When Was Your Last Birth? A Study of the Open Birth Interval

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ABSTRACT

The simple question. "How long has it been since your last birth" differentiates women in a fundamental manner, by the age of their youngest child. This "open interval" shows a characteristic pattern that varies by age, number of living children, residence, and wealth, but also by use of contraception, the intention to use, and unmet need. The open interval differentiates women along such stages as postpartum/amenorrhea, exposure to unplanned pregnancies, contraceptive use, unmet need, and infecundity. An older youngest child releases the woman into pursuits other than those of pregnancy and child care, with profound implications for their personal circumstances and freedom of action; this varies greatly by region. The shape and level of the open interval distribution is closely connected to the fertility rate, based upon the 232 DHS surveys in 74 countries used here. Service programs, including postpartum programs, should examine survey information on numbers of women at various stages for the mix of requirements for personnel, funding, and management attention.

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Introduction

Every woman who has ever given birth has a most recent birth, and she now stands at some remove from it, in an open birth interval. Some women go on to another birth, but some never do, remaining forever in the open interval. It is entirely different from the well known "closed interval," which pertains only to the time between two births that happened in the past.

The length of the open interval is correlated with age. New cohorts of young women, each one often larger than the previous ones, enlarge the numbers close to a recent birth. Older women are fewer in the population pyramid in most developing countries and tend to have longer open intervals, consistent with their lower current fertility rates. When women go a long time without a birth, more of them are using contraception, not cohabiting, or are infecund, and fewer have an unmet need for contraception. Also, fewer are currently pregnant or amenorrhoeic. The reverse is true for women with short intervals.

For some women the last birth was in the distant past; they have teenagers and children in their twenties or older, but are still in the reproductive age range (15-49). In low-fertility countries childbearing tends to cease relatively early, after which long open intervals accumulate. In general, apart from first births, most births are to women who already have young children, mostly ages 1 to five. Those women reside in the shorter open intervals; childbearing becomes less common as the youngest child ages.

Over time, increases in contraceptive use defer the next pregnancies and births, changing the distribution of women within the open interval. In general, where fertility has either risen quickly or fallen quickly, there can be a bunching up of women either close to or farther away from the latest birth. Otherwise, the tendency is toward a stable state that persists over time, with a consistent profile across the interval lengths. That profile takes a characteristic shape, with interesting variations as presented below.

Many reasons can help explain why a next birth may be postponed, including miscarriages, abortions, contraceptive use, low sexual activity, noncohabitation, infecundity onset, and simple chance by which an exposed woman does not happen to conceive. Heterogeneity of fecundity between the couple can be a factor, by which some couples have a low probability of conceiving again. This article does not go into the role of each such cause; the focus is upon the length of the open interval itself and what it may offer for a better understanding of fertility dynamics and programs oriented to improving reproductive health.

Some interest attaches to the open birth interval for its use in family planning/reproductive health programs, since it is a useful indicator of which women may want to adopt contraception. Many new mothers, with short intervals, are preoccupied with the infant, and few desire another pregnancy soon, as low as only 5% in many surveys.[1] Postpartum family planning programs are directed to women with a recent birth, partly because the most highly fecund ones may conceive again quickly with an unplanned pregnancy. On the other hand, the longer the interval, the smaller the chance of ever having another birth. After a birth most succeeding births (if any) come within five years; longer delays signal the use of contraception, non-exposure, and infecundity, but they also contain subgroups with unmet need.

In countries with marked fertility declines and more contraceptive use, births at the higher parities began to disappear [2],[3] and there is a timing effect, with fewer births occurring during the transition to a new, lower fertility level. That means more women go longer with no births. In addition to the transition effect, a new, stable fertility level means a permanent extension of the average interval after birth. As noted above long periods (over 25 years) can exists among women who had their children young, then stopped, but still have many years left in the reproductive period. Extremely long periods may tend to decline as the age at marriage rises, though the amount of the change may not be large

Reliance on open interval data for the guidance of large-scale family planning programs has been largely forgotten in recent years, whether for its relation to other fertility measures or for its reproductive health implications. An important research opportunity therefore exists, to highlight its advantages, to restore it to wider attention, and to demonstrate its potential for a fuller understanding of fertility and reproductive health behavior, both cross-sectionally and over time within particular countries.

Past neglect has been partly due to the unavailability of open interval information in the standard outputs of national surveys, so that laborious special tabulations have been needed. With those in hand, and with the advantage of improved software the international patterns and trends for the open intervals of women can now be examined empirically for the first time, using some 232 surveys in the Demographic and Health Series (DHS).[4]

Open birth intervals can also be more easily collected in surveys than closed birth intervals. While Demographic and Health Surveys collect entire birth histories, permitting the study of closed birth

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[1] Ross, John A., and William L. Winfrey. "Contraceptive Use, Intention to Use and Unmet Need During the Extended Postpartum Period." *International Family Planning Perspectives* 27(1), 20-27. 2001.

[2] Cleland, J., A. Conde-Agudelo, H. Peterson, J. Ross, A. Tsui. "Contraception and health." *The Lancet*, 10 July 2012. doi: 10.1016/S0140-6736(12)60609-6.

[3] Stover, J. and J. Ross. "Changes in the distribution of high-risk births associated with changes in contraceptive prevalence." *BMC Public Health* 2013, **13**(Suppl 3):S4 doi:10.1186/1471-2458-13-S3-S4

[4] The DHS Program, STATcompiler, ICF International. Rockville, Maryland, USA.

intervals, a single question provides the length of the open interval. In addition, some other surveys lack the detail needed for closed intervals. Adding the single question for time since the last birth (together with an inquiry about current pregnancy) can be a small addition to non-DHS surveys.

Literature Review

Literature on the open interval is composed primarily of highly technical modelling work, starting in the mid-1960s with publications by Sheps et al.,[5] and later by Srinivasan[6], and Schmertmann, [7] among others. A recent review by Singh[8] gives a thorough account of the modeling analyses through 2015, with brief explanations of their main assumptions. Some of this literature focuses on the possible relationships between closed and open intervals. Very little empirical information on actual open intervals has been available; only now do we have a large set of national surveys, over time, for women's intervals since their last birth.

However for four countries, a notable analysis of past survey trends in Ethiopia, Kenya, Tanzania, and Zimbabwe[9] incorporates both closed and open intervals, using technical methods to combine data for both to estimate time trends and determinants. They find that intervals in all four countries have lengthened, but especially in urban areas and predominantly due to more contraceptive use. Intervals in these countries now range from 35 to 51 months in length. They have been lengthening continuously in the past, and at a faster pace in urban areas and up to higher levels than in rural areas.

An early Taiwan survey that included the open interval showed that it explained social-economic variations in fertility levels at ages 30-39 better than past closed intervals did. Further, contraceptive practice had helped extend the intervals.[10]

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[5] Sheps, M.C., J.A. Menken, J. C. Ridley, and J.W. Linger. "Truncation Effect in Closed and Open Birth Interval Data." *J. of the American Statistical Association*, 65(330):678-693, June 1970. See also Sheps et al., "Birth Intervals; Artifact and Reality," *Contributed Papers, Sidney Conference*, International Union for the Scientific Study of Population, 1967,857-68

[6] Srinivasan, K. A Set of Analytical Models for the Study of Open Birth Intervals. *Demography* 5, 34-44. 1968.

[7] Schmertmann, C.P. "Fertility Estimation from Open Birth Interval Data." *Demography:*36(4):505-19. 1999. See also Schmertmann, C.P. and A.J. Caetano. "Estimating Parametric Fertility Models with Open Birth Interval Data." *Demographic Research*, Max Planck Institute for Demographic Research. Vol1/5/ DOI: 10.4054/DemRes. 1999. https://www.demographic-research.org/volumes/vol1/5/1-5

[8] Singh, Ajay Shankar, "Human Fertility Behavior Through Birth Interval Models: Overview." *American Journal of Theoretical and Applied Statistics*. 5(3):132-137. 2016. Doi: 10.11648/j.ajtas.20160503.18

[9] Cleland, John, Iqbal H. Shah, and Marina Daniele, "Interventions to Improve Postpartum Family Planning in Low- and Middle-Income Countries: Program Implications and Research Priorities. Studies in Family Planning, December 2015.

[10] Mohapatra, Partha Sarathi. "The effect of age at marriage and birth control practices on fertility differentials in Taiwan. 1966. Doctoral dissertation, University of Michigan.

One experimental study included the open interval as a predictor of contraceptive adoption.[11] It used before and after surveys in two Korean counties to test which initial characteristics of the women would correspond to adoption of a method between the surveys. These included such items as age, family size, education, having enough sons, stated desire to use a method, and exposure to mass media, but also time since the last birth. In the county with a strong family planning, 57% of women with open intervals below 30 months adopted a method but only 9% did so if the intervals were longer. The other country, with a weaker program, found the stated desire to use a method as the strongest predictor.

One section below concerns the first year after birth, termed the "extended postpartum period." There is an extensive literature on women's needs and behavior in that year; but here we refer to only four sources, as explained in that section, for postpartum programs offered at or soon after women give birth.

Data and Methods

This study uses 232 surveys in the Demographic and Health Series (DHS) conducted from 1985 onward, in 74 countries possessing information on the items required for the study, of which 56 have multiple surveys. The focus throughout is on married women of reproductive age, to examine the time since the woman's last birth. The reader should therefore bear in mind that the analyses below pertain only to married women who have had at least one birth, although for shorthand we often refer simply to "married women." The inclusion of unmarried women would have complicated this first examination of open intervals across many countries. For all averages below all countries are weighted equally.

Pregnant women are included with the women closest to birth (those in the first three months (or alternatively, first year) after birth). Pregnant women average 9% of all married women, or 31% of those within the first year category. The actual measurement of the open interval is subject to errors, as with omitted births related to infant deaths; also the data on current pregnancies omits early, unrecognized conceptions. We assume here that the error components are either minor for our purposes, or are constant for trend estimates, or both. Actual open intervals can theoretically run from a single birth at age 15 through age 50, for a maximum of 35 years, but in practice most are far shorter.

Stata 15 and the R software were used to access the individual survey files and tabulate the data. The analytic methods included tabulations across countries and over time, with selected summary measures and regression techniques.

Nature of the Open Birth Interval

Across countries a typical pattern emerges for the shape of the open interval distribution, as illustrated by Nigeria and Indonesia in **Figure 1.** One is a high-fertility country with women clustered close to a recent birth, and the other is a mid- to low fertility country with a broader spread. Nigerian women are constantly involved in childbearing, while Indonesian women have gone much longer, with more birth-free time. These profiles vary also by subgroups in any population, as discussed below.

That pattern, with most women located close to birth, parallels the one for the age distribution of women in the typical population pyramid, where most members are near birth, with diminishing numbers as age increases. A high birth rate enlarges the proportion at the start, just as it enlarges the proportion of women with short intervals in the Nigeria illustration. For a country like Nigeria this can tell a good deal

[11] Ross, John A. and Sook Bang. "Predicting the Adoption of Family Planning." Studies in Family Planning, Vol. 1, No. 9: 8-12. January 1966.

about program priorities. With 39% of married women pregnant or within a year of birth, substantial resources must be allocated to pregnancy care, delivery and postpartum care, and child services including basic inoculations. That is less so in Indonesia, where only 15% of married women are pregnant or close to the last birth, and many more are farther along, using a contraceptive method. Depending on the length of interval, women may desire different methods of contraception- shorter desired birth intervals may prefer short term methods, and women who want a longer interval or no more children may prefer a long-term modern method. In the second year another 20% in Nigeria and but only 10% in Indonesia are included. That reflects past fertility declines in Indonesia, which have moved progressively more women into longer intervals as they deferred a next birth either for spacing or for permanently avoiding another birth. From the standpoint of personal options, to be free of child care and to engage in outside pursuits, the youngest child is past age five for 51% of married women in Indonesia; in Nigeria that is a mere 21%.

