

# Impact 2 version 5

An innovative tool for estimating the impact of reproductive health programmes

# Methodology paper

July 2018

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## Acknowledgements

This model is based on two earlier MSI models—the REACH Calculator and the Impact Estimator. We would like to acknowledge the foundational work done in the development of these two models, as published in (1) Pozo-Martin F, Weinberger M, Hopkins K, Boler T. MSI's REACH Calculator 1.2: methodology and assumptions. London: Marie Stopes International, 2011, and (2) Corby N, Boler T, Hovig D. The MSI Impact Calculator: methodology and assumptions. London: Marie Stopes International, 2009.

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## Acronyms

ANC	Antenatal care
CPR	Contraceptive prevalence rate
CYP	Couple years protection
DALYs	Disability-adjusted life years
DFID	Department for International Development (UK)
DHS	Demographic and Health Survey
EC	Emergency contraceptive
FP	Family planning
IPPF	International Planned Parenthood Federation
IUD	Intrauterine device
IUS	Intrauterine contraceptive system
LAPM	Long-acting and permanent methods of contraception
LSHTM	London School of Hygiene and Tropical Medicine
MLT	Model life table
MMR	Maternal mortality ratio
MSI	Marie Stopes International
PAC	Post-abortion care
PBI	Previous birth interval
PSI	Population Services International
RHCT	Reproductive Health Costing Tool
SDM	Standard Days Method
TFR	Total fertility rate
UN	United Nations
UNFPA	United Nations Population Fund
US	United States
USAID	United States Agency for International Development
YLL	Years lost of life
YLD	Years lost to disability
WHO	World Health Organization
WRA	Women of reproductive age

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## Executive summary

Marie Stopes International (MSI) has developed Impact 2 as part of our commitment to quantifying the impact of our work. Impact 2 replaces two previous MSI models – REACH Calculator 1.2 and Impact Estimator 1.2 – with improved data sources and methods. The fifth iteration of our Impact 2 model (v5) published in 2018 includes updated data, an expansion of estimates to 2030, an improved user interface, and methodological changes to harmonize our model with others in the sector.<sup>i</sup>

Impact 2 can be used to estimate your past, current and future contributions to national contraceptive use, contraceptive prevalence, and safe abortion or post-abortion care services nationally. In addition, Impact 2 can be used to estimate the wider health, demographic and economic impacts of these services.

Impact 2 is useful for:

- **Estimating increases in CPR and additional users reached** based on family planning service provision data.
- **Planning a realistic programme** that makes a big difference at national level, and monitoring this contribution over time.
- **Facilitating communication between service providers, national governments and donors** on the value of investing in reproductive health services.
- **Motivating staff** by expressing their achievements in more human terms, such as the number of women's lives they have saved.

### An innovative and unique model

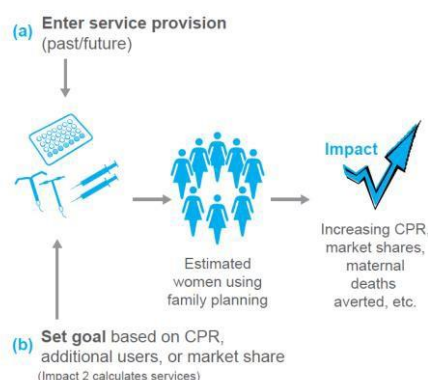
Impact 2 is the first reproductive health model designed to run off service provision data— meaning it can be used to estimate the impact of services provided by a particular organisation, or, across the entire country. In addition, Impact 2 can be used both to estimate services needed to reach a goal<sup>ii</sup> (b), as well as monitoring progress over time (a). Most other tools only allow the bottom route (b).

This updated version of Impact 2 allows the tool to be used both from the national perspective (covering all services provided in the country) as well as from an organisational perspective (accounting for issues such as substitution between providers)—see page 2 for details.

### Who can use it?

The tool is user friendly and requires no expertise, apart from basic Excel skills. It has already been pre-loaded with national data for all developing countries, from sources including

Figure 1 Illustration of Impact 2 model



<sup>i</sup> [http://www.popcouncil.org/uploads/pdfs/2014STEPUP\\_MeasuringImpact.pdf](http://www.popcouncil.org/uploads/pdfs/2014STEPUP_MeasuringImpact.pdf)

<sup>ii</sup> The Impact 2 model is a tool to help your programme set realistic goals and plan for future provision within the allocated resources available. It is important that programmes ensure that all clients are able to make an informed and voluntary choice of what FP method to use.

Demographic and Health Surveys (DHS), UN Population Prospects, UN maternal and child mortality data, World Health Organization (WHO) Global Burden of Disease and the Guttmacher Institute. This makes it quick and simple for your organisation to harness this data and apply it to your own service numbers.

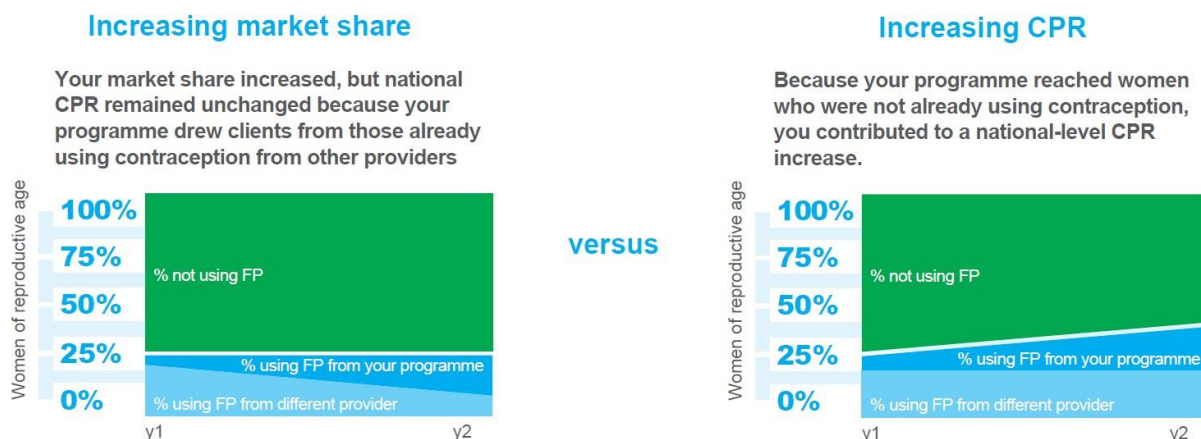
## At the national level

This new feature allows the benefits of Impact 2 to be easily harnessed for national-level analysis. Innovative features include:

- Developing ‘bottom-up’ CPR estimates based on nationally representative service data (e.g. HMIS data)
- Estimating services needed, and resulting impacts, of reaching national goals to increase CPR or reach additional users
- Allowing for easy monitoring of year-on-year of progress towards these goals based on annual service provision data

## At the organisation level

By considering the unique perspective of an individual service delivery organisation, Impact 2 helps organisations think about who they are reaching, and how this translates to national-level changes. Some women who are “new” to a provider may not be new to using contraception. While it is important to ensure these women have access to high quality services and a full choice of methods, providing these clients with services will not result in national-level increases in contraceptive use (illustrated below)



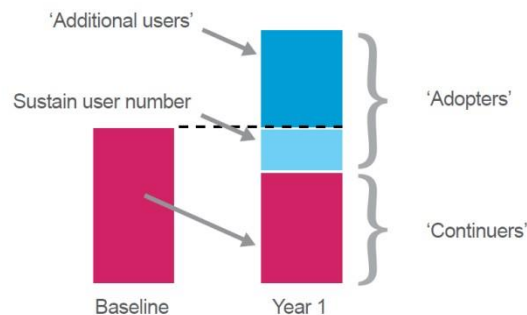
Impact 2 addresses this by including a “client profile” which shows what proportion of clients are:

- **adopters:** clients who were not using a modern family planning method before receiving services
- **continuers:** clients who were already using a modern family planning method which they received from the service delivery organisation
- **provider changers:** clients who were already using modern family planning, but previously received their method from a different provider.

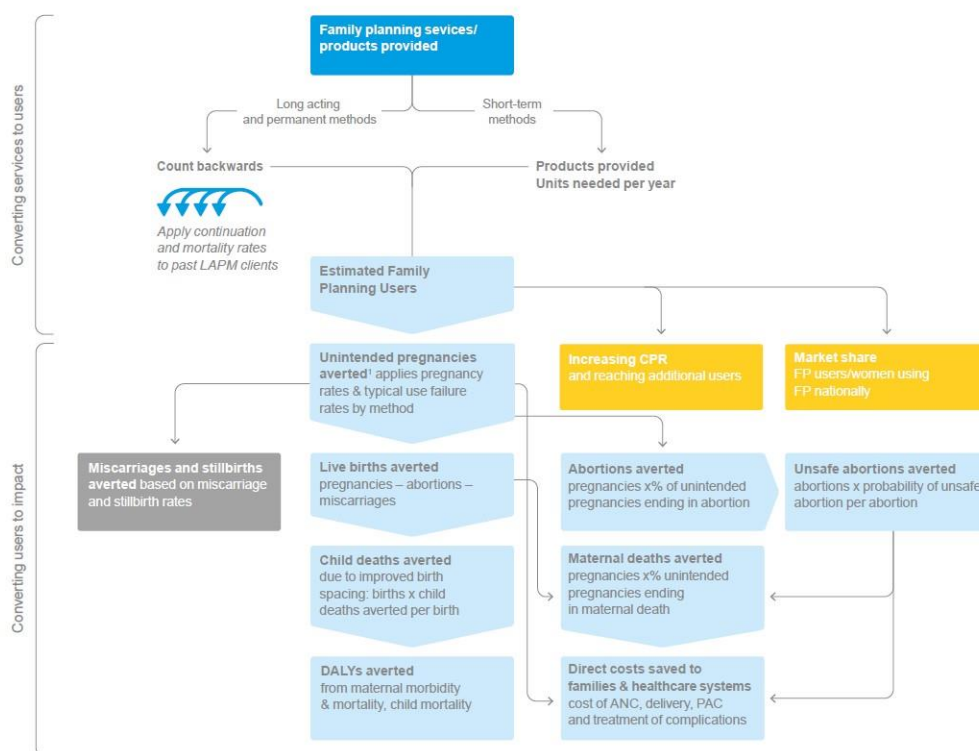
This feature is optional, but, when included you will see results showing your programme’s estimated contribution to increasing CPR, reaching additional users, and incremental and national level impacts.

## In the context of FP2020

Family Planning 2020 (FP2020) aims to expand family planning to 120 million additional women in the poorest countries of the world by 2020. This is in addition to sustaining services to the 260 million women already using modern contraception in these countries<sup>1iii</sup>. In order to fully understand progress towards this important goal, we must look at the full picture of contraceptive use, ensuring that we are both sustain existing levels of use, and, reaching additional women. For individual organisations, efforts must be made to sustain their own baseline contributions while also expanding services to women not already using FP.



## Family planning services: how the model works



<sup>1</sup>In the 2015 updates of Impact 2 the distribution of pregnancy outcomes averted (e.g. live births, abortions) has been recalculated to reflect outcomes of unintended pregnancies. This change was based on a joint working group to harmonize assumptions used in FP impact models: [http://www.popcouncil.org/uploads/pdfs/2014STEPUP\\_MeasuringImpact.pdf](http://www.popcouncil.org/uploads/pdfs/2014STEPUP_MeasuringImpact.pdf)

### Why convert services to users?

National data on contraceptive prevalence from a snapshot survey (eg DHS) includes women who received their method in the year of the survey, but also those who are still using long-acting and permanent methods received in previous years. To compare results to the CPR, and to get an idea of the total impact of a programme, we need to estimate the total number of women *using* an FP method from your programme each year, rather than the total number who received services each year (i.e. clients).

<sup>iii</sup> In reality, family planning use is dynamic since women's need for contraception changes over time. Therefore, it will not be the same 260 million individuals using modern contraception in 2020, but rather, efforts must be made to sustain this absolute number of users.



