RESEARCH ARTICLE

REVISED Fertility transition in selected sub-Saharan African countries: the role of family planning programs [version 2; peer review: 2 approved]

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Abstract

Background: Change in fertility rate across societies is a complex process that involves changes in the demand for children, the diffusion of new attitudes about family planning and greater accessibility to contraception. Scholars have concentrated on a range of factors associated with fertility majorly at the national scale. However, considerably less attention has been paid to fertility preference - a pathway through which various variables act on fertility. It is understood that women have inherent fertility preferences which each they seek to achieve over her reproductive cycle. However, the service delivery enhancement levels and capacity across countries as integral pathways to this goal accomplishment stand on their way towards eventual outcomes. Precisely, the Sub-Saharan African countries' disparities amid similarities in their population policies is a cause of concern.

Methods: Using Bongaarts reformulation of Easterlin conceptual scheme of 1985 on DHS data, the understanding of the current fertility transition in general would provide explanations to the observed fertility dynamics. This study therefore is an attempt to explain the current fertility transition through women's fertility preference.

Results: Results reveal that fertility transition is diverse across sub-Saharan Africa; generally, on a decline course in most of the countries. The huge disparities in fertility preferences among women of reproductive age and its non-significant change in the implementation indices points at the service delivery performance underneath regarding the proportion of demand to family planning commodities satisfied. Service delivery indicators are integral to fertility preference achievement within households as well as a country's overall positioning regarding fertility transition at the macroscale.

Conclusions: It is therefore plausible to conclude that the improvement of service delivery in general; precisely touching on the availability and the uptake of quality birth control technologies is one of the most feasible means through which countries can fast track their fertility transitions.

Keywords

Fertility, Preference Implementation index, family planning, Transition, Sub-Saharan Africa

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Any reports and responses or comments on the article can be found at the end of the article.

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REVISED **Amendments from Version 1**

I have reworked the abstract section as per reviewers comments

I have beefed up literature and edited my citations to conform to the reviewers comments

I have also revised the discussions section to include FP/RH policy implications

I have also allowed for an objective review of the statistical analysis from one of the authors - Prof Alfred Agwanda

Any further responses from the reviewers can be found at the end of the article

Introduction

Change in fertility rate across societies is a complex process that involves changes in the demand for children, the diffusion of new attitudes about family planning and greater accessibility to contraception provided by family planning programs[1,2]. Debates about this transition in Sub-Saharan Africa have almost reached a consensus about its uniqueness since they began in the mid-1990s. The trajectory of African fertility transitions occurred earlier than anticipated if Africa had followed the non-African relationship between fertility and development[3]. However, the pace of decline in fertility rate at the time of onset of the transition in this rate was slower than the comparable pace at the onsets of non-African transitions. The key features of African fertility regimes indicate that at a given level of development, Africa's fertility is higher, contraceptive use is lower, and desired family size is higher than in non-African less-developed countries[1,2].

Fertility preference is anchored by service delivery advancement; precisely contraceptive uptake among modern societies. It is evident that contraceptive prevalence is rising with fertility subsequently falling across countries at varied intensities[4]. The speed within which these changes are occurring in countries points at the diverse entry periods of countries into transition[1]; which also is dependent on the levels of endowment within service delivery points. Underlying the changed contraceptive fertility behavior, there appears to have been a major shift in attitudes regarding desired family size overtime[5]. With the intention to lower births, the availability and advancement in contraceptive technology overtime as well as the improvement in the dispensation mechanisms of these vital birth regulation commodities through extensively devolved service delivery points is key[1,6,7]. It is clear that a direct correlation exists between contraceptive uptake and service delivery points including the continuum of care. In her studies of the Standard Days Method (SDM) as a component within the contraceptive method mix, Weis (2020) noted evidence of demonstrated high level acceptability of the method just as the others across diversity in demographic characteristics of users.

This raises two fundamentally interrelated concepts observed in a number of developing countries, namely: the extent to which changes in fertility levels are due to changes in fertility preference and the extent to which the observed fertility changes result from the ability of women to implement these fertility desires[2]. In this study we seek to add to our understanding of the fertility transition by examining how countries differ in their patterns of reproductive behavior. We specifically examine trends in the fertility desires and the extent at which the ability to implement fertility desires contributes to the prevailing fertility change.

Methods

Analytical model

Using all the trend data from Measure DHS gathered between 1986 and 2016 across sub-Saharan African countries (listed in Table 1), we apply[2] a reformulation of[8–10] a conceptual scheme in which the variable 'fertility' is measured by the total fertility rate (F_0), a function of the supply of births (natural fertility), the demand for births (wanted fertility) and the degree of preference implementation index[9]. The latter in turn is dependent on cost of fertility regulation and cost of unwanted childbearing. The degree of preference implementation is the net result of a decision-making process in which couples weigh the cost of fertility regulation and the cost of unwanted pregnancy. Figure 1 shows the diagrammatic presentation.

Relationship between variables

According to Bongaarts (1993):

$$F_n = F_0 / C \quad (1)$$

C is an index ranging from 0 to 1 measuring the proportional reduction in F_n attributed to deliberate birth control mechanisms. Birth control not only confined to contraception also encompass induced abortion practices though always ignored in studies. F_0 data is always available and hence the only additional task required is to compute F_n in (i) with an estimate of C. Bongaarts further provided a procedure for deducing C, with an approach though the limitation was the unavailability of data. Hence:

$$C = 1 - 1.02 \times U \quad (2)$$

Where U is the fraction of women in marriage practicing all forms of birth regulation except during the post-partum infecundity period. The error associated with this is negligible hence ignored sometimes. By substituting C in Equation 1 above yields the anticipated approximation of natural total fertility.

