The Dynamics of Family Planning
Key Demographic Insights

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About the author

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THE DYNAMICS OF FAMILY PLANNING
Key Demographic Insights

BY **JOHN ROSS**

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- Introduction -

Since the early 1960s, many countries have instituted large-scale programs to provide contraceptive protection to their populations. These programs were launched as the new technology of birth control advanced through the appearance of the intrauterine device (IUD), the pill, simpler female sterilization, and subsequently the injectable and other methods. Public education and encouragement to adopt these methods were part of many national programs, along with field support through augmentation of health infrastructures to deliver the new methods. The private commercial and medical systems also grew during these years.

Meanwhile, research activities emerged to track the extent and effects of the programs. Hundreds of national surveys have been conducted, and statistics have been collected from clinics and health centers at local levels. The rich data sets that have appeared over the years permit insights into the dynamics of how large-scale programs do and do not work well.

The topics in this publication are selected to portray various relationships among contraceptive elements and among certain demographic outcomes. This publication is useful for those who seek a deeper understanding of the dynamics that surround contraceptive use, as well as the action programs that extend it to national populations. Population growth is one of those problems that is often ignored in the short run but is important in the long run. To appreciate fully the processes that operate even in the short run, numerous audiences are important, including:

- People just entering the fields of family planning and demographic change.

- University faculty members developing graduate courses for population issues.

- Analysts studying the processes by which contraceptive use and demographic changes interact.

- Staff at implementing agencies devoted to large-scale programs to advance reproductive health in developing countries.

- All others, including journalists and commentators on public affairs, who seek an understanding of the processes that affect the extension of family planning methods to national populations.

The format for each topic states first the key relationship, then discusses it briefly, usually with references for further reading, and with an accompanying chart that illustrates the dynamics involved. A Glossary of Terms is included.

- 1 -
Use of a Contraceptive Method Declines Systematically Over Time

If 100 women start to use a contraceptive method, some will discontinue each month and the number still using tends to follow a decay curve like that in Figure 1. It shows the percent of women still using a method at each month up to the 36th month after adoption, using a monthly dropout rate of 5 percent. The monthly dropout rate is assumed to be steady and the equation for the curve is $P = e^{(-rt)}$ where "P" is the overall percentage still using the method as of each month, "r" is the monthly dropout rate, and "t" is the time elapsed. The equation assumes instantaneous compounding of the dropout rate, hence the exponential "e" is used. At a monthly dropout rate of 5 percent, the percentage still using as of 12 months is about 55 percent.

If a method has a lower dropout rate, say with a rate of only 2 percent, the curve will decay more softly and the average time of use will be greater. A set of such curves is easy to create.

While the starting group is 100 percent of women, as in Figure 1, some analysts allow for an "immediate" dropout of, for example, 5 percent, so the starting group is only 95 percent, and the entire curve is moved downward that much.

The basic information usually comes from survey data on the length of time each woman has used the contraceptive method before dropping out. That information is employed in **life table applications** to show the month-specific dropout rate and to produce a smooth curve like that shown in Figure 1. Published reports often simply tell the percent continuing at the 12-month point and the 24-month point.

Note that the average (mean) continuation time for a method comes from the dropout rate ("r"). The mean is just the reciprocal of the rate, so a monthly rate of 0.1 gives a mean

use time of 10 years. (It is also the total area under the curve.) However the decay curve cannot go on forever since some users age out, no longer live with a spouse, or die, so the mean must be adjusted by cutting off the tail of the decay curve at some point, for example at 10 or 15 years.

That matters little in practice since few of the original adopters use their first method that long. Most have switched to another method, become accidentally pregnant during use, or in some cases begun another segment of use of the same method after a delay. Still others use nothing at all and risk pregnancy.

"Dropout" can be defined in various ways: If it means the time from adoption to stopping use of *any* method (allowing for switching), the continuation time is lengthened. Other variations just follow the woman rather than any method. In this case, the time can be from adoption to a conception, ignoring irregular use in between. Or it may be to a birth, allowing for any miscarriages or abortions. Life tables have been created for all these end points to "follow the woman," not just the use of the initial method.

Note: The **life table applications** method, developed for mortality studies, is distinguished by its attention to deaths at each age rather than deaths in general, thus removing the effect of distorted age distributions upon average death rates. In the same way, month-specific contraceptive dropout rates remove the effect of dissimilar durations of use on average dropout rates.

FIGURE 1

"P": The Percent of Women Still Using a Method of Contraception After Adopting It

Percent

Months
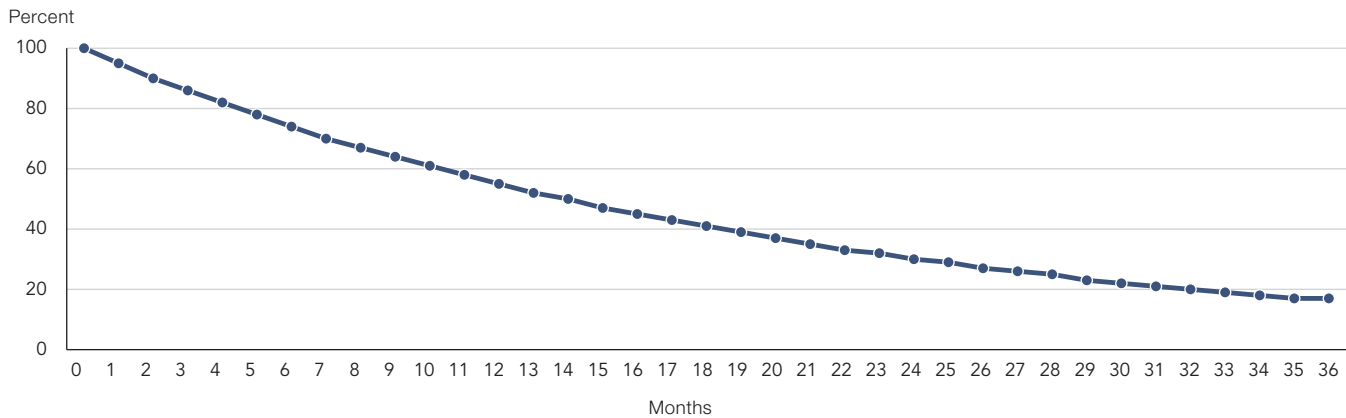
Source: Illustrative data by author.

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- 2 -
Contraceptive Use in a Population Tends to Level Off

Even if a contraceptive method continues to attract a new set of adopters over time, the percentage of women using it reaches a plateau at a certain level due to discontinuation rates.

Imagine a new family planning program that attracts 1,000 adopters of a method each month. It starts with 1,000 in the first month, some of whom discontinue in each succeeding month. But 1,000 more start in the second month, and some also discontinue each month. There is a net buildup for some time, since there are more new adopters than there are dropouts.

However, the pool of all users finally grows enough so that the total dropouts each month equal the 1,000 new adopters, so users level off. They stabilize at different levels depending upon the average use time. Figure 2 shows the number of users over time when 1,000 women adopt the method every month and the average use time is three years. A mean use time of three years gives a plateau of 3,000 users.

This dynamic tends to occur for entire family planning programs. Total use tends to level off due to the constant loss of users from the overall pool for all methods. It is true that total use has risen in many countries over the years; this can occur because a growing proportion of users are on high-continuation methods like sterilization, the IUD, or the implant. Or instead it can occur because a low-continuation method like the injectable enters a take-off stage as in eastern and southern Africa, raising the number of adopters each month. Regardless, total use eventually levels off.

By and large, all methods fall into either the high-continuation group of sterilization, IUD, and implant, for which a single step gives automatic continuation, or else into the low-continuation group of the pill, injectable, condom, rhythm, and withdrawal, which require continuously repeated actions.