## Post-abortion care (PAC) and safe abortion services: how the model works



### Limitations

This is a model, rather than a measure of real life. As such, the estimates it produces are only as good as the data and assumptions available. While we have used the best available assumptions and data for all developing countries, much of this data is:

- reported infrequently – difficult to establish trends over time
- not available at national level – only sub-regional or regional estimates used.

Therefore, all results from Impact 2 should be presented as 'estimates' only.

# 1 Introduction

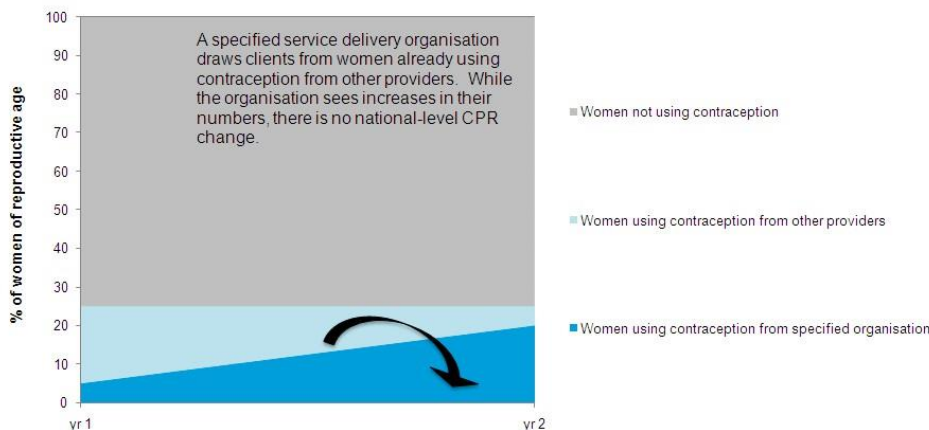
Marie Stopes International (MSI) is one of the largest and most experienced reproductive health organisations in the world. We currently work in more than 40 countries across Africa, Asia, Latin America and Europe, delivering high quality reproductive health services and products, including family planning, safe abortion, post-abortion care, maternal and child health, and treatment for sexually transmitted infections.

MSI and other reproductive health programmes have a wealth of experience in measuring programme outputs, commodities and services delivered. However, measuring progress towards higher level outcomes and goals – such as a programme’s broader health, demographic and economic impact – is difficult without expensive surveys and experimental studies. In addition, several factors that complicate linking these output measures to national-level changes (such as increases in CPR).

First, there is a need to convert service data into the estimated number of women using family planning in a given year, in order to have a measure that is comparable to the CPR. Because long-acting and permanent methods (LAPMs) offer multiple years of coverage, women will continue to be ‘using’ methods in years when they did not receive services. Therefore, the number of family planning clients served in a given year will not capture all of the women using a family planning method from a particular provider in a given year.

Second, there is a need to account for substitution; some clients whom are ‘new’ to a service delivery organisation are not new to family planning, but rather, were previously receiving contraceptives from a different provider. This means that it is possible for an individual service delivery organization to increase their client numbers without having any effect on national-level increase in CPR (Figure 2). Therefore, even if continued use of LAPMs can be accounted for, increases in user numbers will not automatically translate into increases in contraceptive prevalence. For example, a study in Honduras found that despite a programme achieving large increases in service delivery, they had no impact on the CPR because women were simply substituting use of contraceptives <sup>1</sup>.

**Figure 2 Illustrative example of an organisation increasing users without increasing CPR**



Therefore, programmes need tools to estimate how much they can realistically contribute towards these goals. While models exist that can show the impact of CPR increases on reductions in national burdens, such as the number of unintended pregnancies, unsafe abortions, or maternal deaths, they do not cater to the unique needs of service delivery organisations described above.

As a leading organisation in this field, MSI is committed to developing better models for estimating the impact of family planning, safe abortion and post-abortion care (PAC) services. MSI previously developed the REACH Calculator <sup>2</sup> to estimate a programme's contribution to national family planning use and safe abortion services. We also developed the Impact Estimator <sup>3</sup> to estimate the broader health, demographic and economic impacts of programmes, such as consequent reductions in maternal mortality or number of disability-adjusted life years (DALYs) saved.

Impact 2, presented in this paper, brings together these two models and strengthens MSI's impact modelling work. Key features of Impact 2 include the following:

- It is designed to be used at a programme level by isolating the *contribution* of an individual or a group of organisations.
- The newer version has been updated to allow the benefits of Impact 2 to be easily harnessed for national level analysis.
- It is user-friendly: designed to be used by programme staff, not modelling experts.
- It is pre-loaded with default assumptions for all developing countries – based on the best data available from DHS, UN, WHO and other published sources.

This paper describes the methodology on which Impact 2 v5 is based. In addition, the model has been pre-loaded with default data for all countries; while the main content of this paper focuses on the methodology (regardless of the data source), values of default data are referenced, with details available in the Annexes. The methodology behind estimating impacts from family planning, PAC and safe abortion services are presented separately, as each type of service follows different pathways to impact. However, in the model, where applicable to more than one type of service, results are presented as a sum of the impacts from each set of services. In general, each section begins with a general introduction to the approach taken, followed by an in-depth description of calculations.

### **Review of Impact 2**

The original Impact 2 methodology and draft model were circulated to a diverse group of partners, academics, and other stakeholders for review in January 2012. Comments were received from 11 reviewers (see acknowledgements). Overall, feedback was positive, and there was general support for use of the model for a wide range of audiences. However, as always will be the case, reviewers highlighted different concerns. We have done our best to respond to these concerns, and, updates are reflected in this version of the methodology paper. In some cases, we have chosen to take a different approach than reviewers recommend based on our own analysis and needs; these diversions are discussed in the green “looking for alternatives” boxes.

### **Harmonization with the sector**

This fifth version of Impact 2 has been updated based on outcomes from an ongoing piece of work to harmonize the estimated impacts of family planning across different models in the sector. This work ensures that when using different models to estimate the impact of contraception, results will be generally in line. Results will not be identical as models have been developed for different needs, which warrant some differences in methodology. However, major assumptions have been aligned as much as possible, and will continue to be more closely aligned in the future.

Throughout this paper, orange “harmonization with the sector” boxes have been added to note changes as a result of this harmonization work. More information can be found here:

[http://www.popcouncil.org/uploads/pdfs/2014STEPUP\\_MeasuringImpact.pdf](http://www.popcouncil.org/uploads/pdfs/2014STEPUP_MeasuringImpact.pdf) (note: updated brief to be published soon).

## 2 General concepts

This section provides important background information to help understand how Impact 2 works. Note that some of these concepts apply to family planning services *only*, but have been included here for ease of understanding. More details are provided in the methodology that can be found in the following sections.

### 2.1 Intended use

Impact 2 is primarily designed to be used at a programme level (either by an individual organisation, or by a group of organisations that contribute towards national coverage of FP, safe abortion and/or PAC services), or, nationally based on bottom-up estimates of services/coverage (e.g. HMIS data). It works at a *micro-level*, tracing out the estimated outcomes for an individual who is using family planning, or has received safe abortion and/or PAC service.

Working on a micro-level, Impact 2 is unable to account for the interactions between the services provided and changes in fertility and population structure. However, the micro-level results from this model are still useful and relevant because: (1) Impact 2 works on a relatively short timeframe; and (2) the model does not attempt to show wider population-level changes (ie reduction in MMR).

### 2.2 Model set up

The model can be run in two modes: (1) organization or (2) whole country. This distinction determines the perspective taken by the modelling (e.g. contributing a share of national use, or, looking at all use in an area). The model can be run on one country, region or sub-region, and see results based on this one area. For each country, region or sub-region that the user selects, the model is populated with default assumptions based on global, regional and national data. A full list of data used in the model (including the data sources of the default assumptions) can be found in Annex 9 . All default data and assumptions used in the model can be edited by the user.

A multiple country mode has also been created to allow organisations to get results from multiple countries at once. However, in this mode, default assumptions *cannot* be edited and requires service data to be pre-loaded into the model. It simply runs the model for each selected country, region and/or sub-region and populates tables with the results. Some of the dynamic functions of the model, such as goal setting, are not available in this mode.

#### **Looking for alternatives – account for differing impacts across groups:**

When initially developing Impact 2, we hoped to subdivide service provision, and therefore impacts, based on key socio-economic or demographic characteristics that might affect a woman's risk of mortality, morbidity and other outcomes. Possible splits considered include: age, parity, urban/rural and service delivery channel. However, there is very limited data available to estimate the relative risk of mortality, or the differential costs and impacts of reaching these different sub-groups. Creating these sub-groups is only worthwhile if data exists to model differential impacts across the groups.

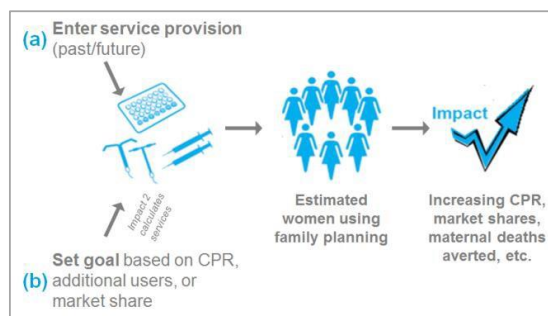
In addition, it would be difficult to balance the inclusion of multiple sub-groups with keeping the model simple and user friendly. It would require the user to subdivide all of their service data, and to deal with multiple sets of assumptions. Therefore, we decided not to create subdivisions within Impact 2. However, by updating default assumptions, the user can tailor the model to look at a particular sub-group, if they have access to the relevant data.

## 2.3 Enter services or set a goal

Impact 2 can be used in two different ways, as shown in Figure 3 below. For a, services are directly entered by the user. For b, a goal is set, and the model calculates the resulting services that would be needed in order to achieve the goal.

\* PAC and safe abortion services go directly to/from impacts, without an interim 'users' step as shown above.

Figure 3 Illustration how the model works\*



## 2.4 Trend dates and historic service data

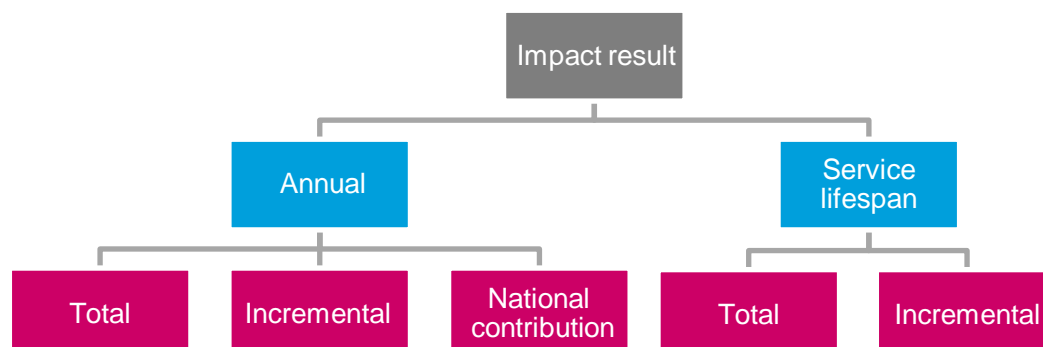
Impact 2 allows the user to look at any period (of any length) from 2001 to 2030. This allows flexibility for how the model is used, as the start date of the trend can be adjusted to match the start date of an existing or potential future programme. When entering data, the programme can enter services from as far back as 1982. In addition, when setting a future goal, the model allows for programmes to account for historic services already provided before the first year selected. This historic data is used to:

- Establish a baseline contribution – it is important to know what a programme was already doing in a country to distinguish between services that are *maintaining* impact, and those that are *increasing* impact.
- Account for historic long-acting and permanent methods of contraception (LAPM) clients who may still be using their method during the selected trend.<sup>iv</sup>

## 2.5 Different ways to view results

Impact 2 allows the user to view results in several different ways in order provide more in-depth information about impacts. Not all of these options are available for all results. However, when viewing results in the model, the user is directed to the different view options that are available. Figure 4 shows the different ways that results can be viewed; there are two key choices when viewing results: (1) timeframe (shown in blue in the diagram); and (2) what to count (shown in fuchsia). These distinctions are described below.