F_w computation: According to Bongaarts, the favoured approach is dependent on the equation below:

$$F_W = F^W + 1.09 - W_m(40 - 49) \quad (3)$$

Where F^w is the proportion of women who want more children, equaling the resulting total fertility after deleting all births to women who want no more children at the time of the survey and Wm (40–49) is the proportion of women in union aged from 40 to 49 who want no more births.

These two equations helped normalize the biases in order to compute the respective F_n and F_w trends across the regions. With most of the erratic curves expected, a normalization process using the

Table 1. Trends in fertility preference estimates of selected Sub-Saharan African countries.

Country	DHS Survey year	Total fertility rate	Total wanted fertility rate	Natural fertility (fertility rate in absence of any contraception)	Index of preference implementation
Angola	2015–16 DHS	6.2	4.99	7.21	0.45
Benin	2011–12 DHS	4.9	4.4	5.64	0.6
Benin	2006 DHS	5.7	4.89	6.89	0.59
Benin	2001 DHS	5.6	4.89	6.91	0.65
Benin	1996 DHS	6	5.28	7.21	0.63
Burkina Faso	2010 DHS	6	5.24	7.19	0.61
Burkina Faso	2003 DHS	5.9	5.21	6.87	0.58
Burkina Faso	1998–99 DHS	6.4	5.71	7.28	0.56
Burkina Faso	1993 DHS	6.5	5.8	8.71	0.76
Burundi	2010 DHS	6.4	5.03	8.24	0.57
Burundi	1987 DHS	6.9	5.7	7.57	0.36
Cameroon	2011 DHS	5.1	4.55	6.7	0.75
Cameroon	2004 DHS	5	4.72	6.8	0.86
Cameroon	1998 DHS	4.8	4.65	5.98	0.89
Cameroon	1991 DHS	5.8	5.6	6.94	0.85
Chad	2014–15 DHS	6.4	6.09	6.8	0.56
Chad	2004 DHS	6.3	6.22	7.1	0.91
Chad	1996–97 DHS	6.4	6.21	6.68	0.6
Congo	2011–12 DHS	5.1	4.93	9.37	0.96
Congo	2005 DHS	4.8	4.67	8.76	0.97
Congo Democratic Republic	2013–14 DHS	6.6	5.63	8.33	0.64
Congo Democratic Republic	2007 DHS	6.3	5.64	7.98	0.72
Cote d'Ivoire	2011–12 DHS	5	4.75	6.14	0.82
Cote d'Ivoire	1998–99 DHS	5.2	4.87	6.14	0.74
Cote d'Ivoire	1994 DHS	5.3	4.9	6	0.63
Ethiopia	2016 DHS	4.6	3.88	7.26	0.79
Ethiopia	2011 DHS	4.8	3.97	6.78	0.7
Ethiopia	2005 DHS	5.4	4.05	6.35	0.41
Ethiopia	2000 DHS	5.5	4.56	6	0.34
Ghana	2014 DHS	4.2	3.65	5.77	0.74
Ghana	2008 DHS	4	3.57	5.26	0.75
Ghana	2003 DHS	4.4	3.8	5.92	0.72
Ghana	1998 DHS	4.4	3.83	5.67	0.69
Ghana	1993 DHS	5.2	4.3	6.56	0.6
Ghana	1988 DHS	6.4	5.36	7.37	0.48
Guinea	2012 DHS	5.1	4.84	5.41	0.55
Guinea	2005 DHS	5.7	5.14	6.28	0.51
Guinea	1999 DHS	5.5	5.06	5.87	0.46
Kenya	2014 DHS	3.9	3.08	9.55	0.87
Kenya	2008–09 DHS	4.6	3.24	8.58	0.75

Country	DHS Survey year	Total fertility rate	Total wanted fertility rate	Natural fertility (fertility rate in absence of any contraception)	Index of preference implementation
Kenya	2003 DHS	4.9	3.55	8.18	0.71
Kenya	1998 DHS	4.7	3.29	7.8	0.69
Kenya	1993 DHS	5.4	3.62	8.1	0.6
Kenya	1989 DHS	6.7	4.13	9.23	0.5
Lesotho	2014 DHS	3.3	2.63	8.55	0.89
Lesotho	2009 DHS	3.3	2.61	6.34	0.81
Lesotho	2004 DHS	3.5	2.81	5.65	0.76
Liberia	2013 DHS	4.7	4.19	5.92	0.71
Liberia	2007 DHS	5.2	4.44	5.88	0.47
Liberia	1986 DHS	6.7	6.04	7.17	0.42
Madagascar	2008–09 DHS	4.8	3.75	8.09	0.76
Madagascar	2003–04 DHS	5.2	4	7.19	0.62
Madagascar	1997 DHS	6	4.53	7.48	0.5
Madagascar	1992 DHS	6.1	4.46	7.35	0.43
Malawi	2015–16 DHS	4.4	3.32	11.11	0.86
Malawi	2010 DHS	5.7	3.97	10.76	0.75
Malawi	2004 DHS	6	4.4	8.98	0.65
Malawi	2000 DHS	6.3	4.47	9.16	0.61
Malawi	1992 DHS	6.7	5.61	7.72	0.48
Mali	2012–13 DHS	6.1	5.42	6.82	0.51
Mali	2006 DHS	6.6	5.85	7.2	0.44
Mali	2001 DHS	6.8	5.87	7.41	0.4
Mali	1995–96 DHS	6.7	5.96	7.19	0.4
Mali	1987 DHS	7.1	6.35	7.46	0.32
Mozambique	2011 DHS	5.9	4.95	6.69	0.46
Mozambique	2003 DHS	5.5	4.91	7.43	0.77
Mozambique	1997 DHS	5.2	5.03	5.52	0.65
Namibia	2013 DHS	3.6	2.91	8.42	0.87
Namibia	2006–07 DHS	3.6	2.68	8.22	0.83
Namibia	2000 DHS	4.2	2.93	7.58	0.73
Namibia	1992 DHS	5.4	4.43	7.66	0.7
Niger	2012 DHS	7.6	7.19	8.86	0.75
Niger	2006 DHS	7	6.72	7.9	0.76
Niger	1998 DHS	7.2	6.83	7.86	0.64
Niger	1992 DHS	7	6.71	7.33	0.53
Nigeria	2013 DHS	5.5	5.16	6.5	0.75
Nigeria	2008 DHS	5.7	5.24	6.7	0.69
Nigeria	2003 DHS	5.7	5.31	6.54	0.68
Nigeria	1990 DHS	6	5.65	6.39	0.53
Rwanda	2014–15 DHS	4.2	3.26	9.18	0.84
Rwanda	2010 DHS	4.6	3.26	9.71	0.79
Rwanda	2007–08 DHS	5.5	3.78	8.75	0.65

