Research Article

Fertility transition in india: An application of Bongaarts model

Aparna Aparajita Dash[1]* and DA Nagdeve[2]

[1]Student (M.Phil. in Population Studies), International Institute for Population Sciences, Mumbai-88, India

[2]Head of the Department; Department of Fertility Studies; International Institute for Population Sciences, Mumbai-88, India

Abstract

Fertility in India has been steadily declining. It almost reached the replacement level in 2015 to 2016 and evidence shows that proximate determinants has a direct influence on fertility. The study aims at calculating the proximate determinants of fertility in India for the period from 2005 to 06 and 2015 to 16 as well as determine the most significant proximate determinant of fertility in India. It also examines the rural – urban fertility differentials for the year 2015 to 2016. The proximate determinants of fertility for few selected states in India has been calculated from 2015 to 2016. The study of the proximate determinants can help expanding clinical and community based contraceptive distribution, promoting breastfeeding, increasing age at marriage and reduce unintended pregnancies. The study is based on data obtained from National Family and Health Survey Round 3 and National Family and Health Survey Round 4. Bivariate analysis had been done to analyze the distribution of currently married women at age of 15 to 49 by biological and behavioral characteristics as well as decomposition analysis had been used to find the contribution of each indices. It is revealed from the study that an increase in use of contraception has led to decline in Total Fertility Rate (TFR) over the decade. The knowledge of contraception is almost universal in India. Even after a slight decline in proportion married, there had been a considerably high contribution of the proportion married towards increasing Total Fertility Rate (TFR). It is evident from the decomposition that only the increase in use of contraception has a positive impact on declining fertility.

Introduction

It is evident from many studies that fertility in India has been steadily declining. A Total Fertility Rate (TFR) of 3.4 children per women was observed for the period of 1990 to 1992, as per the National Family Health Survey 1 (NFHS 1) report *[NFHS 1 Report]*.The TFR declined to 2.9 in 1996 to 1998, i.e. during NFHS 2 *[NFHS 2 Report]*. It further declined to 2.7 during 2005 to 2006 (NFHS 3) *[NFHS 3 Report]*. It almost reached the replacement level in 2015 to 2016 having TFR 2.2 as per NFHS 4 report *[NFHS 4 Report]*. Therefore, it is necessary to understand the mechanism through which socioeconomic and cultural factors affect fertility in order to know the causes of fertility decline. The proximate determinants of fertility are the link between the socioeconomic, cultural and the biological behavioral factors. Proximate determinants has a direct influence on fertility. If a proximate determinant changes, then fertility necessarily changes (assuming other proximate determinants remain constant). Fertility may or may not change in case of a change

in socioeconomic determinant. Socioeconomic determinants influence the proximate determinants which again influence fertility [1]. About the four major states included in the paper:

Punjab: Punjab is the northern state forming the border between India and Pakistan. According to Census 2011, the total population of the state is approximately 27 million and the decadal growth rate is 13.89 percent. There are 22 districts in Punjab [2].

Punjab	1990 to 1992	1996 to 1998	2005 to 2006	2015 to 2016
TFR	2.4	2.2	2.0	1.6
Percentage of use of modern methods of contraception	54.3	53.8	56.1	66.3
Median duration of breastfeeding (in months)	18.4	21.2	21.5	25.3

Source: National Family and Health Survey Factsheets, Round 1, 2, 3 and 4

Bihar: Bihar is an entirely land – locked eastern state. The

009

state has 38 districts and a population of approximately 10 million population as per census 2011. The decadal population growth accounts for 25.07 percent, according to census 2011 [2].

Bihar	1990 to 1992	1996 to 1998	2005 to 2006	2015 to 2016
TFR	4.0	3.5	4	3.4
Percentage of use of modern methods of contraception	39.2	22.4	28.9	23.3
Median duration of breastfeeding (in months)	26.6	≥ 36.0	25.4	≥ 36.0
Source: National Family and Health Survey Factsheets, Round 1, 2, 3 and 4				

Kerala: Kerala is a coastal state in the southern India. According to Census 2011, total population of the state is about 33 million. There are 14 districts in the state and the decadal growth rate as per Census 2011 is 4.9 percent, being the lowest in India [2].