FIGURE 2

Contraceptive Users Level Off If 1,000 Adopt a Method Each Month and Use an Average of Three Years

Number of Users
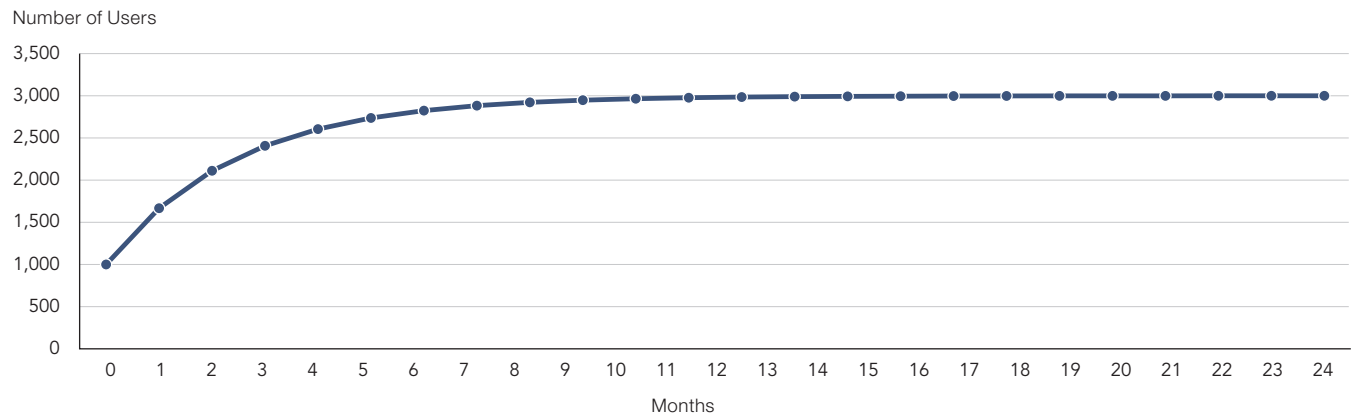
Source: Illustrative data by author.

- 3 -
# Contraceptive Prevalence Depends on Annual Adoptions and the Average Continuation Time

If 5 percent of women adopt a method each year and use it for an average of four years, prevalence will finally level off at 20 percent. This stabilization level "P" is the product of the adoption rate ("A") and the continuation time ("C"): P = AC.

Figure 3 shows that the final prevalence level, on the y-axis, is higher when either the adoption rate (on the x-axis) or the continuation time (represented by the series of lines) is higher, but especially when both are high. Each line rises as we assume a higher adoption rate on the x-axis. In the middle of the figure, at a 3 percent adoption rate and three years' average use time, prevalence levels off at 9 percent. The highest prevalence level assumes a 6 percent adoption rate and a mean use time of five years, giving 30 percent prevalence.

Different determinants affect the adoption rate versus the continuation time. The average continuation time partly reflects the method mix: Use of sterilization or the IUD extends the average while short-term methods like the pill and condom tend to reduce it. Few countries have prevalence above 60 percent or 65 percent without significant use of sterilization or the IUD, because of their long continuation times. Both the continuation time and the adoption rate can respond to action programs that make it easier to access a method and improve the quality of services.

FIGURE 3

Stabilization Level for Percent Using a Method, Related to the Annual Percent Adopting it and the Average Use Time, in Years

Percent Using
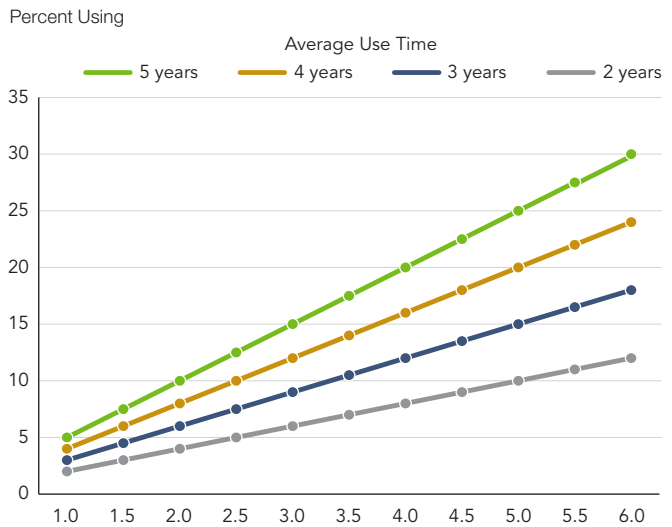
Source: Illustrative data by author.

- 4 -
If Half of Women Use Contraception, the Birth Rate May Not Fall by Half

Several factors diminish contraceptive use:

- Some failures occur during use.

- Some use overlaps with postpartum infecundability.

- Some use is by older women who have become infecund or stopped cohabiting.

- Contraception prolongs only one of the three parts of the birth interval.

On the other hand, women who adopt contraception are self-selected; they probably have a greater chance of becoming pregnant than the average woman does. In that way, half of users may avert a disproportionate share of the births that would otherwise occur.

Therefore the net effects of contraceptive use on the birth rate can vary. These effects can depend especially on the method mix. Accidental pregnancies occur more often with the resupply methods of the condom, injectable, and pill and also with the traditional methods of withdrawal or rhythm, compared to sterilization, the IUD, or implant.

Age also matters—older women tend to choose long-acting methods, which have better reliability; moreover, they have somewhat lower fecundity levels. For them the time between births is greater than among younger women. Figure 4 shows the net effects of contraceptive use and other influences on the actual time between births by age of the women, based on the most recent data available in 86 developing countries from Demographic and Health Surveys (DHS). These effects involve the time between two births, termed "closed intervals," which clearly increase with age, but that does not provide the full picture. There are also "open intervals" that refer to the time since the most recent birth. Older women also have longer open intervals, delaying the next birth or avoiding another one forever.

FIGURE 4

Median Birth Intervals by Age, 86 Developing Countries

Months
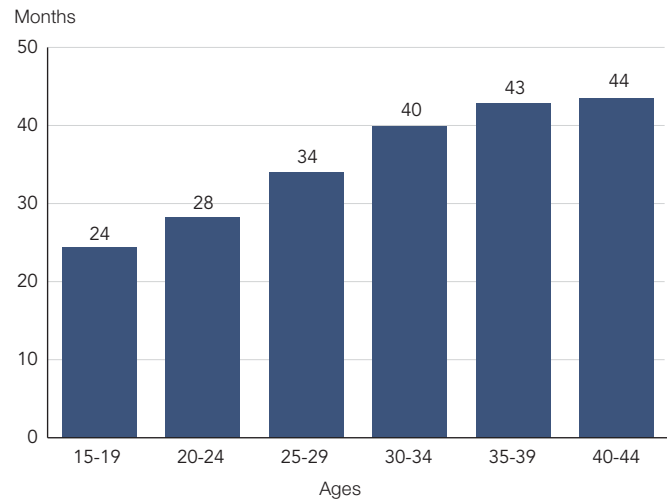
Source: ICF, DHS Statcompiler.

Thus half of women may be using contraception, but whether that reduces the birth rate by half depends upon many factors, including those listed above that weaken it.

Reference

ICF International, The DHS Program, STATCompiler, accessed at www.statcompiler.com/en/.

- 5 -
Abortion and Contraception Affect Birth Intervals Differently

To avoid an unwanted birth, a woman may use either contraception or abortion or both (apart from issues concerning their availability). The aim here is not to argue for or against either one, but rather to provide insights on the empirical effects of using them upon the average lengths of birth intervals.

Birth Interval With No Use of Contraception or Abortion

With no deliberate intervention, the birth interval starts from a birth, followed by approximately eight months of postpartum infecundability, followed by an average waiting time of about five months until the next conception, and nine months for gestation, totaling 22 months between births. (To simplify, this estimate ignores miscarriages and still births.)