Country	DHS Survey year	Total fertility rate	Total wanted fertility rate	Natural fertility (fertility rate in absence of any contraception)	Index of preference implementation
Rwanda	2005 DHS	6.1	4.35	7.42	0.43
Rwanda	2000 DHS	5.8	4.64	6.7	0.44
Rwanda	1992 DHS	6.2	4.71	7.91	0.53
Senegal	2016 DHS	4.7	4.59	6.32	0.93
Senegal	2015 DHS	4.9	4.76	6.43	0.91
Senegal	2014 DHS	5	4.77	6.46	0.87
Senegal	2012–13 DHS	5.3	4.92	6.48	0.76
Senegal	2010–11 DHS	5	4.7	5.77	0.72
Senegal	2005 DHS	5.3	4.92	6.03	0.66
Senegal	1997 DHS	5.7	5.09	6.56	0.59
Senegal	1992–93 DHS	6	5.4	6.5	0.46
Senegal	1986 DHS	6.4	5.74	7.23	0.56
Sierra Leone	2013 DHS	4.9	4.45	5.9	0.69
Sierra Leone	2008 DHS	5.1	4.4	5.57	0.4
Tanzania	2015–16 DHS	5.2	4.51	8.55	0.83
Tanzania	2010 DHS	5.4	4.59	8.32	0.78
Tanzania	2004–05 DHS	5.7	4.78	7.8	0.7
Tanzania	1999 DHS	5.6	4.76	7.56	0.7
Tanzania	1996 DHS	5.8	4.82	7.14	0.58
Tanzania	1991–92 DHS	6.2	5.4	6.94	0.48
Togo	2013–14 DHS	4.8	4.15	6.02	0.65
Togo	1998 DHS	5.2	4.53	6.84	0.71
Togo	1988 DHS	6.4	5.44	9.78	0.78
Uganda	2011 DHS	6.2	4.41	8.93	0.6
Uganda	2006 DHS	6.7	4.72	8.84	0.52
Uganda	2000–01 DHS	6.9	4.97	8.99	0.52
Uganda	1995 DHS	6.9	5.32	8.13	0.44
Uganda	1988–89 DHS	7.4	6.17	7.79	0.24
Zambia	2013–14 DHS	5.3	4.23	10.6	0.83
Zambia	2007 DHS	6.2	4.75	10.62	0.75
Zambia	2001–02 DHS	5.9	4.61	9.06	0.71
Zambia	1996 DHS	6.1	5.06	8.29	0.68
Zambia	1992 DHS	6.5	5.53	7.69	0.55
Zimbabwe	2015 DHS	4	3.43	12.55	0.94
Zimbabwe	2010–11 DHS	4.1	3.49	10.17	0.91
Zimbabwe	2005–06 DHS	3.8	3.22	9.85	0.91
Zimbabwe	1999 DHS	4	3.43	8.8	0.89
Zimbabwe	1994 DHS	4.3	3.67	8.44	0.87
Zimbabwe	1988 DHS	5.4	4.38	9.64	0.81

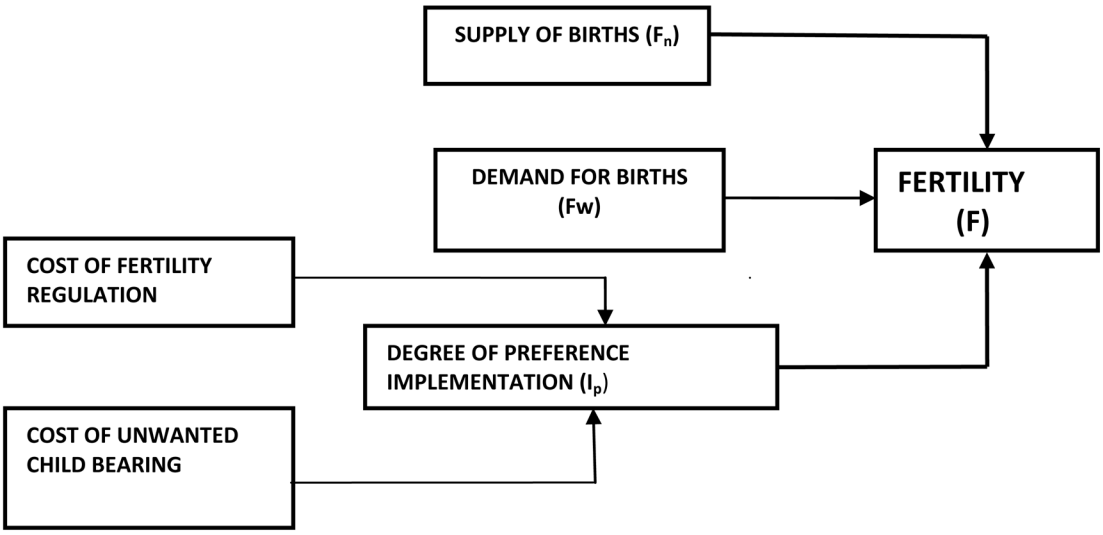

Figure 1. Variants in the supply-demand model.

natural logarithms of the equation was applied to give meaning to the various trend curves.

