

Roles of proximate determinants of fertility in recent fertility decline in Ethiopia: Application of the Revised Bongaarts Model

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Research note

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Abstract

Objectives: Understanding factors contributing to the recent fertility decline and their level of fertility inhibiting effect has a paramount policy implication in a given country . So, in this paper, the 2015 revised Bongaarts model of proximate determinants of fertility was applied, and the contribution and trends of each of the determinants over one and half of the decade (from 2005 to 2016) was evaluated. This study utilized the publicly available data from the Ethiopian demographic and health survey of 2005, 2011 and 2016. The revised and fine-tuned Bongaart's model of proximate fertility determinants was used throughout for data analysis.

Results: Postpartum insusceptibility contributed the highest fertility inhibiting effect in all the three EDHS and its level is more prominent among the poorest women. Contraceptive use was the second leading fertility inhibitor and its effect was significantly increased from 15% (inhibition effect by 2005) to 37% (fertility inhibiting effect by 2016). This is an increment in fertility reduction effect nearly 26%. In conclusion, over the last one and half-decade, contraceptive use was the single most important determinant responsible for fertility decline in Ethiopia. To achieve the fertility of replacement level, the country needs a contraceptive prevalence rate of 69%.

Introduction

Studies indicated that the fertility of a given community is affected by socio-demographic factors such as age at marriage, women's literacy status and contraceptive utilization[1][2].

With the high efforts of governmental and non-governmental organizations', there was an improvement in modern contraceptive prevalence in the last three decades in many sub-Saharan African countries[3]. In Ethiopia, the prevalence of contraceptives was increased from 6.3% in 2005 to 35.9% in 2016. However, the country hasn't achieved the TFR of 4 and contraceptive prevalence of 44% as targeted in the population policy [4][5][6].

Age at marriage affects the total fertility rate of a given population. This is because if a woman marries at an early reproductive age, she will have a long reproductive age duration. The median age at marriage in Ethiopia was 16.6 years. Only 17.2% of the women in the country attended an educational level of high school and above [5][7][8]. Studies indicated the prevalence of premarital sex reaches nearly 20-54% with incremental trends from time to time[9][10]. In 2014, the annual rate of 28 abortions per 1,000 among women aged 15–49 were recorded[11].

In the late 1970s, John Bongaart developed the modified set of proximate determinants of fertility containing four elements: marriage/cohabitation, induced abortion, contraception, and postpartum in fecundability. The existing assumptions were updated on three of the four components with some modifications in 2015[12][13].

The detail Bongaart's proposed revisions are discussed below.

Marriage/union/sexual exposure

Previously, it was considered sexual activity and childbearing happen only among married women. Since extra-marital childbearing become common in developing countries, Bongaart proposed to estimate the number of women who are exposed to the risk of childbearing as the sum of married women and unmarried women, and the name of the index was also changed to index of sexual exposure instead of an index of marriage(Cm)[14][15].

Contraception Index

Previously, the assumption of the postpartum infecundity period overlaps with postpartum contraceptive use was ignored. In such a case, excluding the overlapped period should be considered [15].

Abortion Index

The fertility reduction associated with a given level of the total abortion rate is calculated as:

$$A = b \times TA = 0.4(1+u) \times TA$$

Where TA=total abortion rate

A=the average number of births averted per woman by the end of her reproductive age[12].

The index of induced abortion is computed as the ratio of the observed total fertility rate, TFR, to the estimated total fertility rate without induced abortion, TFR + A,

$$Ca = \frac{TFR}{TFR + b \times TA}$$

But, in the revised Bongaarts model, the formula is modified to

$$b^* = \frac{14}{18.5+i} \text{ instead of } b = 0.4(1+u) \text{ while the other formula is unchanged [14].}$$

18.5+i

Generally, there was one previously published article[16]. The author of this paper was not satisfied with the previously published findings; as there were major errors observed in the paper. For instance, even though it is clear that fertility in the country is decreasing over time, it was reported as if the TFR of the country increased from 4.04(in 2011) to 4.14(2016) which is not true. This paper intended to fill these gaps. So, the objective of this paper was to assess the magnitude of the proximate determinants of fertility and their variation based on some selected socio-demographic variables.