Birth Interval With Abortion Only

When only abortions are used to avoid births, birth intervals increase only eight months. After a conception, three months elapse for the abortion and recovery period (the average amount of time it takes for women to become fecund again after an abortion), then the five months "waiting time" until the next conception, or eight months total out of a woman's childbearing time. The gain of eight months' protection time compared to the interval (above) of 22 months yields a total of 30 months for the birth interval with abortion alone. Since each abortion adds only eight months to the 22-month birth interval, it adds only 36 percent (8/22) of the interval; restated, if a woman uses abortions alone, it would take 2.75 abortions (or 22/8) to offset one birth.
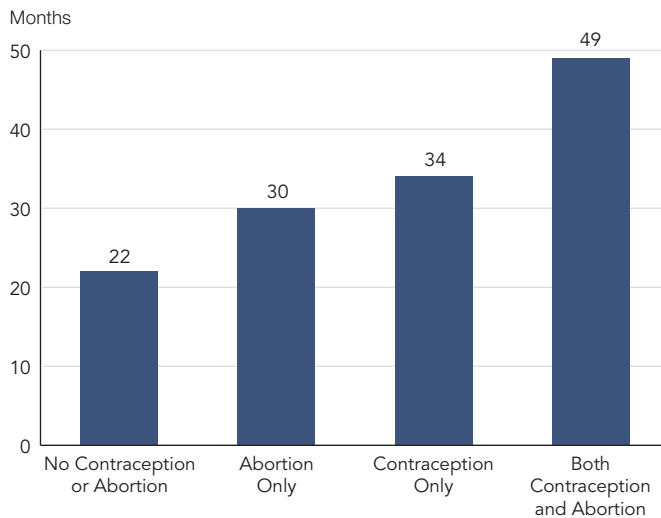
Birth Interval With Contraceptive Use Only

Women use contraceptives to delay or space births. Contraceptive use may be interrupted by side effects or failures, or may end due to issues such as distance or cost, leading to unwanted births.

Consider a woman who uses contraceptives alone to keep avoiding a birth. Starting after one birth she experiences for example an eight-month postpartum period of infecundability, then, 12 months of contraceptive use, five months average of unprotected "waiting time" to the next conception, and nine months to gestation. The total interval between births in this case is 34 months instead of 22 months (above) with no contraception. The gain of 12 months' protection time is only 55 percent (12/22) of a full birth interval.

Length of Birth Interval

Source: Illustrative data by author.

Birth Interval Using Both Contraception and Abortion

When a woman experiences a contraceptive failure and has an abortion to end the pregnancy, she can start using contraception again to protect herself for a longer interval. Thus the two combined prolong the birth interval, more than either one alone.

The longer the average contraceptive use time following an abortion, the longer the overall birth interval. Model calculations indicate that an abortion in combination with extended contraceptive use can avert up to nine in 10 births.

To illustrate, if a woman uses contraception for 12 months and experiences a failure, has an abortion (taking up three months), then returns to using contraception for another 12 months, the total is 27 months added to the unprotected interval of 22 months, for a total of 49 months. Figure 5 contrasts the interval for no contraceptive use, abortion alone, and contraception alone, along with the substantial gain for the two in combination.

The need for abortions is far less frequent when they are used only as a back-up to contraceptive failures, since

the contraceptive use is occupying most of the woman's childbearing time, apart from wanted pregnancies and births. Reliance primarily on contraception is easier on the woman and lessens the burden on health facilities.

After an abortion, in practice much depends on what different women do. Some follow the abortion with irregular contraceptive use, or employ a high-failure method such as condom, withdrawal, or rhythm. Others choose a more reliable method and use it carefully but still have another failure. The mix of such variations in a population helps to determine the birth rate, as well as the final number of births to the individual women.

(Note finally that in some cases an abortion can actually reduce a woman's time out of childbearing. If it had not occurred, the outcome might later have been a miscarriage or stillbirth, which would have delayed the next conception longer.)

Notes: Waiting time: for fecund couples not using contraception, the monthly chance of conception is commonly put at 20 percent. That translates to five months as the average **waiting time** to conception. **Twenty-two months is the *average* birth interval** without any contraception or abortion. This interval varies, so some women may have births a year apart while others end up waiting for several years or more for the next birth.

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Relatively Few Countries Reach High Contraceptive Prevalence Levels Without Including Long-Acting Methods

The three methods with long continuation times—sterilization (both male and female), the IUD, and the implant—account for a substantial share of all use in many countries. Relatively few countries achieve high contraceptive prevalence levels without the use of the long-acting methods. In contrast to those, the resupply methods of the pill, injectable, and condom and the traditional methods of rhythm and withdrawal all suffer from high discontinuation rates, and many women who discontinue a method become pregnant before adopting another method. Others move in and out of use, switching methods. This "churning" between women's use and non-use partly reflects the "easy start–easy stop" nature of the resupply methods and the traditional methods. On the other hand, long-acting methods provide automatic

continuation. It is obviously longest with sterilization, which has the longest average continuation time, running until women age out, past the usual cutoff ages of 45 or 50.

Due to its long continuation time, the pool of current sterilization users grows considerably over time. It is highest when the age of adoption is early (it is below age 30 in many counties), and when sterilization has been offered for many years, allowing for a buildup over time. In both cases the sterilization adopters stay in the using pool for many years, elevating the total prevalence of use.

Figure 6 shows how the percent of women using any method is correlated with the percent using long-acting

FIGURE 6

Total Contraceptive Use Depends Partly on Long-Acting Methods

Percent Married Women 15-49 Using Any Method

Percent Married Women 15-49 Using Long-Acting Methods
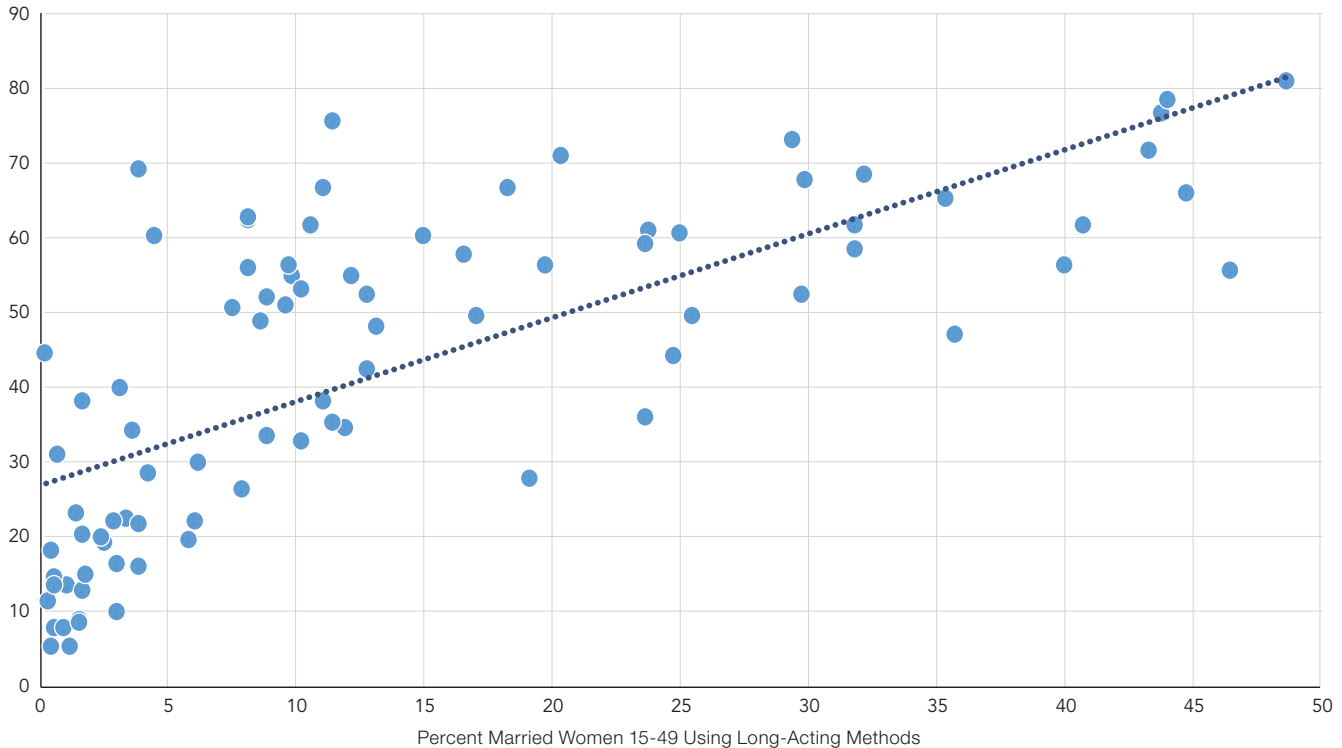
Source: ICF, DHS Statcompiler.