Figure 4 Different ways to view results



<sup>iv</sup> The model allows the user to include historic data back to 1982. This is to account for past sterilisation clients who, depending on the median age of sterilisation, may still be protected by the sterilisation in/after 2001; thus, they should still be counted as a programme user (see section 3.1.1 below).

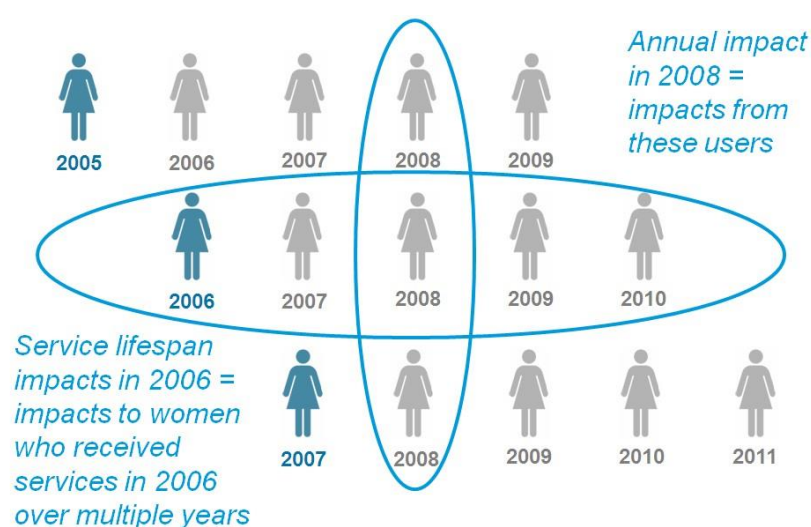
### 2.5.1 Timeframe: annual versus service lifespan

When looking at health, demographic and economic impacts, results can be presented in two ways:

- **Annual:** impact during a given year; this includes the impact from women who received services in that year, plus the impact of women who are still protected by an LAPM received in a previous year.
- **Service lifespan:** impact of services provided in a given year over the full use of the methods. For LAPM services only, this traces out impacts until the method is discontinued, or until a woman is no longer protected by sterilisation. These are *similar* (but not identical) to impacts based on couple years protection (CYP).

Note: family planning user numbers are always presented as annual estimates.

Figure 5 Illustration of annual and service lifespan impacts

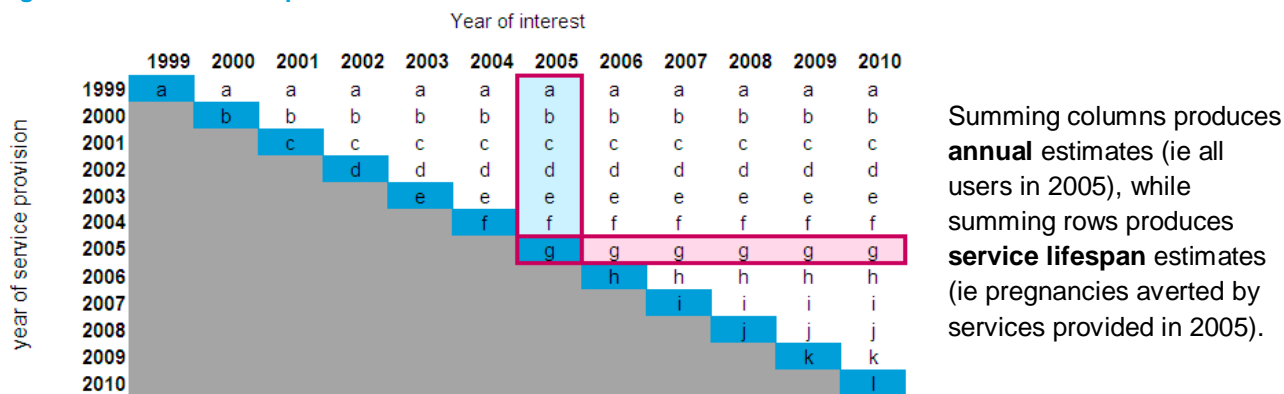


These concepts apply to LAPM services only, since women who receive these methods carry on using them into future years. For short term methods, PAC and safe abortion services there is no carry over into future years. Therefore, for these services, annual and service lifespan are identical.

While a single summed value is presented in the results (ie number of implant users in 2010), in the model cohorts of users (or other impacts) are traced out in matrices similar to the example shown in Figure 6 below. These matrices are used for any impacts where rates vary over time; either by the age of the cohort (for example, pregnancy rates), or by the year of interest (for example, MMR). More details are provided in the following sections.



Figure 6 Illustrative example of virtual cohorts



Each LAPM has its own matrix. In order to capture the full impact of service provision, the matrices go from 1982 (to capture historic services) out to 2045 (to capture the full impact of LAPM services into future years). The following impacts are calculated using matrices as shown above:

- family planning users
- pregnancies averted
- maternal deaths averted
- maternal DALYs averted – mortality related (YLL)
- maternal DALYs averted – morbidity related (YLD)

The details of the calculations carried out to produce the results within each matrix are described in the following sections. Once the matrices are filled in, annual and service lifespan totals can be calculated by summing across rows and columns, as described above.

### 2.5.2 What to count – total, incremental or national contribution

When Impact 2 is used on “organisation” mode, it needs to take into account the clients a programme might be reaching. It is possible for a service provider to increase their client numbers without affecting the number of family planning users at the national level. This happens when clients change from another provider. To account for this, Impact 2 distinguished between three different ways of counting impacts. These are described below. When in whole country mode only total impact results are available.

- **Total impact:** counts all of these impacts – ie includes impacts to women who were already lowering the national burden, because they were already using family planning.

Some women included in this total impact are already using family planning; therefore they are already counted in CPR, and are already contributing to a lower number of unintended pregnancies, maternal deaths and other national burdens. While it is important to continue to re-supply these women with contraception, the services provided to them do not reduce the national burden of disease further, or increase national contraceptive prevalence. Therefore, the following results have been included to better understand these dynamics.

To account for the fact that some of these women may have changed to your programme from a different provider, meaning that you may be ‘taking’ impact from that previous provider:

- **Incremental impact:** counts only impacts for which your programme is responsible – ie excludes impacts to clients that were ‘taken’ from other providers.

Finally, in order to create national level changes, such as increasing CPR or reducing maternal deaths, you need to maintain your contribution from the previous year. You also need to reach enough family planning adopters to keep up with population growth, as well as making an additional national level contribution:

- **National contribution:** counts only impacts that contribute to a national reduction in burden (eg maternal deaths); in other words, impacts to women that increase CPR.

For family planning services, these three types of results are calculated by applying an annual ‘client profile’ that separates clients into three groups: adopters, continuers and provider changers (see chapter 4).

For safe abortion and PAC services these concepts are applied slightly differently, given the nature of the services. For all PAC and safe abortion services the model considers what would have happened if the client had not accessed the services. This captures the fact that they may have accessed the service from another provider (see chapters 7 and 8 ). Therefore:

- **Total and incremental:** these two results are identical for PAC and safe abortion services. This is because, when calculating the impact from these services, the model accounts for what would have happened if the client did not access the services.
- **National contribution:** counts only impacts that contribute to a national reduction in burden (eg maternal deaths); in other words, impacts of service provided that increase market share.

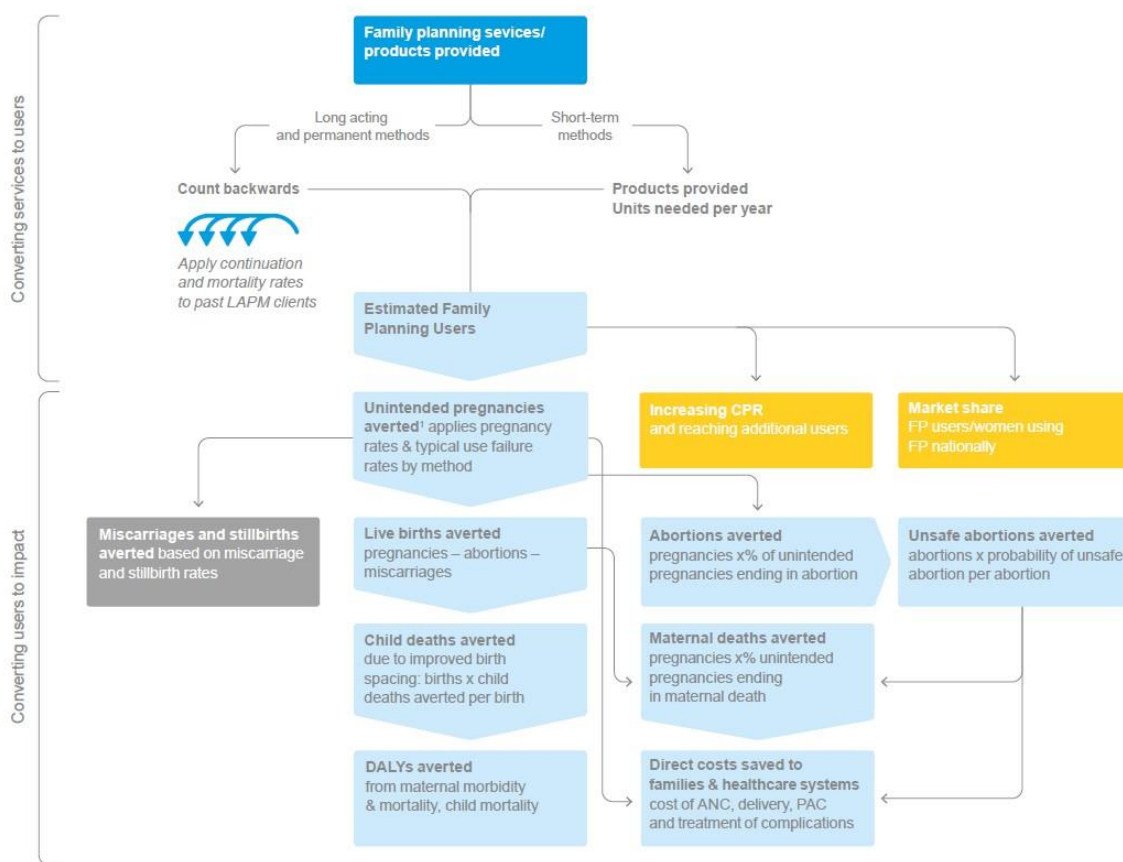
Estimating the total impact of a programme is important. However, it is also useful to consider incremental impacts and national contributions to improve understanding about how programmes are affecting the national picture. Comparing these three results allows a programme to see the importance of targeting services to clients who do not already have access. The ability to create these distinctions makes Impact 2 innovative and unique.



### 3 Family planning services to total impacts

This section presents the methodology, data and assumptions used to translate data on family planning service provision into total impacts. It explains the methodology behind estimating incremental and national contributions from family planning services. The section is divided into two sub-sections representing the two stages behind the methodology of moving from services to impacts. First, services are translated into the estimated number of women using family planning. Then, impacts are estimated based on the potential outcomes of these women. Figure 7 shows the overall approach to modelling impacts from family planning services. Each box represents a model output, and will be discussed in more detail below.

Figure 7 Family planning services to impact



<sup>1</sup>In the 2015 updates of Impact 2 the distribution of pregnancy outcomes averted (e.g. live births, abortions) has been recalculated to reflect outcomes of unintended pregnancies. This change was based on a joint working group to harmonize assumptions used in FP impact models: [http://www.popcouncil.org/uploads/pdfs/2014STEPUP\\_MeasuringImpact.pdf](http://www.popcouncil.org/uploads/pdfs/2014STEPUP_MeasuringImpact.pdf)

#### 3.1 Services to users

The user enters data for annual service provision into the model, by method. Or, these services are calculated from (1) creating baseline services from the CPR (whole country mode), and/or (2) setting a goal for CPR or market share increases, or reaching additional users. See sections 5.1 and 6 for more details on these calculations. This data serves as the foundation for all calculations carried out in the model.