Kerala	1990 to 1992	1996 to 1998	2005 to 2006	2015 to 2016
TFR	2	1.96	1.9	1.6
Percentage of use of modern methods of contraception	57.3	56.1	57.9	50.3
Median duration of breastfeeding (in months)	23.5	24.5	22.2	25.4
Source: National Family and Health Survey Factsheets, Round 1, 2, 3 and 4				

Maharashtra: The state of Maharashtra lies in the western peninsular region of India, covering a major portion of the Deccan plateau. It has 36 districts. According to the Census 2011, it has a population of about 1 billion which comprises of 9.28 percent of India's total population. The decadal growth in 2011 was 15.99 percent [2].

Maharashtra	1990 to 1992	1996 to 1998	2005 to 2006	2015 to 2016
TFR	2.9	2.5	2.1	1.9
Percentage of use of modern methods of contraception	50.8	65.4	64.9	62.6
Median duration of breastfeeding (in months)	23.0	23.8	25.2	28.71
Source: National Family and Health Survey Factsheets, Round 1, 2, 3 and 4				

Need for the study

The study of the proximate determinants can help expanding clinical and community based contraceptive distribution, promoting breastfeeding as a significant way to increase time span between pregnancies, increasing age at marriage, improve coverage of family planning program, develop women's access to family planning program and other reproductive health program and reduce unintended pregnancies. It will ensure women's empowerment regarding choice of contraception and reduction of fertility. There are very few studies focused on fertility transition in India using Bongaarts model. Therefore, the study aims at calculating the proximate determinants of fertility of India for the period 2005 – 06 and 2015 – 16 and determine the most significant proximate determinant of fertility in India. It also examines

the rural – urban differentials for the year 2015 to 2016. The indices of proximate determinants for some selected states of India in 2015 to 2016 are also calculated.

Data and methodology

Data source: The study was based on secondary data source and the data was obtained from two rounds of National Family and Health Survey (NFHS) i.e. NFHS 3 (to 2006) and NFHS 4 [3]. As it is a secondary survey, the data is available free for analysis and there is no ethical certification no. provided for this study. Inclusion and exclusion criteria are also not included because of the secondary nature of the study. The institution involved in conducting the survey is International Institute for Population Sciences (IIPS), Mumbai.

NFHS is a large –scale, multi – round survey conducted in a representative sample of households throughout India. It is a project of International Institute for Population Sciences (IIPS), Mumbai, India in collaboration with ORC Macro, Calverton, Maryland, USA and East – West Centre, Honolulu, Hawaii, USA. IIPS was designated as the nodal agency by the Ministry of Health and Family Welfare (MoHFW). The survey is funded by United States Agency for International Development (USAID). Supplementary support is given by United Nations Children's Fund (UNICEF).

NFHS 3: It was carried out in 2005 to 2006, in which 18 Research Organization including 5 Population Research Centers were involved to carry out the survey in 29 states of India. It collected information from a nationally representative sample of 109,041 households, 124,385 women age 15-49 and 74,369 men age 15-54. The sample covers 99 percent of India's population living in all 29 states. From among all the women and men interviewed, 102,946 were tested for HIV. It also collected information on population and health indicators for slum and non – slum population in 8 cities, namely Delhi, Mumbai, Chennai, Kolkata, Hyderabad, Indore, Meerut and Nagpur.

NFHS 4: It has a stratified two-stage sample. 601,509 households, 699,686 women age 15-49 and 112,122 men aged 15-54 were interviewed. Indicators were produced for the district, state/UTs and national level. Separate estimates were done for urban and rural areas in 157 districts that have 30-70 percent of the population living in urban areas as per 2011 Census.