I_p is derived from a synthesis of past studies. It begins from the fact that all social and economic factors of fertility operate through a unified pack of proximate factors to exert an impact on fertility[8]. Easterlin's economic approach is a model of behavioural and biological factors affecting fertility in developing countries. The model consists of three central concepts: demand for children; the potential supply of children, and the momentary and psychic costs of contraception. According to the model, women whose potential supply of births exceeds demand would consider contraception, taking into consideration the costs involved while choosing suitable family planning methods[8,9].

The model is simple and attractive; however, it cannot address dynamic issues and has not succeeded in quantifying these factors in acceptable manner[2]. Emerging from the model is the fact that fertility (measured using F_0) is a function of three determinants namely: supply of births (F_n), demand for births (F_w) and the degree of I_p (Figure 1).

Supply of births (F_n) is measured as natural total fertility. F_n infers the rate of birthing likely to prevail minus the premeditated attempts by spouses to limit their number of children. Demand for births (F_w) is the wanted total fertility defined as the rate of prevailing childbearing after eliminating all unwanted births. Under normal circumstances, it is simply calculated as F_0 while eliminating the unwanted births from the numerator. Unwanted births are births occurring after an achievement of the ideal family size. Any births that are mistimed though occurring before the achievement of the desired family size are considered wanted births as well.

The degree of I_p is an index from zero value to unity. Its level of implementation implies the net result of decision-making process. This is the state in which a spouse ponders the cost of fertility regulation as they consider costs of bearing an unwanted child to its end. In general, the index has an inverse variation to the cost of fertility regulation as well as a reverse correlation to the unwanted births. If couples fully implement their fertility preference, the index is equal to unity. This signifies that no unwanted births occur as actual fertility corresponds to F_w. Conversely, if the index is equal to zero, the observed fertility equals F_n, that is, fertility in the absence of any deliberate fertility control assuming women remain sexually active over their reproductive cycles. The value of the index at play stipulates the position where actual fertility falls as dictated by the range set between wanted and F_n parameter levels.

F_0 gives the estimate of the number of children a woman would have by the end of childbearing if she were to pass through her reproductive cycle at the customary age specific birth rates. The model shows that the operation of these variables determines the level of fertility in a community or households. In this variant of the original Easterlin and Crimmins (1985) model, infant and child mortality dynamics affects the desired fertility rather than F_n. Women are deemed to possess precise desired fertility size translated and actualized into numbers through subsequent births after considering past child losses and risks related to future child deaths as well.

According to this variant, as development occurs, the trend in prevailing fertility transforms to become a function of the equilibrium between the F_w, F_n and the degree of fertility I_p. F_w is expected to decline over time, as a result of the changes associated with the costs and benefits of child bearing[9], as well as reductions in the infant-child mortality. I_p rises as fertility

regulation costs decline; with the benefit of fertility regulation focusing on the elimination of any unwanted births[8]. According to 8, the relationship between these variables under discussions and fertility can be expressed in statistical form as follows:

$$F_0 = F_w + F_u \quad (4)$$

Where F_u is the unwanted fertility (which can simply be expressed as $F_0 - F_w$).

$$F_u = (F_n - F_w) \times (1 - I_p) \quad (5)$$

Where I_p has a range of 0 to 1. With full I_p, $I_p = 1$ (which implies that $F_u = 0$ and $F_0 = F_w$) and $I_p = 0$ with no prefer I_p (This implies a substantial level of unwanted childbearing and $F_0 = F_n$). Noted here is that as defined by Bongaarts, F_n here is not the same as in total fecundity as in the Bongaarts proximate determinants but taken to mean fertility level achieved in absence of contraception[8].

F_u is a function of the difference between supply and demand, and the degree of I_p.

Substitution of Equation 5 in Equation 6 yields:

$$F = F_w \times I_p + F_n \times (1 - I_p) \quad (6)$$

Noting that F_n is given by:

$$F_n = F_0 / C$$

Where C implies an index ranging from 0 to 1 measuring the reduction in proportional of F_n attributable to deliberate birth control is estimated as:

$$C = 1 - 1.02 \times U$$

Where U represents the proportion of married women who were practicing contraception at the time of survey. It is measured as the number of married women using contraceptive method to the total number of married women. The values for U and C can be used to estimate F_n

Rearranging Equation 6 gives:

$$I_p = (F_n - F_o) / (F_n - F_w) \quad (7)$$

Equation 7 can now be used to estimate the degree of I_p once F_n (fertility in absence of contraception), actual fertility and F_w are known. One thing to note is that the estimation of F_w, as previously done overtime contain traits of upward bias as per the recent observation. An alternative estimation of F_w from Bongaarts model detail that the average F_w derived from the wanted status of births as reported by women was 2.8, indicating that this measure of wanted fertility contains an average upward bias of 0.4 birth.