The shape of the open interval distribution can change over time; an example is that of Rwanda, which has experienced a strong anti-natalist national policy with strong implementation. On average between 1992 and 2005, 44% of married women were either pregnant or in the first year after birth; that fell to a remarkable 30% in the 2011 and 2014 surveys. (**Figure 2**: note that the 2010 and 2014 lines start at identical points, for 30%).

These differences vary by region and by countries within each region; **Annex 1**shows the open interval distributions for the latest surveys in the 74 countries of interest. Sub-Saharan Africa, as expected, has the highest proportions close to pregnancy and birth.

A simple model turns out to give a very close fit to the open interval distribution, which is remarkably similar in shape across countries. Because the pattern is nearly universal, just two parameters capture the level and the sharpness of the decline in numbers of women as the intervals lengthen. These two parameters, labelled “a” and “b” in a power equation, are discussed in **Annex 2** and the values of the parameters are provided for all surveys in the 74 countries.

The open interval distribution is different from the common fertility measures of the TFR, GFR, and age-specific rates, which usually refer to the previous three or five years. The open interval gives a snapshot of the current state, but one that comes both from recent childbearing and from behavior over many years. All these rates however are closely related, as shown below.

FIGURE 1

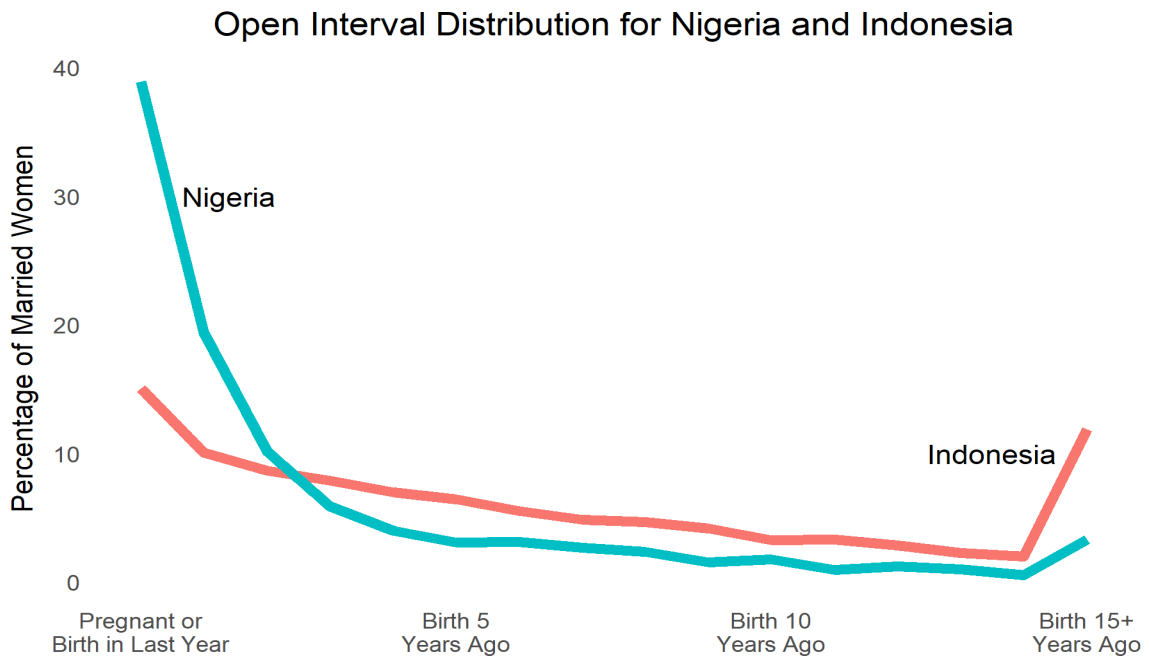
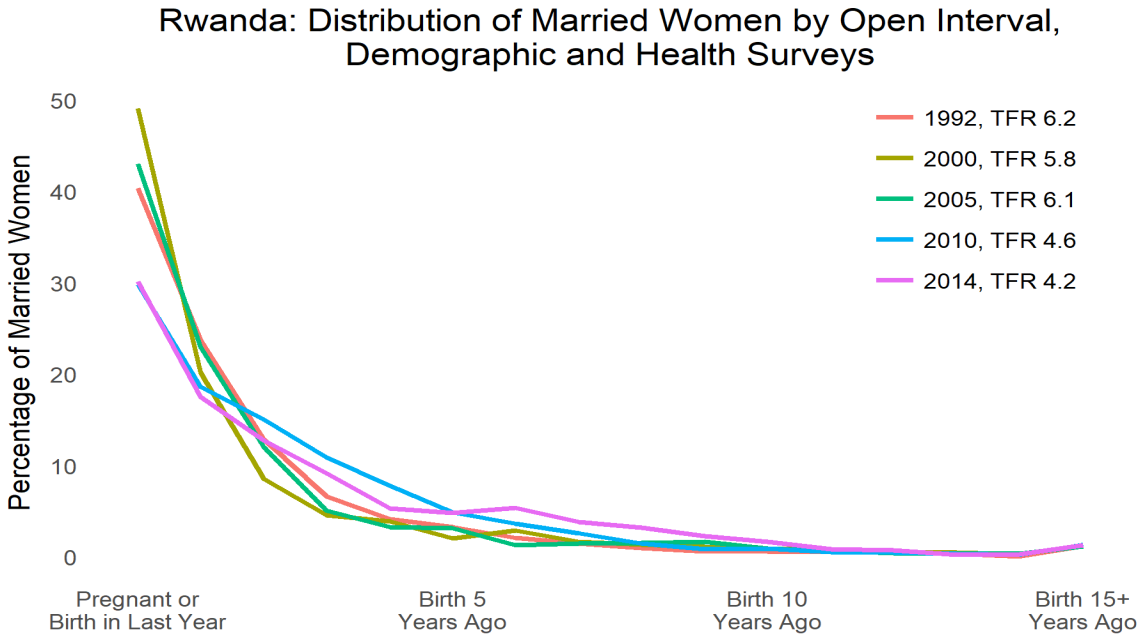


FIGURE 2

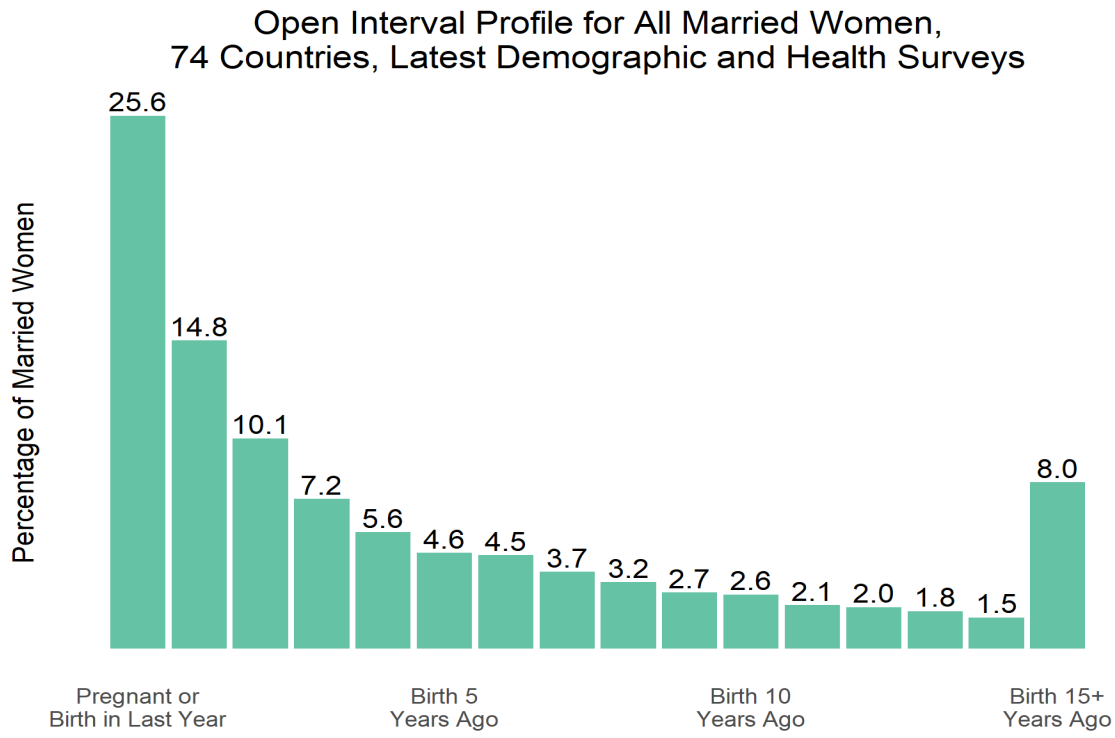


The Open Interval Distribution According to Personal Characteristics

The general pattern for the open interval distribution appears in **Figure 3** (mean values for the latest surveys in 74 countries). One fourth of married women are either pregnant or have an infant below age one. That share drops quickly, to one in seven with a child in its second year, on down regularly to very low percentages. The final interval of 8% is for those whose youngest is a teenager aged 15 or older.

That picture is an average; countries and regions vary around the figures shown, as **Annex 1** documents. Among regions the share who are pregnant or have an infant is as low as 10% in Europe/West Asia and as high as 36% in West/Central sub-Saharan Africa. Among countries it is 15% or less in India, Bangladesh, Viet Nam, Indonesia, and Nepal, as well as in Kazakhstan and Turkey, and in most countries listed in Europe/W. Asia. Highest percentages are in the two sub-Saharan regions, exceeding 40% in Chad, DR Congo, and Niger. That range, from 10% to over 40%, says a great deal about the daily activities and personal options for the women involved. It suggests large variations in how women's lives can change when they no longer have the care of very young children.

FIGURE 3



Variations are both large and systematic according to personal characteristics (**Table 1)**. A brief summary follows; for brevity of display the intervals from 60+ months onward are collapsed, but it is important to remember that although the group for 60+ months is large in the table it is the sum of a steady decline in members as the years increase. Table 1 uses the average values for the 74 countries (unweighted means) to give the patterns according to age, number of living children, residence, and wealth quintiles.

Age: The older the women the more time has elapsed since their latest births. A clear pattern emerges in the first interval; the older the women the smaller the percentage. That continues in the 12-23 month interval. Then at the other extreme, for the longest interval, the pattern reverses, showing a concentration of the oldest women. The profiles of the youngest and oldest women are exactly reversed, with regular transitions in between. Women aged 15-19 nearly disappear across the intervals, while women 45-49 are nearly invisible until the longest interval is reached.

Number of Living Children: The age pattern is mirrored regarding family size. The shift of the profiles is perfectly regular from women with one child to those with four or more. (If the only child died a code of "1" is used.) Interestingly, many women with one child (24%) have long intervals, for any of several reasons: contraceptive use, miscarriages, abortions, interrupted cohabitation. Also, a long enough interval can preclude having another birth, as infecundity sets in with age.

Residence: Residential differences are not large, and they run in the expected direction: rural women with their higher fertility rates show shorter intervals, with more recent births.

Wealth Quintiles: The contrasts are entirely regular across the five wealth quintiles: the poorer the women[12] the more are pregnant or have an infant in arms. They have the youngest children. Among the wealthiest the youngest child is older than in any poorer group, and the poorest of all show the youngest of all.