Methods

Sources of Data

This study utilized the publicly available data from the Ethiopian demographic and health survey of 2005, 2011 and 2016. The EDHS data were the representative data collected through a cross-sectional study from the reproductive-age women living in Ethiopia. The detail data collection procedure, tool used, ethical issue and others were mentioned in each EDHS[4][5][17]. The components needed for the current Bongaarts model analysis were extracted from EDHS data using the *STAT compiler*, and also with manual extraction in case the data not available directly and finally analyzed using Microsoft excel.

Data Analysis Methods

In this study, 2015 revised and fine-tuned Bongaart's model of PD of fertility were used for data analysis [14].

Bongaart proposed the total fertility rate (TFR) of a given community is the product of the four indexes and put the formula as follows:

$$TFR = Cm(a) * Cc(a) * Ci(a) * Ca(a) * ff \dots\dots\dots (1)$$

Where TFR=total fertility rate

Cm=index of marriage, Cc=index of contraception, Ci=index of postpartum infecundity, Ca= index of abortion, and ff=total fecundity rate, which is assumed to be 15.3.

Each index has values that range from 1 to 0 depending on the degree of fertility inhibition. The index equals 1 if it has no fertility inhibition effect at all and zero when it has a 100% fertility inhibition effect.

Estimation of Index of sexual exposure (Cm)

This index measures to what extent does sexual exposure (includes formal marriage and cohabitation) is contributing to the fertility rate of a given community.

Accordingly, the index is given as follows:

$$Cm(a) = Cm(a) \times wm(a) \dots\dots\dots (2)$$

$$Wm(a) = \frac{fm(a)}{fm(a)} \dots\dots\dots (3)$$

$$\frac{fm(a)}{fm(a)}$$

Where Cm (a) is the index of marriage, wm (a) is weighted age-specific marital fertility rate, and fm is the marital fertility rate. In a case where the age disaggregate data is not available, Bongaarts proposed the following model as a proxy measure for the marriage index.

$$Cm(a) = m(a) + ex(a) \dots\dots\dots (4) \text{ Or}$$

$$Cm(a) = TFR/TMFR \dots\dots\dots (5)$$

Where $m(a)$ = proportion married/in union and $ex(a)$ =proportion of extramarital sexual exposure, TFR=total fertility rate, and TMFR= total marital fertility rate.

Estimation of the index of Contraception use (Cc)

This index measures the fertility inhibition effect of contraceptive use, and it's the function of contraceptive prevalence and the effectiveness of each used method. The contraceptive index is estimated as follows.

$$Cc(a) = 1 - r(a) (u(a) - o(a)) e(a) \dots\dots\dots (6)$$

Where: Cc=index of contraceptive use, $u(a)$ =contraceptive prevalence (among sexually exposed women), $O(a)$ =contraceptive use overlap with postpartum infecundability, $e(a)$ =average contraceptive effectiveness, $r(a)$ =fecundity adjustment.

For the computation of the index, the prevalence of contraceptive use among both married and unmarried women was used, and the average contraceptive effectiveness was calculated. The $r(a)$ has already estimated (1.08) for some countries by Bongaarts[13].

The contraceptive use effectiveness rates were obtained from previous studies done by Trussell and Bongaart [18][19].

Estimating Index of postpartum infecundity (Ci)

Ci estimates the fertility inhibition effect of postpartum infecundity due to lactational amenorrhea or postpartum sexual abstinence. The ratio of the average of birth intervals without and with lactation is called the index of lactational infecundity and calculated as follows[12].

$$C_i^* = \frac{\sum C_i^*(a) w_i(a)}{\sum C_i} \quad (7)$$

$$C_i = \frac{20}{18.5 + i(a)} \quad (8)$$

Where i= average total duration of postpartum infecundity.