The analysis consists of two stages. First, we computed the degree of I_p within the variable categories overtime from F_n, F_w and F_0. F_0 and F_w as a series of indicators are provided by the various country specific DHS reports. This involves compiling all the components of the index within the equation so as to come with the actual figures per the subsequent time intervals. The component variables are F_n, F_w computed to form the degree of I_p. Further correlation analysis between the degree of I_p and the unmet need to contraception, conducted using SPSS v18, was run.

Decomposition of fertility trends

According to Bongaarts (1993), the core objective of the demand framework lies in the identification of the causes of fertility decline in a population, with proceeding comparative analysis providing worthwhile insights yet not achieving its sole objective. Turning to the issue at hand, the decomposition of the variations in fertility and to abridge the methodological exposition, trends therefore should inform the basis of focus between two points in time, i.e. T_1 and T_2 running up to the determinants. The derivation of the decomposition equation also warrants the introduction of the variables listed in Table 2.

The decline in fertility between the two periods is F_1-F_2, conveyed by substitution as

$$F_1 - F_2 = \left[F_{w1} I_{p1} + F_{n1}(1 - I_{p1})\right] - \left[F_{w2} I_{P2} + F_{n2}(1 - I_{p2})\right] \quad (8)$$

The above equation therefore can be written as below

$$\Delta F = \Delta F_w \bar{I}_p + \Delta I_p (\acute{\Gamma}_w - \acute{\Gamma}_n) + \Delta F_n (1 - \bar{I}_p) \quad (9)$$

In Equation 8: ΔF, ΔF_w, ΔF_n and ΔI_p are the change within F, F_w, F_n and I_p respectively.

In Equation 9: $\acute{\Gamma}_w$, $\acute{\Gamma}n$ and $\bar{I}_p$ are the mean values of correspondingly, F_w, F_n and I_p. For example, the mean of the degree of implementation index ($\bar{I}_p$) is: - $[0.5(I_{p1} + I_{p2})]$

$\bar{I}_p$ implies the average of the Degree of Fertility Implementation Index (I_p). The influence of change in wanted (ΔF_w)

Table 2. Fertility decomposition.

Variable	Observation point	
Time Periods	T_1	T_2
Total Fertility	F_1	F_2
Natural Fertility	F_{n1}	F_{n2}
Wanted Fertility	F_{w1}	F_{w2}
Index of Implementation	I_{p1}	I_{p2}

Source: Bongaarts (1993)

as well as the natural (ΔF_n) fertility to prevailing fertility change hinge on the average extent or degree of implementation. Consequently, the outcome of fertility from every shift registered on the degree of fertility implementation index is determined by the corresponding mean change between F_n and F_w ($\acute{\Gamma}_w$-$\acute{\Gamma}_n$). This function requires two successive points in the estimates of the parameter measurers i.e. F_0, natural and F_w including the implementation index as well within the population under consideration. It is this function that is used to determine the extent to which implementation of fertility desires contributes to fertility transition (Table 4).

Results

Decomposition of fertility change and the contribution of F_w and I_p

As Table 1 shows the trend change in fertility parameters measurers, Table 3 further shows the decomposition of fertility changes among countries with two or more surveys. Results reveal there are indeed substantial variations between countries in terms of fertility preference parameter measurers as well as the implementation indices by countries. These results clearly indicate the important role played by the changes in I_p, F_w and F_n. Converse to the expected, eight countries actually increased

Table 3. Contribution of wanted fertility rate and preference implementation index to fertility change in selected Sub-Saharan African countries.

Country	Surveys	Change in F_o	Change in F_o		Absolute Contribution to F_o Change			Percent Contribution to F_o Change		
	Baseline	Last	Gap	F_o	Tw	Fn	Ip	Tw	Fn	Ip
Rwanda	2005	2014	9	1.89	0.69	-0.64	1.84	37	-34	97
Malawi	2004	2015	11	1.59	0.82	-0.52	1.3	51	-33	82
Kenya	2003	2014	11	1.00	0.45	-0.29	0.84	45	-29	84
Ethiopia	2005	2016	11	0.82	0.10	-0.36	1.08	45	-29	84
Benin	2001	2011	10	0.70	0.31	0.48	-0.08	44	68	-12
Uganda	2000	2011	11	0.68	0.31	0.03	0.34	46	4	50
Guinea	2005	2012	7	0.60	0.16	0.41	0.03	0.34	46	4
Senegal	2005	2016	11	0.59	0.26	-0.06	0.38	45	-10	65
Zambia	2001	2013	12	0.59	0.29	-0.35	0.65	50	-60	111
Namibia	2000	2013	13	0.56	0.02	-0.17	0.71	3	-30	127
Lesotho	2004	2014	10	0.51	0.15	-0.02	0.38	29	-3	74
Liberia	2007	2013	6	0.51	0.15	-0.02	0.38	29	-3	74
Mali	2006	2012	6	0.50	0.20	0.2	0.1	41	40	19
Tanzania	2004	2015	11	0.49	0.21	-0.18	0.46	42	-36	94
Madagascar	2003	2008	5	0.42	0.17	-0.28	0.53	41	-66	125
Nigeria	2003	2013	10	0.42	0.11	0.01	0.09	37	-34	97
Cote d'Ivoire	1998	2011	13	0.21	0.09	0	0.11	47	0	53
Sierra Leone	2008	2013	5	0.20	-0.03	-0.15	0.38	-14	-74	188
Ghana	2003	2014	11	0.20	0.11	0.04	0.04	57	21	22
Cameroon	2004	2011	7	0.19	0.14	-0.02	-0.23	-179	26	305
Burkina Faso	2003	2010	7	-0.08	-0.02	-0.13	0.05	19	139	-58
Chad	2004	2014	10	-0.09	-0.10	0.08	-0.28	-93	-77	270
Zimbabwe	2005	2015	10	-0.10	-0.19	-0.02	0.24	121	126	-147
Congo	2005	2011	6	-0.31	-0.25	-0.02	-0.04	80	7	14
Congo DR	2007	2013	6	-0.31	-0.01	-0.11	-0.2	-2	37	66
Mozambique	2003	2011	8	-0.40	-0.03	-0.29	-0.66	6	-71	165
Niger	2006	2012	6	-0.60	-0.36	-0.24	-0.01	59	39	2

F_0, total fertility rate.