Summing up, the variations in the open interval across these characteristics parallel those with the usual fertility rates of the TFR and GFR, but they offer special insights, giving a snapshot to show the consequences of past fertility changes upon the age of the youngest children in the population; the places where women stand along the axis of their youngest child's age; and the implication of those for public programs directed to reproductive health services.

[12] Technically, the measure of wealth goes by the household in which the woman lives.

Table 1

Profiles of Married Women by Open Intervals and Personal Characteristics							
	Open Intervals (Months)						
	Pregnant to 11 mo.	12 - 23	24 - 35	36 - 47	48 - 59	60+	Sum
ALL WOMEN	25.6	14.8	10.1	7.2	5.6	36.7	100.0
AGE							
15-19	63.7	24.9	8.3	2.3	0.6	0.3	100.0
20-24	46.5	24.9	13.7	7.5	3.7	3.6	100.0
25-29	35.8	20.6	13.9	9.3	6.5	14.1	100.0
30-34	27.2	16.0	12.2	9.0	7.2	28.4	100.0
35-39	18.4	11.8	9.5	8.0	6.9	45.5	100.0
40-44	8.4	6.5	6.6	6.5	6.3	65.6	100.0
45-49	2.1	2.0	2.5	3.2	3.6	86.7	100.0
No. of LIVING CHILDREN							
1	36.3	17.5	10.7	6.8	4.5	24.2	100.0
2	28.2	15.6	10.5	7.0	5.1	33.6	100.0
3	24.5	14.4	9.6	7.0	5.7	38.7	100.0
4+	20.2	13.1	9.5	7.3	6.2	43.7	100.0
RESIDENCE							
Urban	23.2	13.5	9.9	7.4	6.0	40.1	100.0
Rural	27.7	15.7	10.2	7.1	5.4	33.9	100.0
WEALTH QUINTILES							
Low	30.9	17.6	10.7	7.2	5.0	28.5	100.0
Low Medium	28.9	16.1	10.4	7.0	5.3	32.2	100.0
Medium	27.1	15.3	10.1	7.3	5.5	34.8	100.0
High Medium	24.7	14.1	10.2	7.3	5.7	37.9	100.0
High	21.7	12.9	9.8	7.5	5.9	42.3	100.0

Profiles by Reproductive Health Measures

The patterns for contraceptive use, unmet need, and intention to use a method are also quite systematic (**Table 2).** Brief notes follow:

Contraceptive Use: the type of contraceptive use changes as women move toward the longer intervals, with older children. Nonusers are concentrated among those pregnant or in the first year after birth; after that the decline in non-use is quite marked, and it continues to fall off within the final group at 60+ months . There is a regular shift by users of traditional methods as intervals lengthen; that is true also for users of short term ones. Balancing those is the pattern for long term methods: their dominance after the five-year point reflects a dual process: that with time women tend to choose a longer-term method, but also that women who choose a long-term method automatically extend their intervals.

Unmet Need: Women with unmet needs for spacing methods are concentrated early after birth, with declines steadily thereafter. Women with limiting needs are also numerous early on, with intermediate declines but with a large percentage within the post-five-year interval. Most of those with no need are concentrated heavily at the beginning, with over half close to birth; they then decline through all remaining intervals. These shifts and differences among married women contain significant guidelines for the mix of needed services.

Intention to Use a Method: The more women who are already using a method the fewer who have unmet need, so the two distributions tend to differ. Over half those who intend to use a method come early, being either pregnant or in the first year after birth. Fewer users are in that interval, still a total of 47% fall within the first three years, with a third in the final group, a fairly wide spread. The distribution for those not intending to use, with half in the final interval, reflects a mix: some are not interested, some lack access to services, some are already menopausal/infecund, and some for other reasons.

TABLE 2

Profiles of Married Women by Open Intervals,
Contraceptive Use, Unmet Need, and Intention to Use a Method

	Open Intervals (Months)						
	Pregnant to 11 mo.	**12 - 23**	**24 - 35**	**36 - 47**	**48 - 59**	**60+**	**Sum**
ALL WOMEN	25.6	14.8	10.1	7.2	5.6	36.7	100.0
CONTRACEPTION METHOD							
None	36.0	12.0	7.1	5.2	4.1	35.6	100.0
Traditional	14.6	18.1	13.1	8.8	7.0	38.5	100.0
Modern, Short	16.9	21.0	15.4	10.5	7.4	28.8	100.0
Modern, Long	7.4	12.7	12.0	9.4	8.1	50.4	100.0
UNMET NEED							
Unmet Need, Spacing	44.8	23.3	12.0	6.8	4.3	8.7	100.0
Unmet Need, Limiting	21.6	14.4	11.3	8.9	7.4	36.3	100.0
No Need	57.2	10.6	6.4	5.4	4.5	15.9	100.0
Infecund/Menapausal	2.7	1.9	1.2	1.2	1.3	91.6	100.0
INTENTION TO USE							
Using	13.9	18.7	14.1	9.9	7.3	36.1	100.0
Intends to Use	54.9	13.8	7.2	4.9	3.5	15.8	100.0
Does Not Intend to Use	20.0	10.4	6.9	5.3	4.5	52.8	100.0

Differences Within Intervals, by Region

Whereas the base in the previous section was the women within each subgroup, such as all contraceptive users, to see how they were spread across the intervals, in this section the base is all women within each interval. The women falling into the first interval are now spread across the various subgroups: showing for example what percentage of all women are using a method and how that changes from one interval to the next.

The women are classified by one of the following states, adding to 100% within each interval.

Currently pregnant
Contraceptive use by method
Unmet need
    And intends to use a method
    Does not intend to use a method
Has no unmet need
    But intends to use a method
    Does not intend to use a method
Infecund

Annex 2 provides the breakdowns for all groups, by interval, for each region. Here, in **Figure 4**, we display the regional differences for use, unmet need, and intention to use.

Contraceptive Use: The use levels start relatively low for women who are in their first year after birth or are pregnant, but then they rise to much higher levels and remain there through the first five years. Then they fall off, but not greatly so. The regions cluster: at the top are Latin America, the Middle East/No. Africa, and Europe/W. Asia. Three others are in the middle, along with the all-region line: Asia, the Central Asian Republics, and East/Southern Africa. By far the lowest use level is Central/Middle Africa. For all regions, about 60% are using through most of the intervals.

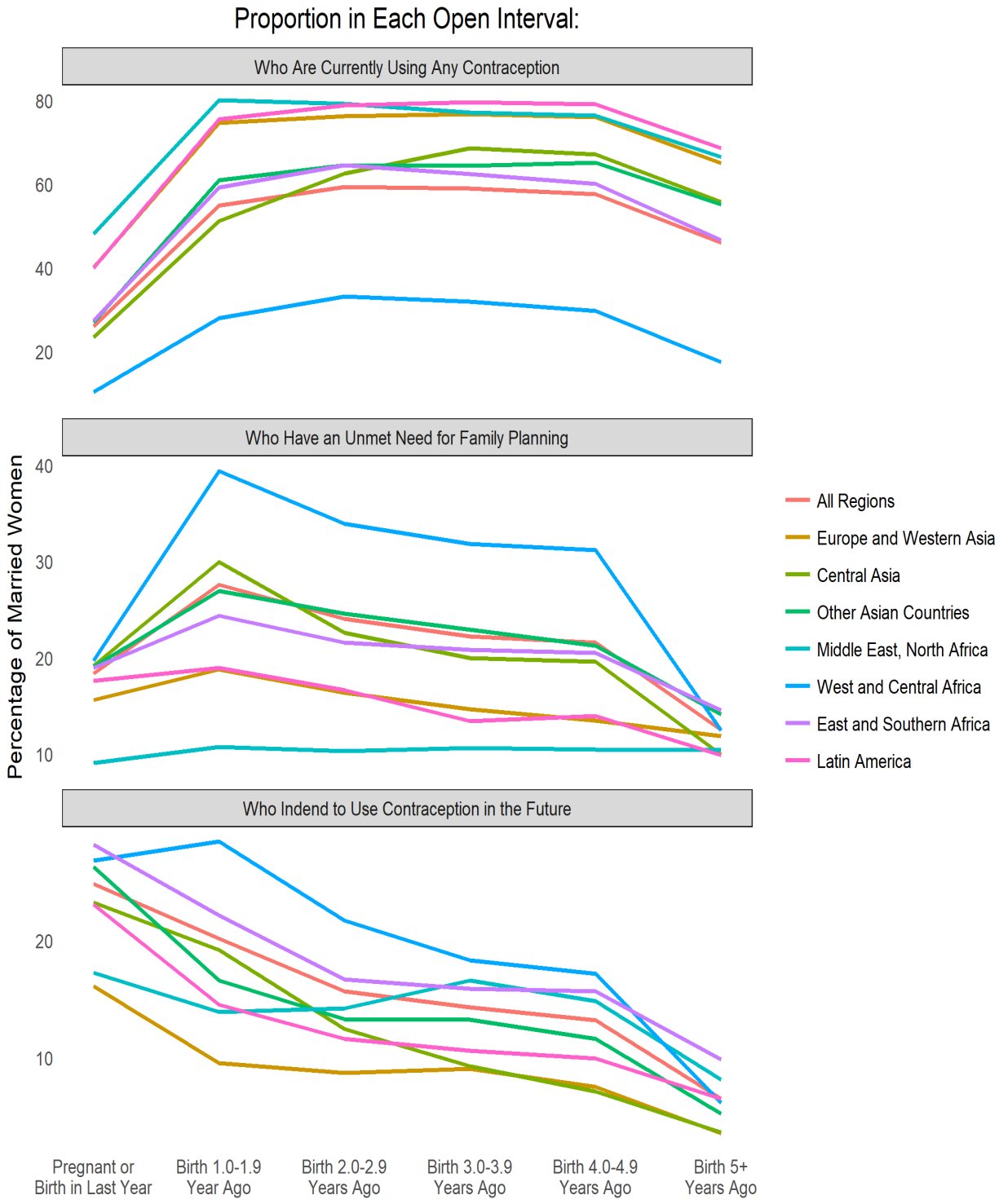
Unmet Need: The pattern is quite different for unmet need, with a partial reversal of the regional ranking. West/Central Africa is now at the top, with over 30% of women in need through the middle intervals. At the middle, close to 20%, is a cluster of Asia, the Central Asian Republics, and East/Southern Africa. Below them, at roughly 15%, are Latin America and Europe/W. Asia, with the Middle East/N. Africa well below at 10%. This ordering does not change appreciably through most of the intervals.

Intention to Use a Method: A third pattern, quite different from the others, appears for the intention to use a method. The All-Region line shows the decline from every interval to the next in the percentage intending to use a method, from about 25% to less than 5%. Most regions follow that pattern, except that the West/Central Africa region peaks in the second interval, and that the Middle East/N. Africa region rises in the third year. The declines probably show a balance among growing contraceptive use, less unmet need, and more infecundity.

By a considerable margin, the West/Central region of sub-Saharan Africa has the least contraceptive use and the most unmet need, but also the most who intend to use. That suggests a lag in the provision of contraceptive services with evident demand that is going unsatisfied. Elsewhere about 60% of married

women are using some method, with about 20% classified with unmet need for a method and about 15% in the middle intervals intending to use one.