Note: Data are for 85 countries.

methods, based on data from 85 countries with DHS surveys. The two increase nearly at the same rates: that is, a 1.1 percent increase in the percent of women using long-acting methods is associated with 1 percent increase in the percent using any methods. Use of long-acting methods runs as high as 50 percent of all married women and overall, accounts for a large share of all use, which is as high as 80 percent.

Age is a key deciding factor. Figure 7 shows how the percent of women using long-acting methods increases consistently with age. From a country average of only 11 percent of the youngest women ages 15 to 19 using a long-acting method, the percentage rises to 44 percent for the oldest women ages 45 to 49. With each step upward in age, an additional 4 to 7 percent are relying on the long-acting methods.

The mix among the three methods differs sharply by region. The IUD is widely prevalent in the Middle East, while sterilization is prominent in India and in much of Latin America. The implant has emerged in recent years, notably in East Africa.
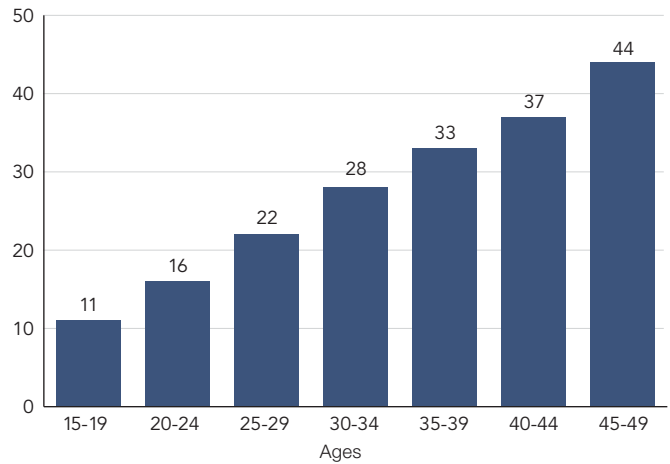
References

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Percent of All Users Relying on Long-Acting Methods, by Age

Percent Married Women 15-49

Source: ICF, DHS Statcompiler.
Note: Data are for 85 countries.

- 7 -
How Are Contraceptive Users Like a Population of Living Persons?

Contraceptive users are like a population of living persons in that:

- Both groups experience entries: adoptions of contraceptive methods by new users in one case, and births in the other case.

- Both experience exits: users stopping use in one case, and deaths in the other case.

- As there is an annual rate of new adopters in one case, there is a birth rate in the other.

- As there is a monthly risk of stopping use as time passes, there is an annual risk of death as time passes.

- As there is the average use time for new adopters of a method, there is an average life expectancy for people.

To sum up, users are like living persons, new adopters are like births, discontinuers are like deaths, and average use time is like life expectancy.

Because of these similarities, life table methods have been applied to contraceptive use, based on the monthly risk of terminating use. In mortality analyses, life table methods use age-specific probabilities of dying to estimate life expectancy and related outcomes. The key is the age-specific focus,

to be able to compare rates across populations and age groups regardless of the size of each age group. In the same way, these methods have been applied to contraceptive continuation rates, to work from the month-specific dropout rates. In practice, these track a new cohort of adopters to see how many drop out by one month, by two months, and so forth, comparable to mortality data to track deaths by age 1, by age 2, and so forth.

The percentage dropping out by one year is the most common summary statistic, and Figure 8 shows that percentage for each of the main methods, taken from DHS results in 54 developing countries. Each bar shows, for one method, the percent of women starting on the method who have discontinued within the first year. The "total" value on the left is the weighted average; it reflects the method mix, since it is lower when more users are on the low-discontinuation methods.

The "automatic continuation" methods, such as sterilization, IUD, and implant, are on the left, which do not depend on repeated supplies or repeated use. For female sterilization, only 0.1 percent have discontinued use by one year, so low that the bar is invisible. At the other extreme, all the resupply or repeat-use methods, such as pill, condom, and rhythm, have high discontinuation levels. At the two-year point, even more will have dropped out.

FIGURE 8

First-Year Contraceptive Discontinuation Rates Due to All Reasons
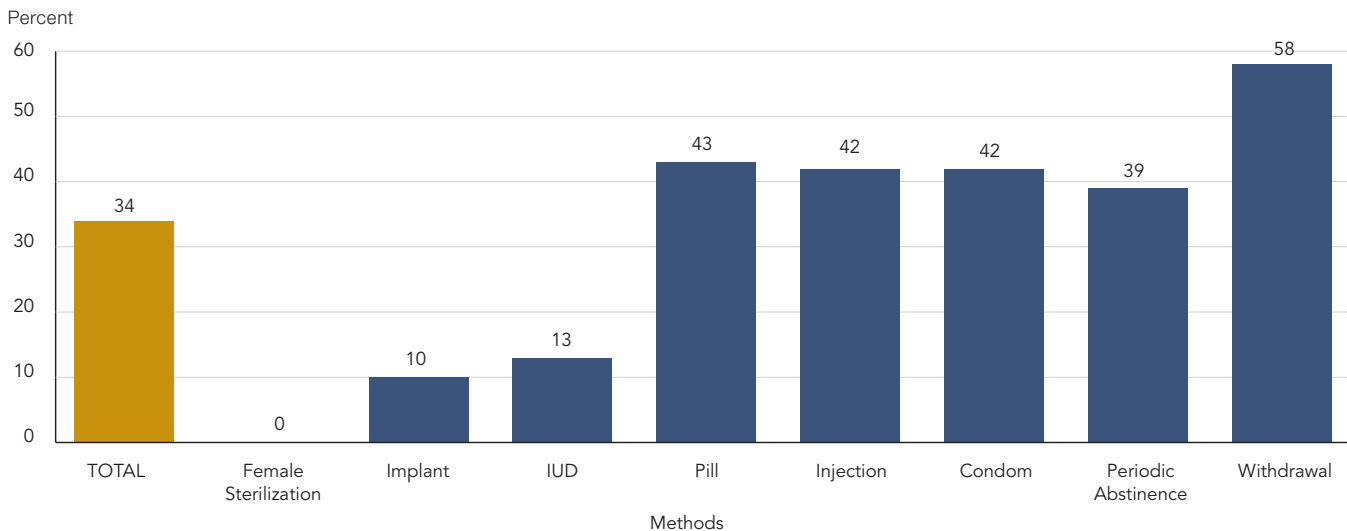
Source: ICF, DHS Statcompiler.

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The Open Birth Interval (Time Since the Latest Birth) Separates Women by Unmet Need and Interest in Contraception

The open interval is the time since the last birth. Long intervals—that is, when women go a long time without a birth—may occur for several reasons: more of them are using contraception, or are no longer living with a spouse, or are infecund. Fewer have an unmet need for contraception. Also, fewer are currently pregnant or amenorrheic.

