

Technical Note: The Maximum CPR Model

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Motivation

The Maximum CPR Model allows policy makers, family planning advocates, and individuals to determine a country's highest potential contraceptive prevalence rate (CPR), both in terms of use for spacing and for limiting, based on an ideal number of children and key demographic life events. Understanding the highest potential level of CPR achievable under current circumstances in a population leads to realistic expectations and appropriate policy implementation. By breaking down the CPR into use for spacing and limiting, family planning programs can better plan for the most appropriate contraceptive method mix. For example, a country with a large untapped market for family planning methods that can help women limit births may want to increase the availability of long acting methods such as IUDs and implants. Countries where the maximum potential CPR is near the actual CPR may need to shift their focus to demand generation or postpartum family planning programs. The tool is easy to use, with default data preloaded from countries' most recent Demographic and Health Surveys. All numbers are customizable, allowing the user to create their own scenarios and see how the changes they make impact the maximum potential CPR.

Underlying Equations and Assumptions of the Maximum CPR Model

The main assumption in the Maximum CPR Model is that women who are sexually active are using contraception at all times, unless they are actively trying to conceive, already pregnant, or postpartum infecund (some women use family planning while postpartum, which is also incorporated into the model). The idea is to estimate, at each stage of a woman's life, what percent of that period would she need contraception. The stages of reproductive life are described in detail below. Once we have a reproductive life course constructed, we use a recent survey to find the percent of the population that is in each group. Combining the life course with the population data, we can estimate the maximum CPR for the population.

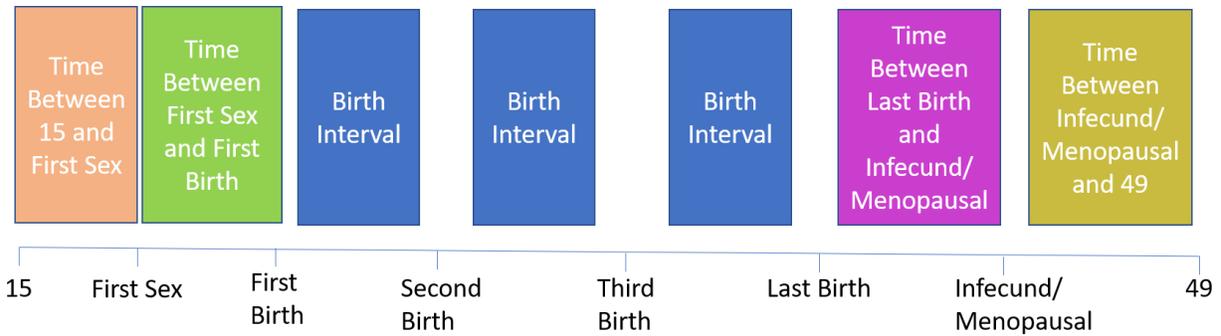
Reproductive Life Course

In this model, the reproductive life course runs from ages 15 to 49. Within this period there are the following events:

- First Sex
- First Birth
- Birth Intervals
- Last Birth
- Becoming infecund/menopausal

Birth intervals are repeated (Ideal number of children – 1) times.

Therefore, there are five distinct periods of reproductive life (illustrated below for an ideal number of children of 4):



- Time Between Age 15 and First Sex
- Time Between First Sex and First Birth
- Birth Intervals- repeated (ideal number of children -1) times
- Time between last birth and becoming infecund/menopausal
- Time between becoming infecund/menopausal and age 49

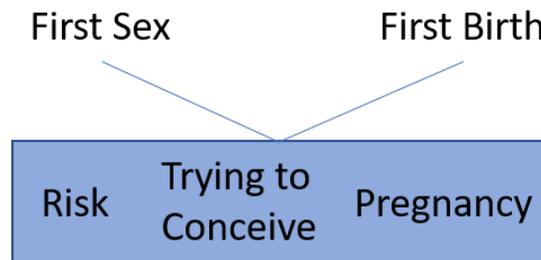
For each period, we need to estimate the percent of time a woman would be using contraception.