The survey provide information on sexual behavior, HIV/AIDS knowledge, attitudes, and behavior and domestic violence only at the state level.

Methodology

Calculation of indices

Estimation of index of proportion married (Cm): At the time Bongaarts proposed this model, the basic assumption was that there was negligible union outside marriage. So, the basic assumption of the model is the inclusion of only married women. This study is based on the original model of Bongaarts

as most of the Indian societies do not accept births out of wedlock. Age as first marriage is considered to be synonymous with the age of entry into sexual relations. Also, the data for premarital and extramarital births is hardly available. The formula to calculate the index of proportion married is:

$$Cm = \frac{\Sigma m(a)g(a)}{\Sigma g(a)} \quad [1]$$

Where,

Cm = Index of proportion married

(a)= Age – specific proportion married

(a)= Age – specific marital fertility

Further, age – specific proportion married and age – specific marital fertility can be calculated as:

$$m(a) = \frac{\text{Number of married women of a particular age group}}{\text{Total number of women in the same age group}}$$

$$g(a) = \frac{\text{Birth of a particular age group}}{\text{Number of married women in the age group}}$$

Age specific measures were calculated in STATA by crosstabulating five year age group with the required variable like current marital status and birth in past three years. For the calculation of total number of births in each age–group the following formula was used after the crosstabulation process:

Total number of births in each age group= No. of women giving 1 birth + (2× no. of women giving 2 births) + (3× no. of women giving 3 births) + (4× no. of women giving 4 births) + (5× no. of women giving 5 births)

Estimation of index of contraception (Cc)

Cc = 1 – 1.08ue[1]

Where,

Cc= Index of contraception

u= Proportion of women using contraception

e= Average use of effectiveness of contraception

The coefficient 1.08 represents an adjustment for the fact that women do not use contraception of they know they are sterile.

Further, proportion of women using contraception and average use of effectiveness of contraception can be calculated as:

$$u = \frac{\text{Women using conteaception (15-49)}}{\text{Total married women (15-49)}}$$

The use of effectiveness of contraception was used as given by World Health Organization (WHO).

Methods of contraception	Effectiveness
Pills	0.92
IUDs	0.99 c
Injections	0.97
Diaphragm	0.84
Condom	0.85
Female sterilization	0.99
Male sterilization	0.99
Implants	0.99
Female condom	0.79
Foam/Jelly	0.71
Standard days	0.88
Rhythm/periodic abstinence	0.75
Withdrawal	0.73
Lactational amenorrhea	0.98

The number of currently married women using a particular type of contraception was calculated in STATA by cross–tabulating current method of contraception with the current marital status.

The number of women using contraception was calculated by subtracting the number of women not using any method from the total number of currently married women.

Estimation of index of abortion (Ca)

$$Ca = \frac{T\,F\,R\,(obs.)}{T\,F\,R\,(obs.)+A} \quad [1]$$

Where,

Ca = Index of abortion

TF(obs.) = Observed Total Fertility Rate Further A can be calculated as:

A = b * TA, where TA is total abortion rate and;

b = 0.4(1 + u), where u is the proportion of women using contraception as computed for previous index.

Total Abortion Rate can be calculated as:

$$TA = \frac{\text{Total no.of abortion}}{\text{Total no.of married women}}$$

The data for abortion was unavailable for NFHS 3. So the value for abortion for both, NFHS 3 and NFHS 4 was derived from the formula proposed by Bongaarts to calculate TFR. (See estimation of TFR).

Estimation of index of Postpartum Infecundability (Ci)

Where,
$$Ci = \frac{20}{18.5+i}$$

i= Median duration of postpartum infecundability due to lactational infecundability measured in months

If no breastfeeding and postpartum abstinence are practiced, the birth interval averages about 20 months. In the

presence of breastfeeding and postpartum abstinence, the average birth interval equals approximately 18.5 months.

