who responded not working at the time of the interview or did not work in the last 12 months before the survey were grouped as have no work. Professional/technical/managerial category constitutes teaching professionals, health professionals, science and engineering professionals, business and administration professionals, information and communication professionals, legal and social workers, managers, etc. Agricultural categories also include fishermen, foresters and hunters. Other categories include daily laborers, street and related sales and service workers.</p> <p>This is explained on page 7.</p>
3	<p>Authors should delete the use of 'about' and 'only' in result presentation. the actual figure should be reported</p>	<p>Changes have been made accordingly.</p>
4	<p>Include sample size in Table 1</p>	<p>The total sample size (N= 8473) is in the table title.</p>
5	<p>Women who had no children ever born ought to be excluded from the analysis</p>	<p>As long as they are sexually active or in a marriage/union, they should be included in the analysis. Having had no child doesn't mean that they are infecund.</p> <p>Women are assumed to be infecund if:</p> <ul style="list-style-type: none"> ✓ They were first married five or more years ago, have not had a birth in the past five years, are not currently pregnant, and have never used any kind of contraceptive method; or ✓ They self-report that they are infecund, menopausal or have had a hysterectomy, never menstruated, or have been postpartum amenorrhoeic for 5 years or longer; or ✓ (for women who are not pregnant or in postpartum amenorrhea) their last menstrual period occurred more than six months prior to the survey. <p>However, DHS does not include all of the details necessary to ascertain women's status. Therefore, women without children have been included so as to not bias the estimate.</p>
6	<p>In the Discussion section, authors should strictly discuss the key findings and not re-</p>	<p>We have made changes accordingly. We have discussed the main findings and implications as well.</p>

	present results or review literature.	
--	---------------------------------------	--

S.N o	Reviewer 2 comment	Authors Response
1	Why focus on only married women? This is not provided anywhere in the rationale of the paper. In particular this matters in the younger age groups -- the 15-19 year old married group is nowhere near representative of this age group and contraception at this phase of life may be more critical for single adolescents/young women.	Yes, contraception is more critical for adolescents and/or youths. The rationale behind including only married women in our study was that married women or in union are supposed to be sexually active as opposed to single, divorced or widowed women. This is stated on the last paragraph in the introduction section – page 5.
2	Sample size 8000 in 1000 facilities seems like an odd ratio. Some facilities must have hardly been sampled?	Yes, it would be great if more health facilities were sampled. However, the health facility survey (the ESPA+ survey) collected data from 1165 facilities. The ESPA+ survey used a combination of census of hospitals and a sample of other health facilities (health centres, health posts and clinics). Out of the 1165 facilities, 1020 facilities reported providing family planning services. In this analysis, we have included all facilities (1020) reported providing family planning. We have included some details on pages 5 and 6 (under data sources sub-section).
3	Preparedness to offer contraception and uptake seems a bit obvious-hard to decipher what the reported effect size (1 unit in facility score = 20-fold increase) means. The facility score that is used throughout the paper should be better explained.	Details of computing health service environment variables, including family planning service readiness are discussed in the methods section under ‘Health Service Environment’ sub-section – page 6. More details are also discussed in our published paper, which is accessible here: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0219860
4	Study is based on combining 2 large 2014 and 2016 surveys: What was the sample size of these and what was the inclusion criteria for this analysis?	We have included some details on pages 5 and 6 (under data sources sub-section). In the population survey, all women aged 15–49 years were eligible for individual interviews. The survey identified 16583 eligible women. Of these women, from 645 DHS clusters, 15683 were interviewed. In this analysis, 8473 married women who were not pregnant at the time of the interview were included from 622 DHS clusters. A total of 261 married,