Period 1: Time Between Age 15 and First Sex

We assume that in this period, no one is using contraception. This potentially underestimates contraceptive use if women start using contraception in anticipation of coital activities.

$$\% \text{ Using, Period 1} = 0$$

Period 2: Time Between First Sex and First Birth



If we assume women use contraception until they explicitly wish to conceive, then we have three sections of this period: risk of unplanned pregnancy (where contraception would be used), time spent trying to conceive, and pregnancy. We also take into account that not all pregnancies result in live births. For this model, we assume that 10% of recognized pregnancies end in miscarriage¹, and the median length of pregnancy at termination (based on DHS calendar data) is 3 months. We do not assume any abortions in this model- as CPR would be at its maximum in the absence of abortions (we are not accounting for failures in this model).

To calculate the length of this period, we use the median age at first sex (for women aged 25-49) and the median age at first birth (for women aged 25-49). We assume a length of pregnancy of 9 months. The time trying to conceive varies by country. To calculate, we use the contraceptive calendar included

¹ <https://www.acog.org/Clinical-Guidance-and-Publications/Practice-Bulletins/Committee-on-Practice-Bulletins-Gynecology/Early-Pregnancy-Loss?IsMobileSet=false>

in many DHS. Women who stop using a method are asked the reason for discontinuation, one answer being “discontinued to become pregnant.” For these women, we calculate the average time between discontinuation and pregnancy. Across countries, the time varied from 3 to 12 months. For countries without calendar data, we use the median value across countries: 6 months. To calculate the time in each birth interval lost to miscarriage, we take the ideal number of children, divided by 0.9 to calculate the total number of pregnancies needed to obtain the number of live births. The lifetime number of terminations is the difference between number of pregnancies and number of births. The lifetime months spent on non-viable pregnancies is the average time to conception, plus 3 (the median length of pregnancy), multiplied by the number of terminations. The time spent for each birth interval is then the total months divided by the ideal number of children.

$$\text{Months in Period 2} = (\text{Age at First Birth} - \text{Age at First Sex}) \times 12$$

$$\text{Total Pregnancies} = \frac{\text{Ideal Number of Children}}{1 - 0.1}$$

$$\text{Total Terminations} = \text{Total Pregnancies} - \text{Ideal Number of Children}$$

$$\text{Lifetime Months Spent on Terminations} = (\text{Months to Conceive} + 3) \times \text{Total Terminations}$$

$$\text{Months on Termination per Birth Interval} = \frac{\text{Lifetime Months Spent on Terminations}}{\text{Ideal Number of Children}}$$

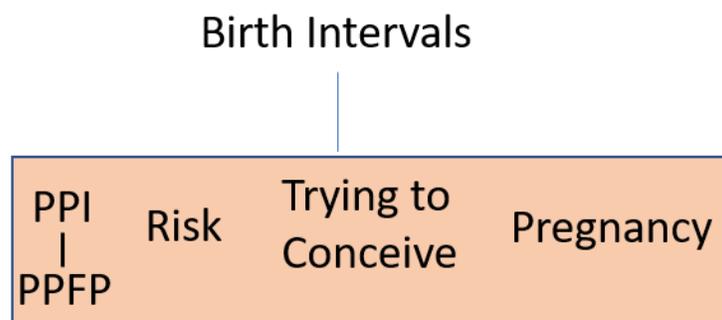
Months at Risk

$$= \text{Months in Period 2} - (\text{Months to Conceive} + \text{Months Pregnant} + \text{Months on Termination})$$

% Using, Period 2

$$= \frac{\text{Months at Risk}}{\text{Months at Risk} + \text{Months to Conceive} + \text{Months Pregnant} + \text{Months on Termination}}$$

Period 3: Birth Intervals



Birth intervals are similar to Period 2 because they include a time at risk, time trying to conceive, and time pregnant, and time lost to terminations. However, they also include a time of postpartum insusceptibility (PPI) following a birth. While some women do not use family planning at this time, others may take part in postpartum family planning (PPFP).