Table 4. Fertility change contribution.

Change (Δ) in key measures	Contribution to fertility decline (ΔF)
ΔF_n	$\Delta F_n(1- \bar{I}_p)$
ΔF_w	$\Delta F \times \bar{I}_p$
Degree of ΔI_p	ΔI_p(Average Fw - Average F_n)

Source: Bongaarts (1993). F_n, natural fertility; F_w, wanted fertility; I_p, fertility implementation index.

their F_0 over the period 1986–2016. In six out of the eight countries where fertility increased, there was a decline in degree of I_p. Subsequently, in five of the eight countries there was an increase in F_w. The largest decline in fertility rate occurred in Rwanda, Malawi, Kenya and Ethiopia. The four countries subsequently had the greatest contribution of the degree of I_p to fertility decline. On the same note the greatest contribution of F_w decline to fertility change occurred in Malawi, Rwanda and Kenya.

In absolute values, Rwanda, Malawi and Kenya experienced the highest fertility changes as well, while Niger, Mozambique and DRC experienced an increase in fertility rate within the periods 1986–2016. Looking at the contributions made by each of the fertility parameters, the fertility preference (F_w) and the degree of I_p are the reasons for the variations in the changes in fertility. Rwanda registered a 37% decrease in its average wanted fertility desires, with a corresponding degree of I_p of 97% (Table 2). Malawi and Kenya on the same note registered a reduction in F_w of 51% and 54% and corresponding implementation indices of 82% and 84%, respectively.

Figure 2 highlights the graphical correlation between I_p and unmet need for family planning. There is an inverse correlation between I_p and the unmet need for family planning. High unmet need for contraception leads to a low implementation index, since contraception is the sole contributing factor to fertility regulation (also referred to as the extent of I_p). This is because the extent of contraceptive availability and subsequent utilization of contraceptives is what defines I_p level. The absence of these essential birth control commodities leads to non-implementation of family planning, thereby failing to restrain F_n.

Figure 3 echoes the performance of I_p in facilitating the reduction of fertility by each of the countries within the periods under study. Ethiopia, Rwanda and Sierra Leone are the three countries where I_p has most contributed to the fertility decline. However, in some countries, the limited or non-implementation of fertility led to the index not facilitating any declines in F_0, thereby allowing the natural increase to take its course. These countries were Mozambique, Chad, Cameroun, Democratic Republic of Congo, Togo, Benin, and Congo Brazzaville.

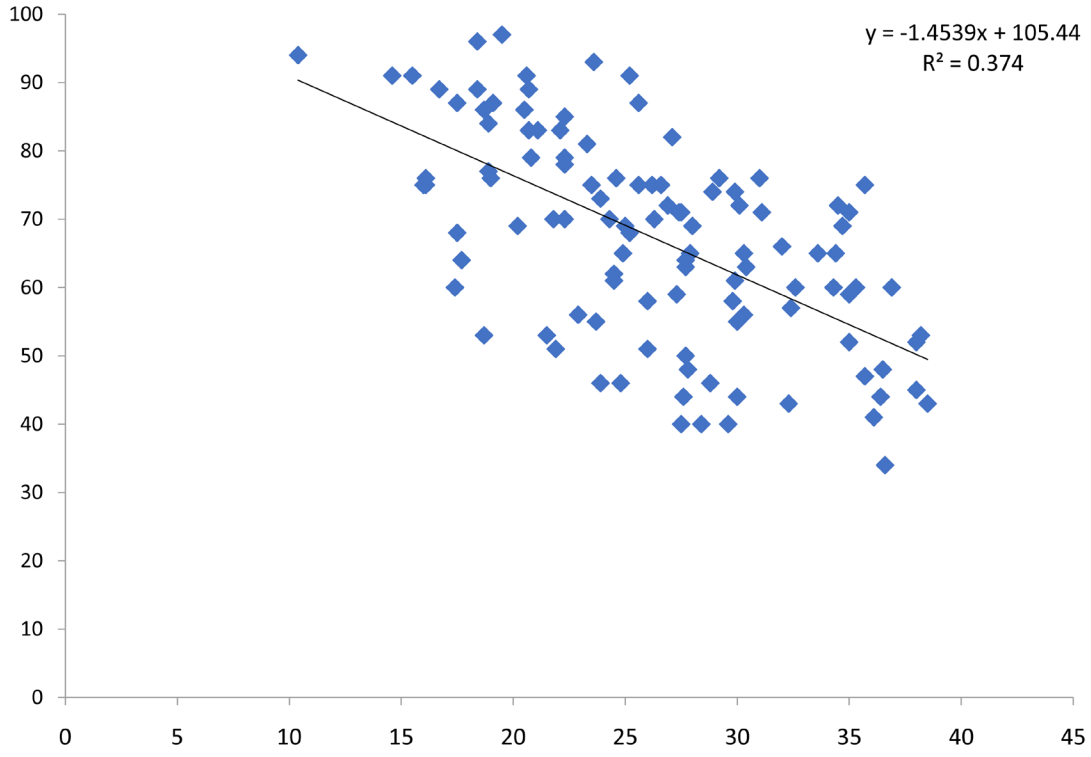

Figure 2. Correlation between implementation index and unmet need for family planning.