The value of i can be calculated using formula: [1]

$i = 1.753e0.1396*B-0.001872*B^2$

Where, B is the mean/median duration of breastfeeding.

The median duration of breastfeeding was taken from the NFHS- 3 and NFHS- 4 reports.

Estimation of Total Fecundity (TF): TF refers to a fertility level that would prevail if all women age 15–49 were married, there was no contraception use in the population concerned, no postpartum insusceptibility (beyond a maximum of 1.5 months), and no induced abortion. Total Fecundity is taken as 15.3. This value was derived by Bongaarts based on data from multiple studies. According to Bongaarts, the total fecundity of most populations falls within the range of 13 to 17 births per woman with an average of approximately 15.3.

Estimation of Total Fertility Rate (TFR)

$$TFR = Cm * Cc * Ca * Ci * TF$$

Where,

TFR= Total Fertility Rate

Cm= Index of marriage

Cc= Index of contraception

Ca= Index of abortion

Ci= Index of postpartum infecundability

TF= Total fecundity, taken as 15.3 as proposed by Bongaarts

Index of abortion was calculated using the formula derived from this formula by using observed TFR as made available by NFHS India Report (for both, NFHS 3 and NFHS 4).

It is:

$$Ca \frac{TFR}{Cm * Cc * Ci * 15.3}$$

The similar formulas were used for the data of NFHS 3 and NFHS 4 – Total, Rural, Urban and some selected states.

Decomposition of change in TFR over the time

NFHS 3 was taken as time period 1 and NFHS 4 was taken as time period 2. The following steps were followed to calculate the sources of changes in the total fertility from 2005 to 2006 to 2015 to 2016.

Step – 1: Decomposition of TFR over time

$$\frac{TFR_2}{TFR_1} = \frac{Cm_2}{Cm_1} * \frac{Ca_2}{Cc_1} * \frac{Ca_2}{Ca_1} * \frac{Ci_2}{Ci_1} * \frac{TF_2}{TF_1} \quad [1]$$

Step – 2: Proportional change for each proximate determinants

Proportional change in TFR (Pf)

$$pf = \frac{TFR_2}{TFR_1} - 1$$

Proportional change in index of proportion married (Pm)

$$pm = \frac{Cm_2}{Cm_1} - 1$$

Proportional change in index of contraception (Pc)

$$pc = \frac{Cc_2}{Cc_1} - 1$$

Proportional change in index of abortion (Pa)

$$pa = \frac{Ca_2}{Ca_1} - 1$$

Proportional change in index of postpartum infecundability (Pi)

$$pi = \frac{Ci_2}{Ci_1} - 1$$

Proportional change in total fecundity (Pr)

$$pr = \frac{TF_2}{TF_1} - 1$$

Step – 3: Percentage of change in each proximate determinants

$$percentage\ of\ change\ in\ the\ proximate\ \det er\min anta = \frac{Time2 - Time1}{Time1} * 100$$

[1]

Step – 4: Distribution of percentage change in each proximate determinants

$$Distribution\ of\ percentage\ change\ in\ each proximate\ determinanta$$
$$= \frac{percentage\ of\ change\ in\ the\ proximate\ \det er\min anta}{Total} * 100$$

[1]

Estimation of indices for some selected states

Four major states were selected randomly according to their region. The selected states along with their regions are:

1. Punjab - NORTH

2. Bihar - EAST

3. Kerala – SOUTH

4. Maharashtra - WEST

Results

Biological and behavioral characteristics influencing the proximate determinants of fertility

The Table 1 shows a comparative analysis of percentage distribution of women age 15–49 by biological and behavioral characteristics in India during 2005 to 2006 and 2015 to 2016. It can be seen from table that knowledge of contraception is almost universal in India. The percentage of non-users of

Table 1: Percentage distribution of women age 15-49 by biological and behavioral characteristics in India, 2005 to 2006 and 2015 to 2016.