The time since the last birth can reveal a great deal about any group of women. Figure 9 shows, for example, the number of women with different unmet need statuses by the length of their open birth interval. First, in sheer numbers, the longer the interval, the fewer the women included in the interval since the open interval is correlated with age. Older women have longer open intervals, consistent with their lower fertility rates. The numbers diminish toward the right of the figure, so every subgroup shrinks with longer open intervals.

For implementing programs, the open interval is a useful indicator of which women want to adopt contraception.

Many new mothers, with short intervals, are preoccupied with the infant and few desire another pregnancy soon, as little as only 5 percent in many surveys. 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 the first birth, most succeeding births (if any) come within 1.5 to 4.5 years.

The open interval is closely correlated with other fertility measures, such as the general fertility rate and the total fertility rate, since any group with low fertility includes many women who are postponing or avoiding another birth. Over time the open interval can be employed to track fertility changes, including their relation to increasing contraceptive use.

FIGURE 9

Unmet Need Status by Length of the Open Interval, Based on Data for Kenya, 1993
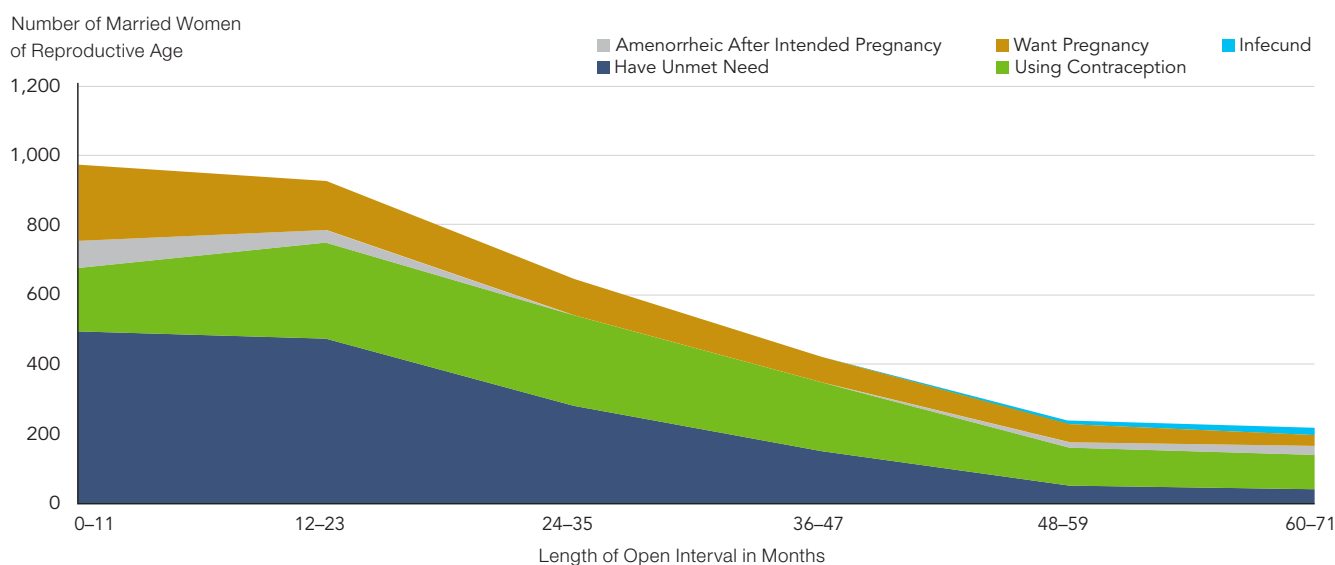
Source: B. Robey, John Ross, and I. Bhushan, "Meeting Unmet Need: New Strategies," *Population Reports,* Series J, no. 43 (September 1996).

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- 9 -
Later Marriage Means Fewer Births Each Year

Older age at marriage has two effects on births in a country. First, when the average age at marriage rises, it means that couples are moving their weddings into future years, so that fewer occur annually so long as the transition continues. The same trend happens to the first births that typically follow marriage—they too are pushed into the future and are fewer annually. During these transition years while countries are experiencing rising marriage ages, the marriage rates and first birth rates are depressed.

A second, entirely different, process is also at work. The later the marriages occur, the later the births—so the generation length, or the number of years between the births of a parent and of a child, is prolonged permanently. The same number of births per woman is spread more thinly, over a longer period, so the annual fertility rate drops.

Thus there are two effects of a rising marriage age: lost marriages and lost first births within the transition years, and a permanently lower annual birth rate due to a longer time between generations.

The reverse process can also happen: if marriages begin occurring earlier, the marriages and the births pile up in the transition years, elevating counts in those years, and the generational length becomes shorter.

Figure 10 shows a hypothetical baseline birth rate of 30 births per year, and a second line that falls during the transition and then stabilizes at a lower rate. While the age at marriage is increasing the birth rate declines, finally stabilizing at the lower level of 29 births per year.

FIGURE 10

Birth Rate Declines When Marriage Is Delayed

Annual Birth Rate
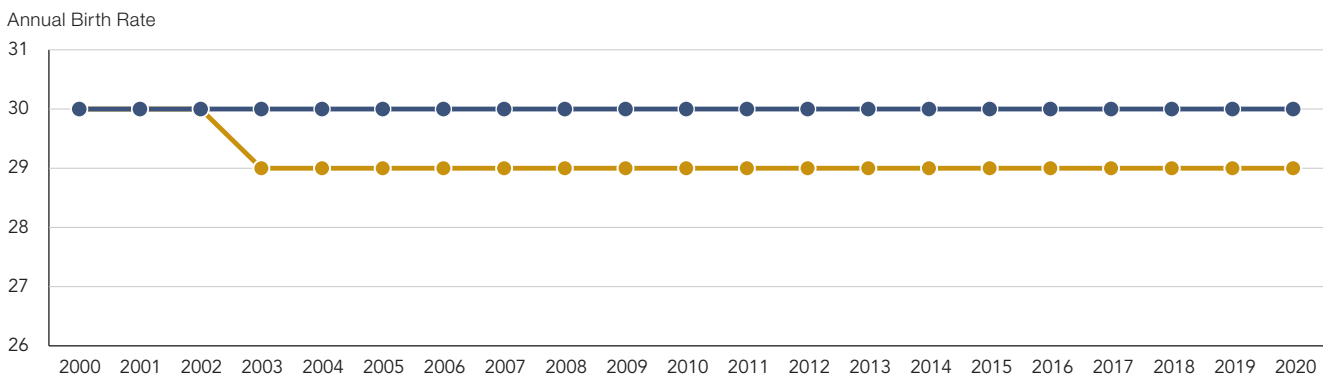
Source: Illustrative data by author.

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# Where Mortality Is High, Most Deaths Are to the Young

Fertility changes relate to mortality changes over the long run. Historically both birth and death rates were high but, with modernization, both fell to relatively low levels. But they did not fall together: death rates fell first, causing a lag before birth rates did the same. As infant survival improved, fewer births became acceptable; concurrently many modernizing forces lowered the desired family sizes.

Figures 11 and 12 show the current mortality picture for the **least developed countries,** where fertility remains at high levels. Remarkably, most deaths are to the young, due to the combination of high infant and child mortality rates and the very large numbers of births. In these especially poor countries, over half of deaths occur among the young, below age 35 (see Figure 11). In fact, in the least developed countries a third (34 percent) of all deaths occur to children below age 5, versus only a fifth (20 percent) above age 65.

As countries advance and the overall mortality level declines, the shape of the mortality curve by age shifts, with a lower risk for infants and children. But this trend can be offset by large numbers of children subject to those rates, so the total numbers of deaths can remain concentrated among the youth. For health services, the irony is that while the infant/child mortality rates improve, more young deaths can occur. Figure 12 shows the curve of total deaths in the least developed countries (estimates of the United Nations (UN) Population Division).