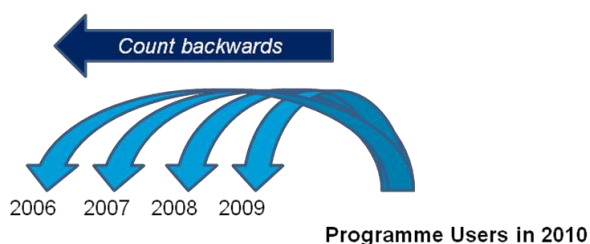
## Accounting for supply chain wastage

When setting up the model, there is an option to include an estimate of supply chain wastage for each method (ie the percentage of commodities that never reach a client). The default is set to 0 percent, although this can be adjusted. This feature is useful for organisations that count their commodities further back in the supply chain, and helps to ensure that impacts are only estimated from commodities that are actually used.

If included, the supply chain wastage factor is applied to the service provision data that is entered by the user to subtract off those commodities that are estimated not to have reached a client. For example: a 20% wastage factor is entered for IUDs, then a total of 10,000 IUDs are entered as services provided in 2010. All calculations in the model run off an estimate of 8,000 IUDs.

The number of women using an FP method is different from the number of women who received an FP method in a given year. This is because some women who received LAPMs in previous years will still be protected by that contraceptive method in the year of interest. Since short term methods require resupply within each year, there is no need to account for short term users who received their method before the year of interest.

Figure 8 Counting backwards to estimate FP users



Impact 2 therefore uses modelling to 'count backwards' to estimate the number of women who are *using* an FP method each year from the specified programme, or in the whole country (Figure 8). To do this, the model predicts the likelihood that women who have had an IUD or implant inserted at a point prior to the year of interest, are still using the method by applying cumulative continuation rates to past clients. For

male and female sterilisation users, the model predicts the likelihood that women who were sterilised, or whose male partner was sterilised, prior to the year of interest are still protected by the sterilisation (still alive and still of reproductive age).

For short term methods, the model estimates the number of women using a short term method provided by the programme in the year of interest based on the number of units needed for a full year of coverage. The details of the calculations for each method are described below.

### 3.1.1 Permanent methods (male and female sterilisation)

For female sterilisation clients, the model estimates the number of females sterilised in the past who are still (1) of reproductive age and (2) alive. For male sterilisation clients, the model counts the number of women being protected by their male partner's sterilisation. The same method is applied to the number of male sterilisation clients, with the model estimating the number of female partners of male sterilisation clients that are still (1) of reproductive age and (2) alive. Because the model counts female partners of male sterilisation clients, it cannot account for partnerships that end (therefore the woman is no longer protected by her male partner's sterilisation), or cases when the sterilised male partner dies.<sup>v</sup>

#### a. Mortality and survival rates

<sup>v</sup> The model may overestimate the number of woman being protected by their partner's sterilisation (if the partnership ends, or the male partner dies). However, it may also underestimate the number of women being protected by their partner's sterilisation (if a male sterilisation client takes a new partner). It is assumed that these two elements will cancel each other out.

Age specific survival rates (5px) for women of reproductive age are derived based on model life tables. Each country is assigned to a family of model life tables (see Annex 2 for details). Then country specific annual estimates of female life expectancy at birth (default values taken from UN Population Projections<sup>4</sup>) are used, matched to the selected family of model life tables to identify the relevant probabilities of survival (5px). These values represent the probability of surviving across a five year age period. These are converted into annual survival estimates by raising the probability to the 1/5:

$$(5px)^{(1/5)}$$

Note: this assumes an even distribution of mortality across the five year age group.

**b. Median age of sterilisation**

The median age of sterilisation is used to determine when women ‘age out’ of needing protection from sterilisation (after age 49). The median age of sterilisation is an input in the model; defaults have been pre-loaded based on DHS data. For countries with no DHS survey, or for countries where the sample size of sterilised women is less than 30, weighted sub-regional averages are used (see Annex 5 for details).

**c. Converting services to users**

The model treats the group of women sterilised in each year as a cohort, and traces them out into future years. To account for the fact that some women may die within the year they are sterilised, the appropriate survival rate (based on the year and median age of sterilisation) is applied to the total number of sterilisations conducted to estimate ‘sterilisation users’ in the first year.<sup>vi</sup> For each subsequent year, the cohort of women is aged by one additional year. When the group’s median age reaches 50, all sterilisation users are removed from the model. Before this point, the appropriate survival rate (based on the year and median age of the cohort) is applied to the total number of users in the previous year to estimate the number who are still alive in the subsequent year.

Each year of service provision has its own row in the method specific user matrix. These user estimates fill in columns corresponding to the correct row (ie if services were provided in 2010, y1 users are in the 2010 column, y2 users in the 2011 column etc). See Figure 6 in section 2.5.1 for an illustration of these different totals.

Calculations are done for male and female sterilisation separately, but as discussed above, the same mortality rates and median ages are applied.

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<sup>vi</sup> This is a slight underestimate of users, technically; you would want an average of the total number of women at the start of the year, and the total number still alive at the end of the year. Because survival rates are not service lifespan (they are applied only to the group of women who are still alive), this approach is not feasible. However, this makes a very small difference in the estimated number of users, so this method was chosen for simplicity.

### 3.1.2 Long-acting methods (10 yr/5yr IUDs; 3yr/5yr IUS; 3yr/4yr/5yr implants and SDM<sup>vii</sup>)

Estimates for long-acting and permanent method users are based on the maximum duration of use of the method and cumulative continuation rates (ie the probability that a woman is still using the method in future years). Implants and IUDs are treated separately based on duration (ie a ten year IUD is modelled independently from a five year IUD. They are treated as different methods).

#### a. Cumulative continuation rates

Annual cumulative continuation rates by method are an input in the model. Default cumulative continuation rates are based on decay curves created for each method as part of the USAID 2011 CYP update.<sup>viii</sup> For IUDs and implants, a continuation curve is created for the longest duration (ie ten years for IUDs and five years for implants) and truncated early for the short duration versions of these methods. For SDM, a ten year continuation curve is used.

#### b. Converting services to users

The model treats the group receiving a long-acting method in a given year as a cohort, and traces them out into future years. The model assumes that all women received their method together at the beginning of the year, and then takes the average of those using at the beginning of the year with those still using at the end of the year to produce an estimate of the average number of users over the year. An illustrative example is shown in Table 1.

**Table 1 Illustrative example of estimating long-acting users from services**

Assume that 1,000 five year implants are given in year y. Cumulative continuation rates are applied to estimate the number of users at the end of each successive year. These are then averaged to give the average number of users over each of the five years. In year six, there will be 0 users, since it is beyond the duration of the five year implant.

	0 yr	1 yr	2 yr	3 yr	4 yr	5 yr
<b>Continuation rates</b>	1	0.87	0.76	0.67	0.58	0.51

1. Apply rates to services	1,000	870	760	670	580	510
2. Average to get 'users'		935	815	715	625	545

The above illustrative example works out as follows in terms of calculations:

- Year 1 users = Services provided\*average (CCR<sub>0</sub>, CCR<sub>1</sub>)
- Year 2 users = Services provided\*average (CCR<sub>1</sub>, CCR<sub>2</sub>)
- Year 3 users = Services provided\*average (CCR<sub>2</sub>, CCR<sub>3</sub>)
- Year 4 users = Services provided\*average (CCR<sub>3</sub>, CCR<sub>4</sub>)
- Year 5 users = Services provided\*average (CCR<sub>4</sub>, CCR<sub>5</sub>)

This process is continued until the end of the method duration is reached. Each year of service provision has its own row in the method specific user matrix. User estimates fill in columns corresponding to the correct row (ie if services

<sup>vii</sup> In order to ensure usability by all audiences, Standard Days Method (SDM) has been included in the model. The SDM, which is not technically categorised as a long-acting method, is treated in the same way as IUDs and implants, because one trained adopter is said to be protected for multiple years.

<sup>viii</sup> We would like to thank Emily Sonneveldt from Futures Institute for sharing the decay curves.

were provided in 2010, y1 users are in the 2010 column, y2 users in the 2011 column etc). See Figure 6 in section 2.5.1 for an illustration of these different totals.

### 3.1.3 Short term methods

Because short term methods require refills within a year period, calculating the number of short term FP users does not require counting backwards to previous years. Given that most reproductive health programmes collect data on services/commodities provided, rather than clients, the model is designed to convert service provision data into estimated users. User estimates are made by dividing the total products provided by the number of units needed for one year of protection. This approach has important limitations.

The actual number of short term users may vary if women do not receive an entire year's worth of provision from one provider. This method used provides a conservative estimate of FP users, which is preferred to overestimating users. Also, in terms of the impacts stemming from pregnancies averted, the same number of pregnancies will be averted by one woman using a full year of a method, or several women each being protected for part of a year.

**Example:** Thirteen pill cycles are need for one year of protection; it is possible that 13 different women each received one cycle of pills (ie 13 'users' are created); or that one women received all 13 cycles (ie one 'user' is created); or something in between these two. In terms of estimating CPR contribution, surveys such as DHS capture 'current contraceptive use' at a single point in time over the year. Depending on when the survey is done, and how the potential pill users (ranging from 1 to 13 users) are distributed across the year, it is possible that the DHS would not pick up any of them, or it would pick up all 13 of them. The model counts only one 'user'. While this could be an underestimate of short term user numbers, we believe that this reflects the probability that a user is captured in the DHS, assuming an even distribution of use across the year.

#### a. Units needed per year of coverage

The number of units needed for a year of coverage is an input to the model. This is slightly different from the CYP factor, because it does not include method effectiveness and wastage (user, not supply chain). Rather, it is the number of units that a woman would need to have a full year's worth of commodities (ie three units of four month injections). Default global estimates are based on workings from the 2011 USAID CYP update<sup>5</sup>.

#### b. Converting services to users

The number of services provided for each short term method in a year is divided by the method specific units needed per year to estimate the users of each method in that year.

$$\frac{\text{Number of commodities provided}}{\text{Units needed for one year of coverage}}$$

### **Note on estimating condom users**

Of all short term methods, condoms prove the most difficult to convert into user numbers for several reasons:

- it is difficult to estimate how many condoms are needed for a year of protection
- it is difficult to estimate what proportion of condoms that clients received are actually used
- some clients who receive condoms also receive another FP method, meaning they are already counted as a ‘user’ based on the other method.

Therefore, the estimated number of condom users should be treated with caution.

Calculations are done separately for each method, using the methodology discussed above, applying method specific units needed for one year of coverage.

#### **3.1.4 Total annual users**

LAPM users are then summed from the method specific matrices two different ways:

1. Annual: this sums the entire column for each year included in the specified trend.
2. Service lifespan: this sums the entire row, for each row representing a year included in the specified trend.

See section 2.5.1. for an illustration of these different totals.

Short term method users only produce one user estimate for each year (it is the same for annual and service lifespan), so no additional summing is needed.

## **3.2 Market shares**

Market shares are only calculated when in organisation mode. These calculations compare the number of programme users to different markets to understand a programmes contribution to each. Impact 2 presents several different market shares, as outlined below.

### **3.2.1 Including or excluding condoms**

There is an option in the model to include or exclude condoms from market share calculations. There are several reasons you might want to consider excluding condoms from market share calculations:

1. Converting from condoms distributed to users is difficult- we don't know very much about how many condoms are needed for a year of protection, what proportion of condoms that clients received are actually used, so, the estimated number of condom users is not very strong.
2. Dual protection (using condoms and another FP method) may mean double counting users- if many women who receive condoms also receive another FP method from your programme, then, they are already counted as a “user”

based on the other method. Including condom users could mean you are over counting your programmes FP users.

### 3.2.2 Defining market shares

Market shares look at what proportion of women using (or in need of) family planning nationally receive a family planning method from a specific programme. The model includes five markets, as shown in Table 2.

**Table 2 Market share definitions**

Market	Who is included
Modern market	All women nationally using a modern method of family planning (married or unmarried, depending on inputs)
LAPM market	All women nationally using a long-acting and permanent method of contraception (married or unmarried, depending on inputs)
Potential market	All women nationally currently using, or in need of a modern method (modern users + traditional users + married/in union women with an unmet need)*
All women market	All women of reproductive age nationally (15-49)
Married/in-union women market	Married women of reproductive age nationally (15-49)

\* Because unmet need is generally only reported for married/in union women; unmarried women with an unmet need are not included in the current potential market.