Variables and Categories	2005 to 2006	2015 to 2016
Knowledge of any contraception (%)		
No	1.96	2.18
Yes	98.04	97.82
Current use of any contraceptive methods (%)		
Non-Users	56.16	59.23
Users	43.84	40.77
Modern contraceptive method (%)		
Not using any method	56.16	59.23
Traditional methods	5.84	4.30
Pills	2.31	2.98
IUDs	1.30	1.13
Injection	0.08	0.13
Diaphragm	0.00	0.00
Condom	3.93	4.16
Female Sterilization	29.55	27.84
Male Sterilization	0.79	0.20
Female Condoms	0.00	0.02
Foam/Jelly	0.02	0.00
Standard days	-	0.01
Implants	0.00	-
Other modern methods	0.01	-
Early marriage (%)		
Less than age 18 years	58	40
More than or equals to age 18 years	42	60
Median age at first marriage (20-49) in years		
Urban	18.8	19.8
Rural	16.4	18.1
Total	17.2	19.0
Median duration of post-partum infecundability in months		
Amenorrhea	7.0	4.9
Abstinence	2.3	3.4
Insusceptibility	8.1	6.6
No. of observation	124385	699686

any contraceptive methods have gone up from 56 percent in 2005 to 2006 to 59 percent in 2015 to 2016 and the percentage of users have come down. The use of traditional methods of contraception has increased. Among the modern contraceptive methods, the percentage of women using pills, injection, condom and female condom has increased and the percentage of women using IUDs, female sterilization, male sterilization and foam/jelly has declined, which means women are adopting methods of spacing than methods of limiting. The percentage of women marrying before 18 years of age has declined. The median age at marriage has increased both in urban and rural areas of India. Postpartum amenorrhea and insusceptibility have declined, whereas postpartum abstinence has increased from 2005 to 2006 to 2015 to 2016.

Bongaarts' proximate determinants indices

The indices of Bongaarts' Proximate determinants calculated for 2005 to 2006 and 2015 to 2016 is presented in Table 2. The proportion married for India has a negligible decline of index from 0.6733 in 2005 to 2006 to 0.6603 in 2015 to 2016. There is a significant increase in the use of contraception from 0.4733 index value in 2005 to 2006 to 0.4934 index value in 2015 to 2016. The index of abortion has declined from 0.9922 index value in 2005 to 2006 to 0.8757 index value in 2015 to 2016. The index of postpartum infecundability has declined from 0.5580 in 2005 to 2006 to 0.5040 in 2015 to 2016.

Decomposition of change in fertility over time

The decomposition of change in fertility from 2005 to 2006 to 2015 to 2016 is depicted in Table 3. The table shows that there was an 18.5 percent decline in TFR from 2005 to 2006 to 2015 to 2016. There was a 10.09 percent increase in TFR due to proportion married, this might be due to most of the couples preferring child soon after marriage. The use of contraception is playing an important role in declining fertility, TFR has been declined by 22.16 percent due to increase use of contraception. The percentage of abortion has declined resulted in 61.41 percent increase in TFR. Similarly, decline in postpartum infecundability resulted in a 50.66 percent increase in TFR.

Rural – Urban differential in the model

Urban bias is an often cited characteristics of state socialist regimes [4]. Urban areas are mostly focused on wealth generation. In consequence, rural areas are at a relative disadvantage due to lack of resources, infrastructure etc. The issue of rural or urban residence is constantly important in terms of differentials in population growth, socioeconomic status and public health [4]. The indices of Bongaarts' Proximate determinants calculated for 2015 to 2016 by

Table 2: Calculation of indices for India, 2005 to 2006 and 2015 to 2016.