FIGURE 11

Percent of Deaths Before Age 35, Least Developed Countries, 2010-2015
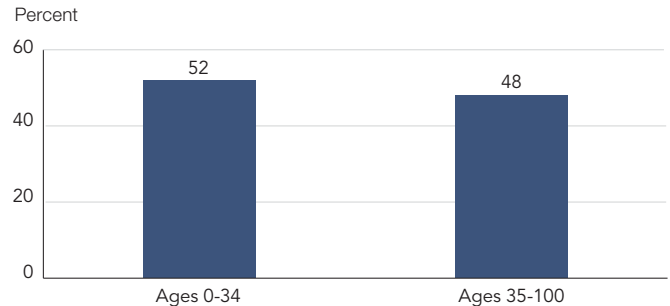
Percent

Source: United Nations (UN) Population Division, *World Population Prospects, The 2015 Revision* (New York, UN, 2015).

Note: The 47 **least developed countries,** as identified by the UN as the poorest countries, are primarily in sub-Saharan Africa but also include nine in Asia, four in Oceania, and one in Latin America and the Caribbean (Haiti).

References

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FIGURE 12

Deaths by Age: Least Developed Countries, 2010-2015
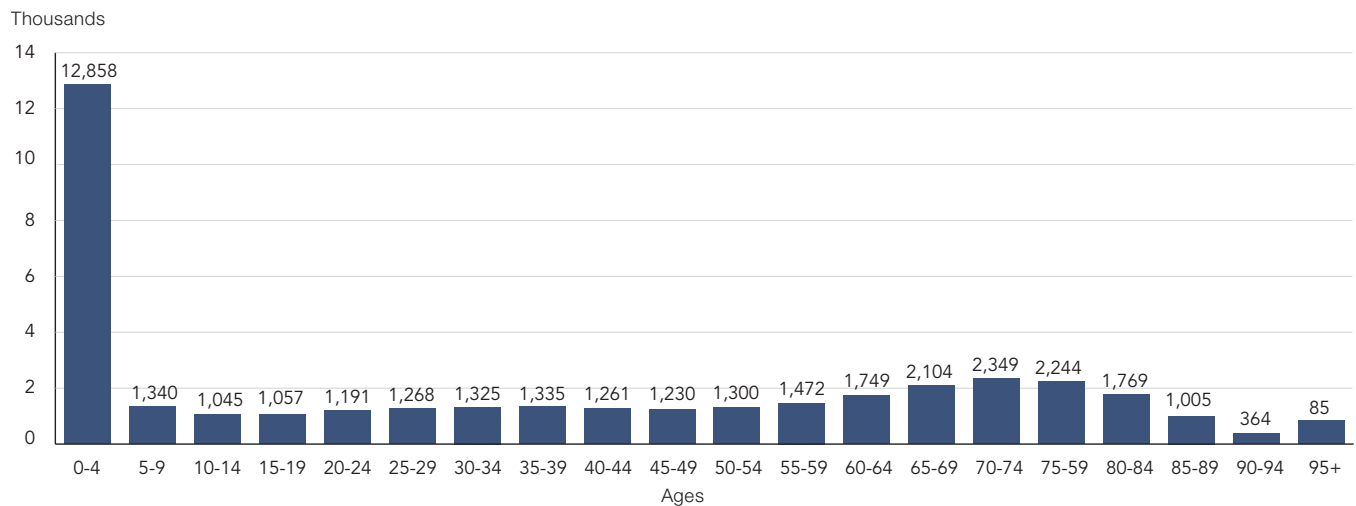
Thousands

Source: United Nations (UN) Population Division, *World Population Prospects, The 2015 Revision* (New York, UN, 2015).

THE DYNAMICS OF FAMILY PLANNING: KEY DEMOGRAPHIC INSIGHTS

Maternal Mortality Ratios Omit Other Key Measures

The usual measure of maternal mortality is a *ratio* (MMR, or maternal deaths per 100,000 births), but the picture is quite different for *rates* (maternal deaths per 1,000 women per year), and absolute *numbers of maternal deaths*.

In addition, the *lifetime risk* of a maternal death depends not just on the per-birth risk but also on the number of births a woman has. The more often a woman becomes pregnant, the higher her lifetime risk of maternal death. If the MMR is 1 percent (1,000 deaths per 100,000 births) and the prevailing total fertility rate (TFR, an estimate of lifetime births per woman) is 5, as in some African countries, the lifetime risk is about 5 percent, or one in twenty women dying from pregnancies and births.

Figure 13 shows three perspectives on maternal mortality from data drawn from 38 countries in the DHS series of national surveys.

First is the MMR itself, *the risk per birth*, which shows the steep rise of risk with age, as well as the elevated risk at ages 15 to 19, where first births dominate. (Note that this is calculated as the risk per *birth*, even though some women die during pregnancy, prior to birth, due to complications including miscarriages and abortions.)

Second is the rate, *the annual number of maternal deaths per 1,000 women*, which is surprisingly low, since most women are not pregnant in a single year and of those who are, most survive. The balance shifts with age, reflecting the age-specific birth rates in combination with the changing risk. At young ages the low risk per birth offsets the large number of births, while at the oldest ages there are so few births that they offset the high risk per birth.

Third is the absolute *number of deaths*, peaking at ages 25 to 29, a reflection of the age groups with the most births and with a substantial risk per birth. At higher ages the risk rises but the number of births falls off sharply, resulting in few deaths.

Each of the three measures has its own uses. The *ratio* is high among older women; it shows the danger to the individual woman in her childbearing experience. But most births do not occur to older women, and the annual *rate* is concentrated among younger women. The absolute *numbers* peak at even younger ages and reflect the total burden on the health system. The basic causes of maternal mortality vary, and they can occur at any age. For all three measures the age patterns simply help to focus strategies for preventive services.
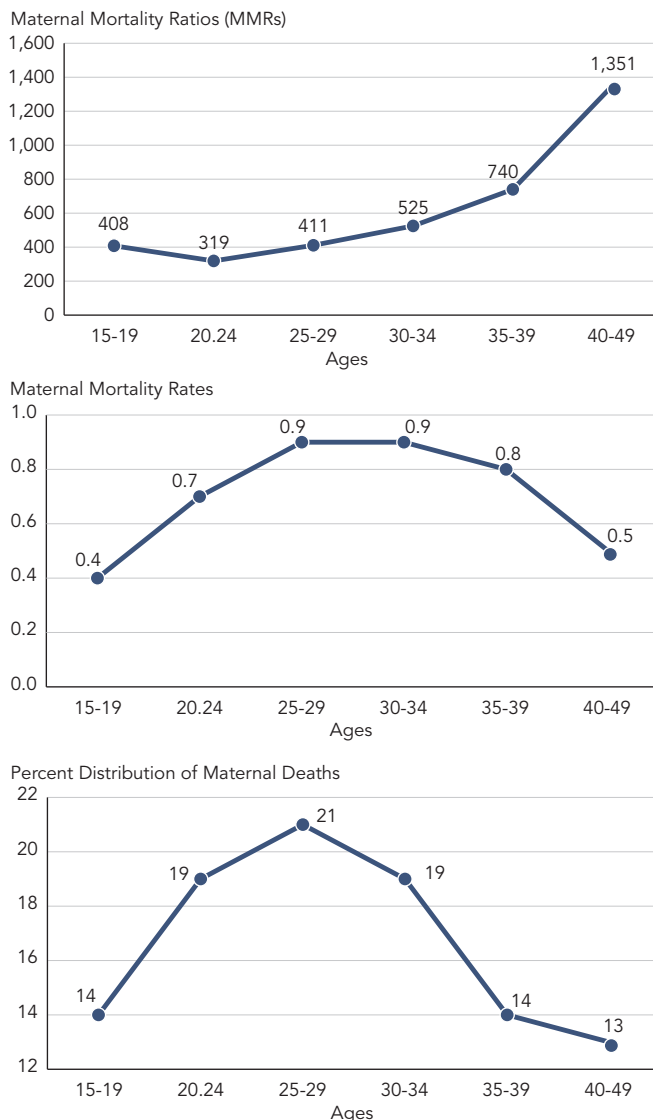
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FIGURE 13

Three Ways of Looking at Maternal Mortality

Maternal Mortality Ratios (MMRs)

Maternal Mortality Rates

Percent Distribution of Maternal Deaths

Source: Ann Blanc, William Winfrey, and John Ross, "New Findings for Maternal Mortality Age Patterns: Aggregated Results for 38 Countries," *PLOS One* 8, no. 4,9 (April 2013).