FIGURE 4



The common reliance upon unmet need as a prominent indicator needs qualification, since so many women classified statistically as needing contraceptive assistance have no interest in it and no plan to use it. Interestingly, many others, not listed as having a need, do plan to use a method. As an average across the 74 countries in this study, as of the 2nd year after birth, 27% of married women have an unmet need, split between 13% who intend to use a method and a full 14% who do not. On the other hand, 20% intend to use a method by their own report, and two thirds of these (13/20) also have an unmet need **(Table 3).**

TABLE 3

Percentage of Married Women by Overlap Between Unmet Need and Intention to Use a Method, As of the 2nd Year After Giving Birth.			
	Has Unmet Need		
Intends to Use a Method	Yes	No	Total
Yes	13	7	20
No	14	10	24
Total	27	17	44

The other two items in this section concern the percentage pregnant and the percentage infecund.

Pregnant women appear only in the first interval, which includes both them and other women within the first 12 month after birth. The ratio between the two groups is very close to 30/70 in all regions; overall, 32% of women in the first interval are pregnant. The range is narrow, only 26% to 34% among the regions regardless of their fertility levels. The reason is simply that where fertility is low, both the numbers of women pregnant and the number who are close to a birth are low, and the reverse holds where fertility is high. That makes for very similar ratios.

The least typical ratios around the 32% average are Europe/W. Asia at a low 26% and West/Central SSA at a high 34%. That suggests a greater wastage factor in the latter, with more pregnancies in relation to the number of surviving infants in their first year. In Europe/W. Asia the opposite seems true: more surviving infants in relation to the number of pregnancies.

Infecundity spans a remarkably wide range within the final interval. Three regions fall in the low range of 16% to 20% of married women (Europe/West Asia, the Middle East/N. Africa, and Latin America), three in the middle range of 27% to 32% (Asia, Central Asian Republics, and East/Southern Africa), and one outlier at 55% (West/Central SSA). The reasons for these large differences are not clear; they may partly reflect the role of early fecundity impairments due to disease especially in West/Central SSA.

Relationships Between the Open Interval and Other Fertility Measures

The open interval offers its own advantages compared to the familiar ones of the total fertility rate (TFR), the general fertility rate (GFR), and the age-specific rates (ASFR). Those rates usually pertain to births over the previous three to five years, as in the DHS reports, but the open interval as a survey snapshot can reflect the current state due both to recent births and to the behavior over many past years that produced the older children.

Further, changes in the open interval and in the other rates behave somewhat differently as annual births occur. More births elevate the GFR and TFR, but they affect the open intervals mainly[13] only at the start, where the births are located. A burst in the fertility rate tends to bunch women up in the early distribution; on the other hand some women leave the distribution by aging out each year, who are located mainly at the longest intervals. On balance higher fertility rates tilt the open interval distribution toward the start.

Closed intervals, as valuable as they are, omit much reproductive behavior. Many women are actively avoiding pregnancy and birth and will never have another one. Most women who have gone five years with no birth will never have another; 84% of closed intervals are less than five years long.[14]

A very close correlation exists between the open interval and the usual fertility rates. For the 74 countries here the correlations are 0.93 to 0.97 between the GFR or TFR and such open interval measures as the percentage of women who are within the first year after birth, or equally, the percentages within two years, or three, four, or five years after birth **(Table 4)**. Those are all positive: the more women with the shorter intervals the higher the fertility rate. But for the longest spans, of six years or more, the correlation (0.93) reverses direction: the more women going without a birth for a long time the lower the fertility rate.

TABLE 4

Fertility and Open Interval Correlations		
	GFR 15-44	**TFR 15-44**
Intervals (months)		
<12	0.96	0.97
<24	0.96	0.97
<36	0.96	0.97
<48	0.95	0.96
<60	0.93	0.94
60+	(0.93)	(0.94)

[13] Other parts of the open interval distribution can change if births start coming more than usually from a particular interval, removing members from it. In general however the shape of the distribution is relatively stable.

[14] Mean across 298 DHS surveys in the STATcompiler, accessed July 22, 2018

Finally, the average level of the TFR is clearly associated with the open interval. Countries averaging a TFR below 3 on average have well over half (56%) of married women with the youngest child over age 5. At the other extreme, countries averaging TFRs over 5 have only a fifth (20%) in that bracket. In between the parallels are exact.

Total Fertility Rates in Relation to the Open Interval Distribution						
	Months					
TFR	Preg/1-11 mo.	12-23	24-35	36-47	48-59	60+
Below 3	14.2	9.4	7.9	6.7	5.8	55.9
3 to 4	23.4	13.9	10.4	7.9	6.3	38.1
4 to 5	30.6	17.2	11.6	8.2	5.9	26.7
Over 5	37.8	20.0	11.0	6.5	4.5	20.3

Programmatic Uses of Open Interval Information

Each part of the open interval distribution tells a story that action programs can benefit from. In each country changes in the proportions and numbers who are pregnant and those closest to birth signal needed modifications in the services needed, preferably by province. These pertain especially to maternity care, postpartum services, and early contraceptive offerings. But equally, attention to the numbers in the intermediate and longer lengths can clarify the likely need, or market, for the changing mix of contraception between short term and long-term methods. Absolute numbers within the various interval lengths are important for planning, as are rapid changes in mix from one survey to the next in particular intervals, as they have been in sub-Saharan Africa toward the implant and injectable.[15] Close monitoring for these, with the numbers involved, will enable modifications to supply lines and to budgets by type of expenditure.

Field workers who concentrate on maternity-related services will typically be concerned with women in the early intervals, from pregnancy through the fourth or fifth year. In rural and peri-urban settlements, where many women lack easy access to services, workers should pay particular attention to women with very young children, as an identifier for those who are most likely to have early, unplanned pregnancies. All outreach activities should recognize that a woman's need for, readiness for, and interest in contraceptive use is tied closely to the age of her youngest child.

In general, program implementation can only gain by knowledge of where women fall within the open interval distribution and how that has changed since the last survey. Both proportions and numbers need attention, bearing in mind that the absolute numbers of women in the population diminish rather sharply with the longer intervals, and that progressively more are infecund or already using contraception.

[15] Benova, Lenka, John Cleland, Marina A.S. Daniele, Moazzam Ali. "Expanding Method Choice in Africa with Long-Acting Methods: IUDs, Implants or Both?" *International Perspectives on Sexual and Reproductive Health*, Volume 43, Issue 4, December 2017 Pages 183 – 191.

The "extended postpartum period," the first year after birth, has been of particular interest since the 1960s.[16] Women who are in the first year after a birth, as well as those who are currently pregnant, are a priority group for family planning counseling and services. Most of them do not want another birth quickly, and at delivery most are in immediate contact with the needed services, as well as later at the six-week checkups. While many will be protected from another conception during much of the first year by amenorrhea, delays often occur before adoption of contraception, and the most fecund "early conceivers" will often have unplanned pregnancies. Some overlap of contraceptive protection with amenorrhea can occur, but given the downside risk of an unplanned pregnancy the better strategy usually lies with adoption of a method relatively soon, and access to it before leaving the hospital is important for those who will not be seen again.

Attention to providing contraceptive information and services to women around the time of delivery began in 1966 with a large international program initiated by the Population Council with collaborating hospitals in some 25 hospitals in 14 countries. It grew rapidly to 112 hospitals by early 1967. Similar programs grew as they became standard practice in many countries, covering millions of births annually. Subsequently the World Health Organization endorsed the programs and sponsored them in numerous countries. [17] , [18]. The postpartum avenue to contraceptive provision has persisted over the five decades from the first large demonstration projects, and attention continues as to "best practices" for the implementation of these programs, as in a review by Cleland, Shah, and Daniele.[19] They examined the effects of 35 interventions by time and type: antenatal, postnatal, both, and integration with other services, finding generally positive impacts of the interventions. The evidence was regarded as incomplete but still useful for guidance on advancing postpartum programs in different contexts.

Changes are rapid during the four quarters of the first year after birth. **Figure 5** shows the diminution of amenorrhea, balanced against the marked growth in contraceptive use. Each of the two changed by 10-12 points: contraceptive use from 23% to 35%, and amenorrhea from 57% to 47%. So to some extent there has been a transfer of one type of protection for another: less amenorrhea but more contraception. However the net effect hinges on one hand whether ovulation has in fact been suppressed and on the other hand how much the method mix has been subject to failures and discontinuations.

Unmet need is a lesser factor, totaling 14% as of the fourth quarter. It is split between women intending to use and those not intending to do so. Two much smaller groups are not in need; they are divided between those intending to use and those not intending to use a method. Combining both "intender" groups totals

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[16] Ross, John A., and William L. Winfrey. "Contraceptive Use, Intention to Use and Unmet Need During the Extended Postpartum Period." *International Family Planning Perspectives* 27(1), 20-27. 2001.

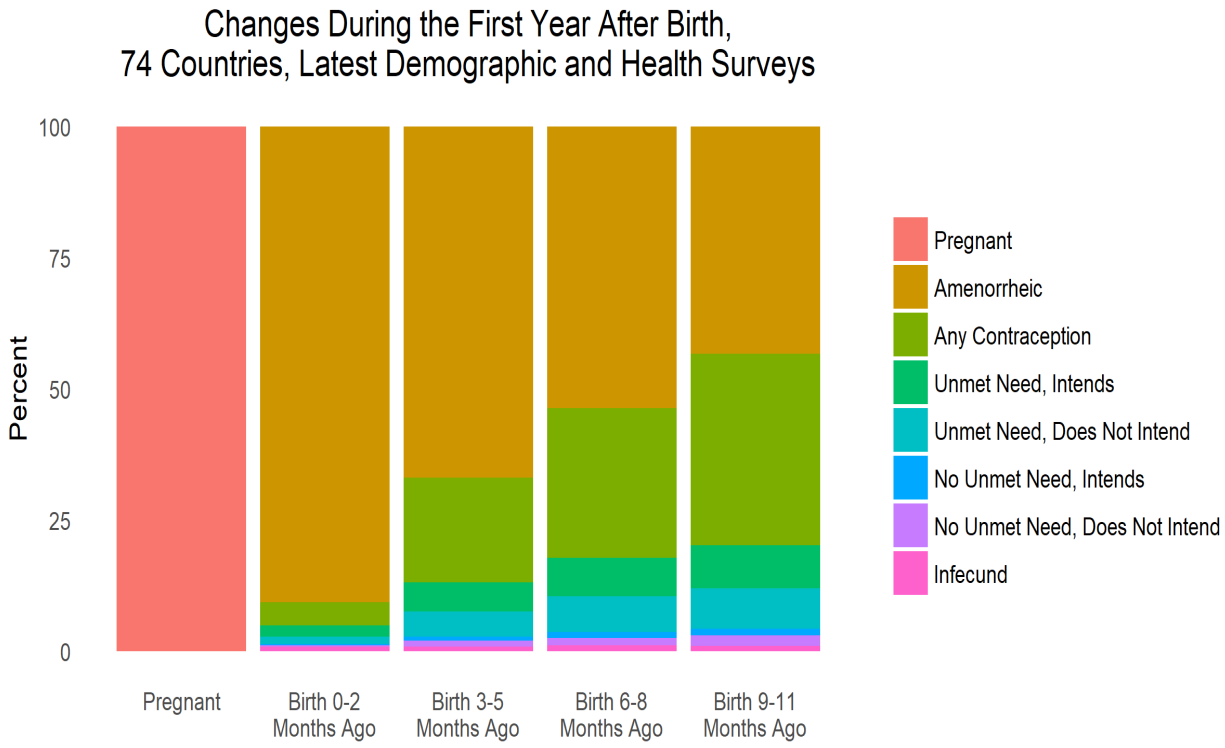
[17] Castadot, Robert G., Irving Sivin, Petra Reyes, J. Oscar Alers, Martha Chapple, and Jerry Russell. 1975. "The international postpartum family planning program: Eight years of experience." *Reports on Population/Family Planning* No. 18. New York: Population Council.