### 3.2.1 Estimating the number of women in the market

In order to know how many women are in the first three markets above markets, annual CPR estimates (by method group) must be made for each year included in the model (2001 to 2030). These estimates can then be multiplied by population projections of women (all or in union) of reproductive age to estimate the number of women in each market nationally.

#### a. Estimating CPR trends

Modified linear CPR trends are created for LAPMs, short term methods and traditional methods using the two most recent survey estimates. Data from DHS surveys is pre-loaded into the model for all countries with at least one survey. For other countries, CPR data is taken from the UN contraceptive wall chart. When possible, data for all women (rather than in union) is used.

#### **Looking for alternatives – non-linear CPR trends:**

Projecting how CPR will change in the future is very difficult since the path of CPR increase will be determined by a large variety of factors (changes in demand, changes in supply). In Impact 2, it was hoped to move from a linear trend to a more sophisticated non-linear model.

We attempted this in several ways:

- fitting S Curves to historic CPR trend data; created several ‘groups’ based on different patterns of CPR increases
- using other published trends as a predictor for changes in CPR.

However, we were unable to find a way to systematically predict CPR increases that could be applied in any country. Therefore, a linear trend (with some



modifications, as noted below) has been used. This weakness should be acknowledged when using market share results, especially for countries without recent CPR estimates.

Three steps are taken to estimate CPR by group (LAPM, short term and traditional) each year, as described below. The estimates are constrained by two assumptions:

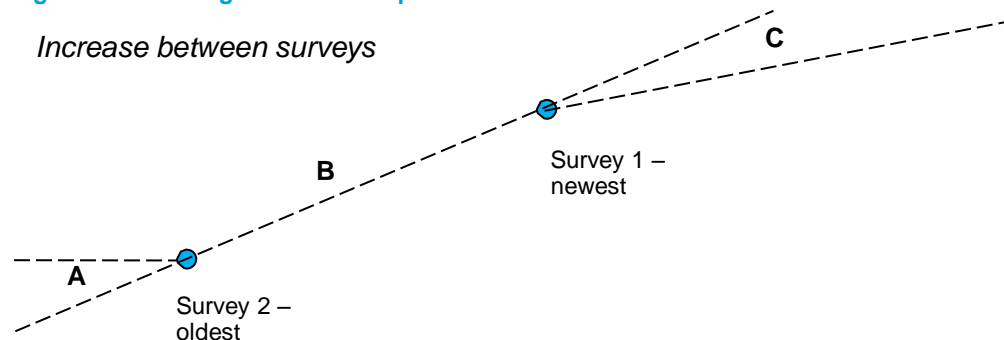
- maximum CPR (default set to 75%) – called  $\max_{\text{CPR}}$
- maximum annual percentage point increase (default set to three percentage points) – called  $\max_{\Delta}$ .

Different rules are applied depending whether the trend is being established prior to the oldest survey, between the two surveys, or after the newest survey.

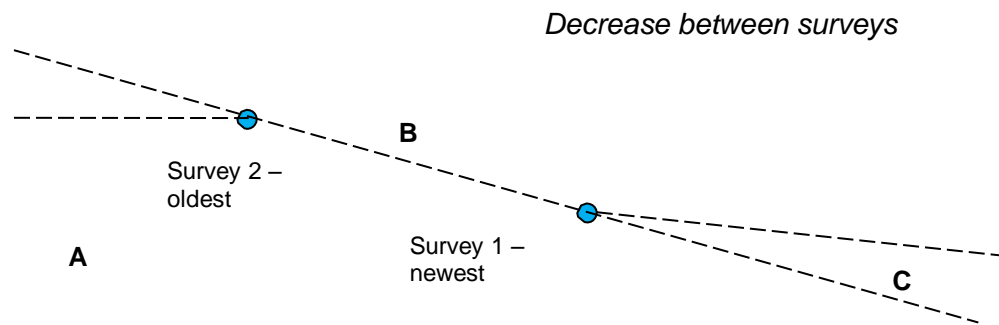
### 1) Apply average annual percentage point change

Average annual percentage point changes are created for each method group. Three sets of percentage point changes are created, one for each period (pre-survey, between surveys, post-survey). The different sets of rules are to account for what is generally 'realistic'. For example, if LAPM use declined slightly between two surveys, this trend may continue into the future. However, applying this into the past would assume a continual increase in LAPMs into the past, which is unlikely to have been the case. Therefore, the rules either constrain the speed of the percentage point increase/decrease, or hold a trend constant, depending on the scenario. Because different percentage point changes are applied to each group of methods (LAPM, short term, traditional), the relationship between the groups is also considered. While not showing the full complexity, Figure 9 illustrates considerations regarding how linear trends may be modified.

Figure 9 Estimating CPR trends – possible linear constraints







*For the period before the oldest survey (A):*

1. If the older CPR was already  $> \max_{\text{CPR}}$ , set % point change to 0 for all methods so that CPR held constant into past.<sup>ix</sup>
2. If LAPM or short term (ST) methods decrease between surveys, set respective % point changes to 0. This way neither increases into the past, as these trends are not likely to have been sustained long into the past.
3. If both LAPM and ST methods increase between the surveys, and if the collective annual % point increase is  $> \max_{\Delta}$ , modern method increase is set to  $\max_{\Delta}$ , while the relative difference between the methods is kept the same.
4. If both LAPM and ST methods increase, but the collective annual % point increase is  $< \max_{\Delta}$ , respective % point increases are set as the % point change between the surveys for each method group.
5. If one of LAPM and ST methods increases between the two surveys, and the other decreases, and the collective annual % point increase  $> \max_{\Delta}$ , for the method that increases, the % point change is set to  $\max_{\Delta}$  and the other method's annual % point change is set to 0 (following rule 2 above).
6. If one of LAPM and ST methods increases between the two surveys, and the other decreases, and the collective annual % point increase  $< \max_{\Delta}$ , for the method that increases, the % point change is set to the % point change between the two surveys, and the other method's annual % point change is set to 0 (following rule 2 above).
7. If traditional methods decrease between the two surveys, % point change is set to 0, to prevent large increases in traditional CPR into the past. If the increase between the two surveys is  $> \max_{\Delta}$ , capped at  $\max_{\Delta}$ , or else it is set to the % point change between the two surveys.

*For the period between the surveys (B) the average annual % point change between the two surveys is applied (by method group: LAPM, short term, traditional). This ensures that the modelled CPR for the year of each survey will be equal to the CPR and method mix from the survey.*

*For the period after the most recent survey (C):*

1. If CPR is already  $> \max_{\text{CPR}}$ , set % point change to 0 for all methods so CPR held constant into the future.
2. If the modern % point change in CPR (LAPM + ST) is negative between the two surveys, set % point change for ST methods and LAPMs to 0, so modern CPR held constant into future years rather than declining. This reflects the fact that a decline in modern CPR is unlikely to be sustained in the long run.
3. If the modern % point change in CPR (LAPM + ST) between the two surveys is  $> \max_{\Delta}$ , the % point change for modern methods is set to  $\max_{\Delta}$ , keeping the relative difference between LAPM and ST methods.

<sup>ix</sup> This may be a weak assumption, but unless additional survey data is added, there is no way to know how long CPR has already been  $> \max$ .

4. If the modern % point change in CPR (LAPM + ST) between the two surveys is positive but  $< \max_{\Delta}$ , the % point change for LAPM and ST are set to the respective % point changes between the two surveys.
5. Traditional methods can increase or decline, but are capped at  $\pm \max_{\Delta}$ .

## 2) Do not allow any CPR estimates to fall below 0%

If the CPR (for any method group) is equal to 0, it will create an error when calculating market shares, since it will result in dividing by zero. In addition, it is unlikely that CPR for any method group would actually fall to 0. Therefore, any CPR value modelled to go to, or below, 0% will be held constant at 0.01%.

## 3) Constrain CPR to stay below the maximum future CPR

CPR projections (after the newest survey) are constrained to  $\max_{\text{CPR}}$ . In the first step, the model holds CPR constant into the past and/or future if the CPR is already over  $\max_{\text{CPR}}$ . In the case where neither CPR estimate is already above the  $\max_{\text{CPR}}$ , this step checks to see if the modelled trends have pushed any overall CPR estimates above the  $\max_{\text{CPR}}$ . If it has, the CPR is set to the last year that was below  $\max_{\text{CPR}}$  (maintain that year's method mix).

### b. National users and national women with unmet need

In each year, the CPR estimates are then multiplied by the corresponding national population of women of reproductive age (15–49). The default population estimates are taken from the UN Population Prospects (2017 Revision).<sup>4</sup>

If the survey based CPR estimates are for all women, then the CPR estimates are multiplied by all women of reproductive age. However, if the survey based CPR estimates are for in union women, then the projected number of women of reproductive age is multiplied by an estimate of the percentage in union to give an estimated number of in union women of reproductive age. The proportion of women in union is held constant over time. This gives an estimated number of FP users each year by method group.

Since unmet need is generally reported for married women only, unmet need is multiplied by the estimated number of in union women each year.<sup>x</sup>

### c. Potential market

The potential market is calculated each year by adding together the number of modern family planning users, the number of traditional family planning users and the number of women with an unmet need for family planning. As noted above, since unmet need is reported for married women, unmarried women with an unmet need for contraceptives are not included in the short term potential market.

### d. All women and married women market

Women of reproductive age projections for each year are an input into the model. For the all women market share, this input is simply used. The % married is also a model input. For the married women market share, this % is multiplied by the WRA projection each year to get a number of married WRA.

<sup>x</sup> The new definition of unmet need being used by DHS will also include unmarried women. As this data becomes more widely available, the model will be updated so we will be able to use this estimate. However, at the time of publication, the most widely available unmet need estimates were for married women only.

## 3.2.2 Estimating market shares

### a. Calculation of market shares

Market shares are estimated by dividing the number of programme FP users by the number of women in the selected market:

$$\frac{\text{Number of programme FP users}}{\text{Number of women nationally in selected market}}$$

### b. Errors with market share calculations

In some cases, the estimated market share will be above 100%. It is clearly not possible for a programme to cover more than 100% of the market. This means that either the numerator (number of programme FP users) is an overestimate, the denominator (national women in the market) is underestimated, or a combination of the two. Given the difficulty in projecting CPR into the future, this is likely to be the main driver of any errors in market share estimates.

## 3.3 Total Impacts

### 3.3.1 Unintended Pregnancies

Unintended pregnancies averted are estimated by applying method specific failure rates to modelled FP users<sup>xi</sup> and comparing this to the average number of pregnancies that would have occurred had the woman not been using any contraception. This pregnancy rate is referred to as the 'comparison pregnancy rate' and a default value of 41% is used, but this can be updated by the user. The default comparison pregnancy rate was calculated by the Guttmacher Institute, using their source data for the Adding It Up report. It represents the average pregnancy rates of non-users with an unmet need for contraception.

This pregnancy rate is likely to vary by country and region, due to biological, environmental and behavioural differences. However, no studies exist that are able to quantify these differences. And, attempts to create regional rates have produced inconsistent results. Therefore, it has been decided that in Impact 2 a single global comparison pregnancy rate will be used for all countries and regions.

#### Harmonization with the sector

Impact 2 previously used a 31% global comparison pregnancy rate. This has now been revised down to 41% based on calculations provided by the Guttmacher Institute. It has been agreed that various models estimating the impact of FP will all use this higher 41% rate; and continue to use this rate going forward. This ensures consistency across models, and between countries, when calculating the impact of contraceptive use on reducing unintended pregnancies.

The change from a 31% to 41% comparison pregnancy rate means that unintended pregnancies averted estimates will be higher in versions succeeding version 4 of the model. Therefore, care must be taken not to compare results from different versions of Impact 2.

<sup>xi</sup> For long-acting methods (IUDs, implants and SDM) method failure rates are not used, because method failure is included in the discontinuation rate. If the method failed (ie a pregnancy occurred), the woman would already be removed from the model for discontinuing.