The length of the birth interval is determined by the average birth interval in the country. Time trying to conceive and pregnant are calculated the same way as they were in Period 2. The length of PPI is the

median duration from the DHS. To estimate PPFp use, DHS microdata is used to calculate the percent of women who are currently using family planning out of women who are postpartum infecund (either are practicing postpartum abstinence or are postpartum amenorrheic).

$$\% \text{ Using PPFp} = \frac{\text{PPI Women Using Family Planning}}{\text{PPI Women}}$$

Note that this measure of PPFp is different from other measures of PPFp which generally look at postpartum use at a given time after birth, as measured in the contraceptive calendar. For this model, PPFp is a current status measure, and tells, of all PPI women, what percent are currently using family planning.

Therefore, for an individual birth interval, the time spent using contraception would be:

$$\text{Months Using, 1 Birth Interval} = \text{Months of Birth Interval} - \left(\text{Months PPI} \times \frac{100 - \% \text{ Using PPFp}}{100} \right) - \text{Months to Conceive} - \text{Months Pregnant} - \text{Months on Termination}$$

Combining all closed birth intervals together, the percent using in Period 3 is:

$$\% \text{ Using, Period 3} = \frac{(\text{Months Using, 1 Birth Interval}) \times (\text{Ideal Number of Children} - 1)}{\text{Average Birth Interval} \times (\text{Ideal Number of Children} - 1)}$$

Which simplifies to:

$$\% \text{ Using, Period 3} = \frac{\text{Months Using, 1 Birth Interval}}{\text{Average Birth Interval}}$$

Period 4: Time between Last Birth and becoming Infecund/Menopausal

To calculate the expected age at last birth, we use the age at first birth, the number of birth intervals to achieve desired family size, and the average birth interval length.

Age at Last Birth

$$= \text{Age at First Birth} + (\text{Average Birth Interval} \times (\text{Ideal Number of Children} - 1))$$

While some women continue childbearing in their 50s, the DHS and other surveys assume most childbearing ends at 49. Some women may experience infecundity or menopause prior to 50, but for this group, we are going to assume that women remain fecund to 50 (we will account for infecundity in the next period and in the population distribution).



After the last birth, there is only postpartum insusceptibility and risk.

$$\% \text{ Using, Period 4} = \frac{(50 - \text{Age at Last Birth}) \times 12 - \left(\text{Months PPI} \times \frac{100 - \% \text{ Using PPFp}}{100} \right)}{(50 - \text{Age at Last Birth}) \times 12}$$

Period 5: Time between becoming infecund/menopausal and age 49

As with Period 1, we do not believe women who know they are infecund or menopausal will use family planning.

$$\% \text{ Using, Period 5} = 0$$

We now have equations defining contraceptive use during the 5 periods of the reproductive life course. In summary:

Period 1	Time Between Age 15 and First Sex	No Contraceptive Use
Period 2	Time Between First Sex and First Birth	Using to Space
Period 3	Birth Intervals- repeated (ideal number of children -1) times	Using to Space
Period 4	Time between last birth and becoming infecund/menopausal	Using to Limit
Period 5	Time between becoming infecund/menopausal and age 49	No Contraceptive Use

We now need to determine the distribution of women in a population that fall into each period.

Distribution of the Population

We distribute the population of women aged 15-49 into groups:

- Group 1: Percent of women who have never had sex
- Group 2: Percent of women who have had sex but not first birth
- Group 3.1-3.9: Percent of women at each parity (1-9+), who are fecund
- Group 4: Percent of women who are infecund

Groups of women match to different periods on the reproductive life course. Group 1 are in Period 1, Group 2 are in Period 2, and Group 4 are in Period 5. Group 3.1-3.9 are distributed between Period 3 and Period 4, based on the ideal family size. For example, if the ideal number of children is 3, then Group 3.1 and 3.2 are in Period 3 (where they would be using to space) and Group 3.3, Group 3.4, Group 3.5, Group 3.6, Group 3.7, Group 3.8, and Group 3.9 would all be in Period 4 (using to limit).