[18] Zatuchni, Gerald I., ed. *Post-Partum Family Planning: A Report on the International Program*. McGraw-Hill. 1970.

[19] Cleland, John, Iqbal H. Shah, and Marina Daniele, "Interventions to Improve Postpartum Family Planning in Low- and Middle-Income Countries: Program Implications and Research Priorities. *Studies in Family Planning*, December 2015. 46(4):423-441.

about 9.3% of women in the fourth quarter. Adding those already using a method gives a substantial total of about 44% at the end of the extended postpartum period. (The "infecund" group is very tiny, as expected, among these women with a recent birth.)

FIGURE 5: Changes by Quarter in the First Year After Birth



Conclusions

The simple question. "How long has it been since your last birth" differentiates women in a fundamental manner, by the age of their youngest child with its implications for their personal circumstances; it also informs fertility analyses; and it offers guidelines for national action programs devoted to reproductive health. For the first time a large body of empirical information on this "open birth interval" has been assembled and analyzed; it shows that there is a characteristic shape to the distribution, with a substantial proportion of women near a birth or expecting one soon, then tailing off through 15 years and beyond. While this characteristic shape is present everywhere, the relative proportions between the first year and the longer years varies a great deal, from countries with very low fertility and therefore few women either pregnant or in the first year after birth, to countries with high fertility rates and therefore many women who are pregnant or in the first year after birth.

The age of a woman's youngest child carries important implications for her freedom of action, and it varies greatly across regions. In sub-Saharan Africa at one extreme, and in the European/W. Asia countries at the other, women are necessarily preoccupied heavily, or lightly, with the years they spend in pregnancy and childrearing, and the ages at which they are released for other roles. Much of that is captured in the distribution of delays since the latest birth, which in turn is highly correlated with the prevailing fertility level.

For public programs devoted to reproductive health, the distribution of women along the axis of their youngest child, and the absolute numbers who stand in each of the early intervals, is basic for planning. The allocation of funds, the staff mix, and the projections of women in the likely intervals for having a next birth, are all related to the interval distribution. Most future pregnancies and births will emerge from women who currently have a child between ages 18 months and 60 months.

We recommend that national planners for reproductive health programs examine each new survey for the open birth interval distribution and its correlates, in light of changes since the previous surveys.

ANNEX 1

Annex: Open Interval Distribution by Year, and Region, 74 Countries, Latest DHS Surveys.