### a. Pregnancies to LAPM users

For LAPMs, an age specific fertility discount is applied. This represents the fact that, as a woman ages, she becomes less fecund, and therefore fewer pregnancies are being averted. The pregnancy discounting is based on age specific Hutterite fertility rates<sup>9</sup>. The discounts (shown in Table 3) show fertility in each age group relative to average fertility across reproductive years (15–49). Each discount factor is multiplied to the ‘comparison pregnancy rate’ to give an adjusted pregnancy rate for each age group. See Annex 6 for details regarding how these discounts were calculated.

**Table 3 Fertility discounts**

From	To	Discount factor
15	19	1.0
20	24	1.5
25	29	1.3
30	34	1.1
35	39	1.0
40	44	0.6
45	49	0.1

*Source: MSI calculations- see Annex 6*

Similar to the methodology used to estimate LAPM users, each cohort of users is traced out over future years, applying the corresponding pregnancy rate based on the average age of receiving the method. For sterilisation, the median age of female sterilisation is used. For IUDs, implants and SDM, the median age of clients is an input; the default is set to 30 for all three methods. This is a crude estimate; the user can replace this if they have better information from their client records.fertility discounts

Below is an illustrated example based on five year implant users (the calculation of users from services was shown in section 3.1.2). Assume that the median age of implant clients is 30, and that the comparison pregnancy rate is 41%:

**Table 4 Illustrative example of applying fertility discounts**

	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5
Implant users	935	815	715	625	545
Age of cohort	30	31	32	33	34
Age-adjusted pregnancy rate	41%*1.1= 45%	41%*1.1= 45%	41%*1.1= 45%	41%*1.1= 45%	41%*1.1= 45%
Pregnancies with no method	45%*935= 421.7	45%*815= 367.6	45%*715= 322.5	45%*625= 281.9	45%*545= 245.8
Pregnancies to implant users*	0*935= 0	0*815= 0	0*715= 0	0*625= 0	0*545= 0
Pregnancies averted	421.7	367.6	322.5	281.9	245.8

\* the failure rate = 0 because method failure is already accounted for in the discontinuation rate. For sterilisation, and for short term methods, these pregnancies would be subtracted to the estimated pregnancies if the women were using no method to estimate ‘pregnancies averted’.

### b. Pregnancies to short term method users

For short term methods, no pregnancy discounts are applied; instead, the ‘comparison pregnancy rate’ is used. The method specific failure rate is subtracted off, as shown above, to estimate the pregnancies averted by using each method each year.

### c. Total pregnancies averted

Pregnancies averted to LAPM users are then summed two different ways:

1. **Annual:** this sums the entire column for each year included in the specified trend.
2. **Service lifespan:** this sums the entire row, for each row representing a year included in the specified trend.

See section 2.5.1 for an illustration of these different totals.

Pregnancies averted to short term method users only produce one estimate for each year (it is the same for annual and service lifespan), so no additional summing is needed.

### 3.3.2 Live births (*note: methodology change in version 3*)

An estimate of the % of unintended pregnancies averted that would have ended in a live birth is calculated. This is done by accounting for all of the possible outcomes of an unintended pregnancy: live birth, stillbirth, induced abortion or miscarriage.

The number of pregnancies resulting in one live birth can be calculated as follows:

$$UP = LB + SB + A + M_a + M_b$$

Where UP= unintended pregnancy; LB = live birth; SB = still birth; A = abortion;  $M_a$  = miscarriage that would have led to abortions;  $M_b$  = miscarriage that would have led to births (live or stillbirth).

Stillbirths are separated from miscarriages because more extensive and country specific data is available on stillbirths. In order to make use of this data, the model accounts for miscarriages that occur before week 28 separately from stillbirths. The model uses the stillbirth rate (per 1,000 births). The default value for the rate is based on country and regional specific estimates from Cousens et al. (2011).<sup>10</sup> The rate is adjusted to represent the number of stillbirths per live birth as follows:

$$\frac{\text{Stillbirth rate}}{(1,000\text{-stillbirth rate})^*}$$

*\* the stillbirth rate is per 1,000 births (live and still), subtracting out stillbirths gives the number of live births, making this the ratio of still births per life birth.*

For miscarriages, estimates are made for the number of miscarriage for each pregnancy reaching up to 27 weeks, and the number of miscarriages per abortion. Default estimates are based on a life table of spontaneous abortion probabilities created by Hammerslough (1993)<sup>11</sup>. The default assumption used in the model is that there are 0.2 miscarriages for every pregnancy that reaches 27 weeks, and 0.07 miscarriages per abortion. See Annex 7 for details.

A ratio of live births per unintended pregnancy is estimated by accounting for all of the possible pregnancy outcomes, as described in the equation above. Substituting the relevant data sources, the total number of live births per every unintended pregnancy is:

$$\frac{1 - \%UPA - (\%UPA * \text{prob misscarriage per abortion})}{1 + \text{prob miscarriage per birth} + ((\text{SBR}/(1000 - \text{SBR}))) * .2) + (\text{SBR}/(1000 - \text{SBR}))}$$

Live births averted can then be estimated as follows:

Live births averted = unintended pregnancies averted x % UP ending in live birth

### **Harmonization with the sector**

The 2015 version (v4) of Impact 2 updated the distribution of pregnancy outcomes to reflect that unintended pregnancies have different outcomes than an “average” pregnancy. This change in distribution means that estimates of live births averted and abortions averted changed; as both now take into account the fact that unintended pregnancies are more likely to end in an abortion than an average pregnancy (represented by the abortion ratio). Generally, in the updated versions of Impact 2, there will be *fewer* live births averted and *more* abortions averted than in versions preceding version 4 (2015) of the model.

Therefore, care must be taken not to compare results from different versions of Impact 2.

### **3.3.3 Abortions and unsafe abortions (note: methodology change in version 3)**

The total number of abortions averted is estimated using the % of unintended pregnancies ending in abortion (a model input). This percentage is simply multiplied by the number of unintended pregnancies averted:

Abortions averted = unintended pregnancies averted x % UP ending in abortion

Next, the number of unsafe abortions averted is calculated by multiplying the number of abortions averted by the % of abortions that are unsafe (a model input).

Unsafe abortions averted = abortions averted x % abortions that are unsafe

Default data for the % of unintended pregnancies that end in abortion are taken from Bearak J, recalculation of Bayesian estimates for Sedgh G et al., (Sedgh & Shusheela Singh, 2015). The recalculation of unsafe abortion rates are from the WHO and Guttmacher Institute report (Ganatra, *et al*, 2017)<sup>12</sup>. The default (unsafe) abortion ratios used in the tool are therefore based on sub-regional estimates from abortion rates in Ganatra, *et al*, 2017 and live birth estimates from UNPD 2010-2015 (UN, 2017)<sup>13</sup>.

### **Looking for alternatives – modelling changes in abortion over time:**

In Impact 2, it was hoped to vary abortion ratios over time, in the same way that other rates were changed in the model. However, data on abortion is very limited. Most countries in the model rely on regional estimates, because no country specific studies exist. In addition, there is very little known about how abortion rates change over time; there is no clear pattern of how abortion relates to measures such as CPR. Therefore, it was decided to hold the most recent available abortion estimate constant throughout the model.

### 3.3.4 Maternal deaths (*note: methodology change in version 3*)

The pregnancy outcomes (live births and abortions) modelled above represent the distribution of outcomes for an *unintended pregnancy*. The maternal mortality ratio (MMR) as published represents the average risk of dying based on the national distribution of pregnancy outcomes. Therefore, this ratio must be adjusted to reflect the risk of dying from an *unintended pregnancy*. To do this, several steps must be taken.

#### a. Making annual estimates

Impact 2 uses six point-estimates of MMR taken from the data tables associated with the WHO mortality trends<sup>14</sup> (1985, 1990, 2000, 2005, 2010 and 2015). These are then modelled into annual estimates (out to 2040) so that changes in mortality can be taken into account. The 2040 estimate is needed to capture the full service lifespan impact of services delivered in 2030.

Annual estimates are created as follows:

- From 1982 to 1985: MMR held constant, using the 1985 estimate.
- From 1985 to 2015: Linear trends are extrapolated between each point estimate, using the average annual percent change.
- From 2015 onwards: A linear trend is created based on the average annual change from 2010 to 2015. However:
  - A maximum average annual decrease of 20 deaths per 100,000 births is applied to limit future decreases. For countries with an average annual decrease between 2010 and 2015 that exceeds this amount, then a 20 per 100,000 annual decrease is applied.
  - If there is an *increase* in MMR between 2010 and 2015, the MMR is held constant from 2015 forward.<sup>xii</sup>
  - If applying the average annual decrease would cause the MMR to go below 0 in any given year, it is held constant from the year before the MMR would go to 0.

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<sup>xii</sup> Most increases in MMR are due to temporary changes (conflict, disease pandemics etc), and would not likely continue until 2040. It is likely that MMR would begin to decline again at some point. However, it is not possible to predict when this might happen. Therefore we have decided to hold MMR constant from 2015 onwards in countries that experienced an MMR increase between 2010 and 2015.

## b. Calculating a “live birth only” MMR

The Maternal Mortality Ratio (MMR), while applied to the number of live births, includes the mortality associated with other birth outcomes (abortion, stillbirth, miscarriage). A live-birth only MMR can be calculated by isolating portion of the full MMR that is attributable to live births. To do this, all the possible sources of a maternal death must be considered:

Pregnancy outcome	Mortality rate used
Live birth	Calculated live birth MMR (below)
Safe abortion	2 per 100,000 safe abortions (programmed default)
Unsafe abortion	MMR x Unsafe Abortion Mortality Ratio (UAMR)*
Miscarriage	MMR**
Still birth	MMR**

\* This is the ratio between overall MMR and unsafe abortion mortality at the sub-regional level. Since MMR is estimated by *country* while unsafe abortion mortality is only estimated by sub-region, mixing the two data sources can be problematic. Therefore, this ratio is used to create a country-specific unsafe abortion mortality estimate that is scaled to the national MMR. This ratio is an input in the model, default data has been calculated based on WHO estimates of unsafe abortion case fatality (12), and WHO MMR estimates for the same corresponding region and year.

\*\*there is limited evidence available on the risk of mortality from miscarriage or stillbirth. Therefore, the total MMR (unadjusted) has been used as the mortality risk for miscarriages and still births.

$MMR_{LB} = MMR -$

$$\left[ \left[ \frac{\text{abortion ratio}}{100} \times (1 - \% \text{ abortions that are unsafe}) \times \frac{2}{100000} \right] + \left[ \frac{\text{abortion ratio}}{100} \times (\% \text{ abortions that are unsafe}) \times MMR \times UAMR \right] + \left[ \left( \frac{\text{abortion ratio}}{100} \times \frac{\text{miscarriages}}{\text{abortion}} \right) + \left( \frac{\text{miscarriages}}{\text{preg at 27 wks}} \times \left( 1 + \frac{\text{stillbirth rate}}{1,000 - \text{stillbirth rate}} \right) \right) \right] \times MMR \right] + \left[ \left( 1 + \frac{\text{stillbirth rate}}{1,000 - \text{stillbirth rate}} \right) \times MMR \right]$$

## c. Creating a “maternal deaths per unintended pregnancy” rate

A risk of dying per unintended pregnancy can then be created, by combining the morality risk of each unintended pregnancy outcome, as outlined in the table above:

$$\begin{aligned} \text{Maternal deaths per unintended pregnancy} = & (\% \text{ UP ending in live birth} \times MMR_{LB}) + \\ & (\% \text{ UP ending in abortion} \times (1 - \% \text{ abortions that are unsafe}) \times 2/100,000) + \\ & (\% \text{ UP ending in abortion} \times (\% \text{ abortions that are unsafe}) \times MMR \times UAMR) + \\ & (\% \text{ UP ending in abortion} \times \frac{\text{miscarriages}}{\text{abortion}} \times MMR) + \\ & \left( \frac{\text{miscarriages}}{\text{preg at 27 wks}} \times \left( 1 + \frac{\text{stillbirth rate}}{1,000 - \text{stillbirth rate}} \right) \right) \times MMR + \\ & \left( 1 + \frac{\text{stillbirth rate}}{1,000 - \text{stillbirth rate}} \right) \times MMR \end{aligned}$$

This calculation is done for each year, with the MMR and  $MMR_{LB}$  varying by year.