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- 12 -
Exponential Population Growth Leads to Impossible Results

All exponential growth rates are nonlinear: Each year brings a greater change than the year before if the growth rate is positive, as in most of the developing world. The growth rate applies to an ever-increasing base. As with money, frequent compounding of interest makes for faster growth.

Figure 14 shows examples of both positive and negative growth rates, starting from a population of one million and changing over 50 years at 2 percent change per year, either up or down. As noted, the annual changes are greater along the positive line since the rate applies to an ever-increasing base. But for the negative line the base shrinks constantly so the annual changes diminish.

Most attention has gone to positive growth rates, that over time lead to impossible numbers. Ultimately the population would weigh more than the earth itself. In 1962, South Korea had a population of about 21 million, growing at 2.5 percent per year. Five doublings would have produced 672 million people, far more than India's 465 million in the early 1960s—an impossibility in the small southern Korean peninsula. Growth will inevitably slow, due either to rising mortality or falling fertility or both. In South Korea, mortality in fact fell, but fertility fell more than mortality, and did so rapidly, to well below the replacement level.

In Figure 14, within 50 years the positive line is 2.5 times as high while the negative line drops to just 40 percent of the starting population. Japan is an example of negative growth: from its peak size of 127 million in 2010, the UN projects a decline by 20 percent to only 101 million by 2060, with additional declines to follow.

FIGURE 14

Exponential Population Growth, Positive and Negative
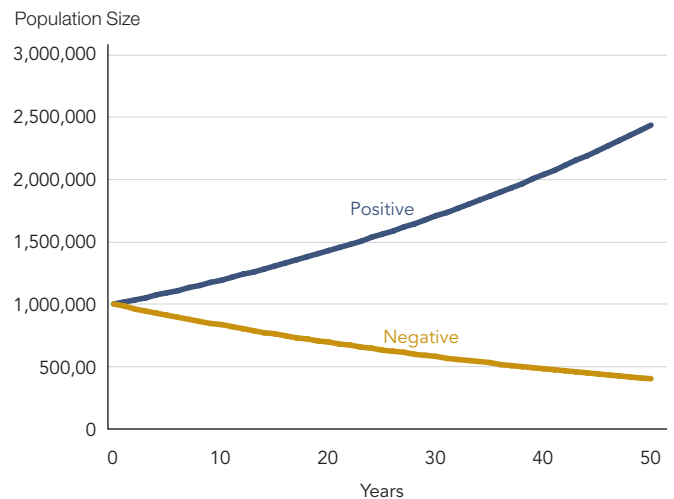
Population Size

Source: Illustrative data by author.

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- 13 -
Unfavorable Age Structures Prolong Population Growth (Momentum)

Population "momentum" means that a great deal of future growth is already built into the current age structure. A young population has so many young women in it that even if their fertility drops immediately to the replacement level, the sheer number of births will far outnumber the number of deaths in the population for a long time.

A simple equation to approximate population momentum is to multiply the crude birth rate (CBR), *annual births per 1,000 persons*, by the life expectancy. This is easy to see by the following example: for a population of 1,000, there may be 35 births, and each birth lives an average of 55 years for life expectancy. Total years lived are the product—1,925—which over time replaces the current population of 1,000. The momentum factor is exactly 1.93, indicating a 93 percent increase in the ultimate population size.

The CBR gives the net effect of both the age structure of women and the pattern of age-specific fertility rates (ASFRs), and in fact both will probably change over time. But most projections for momentum assume that each ASFR will decline by the same proportion, down to a TFR of about 2.1. The current age structure is what drives population momentum. Until the age structure ultimately levels out, large cohorts of young couples, even with only about two births each, will keep generating far more births than there are deaths in the population and will contribute to substantial population growth.

In a developing country with a high fertility rate and a moderate mortality rate, the momentum factor is about 1.6, indicating that even with an immediate fall to the two-child family (TFR of about 2.1), the ultimate population size will be nearly two-thirds larger than the current one (see table).

Further, an immediate fall to replacement is unrealistic. If instead we assume a 15-year delay, keeping fertility the same until then, the ultimate size would be about 2.45 times the current size instead of 1.6 (see Keyfitz 1971, Table 4).

To the extent that fertility has already declined below traditionally high levels, the ratios of the ultimate size to the present size are lower. For national planning, reducing the birth rate is the key to modifying the age structure and lessening the impact of momentum. Family planning programs and other influences on fertility, such as private sector provision of contraception, later marriage, and modernizing trends, can modify the numbers of births and the associated dependency burdens of a young age structure. Population momentum by location of world regions is shown in Figure 15.
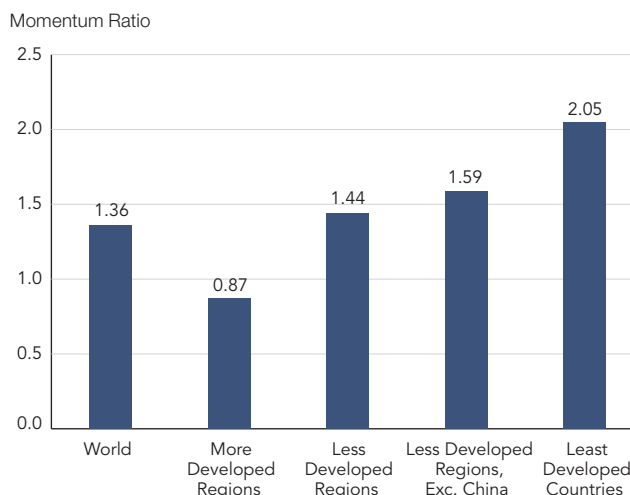
TABLE

Population Momentum by Location, 2015

	CRUDE BIRTH RATE	LIFE EXPECTANCY	MOMENTUM RATIO
World	19.1	71.1	1.36
More Developed Regions	11.0	78.7	0.87
Less Developed Regions	20.8	69.4	1.44
Less Developed Regions, Excluding China	23.5	67.7	1.59
Least Developed Countries	32.5	63.1	2.05

Source: United Nations (UN) Population Division, *World Population Prospects, The 2015 Revision* (New York, UN, 2015).

FIGURE 15

Momentum Ratio

Momentum Ratio

Source: United Nations (UN) Population Division, *World Population Prospects, The 2015 Revision* (New York, UN, 2015).

The table (see page 21) presents the CBR, life expectancy, and momentum ratio for the world, including **more developed regions, less developed regions, and least developed countries.** Momentum is greatest for the least developed countries at 2.05, indicating a doubling of the total population even if replacement fertility occurs now. That reflects especially the relatively high CBR, which considerably exceeds that in the other locations.

The picture reverses for the more developed regions: they are projected to lose population even if their TFRs come up to 2.1 immediately. Their TFRs are below replacement, averaging only 1.68 in 2015 (not shown). Their age structures work in the opposite way from those in developing countries: shortfalls in the childbearing ages mean fewer births for a long time.

Note: The **more developed** regions, as classified by the UN, consist of all of Europe and North America, as well as Australia, Japan, and New Zealand. All other regions and countries are classified as **less developed.**

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- 14 -
Fertility Declines Favor Faster Economic Growth

Low birth rates mean lighter burdens for raising children and for their education, thus releasing resources for broader social and economic development. Question: Will the released resources be used effectively?