		<p>non-pregnant women from 23 clusters were excluded from the analysis since they had missing geographic coordinates.</p> <p>Regarding the facility survey, it would be great if more health facilities were sampled. However, the health facility survey (the ESPA+ survey) collected data from 1165 facilities. The ESPA+ survey used a combination of census of hospitals and a sample of other health facilities (health centres, health posts and clinics). Out of the 1165 facilities, 1020 facilities reported providing family planning services. In this analysis, we have included all facilities (1020) reported providing family planning.</p>
5	<p>Page 8- % in each quintile and contraception use. Is this based on national data? Otherwise wouldn't it be 20% by definition? Not much discussion given to explanations for why the richest AND poorest quintiles use more contraceptives.</p>	<p>The reported findings are based on national data. The figures reported on page 8 and in table 1 are descriptive summaries of sociodemographic characteristics. This is not a cross-tabulation of sociodemographic characteristics and contraceptive use. However, in the multilevel analysis, we found that women in the richest quintile are more likely to use modern contraceptives. We have discussed this in the second paragraph on 19.</p>
6	<p>The exposure to contraceptive message variable is not well defined. This is based on what question(s) capturing which exposure(s)? Many more women seem to know about contraception than have been "exposed" to messages, so they must be learning about it somewhere.</p>	<p>The DHS collected data on woman's exposure to family planning messages whether the respondent has heard about family planning in the last few months (preceding the survey) from any of the following sources: a) heard family planning on the radio last months, b) heard family planning on TV last months and c) heard family planning from the newspaper last months.</p> <p>Therefore, in our analysis, exposure to the contraceptive message was measured if the respondent had exposure to one or more information sources.</p> <p>This is defined on page 7.</p>
7	<p>In table 2 the biggest missing variable is pregnancy desire. That is where the gap is, e.g. where the government needs to roll out contraceptives more effectively. Hard to know what differences in rates mean if this isn't available. Stating the obvious - many women might not be using</p>	<p>We have included women's future intention to use contraception in table 2 and a description under 'Women's Obstetric Characteristics' subsection – page 11.</p>

	contraception simply because they don't want to.	
8	Table 3- would be useful to know the populations of each region in this table (using whatever is closest to 2016 stats)	We have included each region's projected population in table 3 for 2016. This projection is from the Central Statistical Agency – Population Projections for Ethiopia: 2007 – 2037.
9	Several of the correlates of contraceptive use are themselves correlated- wealth, urban/rural, readiness to provide, distance from facility, etc. It would be worth doing some further analysis – stratification/interaction/mediation etc to determine which of the correlated variables drive the effects that are seen.	<p>We appreciate the comments as this is a very important issue. Before building the final model, we ran multicollinearity analysis and the variables included had a variance inflation factor below 6.</p> <p>Regarding stratification and causal mediation analysis, we would be happy to do stratification and causal mediation analysis. However, we did not have a specific treatment variable to run a causal mediation analysis as we were interested in identifying the factors associated with modern contraceptive use. Further, doing the stratified analysis is beyond the main objective of this study as it would result in many more models/tables depending on the grouping variables we use. For instance, we would have another table if we used the urban-rural residence as a grouping variable.</p> <p>In the model building process, we included several interaction effects. However, including interaction effects made the model unstable and we removed interaction terms in the final model. For instance, the interaction effect of wealth and education, family planning service availability and facility's readiness, age and parity on modern contraceptive use was one of our assumptions that did not result in a stable model estimate.</p>
10	Wealth in particular might not be a direct effect, e.g. not money to travel but instead education, privilege, overall health etc.	Wealth might directly or indirectly affect modern contraceptive use. Women might know about the importance of contraception. However, knowledge alone will not be important in some cases. They should have money for transport and service. The trade-off associated with the time they spent on traveling to and from health facilities is also important. They may use that particular time for household activities, farming or other business-generating activities.
11	The fact that contraception increases with parity but decreases with age is counter-intuitive- would be worth looking for interactions/stratified analysis here as well.	The interaction effect of parity and age was carried out. It did not show any association, rather it resulted in an unstable model and we removed the interaction term from the model.