	Currently Pregnant	Under 1 Yr.	Sum: Pregnant, Under 1 Yr	1.0-1.9	2.0-2.9	3.0-3.9	4.0-4.9	5.0-5.9	6.0-6.9	7.0-7.9	8.0-8.9	9.0-9.9	10.0-10.9	11.0-11.9	12.0-12.9	13.0-13.9	14.0-14.9	15+	Total
MEANS, All Countries	8.1	17.5	25.6	14.8	10.1	7.2	5.6	4.6	4.5	3.7	3.2	2.7	2.6	2.1	2.0	1.8	1.5	8.0	100.0
East/Southern SSA																			
Burundi 2016-17	12.2	25.1	37.3	23.9	12.0	6.3	4.9	3.4	2.8	2.3	1.8	1.3	1.1	0.7	0.6	0.3	0.2	1.1	100.0
Comoros 2012	10.6	23.4	34.0	18.1	9.9	6.5	4.6	4.3	3.7	2.4	2.4	2.2	2.4	1.5	1.5	1.0	1.1	4.3	100.0
Ethiopia 2016	9.5	22.2	31.7	19.0	11.5	8.6	6.4	4.2	4.3	2.9	2.4	1.9	2.0	1.0	0.8	1.0	0.4	1.9	100.0
Kenya 2014	7.5	17.1	24.6	16.0	12.1	9.0	6.9	5.5	4.9	3.8	3.0	2.6	2.2	1.6	1.5	1.0	0.9	4.4	100.0
Lesotho 2014	4.1	16.2	20.3	15.7	12.1	7.7	6.5	5.4	5.6	4.5	3.7	2.9	2.3	2.0	1.9	1.3	1.5	6.6	100.0
Madagascar 2008-09 (21)	9.3	20.2	29.4	15.7	11.0	7.9	6.2	4.5	4.9	3.1	3.6	1.9	2.0	1.3	1.4	1.2	1.2	4.7	100.0
Malawi 2015-16 (22)	7.9	18.1	25.9	17.2	14.0	10.6	7.2	5.1	5.0	2.9	2.2	1.8	1.5	1.4	1.0	0.8	0.6	2.6	100.0
Mozambique 2011	12.3	24.9	37.2	21.6	9.8	5.7	3.7	2.8	3.7	2.6	2.0	1.3	1.2	1.5	1.0	1.0	0.7	4.2	100.0
Namibia 2013 (27)	7.8	16.2	24.0	12.3	10.8	9.1	7.3	5.4	4.4	4.2	3.4	3.4	2.2	1.8	1.6	2.0	1.5	6.6	100.0
Rwanda 2014-15	10.1	20.0	30.2	17.5	12.8	9.2	5.4	4.8	5.4	3.9	3.3	2.3	1.7	0.9	0.8	0.3	0.3	1.3	100.0
South Africa 1998	4.3	11.5	15.9	9.7	9.6	7.1	7.1	6.6	6.7	4.9	4.5	3.6	3.4	2.3	2.8	2.3	2.1	11.5	100.0
Swaziland 2006-07	7.3	15.5	22.8	14.2	10.7	9.2	6.2	4.6	5.7	4.0	2.5	2.8	2.9	1.9	1.8	1.8	1.3	7.6	100.0
Tanzania 2015-16 (39)	10.0	21.1	31.1	19.9	11.9	7.4	5.7	4.2	3.3	2.7	2.2	1.8	1.8	1.1	1.4	1.0	0.6	4.0	100.0
Uganda 2016	12.4	24.7	37.0	18.2	11.6	7.4	5.6	4.2	3.3	2.4	2.1	1.4	1.6	1.0	0.9	0.7	0.5	2.1	100.0
Zambia 2013-14 (42)	10.8	21.2	32.1	20.6	13.1	8.4	6.3	3.8	3.5	2.1	1.8	1.4	1.2	1.0	0.7	0.9	0.5	2.5	100.0
Zimbabwe 2015 (45)	7.6	17.8	25.4	17.4	14.2	9.9	8.1	5.7	3.2	3.1	2.0	2.1	1.4	1.2	1.1	1.2	0.8	3.2	100.0
MEANS	**9.0**	**19.7**	**28.7**	**17.3**	**11.7**	**8.1**	**6.1**	**4.7**	**4.4**	**3.2**	**2.7**	**2.2**	**1.9**	**1.4**	**1.3**	**1.1**	**0.9**	**4.3**	**100.0**
West/Central SSA																			
Angola 2015-16	11.5	27.4	38.9	21.5	11.3	6.3	4.5	3.8	2.9	2.3	1.9	0.9	1.1	0.6	0.8	0.6	0.5	2.0	100.0
Benin 2011-12 (6)	11.1	21.8	32.9	19.6	11.3	8.2	4.8	3.9	4.1	3.1	2.5	1.5	1.6	1.1	1.3	0.7	0.7	2.9	100.0
Burkina Faso 2010	11.3	23.8	35.1	21.0	13.2	7.8	4.4	2.9	3.6	2.4	1.9	1.5	1.5	0.8	0.8	0.7	0.5	2.0	100.0
Cameroon 2011	13.1	23.8	36.9	19.1	9.3	6.0	4.2	3.2	3.6	3.2	2.1	1.5	2.0	1.1	1.1	1.2	0.8	4.8	100.0
Central African Republic 1994-9	13.1	23.7	36.8	17.2	8.9	5.9	5.1	3.7	4.4	2.4	2.6	1.4	1.6	1.1	1.4	0.8	1.1	5.7	100.0
Chad 2014-15	16.1	27.4	43.5	19.5	10.8	5.0	4.0	2.8	3.5	2.6	1.9	1.0	1.4	0.6	0.8	0.4	0.5	1.7	100.0
Congo 2011-12	12.5	23.7	36.2	18.6	10.4	7.4	4.8	3.4	3.2	2.4	2.2	1.6	1.3	1.2	1.2	0.9	0.8	4.3	100.0
Congo Democratic Republic 201	15.1	29.5	44.6	20.5	10.4	4.8	3.2	2.7	2.5	2.1	1.5	1.4	1.2	1.0	0.5	0.7	0.6	2.4	100.0
Cote d'Ivoire 2011-12 (13)	12.2	22.3	34.5	19.2	10.4	7.5	5.0	3.3	4.0	2.7	2.5	1.9	1.9	1.2	1.1	0.9	0.7	3.3	100.0
Gabon 2012	11.6	20.3	31.9	13.0	9.8	6.8	5.1	5.2	4.4	3.9	2.9	1.3	2.3	1.5	1.3	1.1	1.3	8.4	100.0
Gambia 2013	10.8	27.5	38.3	23.0	10.1	6.1	4.0	2.7	3.2	2.1	1.7	1.8	1.2	0.9	0.7	0.6	0.5	3.2	100.0
Ghana 2014	9.8	20.4	30.2	17.1	11.2	7.1	5.7	4.1	4.5	2.9	3.0	2.1	2.0	1.6	1.6	1.1	1.3	4.5	100.0
Guinea 2012	12.4	22.0	34.3	18.5	11.6	7.0	4.0	3.1	4.3	3.6	2.5	1.6	2.2	1.0	1.4	0.6	0.8	3.3	100.0
Liberia 2013 (20)	10.0	18.8	28.8	16.0	10.3	8.4	6.4	5.2	5.4	3.5	3.2	2.0	2.1	1.5	1.4	1.2	0.7	3.9	100.0
Mali 2012-13	12.5	24.6	37.1	19.4	12.9	7.7	4.8	3.0	3.0	2.3	1.9	1.3	1.4	0.9	1.1	0.8	0.4	1.9	100.0
Niger 2012	15.1	30.5	45.6	21.9	11.1	5.4	3.0	2.3	2.9	2.1	1.3	0.8	1.0	0.5	0.4	0.4	0.3	0.9	100.0
Nigeria 2013	14.8	24.2	38.9	19.4	10.2	5.9	4.0	3.1	3.1	2.7	2.4	1.6	1.8	0.9	1.2	1.0	0.5	3.3	100.0
Sao Tome and Principe 2008-09	10.1	22.0	32.1	16.1	13.5	8.7	5.0	3.1	4.9	2.6	1.9	2.3	2.0	1.2	1.2	0.9	0.9	3.7	100.0
Senegal 2016 (36)	11.9	21.7	33.7	19.5	11.9	8.5	5.8	4.4	3.7	3.0	2.3	1.7	1.1	0.9	0.6	0.9	0.4	1.6	100.0
Sierra Leone 2013	9.9	20.9	30.8	17.5	11.5	8.1	5.2	5.0	4.8	3.5	2.7	1.6	1.8	1.0	1.1	0.8	0.7	3.8	100.0
Togo 2013-14	10.3	20.4	30.7	19.8	12.7	7.4	5.6	3.4	4.0	3.2	2.4	1.9	1.4	1.2	1.1	1.0	0.8	3.4	100.0
MEANS	**12.2**	**23.6**	**35.8**	**18.9**	**11.1**	**6.9**	**4.7**	**3.5**	**3.8**	**2.8**	**2.2**	**1.6**	**1.6**	**1.0**	**1.1**	**0.8**	**0.7**	**3.4**	**100.0**
Asia																			
Afghanistan 2015	20.6	22.1	42.7	16.0	10.2	5.5	3.6	2.6	4.0	2.9	2.6	1.6	2.0	0.9	1.1	0.7	1.0	2.7	100.0
Bangladesh 2014	4.1	10.0	14.1	10.2	8.6	7.5	6.5	5.7	5.5	5.4	4.5	3.4	4.1	3.0	3.2	2.9	2.5	13.0	100.0
Cambodia 2014	4.4	13.3	17.8	12.1	9.4	7.7	6.9	5.7	6.1	5.3	3.6	3.9	3.1	2.7	2.8	2.3	2.3	8.3	100.0
India 2015-16	4.0	10.1	14.1	8.8	6.7	5.7	4.9	4.4	4.7	4.4	4.2	3.5	4.0	3.3	3.6	3.3	3.0	21.5	100.0
Indonesia 2012	3.9	11.1	15.1	10.1	8.7	7.9	7.0	6.4	5.5	4.9	4.7	4.2	3.3	3.3	2.9	2.3	2.0	11.9	100.0
Maldives 2009 (24)	5.4	14.7	20.1	12.8	9.5	7.6	6.7	4.8	4.6	4.4	4.5	3.6	3.1	2.9	3.2	2.3	1.8	8.2	100.0
Myanmar 2015-16	4.5	11.9	16.3	11.0	9.0	8.8	6.5	6.2	5.6	5.1	4.4	4.1	3.9	2.9	2.7	2.8	2.0	8.8	100.0
Nepal 2016	3.5	10.3	13.7	10.4	8.1	6.7	6.0	5.1	4.3	4.2	4.4	3.7	4.3	3.4	3.3	3.6	2.7	16.0	100.0
Pakistan 2012-13 (30)	9.5	19.5	29.0	14.2	10.4	7.3	4.8	4.9	3.6	3.8	3.4	2.3	2.7	1.9	2.5	1.8	1.6	5.8	100.0
Philippines 2013	4.9	13.9	18.7	12.3	8.7	7.7	6.3	6.3	5.5	4.8	4.1	3.4	3.4	2.9	2.3	2.5	1.6	9.5	100.0
Timor-Leste 2016	7.0	19.8	26.9	16.7	10.8	8.4	6.1	4.3	5.6	3.9	3.3	3.2	2.9	1.9	1.5	1.2	0.7	2.6	100.0
Vietnam 2002	2.8	7.5	10.3	8.1	7.0	6.0	5.8	5.9	5.6	6.3	6.5	5.3	5.6	4.5	4.6	3.4	3.0	12.0	100.0
MEANS	**6.2**	**13.7**	**19.9**	**11.9**	**8.9**	**7.2**	**5.9**	**5.2**	**5.0**	**4.6**	**4.2**	**3.5**	**3.5**	**2.8**	**2.8**	**2.4**	**2.0**	**10.0**	**100.0**
Central Asia Rep.																			
Kazakhstan 1999	3.1	8.2	11.2	7.7	6.7	5.5	6.2	5.8	5.9	5.4	5.5	4.9	5.2	5.2	3.6	4.3	3.0	14.0	100.0
Kyrgyz Republic 2012	7.8	18.3	26.1	12.8	8.8	7.2	5.4	3.7	4.0	3.8	3.3	2.6	2.5	2.0	2.1	2.4	1.8	11.4	100.0
Tajikistan 2012	8.2	17.1	25.3	13.8	11.0	6.5	4.7	3.7	4.5	4.1	3.0	3.5	2.7	2.2	3.1	2.1	2.2	7.7	100.0
Uzbekistan 1996	6.4	14.3	20.8	14.0	9.8	7.4	8.2	5.9	5.1	3.8	3.9	3.6	3.0	2.9	2.1	2.1	1.9	5.6	100.0
MEANS	**6.4**	**14.5**	**20.8**	**12.1**	**9.1**	**6.6**	**6.1**	**4.8**	**4.9**	**4.3**	**3.9**	**3.7**	**3.4**	**3.1**	**2.7**	**2.7**	**2.2**	**9.7**	**100.0**
Middle East/N. Africa																			
Egypt 2014	7.9	17.2	25.1	13.9	9.7	7.5	5.0	5.5	4.6	3.3	3.1	2.7	3.0	2.5	2.2	2.1	1.6	8.0	100.0
Jordan 2012	8.5	16.9	25.4	15.0	11.2	8.3	7.0	5.1	3.5	4.0	4.0	2.6	2.3	2.1	2.1	1.5	1.4	4.5	100.0
Morocco 2003-04 (26)	6.0	14.0	20.0	12.9	10.2	9.3	6.9	5.7	5.3	4.0	3.6	4.0	3.1	2.8	2.2	1.8	1.6	6.4	100.0
Turkey 2003 (41)	4.3	10.5	14.8	8.9	8.5	7.3	6.0	5.0	5.7	4.5	4.0	3.6	3.2	3.0	2.5	3.0	2.7	17.3	100.0
Yemen 2013	12.6	22.6	35.1	16.6	11.1	7.2	5.8	3.6	4.3	3.4	2.6	1.8	2.0	1.3	1.4	1.1	0.6	2.1	100.0
MEANS	**7.8**	**16.2**	**24.1**	**13.5**	**10.1**	**7.9**	**6.1**	**5.0**	**4.7**	**3.8**	**3.5**	**3.0**	**2.7**	**2.3**	**2.1**	**1.9**	**1.6**	**7.6**	**100.0**
Europe/W. Asia																			
Albania 2008-09	1.9	5.8	7.7	5.1	5.4	4.9	5.5	5.0	4.4	5.4	6.1	4.3	4.7	5.1	5.0	5.3	3.7	22.5	100.0
Armenia 2015-16	2.9	9.2	12.1	8.0	6.9	5.3	4.9	4.5	4.7	4.5	4.4	3.7	3.1	3.0	3.0	2.9	2.5	26.6	100.0
Azerbaijan 2006	3.1	9.5	12.6	7.4	5.8	4.8	3.6	3.3	4.9	4.2	4.1	4.8	4.8	4.5	5.0	3.6	4.0	22.5	100.0
Moldova 2005	2.2	6.7	8.9	7.2	5.7	4.6	3.9	3.9	3.9	4.2	3.3	4.2	4.0	4.2	4.2	3.5	4.3	30.0	100.0
Ukraine 2007	2.8	4.7	7.5	5.2	5.5	4.5	4.3	3.8	3.7	3.3	3.3	3.6	3.6	4.0	3.8	3.7	3.6	36.4	100.0
MEANS	**2.6**	**7.2**	**9.8**	**6.6**	**5.9**	**4.8**	**4.4**	**4.1**	**4.3**	**4.3**	**4.2**	**4.1**	**4.1**	**4.1**	**4.2**	**3.8**	**3.6**	**27.6**	**100.0**
Latin America																			
Bolivia 2008	6.6	15.0	21.7	13.6	9.4	7.8	6.3	6.2	6.0	5.2	4.1	2.9	2.9	2.7	2.1	1.8	1.2	6.0	100.0
Brazil 1996	4.2	10.6	14.8	9.2	7.7	6.9	5.9	5.7	6.2	5.6	5.0	4.6	4.5	3.4	2.9	3.2	3.4	11.0	100.0
Colombia 2015	3.0	9.1	12.0	8.5	7.4	6.8	5.9	6.5	5.8	4.6	4.3	3.9	3.5	3.8	3.8	3.1	3.2	16.8	100.0
Dominican Republic 2013	5.9	10.6	16.5	10.6	8.4	6.9	5.3	5.4	4.6	3.4	3.6	3.6	3.9	2.9	2.6	2.9	2.5	16.7	100.0
Guatemala 2014-15 (16)	6.3	15.4	21.7	12.8	10.3	8.3	7.0	4.9	4.5	4.3	3.5	3.0	2.9	2.5	2.6	2.1	2.0	7.5	100.0
Guyana 2009	4.8	11.9	16.7	9.5	8.5	5.0	4.8	5.7	5.1	4.6	4.7	3.9	3.5	3.4	4.2	3.0	2.3	15.0	100.0
Haiti 2012	7.6	18.6	26.1	14.0	11.1	7.5	6.7	5.3	4.8	4.0	3.0	2.7	2.5	2.2	2.1	2.1	0.9	5.1	100.0
Honduras 2011-12 (18)	5.7	13.9	19.6	12.9	10.0	8.1	6.8	5.4	4.9	4.0	3.9	3.5	3.2	3.0	2.9	2.0	2.0	7.9	100.0
Nicaragua 2001	5.6	13.1	18.7	13.4	10.5	7.8	6.3	5.7	6.5	5.3	4.4	3.0	2.4	2.8	2.5	1.9	1.4	7.5	100.0
Paraguay 1990	10.0	19.8	29.8	14.9	9.5	7.2	6.7	5.6	4.8	3.9	2.6	2.8	2.0	1.4	1.1	1.2	0.9	5.5	100.0
Peru 2012	4.2	11.0	15.2	10.7	9.5	8.1	6.9	6.2	6.4	5.1	3.9	3.8	2.7	2.6	2.9	2.2	2.3	11.6	100.0
MEANS	**5.8**	**13.6**	**19.4**	**11.9**	**9.3**	**7.3**	**6.2**	**5.7**	**5.4**	**4.6**	**3.9**	**3.4**	**3.1**	**2.8**	**2.7**	**2.3**	**2.0**	**10.1**	**100.0**