Index of Induced abortion (Ca)

This index estimates the number of births averted by abortion and calculated with the formula

$$C_a^* = \frac{TFR}{TFR + b^*ab(a)} \quad (9)$$

$$TAR = ab(a) \quad (10)$$

$$b^* = 14 / (18.5 + i(a)) \quad (11)$$

Where TFR =total fertility rate, b=births averted by induced abortion, ab(a)= abortion rate.

The value of 14 is the average reproductive duration expected following abortion, 18.5+ i(a) is the average reproductive duration expected following live births, and i(a) represents the average postpartum infecundity interval[14][12].

Results

The estimated effect of the proximate determinants (PD)

In this analysis, delay in marriage inhibited fertility by 35 % (Cm=0.65) in 2016 and contraceptive use inhibited fertility by 37% (Cc=0.63). (Table 1)

Table 1: Estimated Index of Proximate determinants of fertility and their fertility reduction effect in 2005, 2011 and 2016.

Index of sexual exposure (Cm)	Effect on fertility reduction	Index of postpartum insusceptibility (Ci)	Effect on fertility reduction	Index of contraceptive (Cc)	Effect on fertility reduction	Index of induced abortion (Ca)	Effect on fertility reduction
0.65	35%	0.58	42%	0.63	37%	0.997	0.3%
0.63	37%	0.57	43%	0.71	29%	0.997	0.3%
0.64	36%	0.57	43%	0.85	15%	0.997	0.3%

Fertility Differences by Selected socio-economic Backgrounds

Since the most recent trends imply future planning, this paper was confined only to the data extracted from EDHS 2016. There were fertility differences according to women's level of education. Both indexes of sexual exposure (Cm=0.95, 5%), and contraceptive use (Cc=0.68, 32%) contributed the lowest fertility inhibiting effect among women with no education. The differences in PD indexes were also observed among rural and urban residents. Sexual exposure had a low fertility inhibiting effect while postpartum infecundity had a higher fertility inhibiting effect among rural women. The effect of contraception was highest among women in the fourth quintiles of the wealth index. (Table 2 below)

Table 2: Estimation of PD index with some background, data from EDHS 2016

Background	Cm	Ci	Cc	Ca	Fecund(TF)	TFRest	TFR-obs
Residence							
urban	0.67	0.77	0.47	0.99	15.3	3.7	2.3
rural	0.795	0.57	0.67	0.997	15.3	4.6	5.2
Educational background							
No education	0.95	0.56	0.68	0.998	15.3	5.6	5.7
Primary	0.64	0.60	0.62	0.997	15.3	3.6	4.2
Secondary	0.47	0.78	0.47	0.993	15.3	2.6	2.2
higher	0.65	0.80	0.44	0.992	15.3	3.5	1.9
Wealth index							
lowest	0.86	0.56	0.8	0.998	15.3	5.8	6.4
Second	0.82	0.58	0.67	0.998	15.3	4.9	5.6
middle	0.79	0.56	0.62	0.997	15.3	4.2	4.9
fourth	0.74	0.65	0.58	0.997	15.3	4.2	4.3
Highest	0.67	0.76	0.49	0.997	15.3	3.8	2.6

Estimating the Total Fertility rate

The estimated TFR was calculated with the following formula.

$$TFR=Cm*Cc*Ci*Ca *TF \quad (\text{Table 3})$$

Table 3: Estimated TFR using Bongaarts revised model

year of EDHS	Cm	Ci	Cc	Ca	Fecund(TF)	TFR	estimated	TFR-observed
2016	0.65	0.58	0.63	0.997	15.3		3.6	4.6
2011	0.63	0.57	0.71	0.997	15.3		3.9	4.8
2005	0.64	0.56	0.85	0.997	15.3		4.6	5.4