12	Conclusion- not just contraceptives offered but also the mix/choice might be important for uptake.	Yes, the contraceptive method mix/choice is important. We made changes accordingly.
13	Page 5 line 27- the 44% statistic is unclear. Is that the % of pregnancies that were unintended?	Perhaps this is on page 14-line 47/48? If that is the question, the reported figure is an odds ratio. Women who were in the age group of 35-39 were 44% less likely to use modern contraception compared to those in the 15 – 19 age group.
14	The overall point of the last results paragraph (page 15 line 15-29) could be better explained	We have made changes accordingly.
15	Page 17, line 48: the discussion in this paragraph is a bit repetitive	We have made changes accordingly.
16	Page 18 lines 5-9 are unclear	We have made changes accordingly.

VERSION 2 – REVIEW

REVIEWER	Lukman Solanke Obafemi Awolowo University, Nigeria
REVIEW RETURNED	03-Jun-2020

GENERAL COMMENTS	<p>To Authors</p> <p>The study focused an important public health issue in Ethiopia. But the design and execution of the study has few flaws that should be corrected:</p> <p>INTRODUCTION</p> <ol style="list-style-type: none"> 1. The title of the manuscript is not well constructed. Authors should revise the title in line with the focus of the paper. Since service readiness is not the outcome variable, it should not be in the title. My suggestion is: Spatial variations and associated factors of modern contraceptive use in Ethiopia: a multilevel analysis 2. The knowledge gap this study intends to fill is not clearly identified and described. Following authors claim that previous studies have given more prominence to demand-side factors, it is appropriate to provide information on how the supply-side factors affect contraceptive use to justify why the study should be conducted <p>METHODS</p> <ol style="list-style-type: none"> 1. Provide literature to support selection of the explanatory variables 2. There is need to revise the inclusion/exclusion criteria. Did authors consider excluding women who are not sexually active? What is the rationale for including women who have never had a live birth (parity-0) since they cannot have antenatal attendance? 3. Explain how -2LL, AIC and BIC provides information to assess model checking 4. Head of household should be Male or Female <p>RESULTS</p> <p>Well-presented but the fixed and random effects of the model should be presented separately</p>
-------------------------	--

	DISCUSSION Satisfactory but may be redirected if analysis is adjusted CONCLUSION Satisfactory ABSTRACT Satisfactory
--	--

REVIEWER	Lyle McKinnon University of Manitoba, Canada
REVIEW RETURNED	23-Jun-2020

GENERAL COMMENTS	No further comments.
------------------	----------------------

VERSION 2 – AUTHOR RESPONSE

S.No	Reviewer 1 comment	Authors Response
INTRODUCTION		
1	The title of the manuscript is not well constructed. Authors should revise the title in line with the focus of the paper. Since service readiness is not the outcome variable, it should not be in the title. My suggestion is: Spatial variations and associated factors of modern contraceptive use in Ethiopia: a multilevel analysis.	We have changed the title to: Spatial variations and associated factors of modern contraceptive use in Ethiopia: a spatial and multilevel analysis
2	The knowledge gap this study intends to fill is not clearly identified and described. Following authors claim that previous studies have given more prominence to demand-side factors, it is appropriate to provide information on how the supply-side factors affect contraceptive use to justify why the study should be conducted.	Changes have been made accordingly (the last paragraph on page 4).
METHODS		
1	Provide literature to support selection of the explanatory variables	Changes have been made accordingly (page 7).
2	There is need to revise the inclusion/exclusion criteria. Did authors consider excluding women who are not sexually active? What is the rationale for including women who have never had a live birth (parity-0) since they cannot have antenatal attendance?	The rationale behind including only married women in our study was that married women or in union are assumed to be sexually active as opposed to single, divorced or widowed women. This is stated on the first paragraph on page 6. <i>Contraception is more critical for women of reproductive age. However, married women or women in union are more likely to be sexually active as opposed to single, divorced or</i>