Algebraically, the maximum total CPR for an ideal number of 3 would be:

$$\begin{aligned} \text{Maximum } CPR_3 = & (\% \text{ Using, Period 1} \times \% \text{ in Group 1}) + (\% \text{ Using, Period 2} \times \% \text{ in Group 2}) + \\ & (\% \text{ Using, Period 3} \times (\% \text{ in Group 3.1} + \% \text{ in Group 3.2})) + (\% \text{ Using, Period 4} \times \\ & (\% \text{ in Group 3.3} + \% \text{ in Group 3.4} + \% \text{ in Group 3.5} + \% \text{ in Group 3.6} + \% \text{ in Group 3.7} + \\ & \% \text{ in Group 3.8} + \% \text{ in Group 3.9})) + (\% \text{ Using, Period 5} \times \% \text{ in Group 4}) \end{aligned}$$

Since we assume no contraceptive use in Period 1 and Period 5, this simplifies to:

$$\begin{aligned} \text{Maximum } CPR_3 = & (\% \text{ Using, Period 2} \times \% \text{ in Group 2}) + (\% \text{ Using, Period 3} \times \\ & (\% \text{ in Group 3.1} + \% \text{ in Group 3.2})) + (\% \text{ Using, Period 4} \times (\% \text{ in Group 3.3} + \\ & \% \text{ in Group 3.4} + \% \text{ in Group 3.5} + \% \text{ in Group 3.6} + \% \text{ in Group 3.7} + \% \text{ in Group 3.8} + \\ & \% \text{ in Group 3.9})) \end{aligned}$$

From here CPR can be split into using to space and using to limit.

$Maximum\ CPR_3Space = (\% Using, Period\ 2 \times \% in\ Group\ 2) + (\% Using, Period\ 3 \times (\% in\ Group\ 3.1 + \% in\ Group\ 3.2))$

$Maximum\ CPR_3Limit = (\% Using, Period\ 4 \times (\% in\ Group\ 3.3 + \% in\ Group\ 3.4 + \% in\ Group\ 3.5 + \% in\ Group\ 3.6 + \% in\ Group\ 3.7 + \% in\ Group\ 3.8 + \% in\ Group\ 3.9))$

As the ideal number of children changes Groups 3.1-3.9 shift between Period 3 and Period 4. The Groups in Period 3 will be one less than the ideal number of children, and the Groups in Period 4 will be the ideal number of children and above. Note that in this model, ideal number of children is measured at the population level and is rounded to be a whole number.

Concluding Thoughts

The CPRs produced by this model are theoretical maximums, assuming women are using when at risk for pregnancy. The one caveat is use during postpartum insusceptibility. The model does not assume total use during this period, rather it allows the user to determine the amount of PFP. Users who want to see the total effect of postpartum family planning can look at the default level of PFP (based off data from the most recent survey) and the calculated Maximum CPR, then reduce the PFP to 0%, note the Maximum CPR, and finally increase PFP to 100%. These scenarios would show the maximum CPR with current levels of PFP, with no PFP, and with complete PFP, and are a useful policy application of the Maximum CPR tool.