Index	NFHS 3 (2005 to 2006)	NFHS 4 (2015 to 2016)
Index of proportion married (Cm)	0.6733	0.6603
Index of contraception (Cc)	0.4733	0.4934
Index of abortion (Ca)	0.9922	0.8757
Index of Postpartum Infecundability (Ci)	0.5580	0.5040
Total Fecundity (TF)	15.3	15.3
Total Fertility Rate (TFR)	2.7	2.2

Table 3: Decomposition of change in TFR over time, 2005 to 2006 and 2015 to 2016.

	P values	Percentage of change in TFR	Distribution of percentage of change in TFR
Pf	-0.08124	-18.51852	
Pm	-0.01931	-1.93064	-10.09611
Pc	0.04238	+4.23778	+22.16106
Pa	-0.11743	-11.74275	-61.40759
Pi	-0.09687	-9.68702	-50.65735
Pr	0	0	0
Total		-19.12264	100

013

residence is presented in Table 4. The proportion married is higher in rural areas with a value of 0.7018 than urban area with a value of 0.5718 in 2015 to 2016. The use of contraception is higher in rural area with an index value of 0.5029 than urban area with an index value of 0.4572. The index of abortion is higher for rural area with 0.9191 than urban area with 0.8065. It is higher in urban area with 0.5579 index value than rural area with 0.4836 index value.

Calculation of indices for some selected states of India

The calculation of indices for some selected states of India is presented in Table 5. The proportion married is highest in Bihar (east), followed by Maharashtra (west), Kerala (south), lastly Punjab (north). Similarly, the use of contraception was also highest in Bihar, followed by Kerala, Maharashtra and Punjab. However, the postpartum infecundability is highest in Punjab. Kerala and Maharashtra have equal postpartum infecundability. Bihar has the lowest postpartum infecundability among the four. The abortion is highest in Kerala, followed by Bihar. Punjab and Maharashtra have an index of approximately 1, which suggests the negligible abortion in the region. Bihar has the highest TFR followed by Maharashtra, Punjab and Kerala.

Bihar and Kerala represents two contrasting level of development within India.

Table 4: Calculation of indices for the rural-urban differentials in India, 2015 to 2016.

INDEX	NFHS4	
	Rural	Urban
Index of proportion married (Cm)	0.7018	0.5718
Index of contraception (Cc)	0.5029	0.4572
Index of abortion (Ca)	0.9191	0.8065
Index of Postpartum Infecundability (Ci)	0.4836	0.5579
Total Fecundity (TF)	15.3	15.3
Total Fertility Rate (TFR)	2.4	1.8

Table 5: Calculation of indices for some selected states of India, 2015 to 2016.

INDICES	PUNJAB (North)	BIHAR (East)	KERALA (South)	MAHARASHTRA (West)
Cm	0.527704	0.823924	0.600804	0.643201
Cc	0.25689702	0.768579	0.486898	0.37445749
Ci	0.546609	0.475309	0.51124	0.51124
Ca	1.0	0.740476	0.681769	1.0
TF	15.3	15.3	15.3	15.3
TFR	1.6	3.41	1.56	1.9

Discussion

This paper presents a simple but comprehensive model for the relationship between the proximate determinants and fertility as given by Bongaarts. The article by Leela Visaria [5]estimates the values of proximate determinants of fertility for major states by using NFHS (1992 to 1993) data and demonstrated the interstate variations after examining evidences. The study found that in all India level, the fertility rate has declined at a very faster rate than it was expected. According to a study by Nath and Mazumder [6], the declining

TFR in developing countries are the result of decline in marital fertility or delay in age at childbearing or both.

It was evident from the decomposition that only the increase in use of contraception has a positive impact on declining fertility. All other indexes, i.e. marriage, abortion and span of breastfeeding has led to increase in fertility level. However, the use of contraception has compensated for all increase and has a tremendous decline in TFR over the decade. Most of the fertility decline is happening in most of regions of developing world, the major contributor being illiterate women. This change was seen due to increase in prevalence of contraception among women without or less education [7]. In Ethiopia, of the four proximate determinants of fertility, postpartum insusceptibility contributed the highest fertility [8-16].