		<p><i>widowed women, particularly in Ethiopia where sex outside of a union is uncommon. Therefore, this study focused on only married women's modern contraceptive use.</i></p> <p>Women who have never had a live birth, as long as they are sexually active or in a marriage/union, should be included in the analysis. Having had no child doesn't mean that they are infecund.</p> <p>Women are assumed to be infecund if:</p> <ul style="list-style-type: none"> ✓ They were first married five or more years ago, have not had a birth in the past five years, are not currently pregnant, and have never used any kind of contraceptive method; or ✓ They self-report that they are infecund, menopausal or have had a hysterectomy, never menstruated, or have been postpartum amenorrhoeic for 5 years or longer; or ✓ (for women who are not pregnant or in postpartum amenorrhea) their last menstrual period occurred more than six months prior to the survey. <p>However, DHS does not include all of the details necessary to ascertain women's status. Therefore, women without children have been included so as to not bias the estimate.</p>
3	<p>Explain how -2LL, AIC and BIC provides information to assess model checking.</p>	<p>There are different methods used to check model performance. R-squared (R^2), Mean Squared Error (MSE) as well as Residual Standard Error (RSE) and Mean Absolute Error (MAE)). These methods are sensitive to the inclusion of additional variables in the model, even if those variables don't explain significant variation in the outcome. For instance, including additional variables in the model will always increase the R^2 and reduce the MSE. In</p>

		<p>contrast, Akaike's Information Criterion (AIC), and Schwarz's Bayesian information criteria (BIC) penalise the deviance for models with a larger number of parameters, and thus provide more protection against overfitting the model to the data, relative to approaches based on hypothesis testing (e.g., deviance difference, log-likelihood ratio statistic). Therefore, using a more robust metric to guide the model choice is recommended. Adjusted R^2, AIC, BIC, and Mallows C_p are among the most commonly used metrics for measuring regression model quality and for comparing models. It is because of the above-mentioned reasons, we used AIC and BIC. In this revised version, we removed Log-likelihood tests.</p> <p>Therefore, in this revised version of the manuscript, we restricted the model fit statistics based on Akaike's Information Criteria (AIC) and Schwarz's Bayesian Information Criteria (BIC).</p> <p>We have added a brief statement explaining the robust nature of AIC and BIC under the 'Model Fit Statistics' section of the manuscript (page 9).</p> <p><i>The Akaike Information Criteria (AIC) and Schwarz's Bayesian Information Criteria (BIC) were used to assess the best-fitting model (21).</i></p>
--	--	---

		<p><i>The AIC and BIC values of each successive model were compared, and the model with the lowest value was considered as the best-fitting model (23, 24). During model building process, it is possible to increase the likelihood of fitting models by adding parameters. However, increasing model parameters can result in overfitting. Unlike statistical methods that employ hypothesis testing approaches like log-likelihood ratio test, AIC and BIC penalise the deviance for a larger number of parameters (24-26). Thus, they prevent overfitting by introducing a penalty term for the number of parameters in the model.</i></p>
4	Head of household should be Male or Female.	<p>Yes, the head of household is either a male or female. In Table 1, we dichotomised the head of household as the woman herself or someone else (this include her husband and other family members, such father-in law and mother-in law).</p> <p>Here, we would like to emphasise whether the woman herself is the head of the household as it could have impact on decision-making power. This could have influence on her healthcare decision-making, including the use of modern contraceptives.</p>
RESULTS		
1	The fixed and random effects of the model should be presented separately.	We presented the fixed (Table 4) and random (Table 5) effects separately.

VERSION 3 – REVIEW

REVIEWER	Lukman Solanke Obafemi Awolowo University, Nigeria
REVIEW RETURNED	05-Aug-2020
GENERAL COMMENTS	The revised version substantially improve the intellectual content of the manuscript