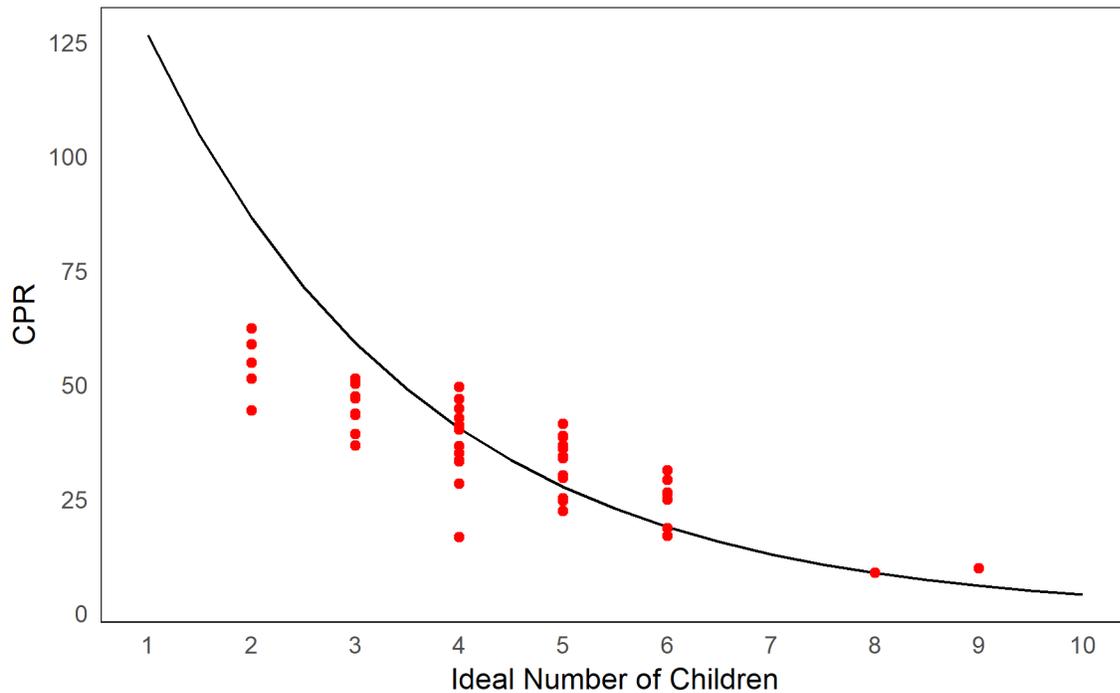
The model produces All Women CPR, since it takes the total population aged 15-49 and distributes them across the reproductive life course. This model can be used even for countries that conduct surveys only of ever married women. Available Stata Do files show how to calculate the inputs from microdata not available on StatCompiler.com.

The distribution into spacing and limiting is determined by the average ideal number of children. In some situations, the displayed CPR from the most recent DHS may have higher spacing than the model would predict- in many cases this is driven by women who have more than their desired number of children defining the contraceptive use as for spacing purposes, not limiting.

This model specifically discusses CPR, not mCPR. This is because the Maximum CPR is also the maximum mCPR- if we assumed no traditional method use.

The Track20 Project has developed other policy tools looking at the relationship between mCPR and the ideal number of children- mainly the Demand Curve, which looks at the ideal number of children and current contraceptive use in a country to determine if a country should consider increased investments in access or demand interventions. Further information on the Demand Curve can be found here: <https://gatesopenresearch.org/articles/1-15/v1>. We have conducted a comparison between the Maximum CPR Model and Demand Curve, and present results below.

Comparing Demand Curve with Spacing/Limiting Model



The Maximum CPR Model results are shown in red, and are close to the demand line for most countries with an ideal number of children of 4 or higher. We do not expect the results of lower fertility areas to overlap- research of the Demand Curve indicates that “for countries with an ideal number of children below 3, there is no curve as in these countries it is assumed that fertility intentions are not limiting mCPR growth.” (Weinberger, Sonneveldt, and Stover 2017)

The Maximum CPR Model is a useful program and policy tool which allows individuals to see the current and potential maximum CPR for a specific country. It is completely user-driven, allowing the individual to change inputs and see the impact on Maximum CPR, as well as the distribution of CPR into use for spacing and use for limiting.