The estimated total fertility rate was 3.6, 3.9, and 4.2 in 2016, 2011 and 2005 respectively. There was a difference in observed and estimated TFR. These observed variations could be mainly due to:

1. variation during measuring the intermediate variables
2. The total fecundity assumed was 15.3 (13 to 17), which is the approximation [18].
3. The change in model

Future Projection of Fertility and contraceptive Prevalence

To forecast what proportion of contraceptive is needed to achieve the replacement fertility level (TFR=2.1) in Ethiopia:

Let TFR1=current fertility rate, TFR2 =replacement fertility we are intended to achieve, and Cc1 is the current contraceptive index and Cc2 is a contraceptive index in the future. Also, let u1 is the current contraceptive prevalence and u2 is the contraceptive prevalence we are interested to achieve the replacement level of fertility. Assuming that except for the Cc index, the other indexes will be constant throughout the year.

Accordingly:

$$TFR2/TFR1=Cc2/Cc1$$

Which is equivalent with:

$$TFR2 = 1 - 1.08(U2) e^*$$

$$TFR1 = 1 - 1.08(U1) e^*$$

From the above formula, we can drive the contraceptive prevalence needed as in the future (u2) as follow.

$$U2 = \frac{1}{1.08e2} \times [1 - TFR2/TFR1 \times Cc1]$$

$$TFR2=2.1, TFR1=4.6, Cc1=0.63 \text{ and } e2=0.95$$

Accordingly, Ethiopia needs a contraceptive prevalence rate of 69%, to achieve the fertility replacement level.

Discussion

Of the four PD, postpartum infecundity contributes to the highest fertility inhibiting effect followed by contraceptive use. The reasons for this could be, the majority of the study participants were from a rural setting where CPR was low. Similar finding was reported from Sudan [20]. The effect of contraceptive was significantly increased over the last fifteen years. The fertility decline between 2005 and 2016 was mainly contributed by the contraceptive use (26% increase); while the effect of the other indices was relatively decreased. The fertility

inhibiting effect of the PD varies according to the women's level of education, residence and wealth quintiles. The same finding was reported in Zambia[21].

In conclusion, over the last decades, contraceptive use was the single most important determinant responsible for fertility decline in Ethiopia. To achieve the fertility of replacement level, the country needs to double the current CPR. Meeting the unmet need for family planning is the key area to be focused on through ensuring service availability and accessibility. Activities targeting contraceptive service delivery should give due attention to the poor, rural and uneducated women.

Limitations Of The Study

There could be errors/variation during primary data collection which can directly or indirectly affect the intermediate variables (proximate determinates of fertility) in all EDHS. So, interpretation of the finding should put this into consideration.

Abbreviations

Ca- *index of abortion*

Cc-*index of contraceptive use*

Ci-*index of postpartum insusceptibility*

Cm-*index of marriage*

CPR-*contraceptive prevalence rate*

EDHS-*Ethiopian Demographic AND Health Survey*

TF-*Total Fecundity*

TFR-*Total Fertility Rate*

Declarations

Ethical approval

The consent to participate in the study was already assured during primary data collection in EDHS. The detail ethical issues of the collected data were mentioned in all the three EDHS i.e. EDHS 2005-2016.

Consents from participants

Before starting the data collection process, both written and informed verbal consent was taken from each respondent during the primary data collection. The detail ethical issues of the collected data were mentioned in all the three EDHS.

Consent for publication

Not applicable

Availability of data and material

All data generated or analyzed during this study were included in this published article and its supplementary information files are attached as an additional file with this manuscript. Also, the whole raw data of EDHS can be accessed online from *STATcompiler.com*.

Competing interests

The author declares that there was no competing interest.

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The author didn't receive any funds for this specific work.

Authors' contributions

SAS developed the proposal, analyzed the data, wrote the final manuscript, and authors of the paper.

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- [Bongaartsto20052016.xlsx](#)