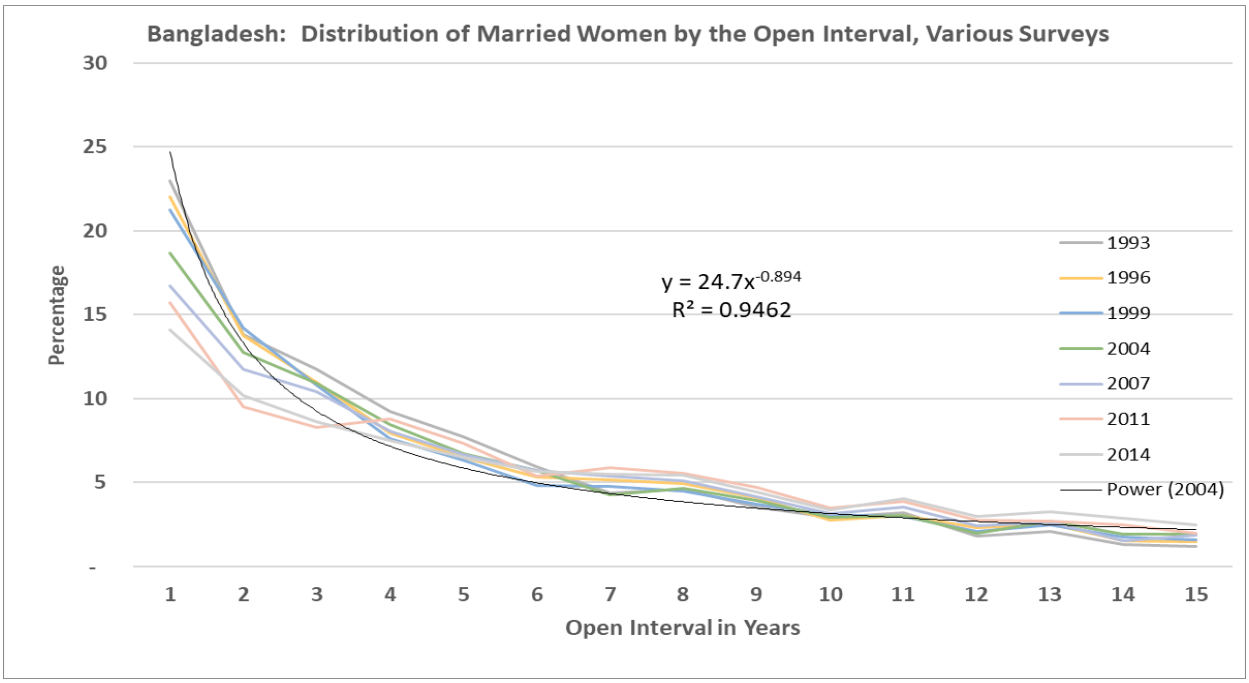
ANNEX 2: Open Intervals by Exclusive Statuses, by Region, Latest Surveys						
	Open Interval Lengths					
All Regions						
Preg/1-11 mo.	**12-23**	**24-35**	**36-47**	**48-59**	**60+**	
Preg/Yr 1	31.4	-	-	-	-	-
Using, Traditional	5.1	11.0	11.1	10.7	10.5	9.3
Using, Modern STM	16.4	32.4	33.3	31.6	28.8	17.8
Using, Modern LTM	4.5	11.5	14.9	16.6	18.4	18.9
Using, Any Method	26.1	54.8	59.3	58.9	57.6	46.0
Unmet Need, Intends Use	11.8	13.5	10.3	8.3	7.1	3.4
Unmet Need, Does Not Intend	6.6	14.1	13.8	13.9	14.5	9.2
No Unmet Need, Intends Use	13.0	6.7	5.4	6.0	6.1	3.1
No Unmet Need, Does Not Inte	10.1	9.6	10.1	11.2	12.1	5.6
Infecund	1.1	1.3	1.2	1.6	2.6	32.7
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
East Southern Africa						
Preg/Yr 1	30.9	-	-	-	-	-
Using, Traditional	1.8	4.2	4.5	4.2	4.3	4.1
Using, Modern STM	22.2	46.3	48.1	44.1	40.6	27.7
Using, Modern LTM	3.3	8.6	11.9	14.2	15.1	14.9
Using, Any Method	27.3	59.2	64.5	62.5	60.0	46.7
Unmet Need, Intends Use	13.8	14.1	11.0	9.0	8.3	4.6
Unmet Need, Does Not Intend	5.2	10.2	10.6	11.9	12.2	10.0
No Unmet Need, Intends Use	14.4	8.0	5.7	6.9	7.4	5.3
No Unmet Need, Does Not Inte	7.3	7.2	7.1	8.1	10.0	6.1
Infecund	1.1	1.3	1.1	1.7	2.0	27.4
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Western and Central Africa						
Preg/Yr 1	35.0	-	-	-	-	-
Using, Traditional	2.8	7.9	9.1	8.0	7.7	4.9
Using, Modern STM	6.8	17.5	19.6	19.6	17.4	9.1
Using, Modern LTM	0.8	2.6	4.4	4.3	4.6	3.4
Using, Any Method	10.4	28.1	33.1	31.9	29.7	17.5
Unmet Need, Intends Use	11.7	18.0	13.2	9.8	8.7	2.7
Unmet Need, Does Not Intend	8.0	21.4	20.7	22.1	22.5	9.8
No Unmet Need, Intends Use	15.1	10.4	8.5	8.5	8.5	3.5
No Unmet Need, Does Not Inte	18.5	20.1	22.6	25.1	25.9	11.4
Infecund	1.4	2.0	1.9	2.6	4.7	55.1
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Asia						
Preg/Yr 1	29.1	-	-	-	-	-
Using, Traditional	5.2	11.4	10.4	10.4	10.8	10.0
Using, Modern STM	17.5	37.2	38.3	36.9	34.2	21.8
Using, Modern LTM	4.2	12.3	15.9	17.0	20.1	23.4
Using, Any Method	27.0	60.9	64.5	64.4	65.1	55.1
Unmet Need, Intends Use	11.7	12.0	9.4	8.6	7.2	3.5
Unmet Need, Does Not Intend	7.3	15.0	15.3	14.4	14.1	10.6
No Unmet Need, Intends Use	14.5	4.6	3.9	4.7	4.4	1.7
No Unmet Need, Does Not Inte	9.1	6.1	5.7	6.3	7.0	2.1
Infecund	1.3	1.3	1.2	1.7	2.2	26.9
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Central Asian Rep.						
Preg/Yr 1	30.2	-	-	-	-	-
Using, Traditional	5.8	6.9	7.8	5.5	4.8	6.3
Using, Modern STM	4.5	8.9	10.0	11.3	11.8	7.7
Using, Modern LTM	13.1	35.4	44.7	51.8	50.4	41.9
Using, Any Method	23.4	51.1	62.6	68.6	67.1	55.8
Unmet Need, Intends Use	9.4	12.4	7.7	6.2	4.2	2.5
Unmet Need, Does Not Intend	9.8	17.6	14.9	13.8	15.4	7.4
No Unmet Need, Intends Use	13.8	6.8	4.7	3.1	2.9	1.1
No Unmet Need, Does Not Inte	11.8	11.1	9.5	7.5	8.8	1.4
Infecund	1.6	0.9	0.5	0.8	1.5	31.8
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Middle East/N. Africa						
Preg/Yr 1	30.7	-	-	-	-	-
Using, Traditional	3.7	5.9	5.4	5.2	5.7	6.0
Using, Modern STM	34.8	54.4	51.6	47.0	44.1	31.5
Using, Modern LTM	9.6	19.8	22.2	24.9	26.6	29.0
Using, Any Method	48.1	80.1	79.2	77.1	76.3	66.5
Unmet Need, Intends Use	7.7	7.6	6.5	7.5	6.0	4.2
Unmet Need, Does Not Intend	1.4	3.2	3.8	3.2	4.5	6.3
No Unmet Need, Intends Use	9.5	6.3	7.7	9.1	8.9	4.0
No Unmet Need, Does Not Inte	2.0	2.3	2.3	2.6	3.1	1.9
Infecund	0.6	0.6	0.5	0.6	1.1	17.2
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Europe/W. Asia						
Preg/Yr 1	29.4	-	-	-	-	-
Using, Traditional	18.2	34.6	31.9	32.6	31.1	30.7
Using, Modern STM	17.5	24.5	23.7	22.0	20.0	13.2
Using, Modern LTM	4.5	15.6	20.6	22.1	24.8	21.1
Using, Any Method	40.1	74.7	76.2	76.7	75.9	65.0
Unmet Need, Intends Use	7.8	7.0	5.8	5.4	2.5	2.1
Unmet Need, Does Not Intend	7.8	11.7	10.6	9.3	11.0	9.7
No Unmet Need, Intends Use	8.3	2.5	2.9	3.7	5.0	1.4
No Unmet Need, Does Not Inte	5.7	3.8	4.2	4.6	4.7	1.4
Infecund	0.9	0.3	0.2	0.3	0.9	20.3
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
Latin America						
Preg/Yr 1	29.7	-	-	-	-	-
Using, Traditional	4.8	11.5	12.3	12.7	12.3	10.5
Using, Modern STM	25.4	45.5	44.8	42.1	37.2	20.3
Using, Modern LTM	9.7	18.5	21.7	24.8	29.5	37.7
Using, Any Method	39.9	75.5	78.8	79.6	79.0	68.6
Unmet Need, Intends Use	13.7	11.7	9.4	7.2	7.0	3.9
Unmet Need, Does Not Intend	3.9	7.2	7.3	6.2	7.0	6.0
No Unmet Need, Intends Use	9.4	2.8	2.2	3.4	3.0	2.6
No Unmet Need, Does Not Inte	3.0	2.1	1.5	2.4	2.4	2.5
Infecund	0.4	0.6	0.8	1.2	1.7	16.4
	100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

ANNEX 3. Curve-Fitting of the Open Interval Distribution

In early tabulations we noticed that the shape of the open interval distribution was markedly similar across countries. The married women were clustered close to the shorter intervals since their last birth, with regularly descending percentages toward the longer intervals. We therefore questioned whether a simple fitted curve with only a few parameters might be possible.

Using all 15 intervals (from the first year to 15 years) we generated curves like those shown in **Figure 6** for Bangladesh at various dates. The pattern is consistent, varying only as the fertility level fell and progressively fewer women were clustered near a recent birth.

FIGURE 6



The dominant pattern in all other countries studied is the same. Women are concentrated to the left. Then the curve descends, at varying slopes depending upon the prevailing fertility level. The descent is due partly to fewer women at the upper ages, which is correlated with lower fertility rates.

Because this pattern is so universal, we fitted various equations to the typical shape, and found a "power" equation to provide a very close fit. It is of the form Y = "a" times (X taken to the "b" power) or $Y=a(x^b)$. It is a negative exponential curve as in the Figure, in which the curve falls off faster with a larger "b" value. The curve as a whole is placed higher or lower according to the "a" value.

Those two summary measures, "a" and "b", appear in the Annex; it pertains to the 74 countries used above, including the latest surveys for all countries, and 56 more for the earliest surveys in those countries with multiple surveys, making 130 total. The Annex also includes the general fertility rate (GFR) and the total fertility rate (TFR) and the R2 results. Anyone can generate the full estimated curve along the X-axis of 15 years by plugging the "a" and "b" values into the equation for any country.

A close relation exists between the open interval distribution and the usual fertility measures of the GFR and the TFR. The following Matrix ("r" values, which give R2 values if squared) shows the correlations to be above 0.90 across the 74 countries with the latest surveys.

Matrix for Correlations Between Fertility and Open Interval

	"a" Value	*"b" Value*	*GFR*	*TFR*
"a" Value	1.00			
"b" Value	0.98	1.00		
GFR	0.92	0.94	1.00	
TFR	0.93	0.95	0.99	1.00

(The matrix gives "r" values, which give R2 values when squared)

Over time the average values have moved toward lower fertility levels. The following table shows the average decline of 16% to 17% in the GFR and TFR in the 56 countries with multiple surveys, over the average period of 17 years. Changes in the "a" and "b" values, at 13% and 11%, have been basically similar. (The R2 values have hardly changed at all, most being well above 0.900.)

Summary of Changes in the "a" and "b" Values and in GFR and TFR

	"a" Value	"b" Value	R2	GFR	TFR
Earliest Surveys	0.416	(1.287)	0.949	165	4.8
Latest Surveys	0.369	(1.147)	0.944	140	4.0
Change	(0.047)	0.140	(0.004)	(25)	(0.8)
% Change	(12.6)	10.6	(0.2)	(15.7)	(16.8)

File: Extended tail 15 Excel June 13 Tab: Differences

The search for summary measures of the full 15-year distribution of intervals can use the "a" and "b" values, along with such others as the percentage of intervals less than one year, two years, etc. Succinct summary measures can be employed to examine such determinants as age, family size, and residence, along with contraceptive use, intention to use, and unmet need. Separately, a study of the rapidity of change within individual countries is of interest.

The close match between the "a" and "b" values for individual countries, appears in **Figure 7**. The two run closely together, with the "b" value at a negative 2.5 times the "a" value. Further, as **Figure 8** shows, the "b" value matches the GFR closely in individual countries.