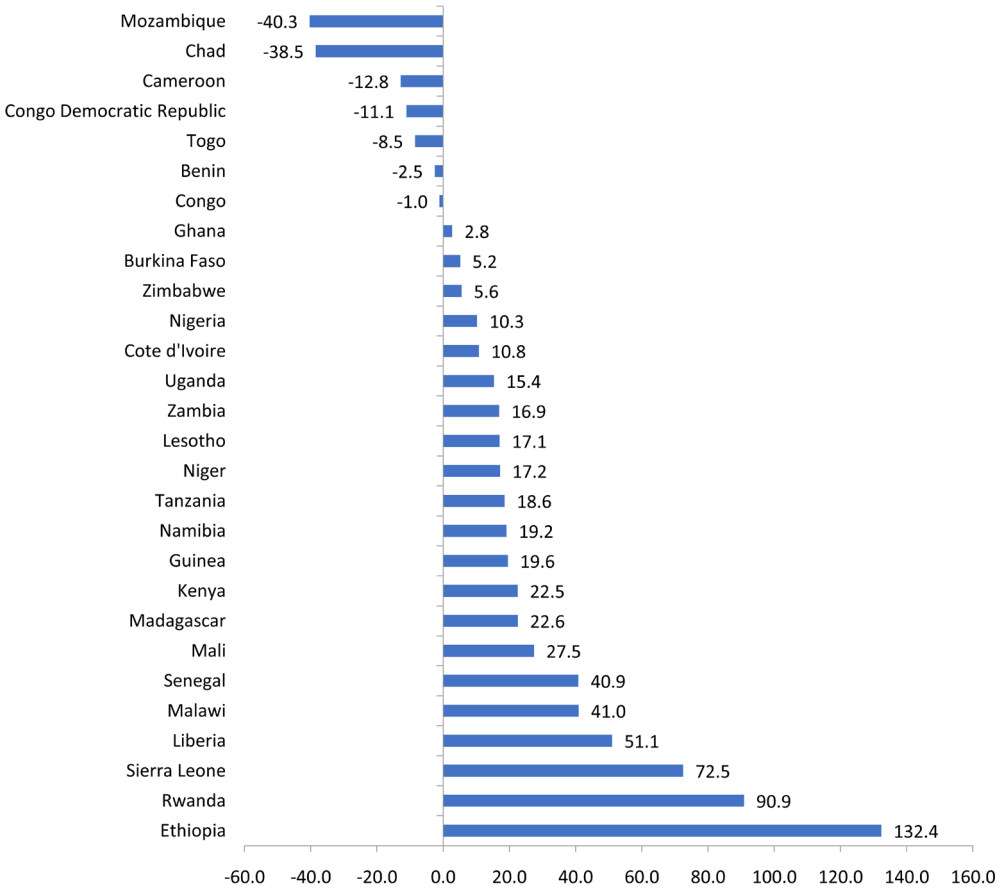

Figure 3. Percent change in preference implementation since 2000.

Discussion and conclusion

Based on the fertility preference and implementation indicators, fertility transition is indeed on course in a number of countries, going by the trend data for each country though at varied levels. The extent at which this occurs varies across countries, with each country exhibiting varied levels of implementation pointing at the service delivery state of advancement. The F_w and the degree of I_p are therefore key to the prevailing fertility in each country[9]. Countries where populations desired or F_w are in decline over time are believed to be high in their drive to lower their overall F_0 supported by the state of the service providers.

The suppressed desired or wanted fertility rates correspond to high index of implementation subsequently exhibiting the highest transition changes. The prevailing F_0 of a country therefore depends on the interplay between the fertility desires and the degree of fertility preference implementation index which is dependent on the availability of family planning commodities (proportion of demand satisfied). Reduction in fertility hence demands low desired fertility and high index of implementation simultaneously. This implies that those countries with only one high parameter performance (i.e. either suppressed wanted fertility or high implementation index) among the two exhibits only but between moderate to limited reduction in fertility change.

Further, the generally observed decline in the indices of fertility (i.e. F_0, F_n, F_w and I_p) confirms the strength of the service delivery especially the family planning program efforts by the various stakeholders in making birth control technologies available (to curb the unmet need thereby satisfying demand), accessible and affordable to their populaceas well as improved contraceptive technology. This is due to the fact that only birth control technologies are known to facilitatethe implementation of couples' fertility desires. Looking at the association between fertility preference implementation index and the unmet need for contraception (Figure 2), countries with high unmet need for contraception exhibit low values of fertility preference implementation index[3] which in turn implies weak service delivery.

The converse is also true. The unmet need for contraception also reflects the proportion of demand satisfied. High unmet need for contraception is a function of lower total supply of family planning commodities required by all those women in need; implying low proportion of demand satisfied by the birth

control commodities under the assumption that women of reproductive age are sexually active. This therefore leads to a surge in births as family planning is reduced owing to lower supplies of commodities than demanded. The unmet need has, however, progressively slowed over the years as births have reduced overtime in the majority of countries within the sub-Saharan Africa; reflected too by the surging implementation index overtime (Table 2).

This finding reflects the level of increase in sensitization, advocacy and public education by programs as well as the utilization of birth control technologies and improvements within the service delivery points. The wanted fertility, as a key parameter measure for the fertility change, relies heavily on the proportion of demand for contraception that is satisfied[6]. The wanted fertility rate is only achievable through the conscious attempt by spouses to deliberately control the number of births they wish to have, assuming all women are reproductive and sexually active at the same time.