#### d. Calculating maternal deaths averted

Maternal deaths averted are then estimated by multiplying the estimated number of unintended pregnancies averted in a given year by the number of maternal deaths # per unintended pregnancy in that same year:

$$\text{Maternal deaths averted in year } y = \text{Unintended pregnancies averted in year } y \times \text{maternal deaths per unintended pregnancy in year } y$$

For LAPMs, these calculations are done in matrices, based on the matrices containing the estimated number of pregnancies averted, to allow for the correct risk of death to be used each year. Maternal deaths averted to LAPM users are then summed two different ways:

1. **Annual:** this sums the entire column for each year included in the specified trend.
2. **Service lifespan:** this sums the entire row, for each row representing a year included in the specified trend.

See sections 2.5.1 for an illustration of these different totals.

For short term methods, this calculation is done based on the total number of pregnancies averted. Since this is the same for annual and service lifespan, no additional summing is needed.

#### Harmonization with the sector

In order to accommodate the updated distribution on unintended pregnancy outcomes, a new approach to estimating maternal deaths averted was needed to represent the risk of dying from an unintended pregnancy. The approach now used by Impact 2 has been agreed by several modellers. However, one further change has been agreed for 2016 that has not yet been updated in Impact 2: the source data for unsafe abortion-related mortality. Impact 2 (as well as other models) currently use the WHO's unsafe abortion case fatality estimates from *Unsafe abortion: global and regional estimates of the incidence of unsafe abortion and associated mortality in 2008*. This publication estimates unsafe abortion to make up around 13% of global maternal mortality. However, the WHO has since published a systematic review of global causes of maternal death (Say, 2014) which estimates unsafe abortion to account for 8% of global maternal mortality. While there is some criticism that this underestimates unsafe abortion impacts, based on recent WHO guidance, Impact 2 will be updated to use these estimates for unsafe abortion mortality to recalculate the regional unsafe abortion mortality to maternal mortality ratio (UAMR). As they are lower than the current figures being used, this change would mean a drop in maternal deaths averted estimated by the model.

### 3.3.5 Child deaths (due to improved birth spacing)

This is an estimate of the number of deaths averted among children under the age of five due to improved birth spacing, or increasing the previous birth interval (PBI). This does not capture the *demographic* impact of increased contraceptive use- e.g. fewer children are born, therefore fewer children die. Rather, this captures the reduction in risk based on a change in birth profiles. A PBI coefficient, representing the estimated number of child deaths averted per live birth averted, is used in this calculation.

Coefficients specific to countries, regions and sub-regions were developed for Impact 2, based on a methodology developed by PSI that estimates the incremental effect of birth spacing from large sub-regional datasets from DHS, and country/region specific fertility and mortality rates<sup>15</sup> (see Annex 10 for coefficient methodology).

The coefficient is multiplied by the estimated number of births averted to give an estimated number of PBI child deaths averted:

$$\text{Child deaths averted} = \text{live births averted} \times \text{PBI coefficient}$$

**Note:** this estimate may be unreliable because there is currently very limited data about the linkages between CPR, birth spacing and child mortality. This part of Impact 2 will be updated as improved research becomes available.

### 3.3.6 Maternal DALYS

Maternal DALYS are separated into:

- Years lost of life (YLL) – mortality related DALYS
- Years lost to disability (YLD) – morbidity related DALYS

These two sub-sets of the maternal DALY are calculated separately; however the results only show the summed total of maternal DALYS averted.

#### a. Estimating YLL

YLL per maternal death (all causes) is an input to the model. Default values are sub-regional estimates based on Global Burden of Disease 2016 results; dividing the total number of maternal YLL in each sub-region by the total number of maternal deaths in the same sub-region. The number of YLL per maternal death averted is held constant over time.

This value is then multiplied by the total number of maternal deaths averted to get a total YLL averted.

$$\text{Maternal YLL averted} = \text{maternal deaths averted} \times \frac{\text{YLL}}{\text{maternal death}}$$

#### b. Estimating YLD

The model follows the methodology of the 2004 *Global Burden of Disease*<sup>17</sup> and uses a sub-regional ratio of YLD to YLL to estimate years lost to disability. The ratio between YLL and YLD is assumed to remain constant over time.

Default sub-regional ratios are used based on 2016 DALY estimates by sub-region<sup>18</sup>.

$$\text{Maternal YLD averted} = \text{Maternal YLL averted} \times \text{ratio of maternal YLD/YLL}$$

### c. Total maternal DALYs

The total estimates of YLDs and YLLs for each year are then summed to get corresponding estimates of total maternal DALYs averted.

#### Note on DALY estimates:

The DALY calculations in Impact 2 are based on the 2016 Global Burden of Disease. This includes 2 changes from early DALY calculations:

- Removing non-uniform age weighting
- Removing 3% discounting

These two changes have a large impact on the DALY calculations; therefore care should be taken not to compare results from Impact 2 with DALY averted calculations with include age-weighting and discounting.

### 3.3.7 Child DALYs

These DALYs include mortality only (YLL), and are based on the estimated number of child deaths averted due to improved birth spacing, described in section 3.3.5. YLL per PBI death averted is a model input. The default value has been calculated based on an average age of death of 1.8; and comes to 84.55 YLL lost per child death at age 1.8.

Child DALYs averted are then calculated as:

$$\text{PBI child deaths averted} \times \text{YLL per PBI death}$$

### 3.3.8 Direct healthcare costs saved

The costs saved modelled in Impact 2 are an estimation of the direct costs (supplies and personnel) associated with pregnancies and birth. The cost estimate represents money that would have been spent by families or the healthcare system for pregnancy care, safe delivery and treatment of complications.

Two pieces of information are needed:

- cost per service
- coverage – ie percent of pregnancies/births requiring the service.

These are then multiplied together, and summed across all services<sup>xiii</sup> to get an average cost per pregnancy.

The default assumptions for cost and incidence are based on the UNFPA Reproductive Health Costing Tool (RHCT)<sup>20</sup>, and *Adding it Up* methodology<sup>7</sup>, which

<sup>xiii</sup> For services that are only provided to births (ie delivery care), the birth to pregnancy rate converted is used to estimate the corresponding proportion of pregnancies that would need the service.

also used estimates from the RHCT. See Annex 9 for more details about the default assumptions used for incidence.

The default assumptions used in the model are based on full coverage – meaning every women who needs services receive them. Therefore, the default cost savings estimate may not realistically reflect savings based on current levels of coverage.

The default cost data is entered in 2011 USD (\$). However, the model allows the user to enter data in any currency and year and, to show results in a specified currency and specified year. To do this, the user must enter:

- an estimate of the inflation between the year of the cost data and the specified year
- a conversion rate between the currency of the cost data and the currency of interest, in the specified year.

These two rates are then applied to the cost data to get to an average cost per pregnancy averted in the specified year and currency.

### 3.3.9 Value for money

There is a lot of demand for organisations to be able to show the value for money achieved by investments in reproductive health services. While no value for money results are directly produced by Impact 2, results can be used to show value for money. Any value for money calculations should use **service lifespan impacts only**. This is because, for LAPM methods, the benefit of the costs spent in the year the services are delivered is realised over multiple future years. Therefore, comparing the cost of services in a given year to annual impacts in that year does not give a complete picture of the cost savings generated.

Value for money can be shown at different levels:

- **Cost of services:** estimate of how much it cost to deliver the services
- **Cost effectiveness:** cost per DALY averted\*
- **Partial cost benefit:** cost saved per (specified currency) invested.\*\*

*\* or any other impact in the model—e.g. cost per unintended pregnancy averted.*

*\*\* This only includes direct costs saved to the healthcare system, as outlined in the previous section. Therefore, it could not be used for a full cost-benefit analysis.*

#### **A few notes on showing value for money using Impact 2:**

- The estimated value for money is largely dependent on the cost data (ie cost of providing services) that is entered. It is important to think about what costs are included. Do they represent all of the costs incurred? Or only the programme costs? (ie donated commodities, use of staff who were previously trained, use of existing assets).
- This analysis is unable to account for the numerous benefits that cannot be quantified.
- These results should not be used to compare different types of interventions. For example, a programme designed to reach poor rural communities will likely cost more than a programme aimed at urban youth. However, it may be worthwhile to spend more money to reach groups that are harder to reach. The value for money indicators suggest above cannot make this distinction.

- Caution should be taken when trying to compare value for money results between different organisations, especially if input costs are not comparable, or, if the programmes are providing different types of interventions.
- It is important to balance cost effectiveness with ensuring that women have a choice about what method best suits their needs. In some cases it will not be the most cost effective method.

## 4 Family planning services to incremental impact and national contributions (*organisation mode only*)

The calculations described in the previous section present estimates of the total impact of services provided. These impacts do not take into account the clients a programme is reaching. This means that they include impacts that were already being generated, because some clients were already using family planning, either from the programme or another provider. In order to account for the clients a programme is reaching, Impact 2 calculates two additional types of impacts: incremental and national contribution. Note: these are only relevant when running the model on organisation mode.

Incremental impacts count only those impacts to adopters and women continuing to receive FP services from a programme. This captures the importance of maintaining an impact, and reaching new adopters. Women who have changed from another provider are excluded, since this impact is 'taken' from that provider, rather than generated by the programme.

While incremental impacts take some consideration for the clients a programme is reaching, they do not necessarily translate into national level changes. In order to reduce national burdens, more women need to be protected from unintended pregnancy and the risks associated with pregnancy and childbirth. This happens when the CPR is increased.

It should be noted that the model looks at whether or not a woman was using family planning before receiving services. However, it does not account for whether or not she was previously in need of family planning (ie if she was not sexually active then she was not at risk of an unintended pregnancy and subsequent impacts). However, by accounting for maintaining a programme's percentage point CPR contribution, the model assumes that – within the CPR contribution – there is steady movement of women between those in need and those not in need. In addition, total and incremental impact results are measured from a counterfactual of what might have happened had a woman *not* received family planning services. Therefore, the comparison is not the year before (when she may or may not have been at risk of an unintended pregnancy), but, to the same time period (where, since she is using family planning, it is assumed that she might otherwise be at risk of an unintended pregnancy).

### Limitations to estimating national contributions

The model is unable to account for several very important factors in the estimation of national contributions:

1. The contribution of women switching from less to more effective methods.
2. The contribution of providing higher quality services.

**1. Changing methods:** For example, if a group of 100 women switch from relying on condoms to implants, these women will experience fewer unintended pregnancies. While this change will not result in a change to the CPR (since there will still be 100 women using family planning), the reduction in unintended pregnancies would make a national contribution. However, because most programmes do not have client based data systems that can track method changing, it was not possible to incorporate this into the model. Therefore, in cases where many clients are changing to more effective methods, a programme's national contribution is likely to be underestimated.

Originally, estimations for national contributions were done based on maintaining and increasing levels of *pregnancies averted*, rather than user numbers. Its model constructed a 'hypothetical maximum' number of pregnancies each year (based on population size and maximum fecundity), and created a baseline percentage of this maximum to be maintained. This helped to address this issue partially, because an improved method mix would mean the baseline could be maintained by fewer women. However, even with this approach, the model was still unable to account for the benefit of a woman who was using condoms from a different provider, then came to a new programme for a long term method (see more below). In addition, interpreting and presenting these results was conceptually difficult (a reduction in the proportion of a hypothetical maximum number of pregnancies that did not occur). Therefore, it was decided not to use this method, and instead to link all national contributions to women increasing CPR. As long as there are no drastic changes in method mix, the results from the two approaches are comparable.

**2. Accounting for quality:** If a woman changes provider due to better quality, she may have improved health outcomes (ie lower discontinuation, lower method failure rates). The model is unable to account for any added benefit that comes from better quality services. However, if programmes have access to this information, they can edit assumptions about discontinuation and failure rates to show this impact.