FIGURE 7

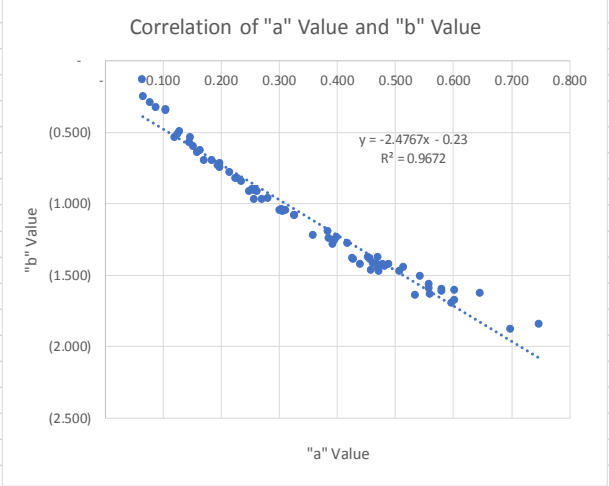
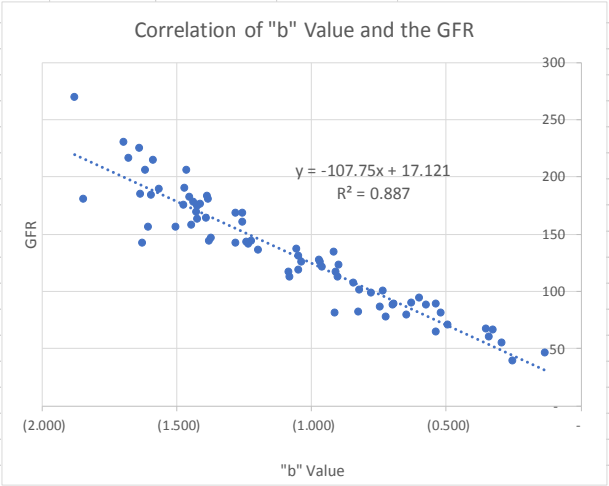


FIGURE 8



The search for summary measures of the full 15-year distribution of intervals can use the “a” and “b” values, along with alternatives such as the percentage of intervals less than one year, two years, etc. Succinct summary measures can be employed to examine such determinants as age, family size, residence, and wealth quintiles, along with contraceptive use, intention to use, and, especially, unmet need. Separately, a study of the rapidity of change within individual countries is of interest, together with a few case studies. The full table follows.

Annex for Curve Fitting: "a" and "b" values, GFR and TFR

This annex lists 130 surveys: 74 for the latest surveys in 74 countries, and 56 more for the earliest surveys in countries with multiple surveys.

	"a" Value	"b" Value	R2	GFR	TFR		"a" Value	"b" Value	R2	GFR	TFR
Afghanistan 2015	0.440	-1.426	0.956	175	5.3	Kyrgyz Republic 1997	0.229	-0.82	0.917	118	3.4
Albania 2008-09	0.065	-0.132	0.390	46	1.6	Kyrgyz Republic 2012	0.257	-0.968	0.985	125	3.6
Angola 2015-16	0.603	-1.678	0.970	216	6.2	Lesotho 2004	0.318	-1.072	0.970	121	3.5
Armenia 2000	0.079	-0.251	0.672	56	1.7	Lesotho 2014	0.312	-1.05	0.929	118	3.3
Armenia 2015-16	0.121	-0.538	0.968	64	1.7	Liberia 2007	0.412	-1.303	0.958	181	5.2
Azerbaijan 2006	0.089	-0.328	0.600	66	2.0	Liberia 2013	0.418	-1.282	0.935	168	4.7
Bangladesh 1999-00	0.333	-1.076	0.918	130	3.3	Madagascar 1992	0.455	-1.483	0.979	212	6.1
Bangladesh 2014	0.165	-0.63	0.943	90	2.3	Madagascar 2008-09	0.396	-1.255	0.958	168	4.8
Benin 1996	0.548	-1.579	0.974	202	6.0	Malawi 1992	0.470	-1.514	0.956	223	6.7
Benin 2011-12	0.508	-1.475	0.956	175	4.9	Malawi 2015-16	0.515	-1.445	0.914	158	4.4
Bolivia 1994	0.397	-1.255	0.970	163	4.8	Maldives 2009	0.228	-0.827	0.962	82	2.5
Bolivia 2008	0.281	-0.963	0.913	121	3.5	Mali 1995-96	0.529	-1.585	0.979	234	6.7
Brazil 1991	0.268	-0.932	0.924	122	3.4	Mali 2012-13	0.559	-1.59	0.967	214	6.1
Brazil 1996	0.147	-0.538	0.931	89	2.5	Moldova 2005	0.078	-0.294	0.747	55	1.7
Burkina Faso 1993	0.691	-1.804	0.946	221	6.5	Morocco 1992	0.412	-1.294	0.981	127	4.0
Burkina Faso 2010	0.581	-1.616	0.961	206	6.0	Morocco 2003-04	0.262	-0.912	0.941	81	2.5
Burundi 2010	0.732	-1.942	0.971	203	6.4	Mozambique 1997	0.440	-1.407	0.991	183	5.2
Burundi 2016-17	0.748	-1.846	0.923	180	5.5	Mozambique 2011	0.458	-1.464	0.975	206	5.9
Cambodia 2000	0.376	-1.178	0.868	119	3.8	Myanmar 2015-16	0.198	-0.723	0.932	77	2.3
Cambodia 2014	0.215	-0.779	0.953	98	2.7	Namibia 1992	0.410	-1.325	0.957	176	5.4
Cameroon 1991	0.437	-1.417	0.972	208	5.8	Namibia 2013	0.305	-1.039	0.948	125	3.6
Cameroon 2011	0.426	-1.385	0.977	180	5.1	Nepal 1996	0.320	-1.097	0.976	167	4.6
Central African Rep. 1994-95	0.428	-1.388	0.966	183	5.1	Nepal 2016	0.146	-0.573	0.970	88	2.3
Chad 1996-97	0.562	-1.679	0.955	229	6.4	Nicaragua 1998	0.284	-0.976	0.973	132	3.6
Chad 2014-15	0.597	-1.697	0.954	230	6.4	Nicaragua 2001	0.258	-0.91	0.906	117	3.2
Colombia 1990	0.245	-0.875	0.956	105	2.8	Niger 1992	0.566	-1.687	0.978	250	7.0
Colombia 2015	0.129	-0.495	0.947	70	2.0	Niger 2012	0.699	-1.881	0.967	269	7.6
Comoros 1996	0.414	-1.349	0.937	148	4.6	Nigeria 1990	0.561	-1.615	0.934	207	6.0
Comoros 2012	0.392	-1.283	0.981	142	4.3	Nigeria 2013	0.473	-1.473	0.969	190	5.5
Congo 2005	0.419	-1.345	0.986	168	4.8	Pakistan 1990-91	0.441	-1.387	0.940	164	4.9
Congo 2011-12	0.471	-1.453	0.988	182	5.1	Pakistan 2012-13	0.301	-1.05	0.979	131	3.8
Congo Democratic Rep. 2007	0.459	-1.477	0.975	210	6.3	Paraguay 1990	0.395	-1.255	0.943	160	4.7
Congo Democratic Rep. 2013-1	0.535	-1.641	0.982	225	6.6	Peru 1991-92	0.301	-1.028	0.969	121	3.5
Cote d'Ivoire 1994	0.571	-1.595	0.949	187	5.3	Peru 2012	0.198	-0.746	0.911	86	2.6
Cote d'Ivoire 2011-12	0.469	-1.423	0.973	174	5.0	Philippines 1993	0.302	-1.041	0.985	138	4.1
Dominican Republic 1991	0.247	-0.905	0.981	125	3.3	Philippines 2013	0.225	-0.824	0.940	101	3.0
Dominican Republic 2013	0.172	-0.696	0.977	89	2.5	Rwanda 1992	0.888	-2.06	0.919	197	6.2
Egypt 1992	0.353	-1.136	0.959	136	3.9	Rwanda 2014-15	0.646	-1.629	0.832	142	4.2
Egypt 2014	0.271	-0.971	0.985	127	3.5	Sao Tome and Principe 2008-	0.457	-1.392	0.952	164	4.9
Ethiopia 2000	0.588	-1.655	0.940	183	5.5	Senegal 1992-93	0.504	-1.536	0.974	202	6.0
Ethiopia 2016	0.544	-1.506	0.925	156	4.6	Senegal 2016	0.602	-1.607	0.934	156	4.7
Gabon 2000	0.300	-1.044	0.946	153	4.2	Sierra Leone 2008	0.429	-1.323	0.942	180	5.1
Gabon 2012	0.359	-1.225	0.947	144	4.1	Sierra Leone 2013	0.489	-1.428	0.938	169	4.9
Gambia 2013	0.561	-1.635	0.974	185	5.6	South Africa 1998	0.195	-0.735	0.894	100	2.9
Ghana 1993	0.498	-1.465	0.963	178	5.2	Swaziland 2006-07	0.307	-1.055	0.946	137	3.8
Ghana 2014	0.386	-1.242	0.977	143	4.2	Tajikistan 2012	0.249	-0.917	0.959	134	3.8
Guatemala 1995	0.317	-1.114	0.987	177	5.1	Tanzania 1991-92	0.480	-1.498	0.972	212	6.2
Guatemala 2014-15	0.254	-0.904	0.981	112	3.1	Tanzania 2015-16	0.482	-1.437	0.962	178	5.2
Guinea 1999	0.490	-1.448	0.963	195	5.5	Timor-Leste 2009-10	0.575	-1.579	0.923	175	5.7
Guinea 2012	0.462	-1.415	0.937	176	5.1	Timor-Leste 2016	0.384	-1.197	0.913	136	4.2
Guyana 2009	0.152	-0.602	0.914	94	2.8	Togo 1998	0.520	-1.513	0.965	175	5.2
Haiti 1994-95	0.406	-1.324	0.984	156	4.8	Togo 2013-14	0.479	-1.425	0.965	163	4.8
Haiti 2012	0.326	-1.086	0.943	117	3.5	Turkey 1993	0.177	-0.668	0.939	90	2.5
Honduras 2005-06	0.290	-0.991	0.923	117	3.3	Turkey 2003	0.160	-0.646	0.956	79	2.2
Honduras 2011-12	0.235	-0.844	0.974	107	2.9	Uganda 1995	0.592	-1.773	0.966	248	6.9
India 1992-93	0.230	-0.861	0.967	130	3.4	Uganda 2016	0.559	-1.568	0.966	189	5.4
India 2015-16	0.125	-0.52	0.968	81	2.2	Ukraine 2007	0.066	-0.254	0.798	39	1.2
Indonesia 1991	0.256	-0.906	0.929	108	3.0	Uzbekistan 1996	0.259	-0.9	0.959	123	3.3
Indonesia 2012	0.185	-0.698	0.914	88	2.6	Vietnam 1997	0.184	-0.645	0.876	80	2.3
Jordan 1990	0.476	-1.453	0.980	169	5.6	Vietnam 2002	0.106	-0.341	0.753	60	1.9
Jordan 2012	0.326	-1.08	0.967	112	3.5	Yemen 2013	0.454	-1.373	0.959	146	4.4
Kazakhstan 1995	0.144	-0.551	0.839	83	2.5	Zambia 1992	0.495	-1.557	0.971	219	6.5
Kazakhstan 1999	0.105	-0.351	0.819	67	2.0	Zambia 2013-14	0.581	-1.597	0.954	184	5.3
Kenya 1993	0.423	-1.305	0.962	182	5.4	Zimbabwe 1994	0.463	-1.373	0.951	148	4.3
Kenya 2014	0.400	-1.236	0.929	141	3.9	Zimbabwe 2015	0.470	-1.379	0.931	144	4.0