The term "demographic dividend" refers to the boost in economic growth that can result from favorable age structure changes that occur from falling fertility rates. With fewer births, the working-age population grows larger relative to the young dependent population, leaving relatively more people in the labor force and allowing public and private investments to go to development.

This transition can create a window of opportunity for rapid economic growth, if the right social and economic investments and policies are made in health, education, and the economy. The "Asian Tigers" are often cited as countries with lowered fertility rates that reallocated resources to accelerate their economic transitions.

Figure 16 shows the dependency ratio—the ratio (times 100) of the young and the old to the working-age population: ages 0 to 14 plus ages 65 and over, divided by ages 15 to 64. When the ratio is low, the working ages have lighter burdens and more resources are available.

The figure contrasts the two extremes of the least developed countries with the countries in the more developed regions. The least developed countries started after 1950 with high dependency ratios due to their histories of elevated fertility rates, and the ratios rose even more as infant/child survival improved and there were more surviving children. As birth rates fell across much of the developing world, the average ratio declined sharply, and it is projected to fall below 60 over the next several decades.

Meanwhile, in contrast, the more developed regions began with a low ratio due to more people in the working ages relative to both the young and the old. The ratio declined even more as fertility fell to below replacement levels, but by about 2010 the balance shifted, with the older age group growing steadily. So think of three phases: high dependency with high fertility, low dependency as fertility declines, and then high dependency as the older populations come to dominate.

So the demographic dividend, being greatest when the dependency ratio is least, was best in the more developed regions until about 2015, but it is projected to change very rapidly.

Note: Of interest is the relationship between the age structure and political unrest. In Egypt for example, about 810,000 males reach age 20 every year, who need to be absorbed into the working population even though many lack skills and will be under-employed or unemployed. The related implications for the social order are a new subject of study.
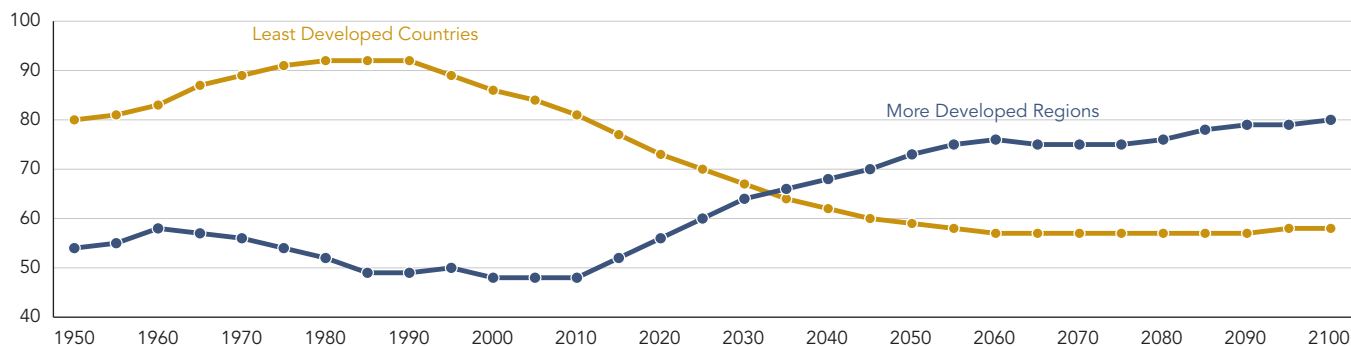
References

The best source for additional reading is:

Amy Tsui, *A Primer on the Demographic Dividend* (Baltimore, MD: Gates Institute, Johns Hopkins Bloomberg School of Public Health, 2011).

FIGURE 16

Dependency Ratios by Location, 1950-2100

Dependency Ratio

Source: United Nations (UN) Population Division, *World Population Prospects, The 2015 Revision* (New York, UN, 2015).

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Glossary of Terms

DEMOGRAPHIC

Age-specific fertility rate: The number of live births per 1,000 women within a given age group in a given year.[1]

Amenorrheic: Relating to the absence of menstruation.[2]

Birth interval-closed: The interval between successive live births.[3]

Birth interval-open: The interval between the date of birth of last child and the date of the data collection or survey.[3]

Contraceptive prevalence rate (CPR): The number of married women of reproductive age who are using any method of contraception per 100 married women of reproductive age. An alternative usage refers to all women of reproductive age rather than just to married women.[2]

Crude birth rate: The number of live births per 1,000 total population in a given year.[1]

Demographic dividend: The long-term economic benefits that result from a decline in fertility and an increase in the working-age population, accompanied by the right investments in human capital.[4]

Dependency ratio: The ratio of children (0 to 14 years old) and older persons (65 years and over) to the working-age population (15 to 64 years old).[1]

General fertility rate: The number of live births per 1,000 women ages 15 to 49 in a given year.[1]

Generation length: The average length of time from the birth of a woman to her average age at the birth of her children.[5]

Infant mortality rate: The number of deaths of infants under age 1 per 1,000 live births in a given year.[1]

Least developed countries (LCDs): Low-income countries facing the largest challenges to sustainable development.[6]

Life table: A table that provides information on the lifetime mortality experience of a newly born cohort, including probability of death within specific age intervals.[7]

Maternal mortality rate: The number of maternal deaths (direct and indirect) in a given period per 100,000 women of reproductive age per year.[8]

Maternal mortality ratio: The number of women who die as a result of complications from pregnancy or childbearing in a given year per 100,000 live births in that year.[1]

Modern contraceptive prevalence rate (mCPR): The number of married women of reproductive age who are using a modern method of contraception per 100 married women of reproductive age. An alternative usage refers to all women of reproductive age rather than just to married women.[2]

Momentum (population momentum, momentum ratio): The tendency for a population with a young age structure to continue growing after fertility falls to the replacement level due to the high concentration of members in the youngest age groups.[1]

Total fertility rate (TFR): The average number of births to a woman by the time she ends childbearing if she were to pass through all her childbearing years conforming to the age-specific fertility rates of a given year.[1]

Under-5 mortality rate: The number of deaths of infants under age 5 per 1,000 live births in a given year.[9]

Unmet need: The percentage of women who currently desire to delay or avoid having a child but are not currently using contraception.[4]

Waiting time: The time between a woman's return to fecundity after a birth and her next conception, assuming she is unprotected from any birth control. Usually taken to be an average of five months with a 20 percent chance of conception each month.[7]

FAMILY PLANNING

Adopter: An individual who begins using a method of contraception.[2]

Continuation (rate): The number of individuals continuing use of a method of contraception at a certain point, over the number of individuals who began using the method at a particular point in time.[2]

Dropout (rate): The number of individuals who have discontinued use of a method of contraception at a certain point over the number of individuals who began using the method at a fixed time.[2]

Fecund/infecund: Relating to fertility; fecund refers to the ability to have children while infecund refers to the inability to have children.[2]

Implant: A small rod, about the size of a matchstick, that prevents pregnancy for up to four or more years.[2]

Injectable: A birth-control shot that contains progestin, which prevents ovulation and protects against unwanted pregnancy for one, two, or three months, depending on the type.[2]

Intrauterine device (IUD): A small long-acting reversible contraceptive device that is placed in the uterus and uses either copper or hormones to prevent pregnancy.[2]

Pill: A hormonal birth-control pill taken by women to prevent pregnancy.[2]

Resupply methods: Short-acting contraceptive methods that require continual resupply (for example, the birth control pill).[2]

Rhythm: A fertility awareness-based method of birth control pertaining to the woman's monthly cycle.[2]

Sterilization: Permanent methods of birth control done through surgery—blocking of the fallopian tubes for women or the vas deferens for men.[2]

Withdrawal: pulling the penis out of the vagina before ejaculation in order to avoid pregnancy.[2]

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