With the population well sensitized to trigger conscious decision making with regards to contraceptive use, the service providers and continuous awareness creation will subsequently influence the couples to work towards the achievement of specific number of births within their means as opposed to mere natural child bearing with no control. It is therefore plausible to conclude that the improvement of the service delivery points towards efficiency, availability and uptake of birth control technologies is one of the most feasible means through which countries can fast track their fertility transitions. The access should not only take into consideration the quantity but also the quality of service and products available.

Service delivery for unconstrained access to contraception is therefore an important marker which policy can tackle for further improvement, with the index level acting as a proxy measure. The association between fertility preference implementation index and the unmet need to contraception suggests that this index can be used as an indicator for program success efforts. Going by the countries' performances over time also taking into consideration the constants (such as reproductive age and economic situation) and non-constants (such as health system endowment), one can conclude that the current fertility transition witnessed in Sub-Saharan Africa is only but modest and a work in progress at the same time. Further research is recommended on how best the fertility preference implementation index can be used as a measure of service delivery for family planning program efforts.

Data availability

The datasets analyzed during the current study are available in the MEASURE DHS repository, (http://www.measuredhs.com). Access to the dataset requires registration, and is granted to those that wish to use the data for legitimate research purposes. A guide for how to apply for dataset access is available at: https://dhsprogram.com/data/Access-Instructions.cfm. The DHS datasets used in this study are shown in Table 1.

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Open Peer Review

Current Peer Review Status: ✔ ✔

Version 2

Reviewer Report 16 June 2020

https://doi.org/10.5256/f1000research.26795.r64108

✔ **Julianne Weis**
Office of Population and Reproductive Health, USAID (United States Agency for International Development), Arlington, VA, USA

Competing Interests: No competing interests were disclosed.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 24 January 2020

https://doi.org/10.5256/f1000research.22630.r57588

✔ **James Kiarie**
Department of Reproductive Health and Research, World Health Organization (WHO), Geneva, Switzerland

Abstract Background: “disparities amid almost similarities in policies is a cause of concern to demographers" – not sure what this is in reference to

Abstract Methods:

- 'Using Bongaarts reformulation of Easterlin and Crimmins conceptual scheme of 1985 on Demographic and Health Survey Data (DHS) data collected overtime across countries' – Not clear what the next sentences are justifying.
- 'The understanding of the current transition in general would help to reassess and provide explanations to the observed latest fertility dynamics at play. This study therefore is an attempt to explain the current fertility transition through women's fertility preference' – Justification should be moved to background or objectives

Introduction:

- The sentences "African fertility transitions occurred earlier than anticipated if Africa had followed the non-African relationship between fertility and development" and "The key features of African fertility regimes indicate that at a given level of development, Africa's fertility is higher," are contradictory.

The authors need to discuss the limitation of the model. Such assumption is that $F_0 = F_w + F_u$ yet we know there are situations that F_0 is less than F_w. How will this explain an increasing observation that due to various factors many women do not achieve their desired fertility.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Reproductive health and epidemiology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Reviewer Report 15 January 2020

https://doi.org/10.5256/f1000research.22630.r58569

Julianne Weis
Office of Population and Reproductive Health, USAID (United States Agency for International Development), Arlington, VA, USA

This is a welcome exploration of a key source of debate in the FP/RH world: what is the more important source of fertility transition: population fertility preferences or contraception service delivery? The analysis was sound, but a qualified statistician needs to review the calculations to ensure accuracy.

However, the conculsions are convincing on the importance of service delivery implementation and its relation to fertility transition.

I would welcome more exploration of literature exploring this critical question - currently the article does not touch on other studies or the debates and calculations other authors have conducted. This is a huge gap in the study.

There is also not enough discussion of implications of findings for policy in FP/RH.

The article also needs a thorough copy-edit, especially the abstract, where results are written in a confused, unclear manner.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
I cannot comment. A qualified statistician is required.

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Family planning, reproductive health, health systems, sub-Saharan Africa, global health, policy

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 20 May 2020

Vincent Otieno, University of Nairobi, Nairobi, Kenya

This is a welcome exploration of a key source of debate in the FP/RH world: what is the more important source of fertility transition: population fertility preferences or contraception service delivery? The analysis was sound, but a qualified statistician needs to review the calculations to ensure accuracy. However, the conclusions are convincing on the importance of service delivery implementation and its relation to fertility transition.

I would welcome more exploration of literature exploring this critical question - currently the article does not touch on other studies or the debates and calculations other authors have conducted. This is a huge gap in the study.

Comment: This is already rectified in the reviewed manuscript and uploaded

There is also not enough discussion of implications of findings for policy in FP/RH.

Comment: I have reworked the discussion of findings section to incorporate FP/RH

The article also needs a thorough copy-edit, especially the abstract, where results are written in a confused, unclear manner

Comment: The abstract has been reworked

- Is the work clearly and accurately presented and does it cite the current literature?Partly
- Comment: All citations updated
- Is the study design appropriate and is the work technically sound?Yes
- Are sufficient details of methods and analysis provided to allow replication by others?Yes
- If applicable, is the statistical analysis and its interpretation appropriate?I cannot comment. A qualified statistician is required.
- Comment: The statistical analysis have been validated by my supervisor Prof Alfred Agwanda of the University of Nairobi - Population Studies and Research Institute (PSRI)
- Are all the source data underlying the results available to ensure full reproducibility?Yes
- Are the conclusions drawn adequately supported by the results?Yes

Competing Interests

No competing interests were disclosed.

Reviewer Expertise

Family planning, reproductive health, health systems, sub-Saharan Africa, global health, policy

Competing Interests: No competing interests were disclosed.

Author Response 20 May 2020

Vincent Otieno, University of Nairobi, Nairobi, Kenya

All reviewer coments rectified

Competing Interests: No competing interests were disclosed.