This study also focuses on the rural – urban differentials of the model where it is evident that out of the four indices, three indices are higher for rural area. Only the fourth indices, i.e. postpartum infecundability, is higher for urban area.

Conclusion

An increase in deliberate marital fertility control is seen when a population moves through the transition from natural to controlled fertility. This control is due to rise in contraceptive use, but induced abortion also plays a major role in many societies. Due to control of marital fertility, there is a transition in marriage and postpartum infecundability as well. To examine the changes in measures of fertility, one cannot rely on time trends in individual population.

However, a comparative analysis of a population in a two different time periods can help.

Limitations of the study

The study also has some of its own limitations. Original model of Bongaarts was used rather than the revised model due to unavailability of pre-marital and extra-marital data. Abortion index was calculated through the TFR formula due to unavailability of abortion data in NFHS 3 and under-reporting of abortion data in NFHS 4. But, this study is a good representation of fertility transition in India from 2005 to 2006 to 2015 to 2016.

References

1. Bongaarts J, Potter R (2013) Fertility, biology, and behavior: An analysis of the proximate determinants. Academic Press. **Link:** https://bit.ly/31Ecp4c

2. Demographic and Training Manual (2011) Census of India. **Link:** https://bit.ly/2BrC0Tr

3. National Family and Health Survey, Round IV. (2015 to 2016). India report. International Institute for Population Sciences.

4. Buckley C (1998) Rural/urban differentials in demographic processes: The Central Asian states. Population Research and Policy Review 17: 71-89. **Link:** https://bit.ly/3eYalaS

5. Visaria L (1999) Proximate determinants of fertility in India: An exploration of NFHS data. Economic and Political Weekly 34: 3033-3040. **Link:** https://bit.ly/3irZfNB

6. Nath DC, Mazumder D (2005) Role of Proximate Determinants of the decline to below the Replacement level Fertility in an urban society of Northeast India. IUSSP2005

7. National Family and Health Survey, Round III (2005 to 2006) India report. International Institute for Population Sciences.

8. Majumder N, Ram F (2015) Explaining the role of proximate determinants on fertility decline among poor and non-poor in Asian countries. PLoS One 10: e0115441. **Link:** https://bit.ly/3dXUN5E

9. Ahmed Shallo S (2020) Roles of Proximate Determinants of Fertility in Recent Fertility Decline in Ethiopia: Application of the Revised Bongaarts Model. Open Access J Contracept 11: 33-41. **Link:** https://bit.ly/2CXAfxp

10. Alazbih NM, Tewabe GN, Demissie TD (2017) Contraception and fertility transition in AMHARA National Regional State of ETHIOPIA: an application of BONGAARTS' model. Fertility Research Practice 3: 12. **Link:** https://bit.ly/3dWbRcr

11. Bhende AA, Kanitkar T (1978) Principles of population studies. Bombay: Himalaya Publishing House.

12. Bongaarts J (2015) Modeling the fertility impact of the proximate determinants: Time for a tune-up. Demographic Research 33: 535-560. **Link:** https://bit.ly/3gpjt92

13. Countinho RZ, Golgher AB (2018) Modelling the Proximate Determinants of Fertility for Brazil: the advent of competing preferences. Revista Brasileira de Estudos de População 35. **Link:** https://bit.ly/2VHEB2o

14. Das KC, Lan NTN, Shekhar C (2016) Proximate determinants and their influences on fertility reduction in Vietnam. IUSSP-2016. **Link:** https://bit.ly/2C1y2Ri

15. Ishida K, Stupp P, Melian M (2009) Fertility decline in Paraguay. Stud Fam Plann 40: 227-234. **Link:** https://bit.ly/3goDHj0

16. Singh S, Casterline JB, Cleland JG (1985) The proximate determinants of fertility: Sub-national variations. Population studies 39: 113-135. **Link:** https://bit.ly/2C0saYn