While estimates from Impact 2 are important, due to these limitations and others, results should only be used to tell part of the story. Many of the benefits of family planning programmes are not, and cannot, be quantified. These other important issues should be considered and addressed alongside quantitative results from the model.

The next section gives an overview of the concept of the client profile, which underlies the calculation of both incremental impacts and national contributions. Then, the two subsequent sections explain in detail how these two types of impacts are calculated.

#### 4.1 Client profile

A client profile can be entered for each year included in the trend. The client profile segments all clients of a specific programme or organisation (ie the one using the model) into three groups:

- **% adopters:** this is the proportion of clients who were not using a modern family planning method before receiving services.
- **% continuing from programme:** this is the proportion of clients who were already using a modern FP method, and received that method from the programme.
- **% changing from other provider:** this is the proportion of clients who were already using a modern FP method, but received this method from a different provider.

These proportions are multiplied through the estimated number of users created each year, so that the users, and corresponding impacts, can be distributed based on those impacts



from adopters, programme continuers and programme changers. The same proportions are applied to all users, regardless of method.

A pre-2001 client profile is applied to all historic clients from before 2001. This is needed to estimate the incremental impact from clients who received LAPM services before 2001.

When estimating incremental impacts and national contributions, the model completely excludes users/impacts to users who changed from other providers, as it considers that any impact from these clients was 'taken' from another provider, rather than generated by a programme.

The client profile can be estimated based on exit interviews, client records, or programme design (for example, if a programme plans to expand to a new area where CPR is very low, they may expect to reach a higher proportion of adopters).

### **Limitations of adopters as a proxy**

What one truly needs to know in order to measure incremental impact is 'what would this client have done had they not come here for services'. Would they have not used FP at all, or would they have gone to another provider? However, getting this information is very difficult. Even if it could be asked in a survey, conceptually it is based on a non-existent reality, so may be difficult to answer. Therefore, the client profile is used as a proxy.

There are some situations where this assumption may not hold, meaning that the client profile will not be a good proxy of incremental impact and national contribution. In these situations, the user may want to modify the client profile to account for the situation.

**Example 1:** There are two main FP service providers in a country, A and B. Imagine that provider B loses funding and will no longer be providing services in the country. This means that provider A is likely to have a large proportion of clients fall under the third group in the client profile (changing from other provider). However, since these clients can no longer receive services from provider B, provider A would not want to remove them fully from their incremental impact. Had they not changed to another provider, these clients would no longer have access to FP. In this case, provider A may want to add a proportion of these clients (those who they think they would not have gone to other providers in the country) into the second group in the client profile (continuing from the programme) so that the women are counted in their incremental impact.

**Example 2:** A programme reaches large numbers of young women who have just started to become sexually active. These young women were not previously using family planning because they were not at risk of unintended pregnancy in the past. It may be the case that they would have had access through other providers; this proxy will not show this. Therefore, in cases where large numbers of young women are being reached, a programme's incremental impact may be overstated. In this case, a programme may wish to lower their percentage of adopters, if they know that many of the women they are reaching could have easily gone elsewhere to initiate contraceptive use.

## **4.2 Incremental impact**

Incremental impacts capture impacts to adopters and clients who are continuing to received family planning services from the specified provider. The calculations done for incremental

impacts are identical to those described in section 3. However, rather than feeding through all services provided, only services provided to adopters and continuers are included in the calculations.

For LAPM method users, this is done by multiplying the total number of services provided each year (an input from the user) by the % adopters + % continuers from the client profile corresponding to the same year. This number of LAPM services is then fed through the matrices of LAPM users as described in sections 3.1.1 and 3.1.2.

For short term users, this is done by multiplying the estimated total number of short term users each year (see section 3.1.3) by the % adopters + % continuers from the client profile corresponding to the same year.

All impacts are then calculated from these incremental user numbers, following the same methodology and data sources described in section 3.

## 4.3 National contribution

### 4.3.1 The approach: maintain then increase

The methodology for estimating incremental national impacts is based on the concept that, year on year, a programme must first maintain the impact that it had in the previous year, then, only once this impact has been maintained, can an additional impact be made. All national contributions are estimated based on a programme maintaining, then increasing, their CPR contribution. As noted earlier, with changes in method mix, maintaining a CPR contribution will not translate directly into maintaining a set number of pregnancies averted. However, the general approach to national contributions says that, by increasing CPR, additional women are being protected from unintended pregnancy. Thus, national burdens can be reduced. See page 37 for more discussion about this limitation.

Note: This approach has been published in BMC public health.

Weinberger et al. Estimating the contribution of a service delivery organisation to the national modern contraceptive prevalence rate: Marie Stopes International's Impact 2 model. BMC Public Health 2013, 13(Suppl 2):S5.

<http://www.biomedcentral.com/1471-2458/13/S2/S5>

In order to account for maintaining an absolute number of users, an estimate is needed of the number of women who are continuing to receive services from an organisation. For LAPMs, continuation is built into the model, so there are already estimates of users continuing to use their LAPM from year to year (Figure 10, a). However, because the model is based on service provision data and not client-based data, it cannot account for:

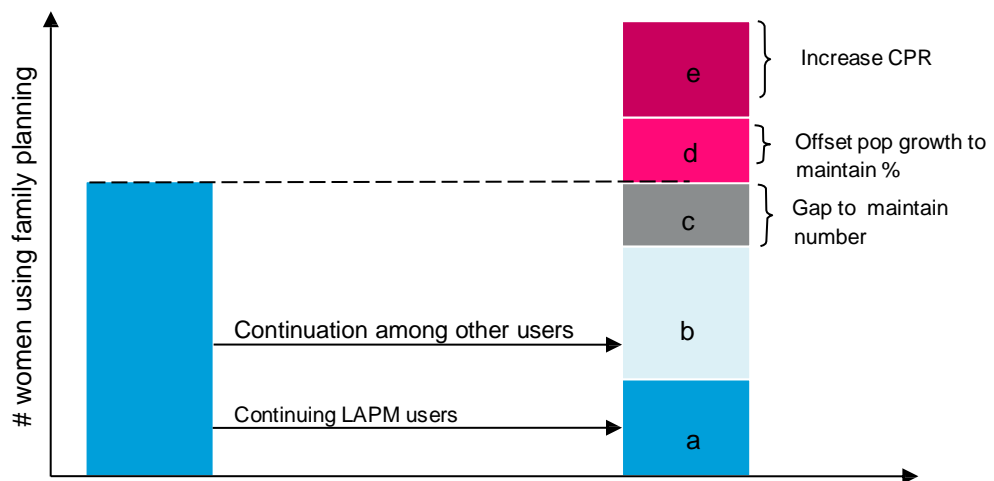
- Short term users who continue to use in future years (the number of short term users is recalculated each year, so, practically, assumes that all discontinue at the end of the year).
- Long-acting users who switch to another method after discontinuing (their re-supply method will be counted in service data, but, not linked to their previous use).



The model uses the proportion of clients who are continuing to receive services from the organisation (based on client profile, see previous section) as a proxy for continuation among the two groups listed above (Figure 10, b). In some cases, once all continuation has been accounted for, there is still a gap between the number of continuing users and the number needed to maintain the previous year's number (Figure 10, c). This is because some women may stop using family planning because they no longer have a need for contraception, or, might stop going to the service organisation for other reasons. When this happens, the gap must be filled by adopters.

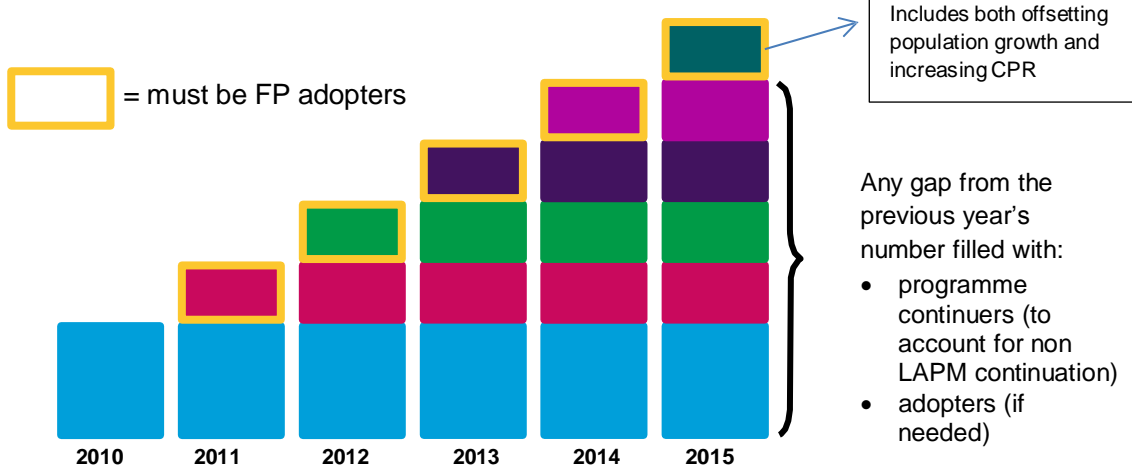
Then, once it is ensured that the previous years' number is maintained, the CPR contribution has to be maintained by offsetting population growth (in countries where population is growing). Only adopters can go to offsetting population growth, because women who were not previously using must be reached to fill this gap (Figure 10, d). Then finally, any remaining adopters will contribute towards increasing CPR (Figure 10, e). Therefore, simply reach adopters will not translate into an organisation contributing to increasing CPR. Rather, increases are only realised on top of maintaining an organizations baseline, both in terms of absolute numbers, and proportional percentage point contribution to CPR.

**Figure 10 Illustration of method behind contribution to increasing CPR**



This process is repeated for each successive year included in the trend, as illustrated below (Figure 11). In this example, enough clients were reached in each year to both maintain and increase the impact. However, it is possible that, depending on the level of service provision and the client profile, in some years there will be no increase. In some years, the previous contribution will not be maintained.

Figure 11 Illustration of year on year national contribution increases



**Note: where a trend starts**

National contributions are measured from a starting point (based on the first year in the selected trend). A 'snapshot' of the situation in the year before the trend is used as the baseline, with increases measured against this snapshot. What year is chosen as the start year in the trend will affect the estimates of national contributions. The client profile is only applied after the baseline, so full credit is claimed for all users in the baseline year, no matter what types of clients were reached historically. This must be done, because some starting point is needed. Unless you trace back to the very first year of a programme, you cannot fully tease out the national contribution of a programme. Rather, the results presented are based on national reductions achieved against this baseline contribution (for example, how many *additional* percentage points are being contributed to CPR on top of maintaining the baseline).

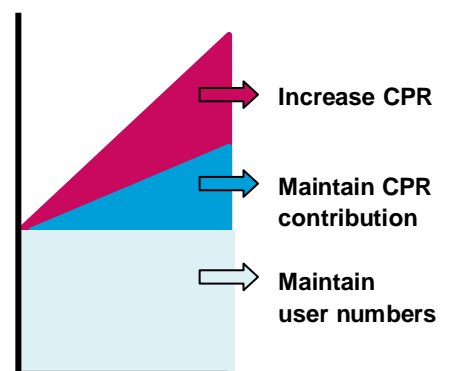
4.3.2 Contribution to increasing CPR

While market shares showed the total impact of family planning users in a country, this national contribution is measured in terms of a programme's contribution to increasing the national CPR. The model is based on the number of FP users each year and distinguishes between those users that are maintaining the *number* of users from the previous year, and those users who are increasing the overall number of users. The year on year increase in user numbers contributes to:

- maintaining the previous year's CPR contribution (see Figure 12– blue)
- increasing the CPR further (see Figure 12– fuchsia)

It is important to note that because of population growth, additional users are needed each year just to maintain a constant level of CPR.

Figure 12 Illustration of increasing CPR



The user selects the start year and end year of the trend; in the descriptions below, these will be referred to as  $y_1$  and  $y_x$ . The baseline year is the year before the start of the trend, referred to as  $y_0$ .

**a. Baseline contribution:**

Two baselines are considered. First, the number of family planning users in the baseline year ( $y_0$ ) is used, since this number must be maintained in  $y_1$ .

Next, the baseline CPR contribution is estimated by dividing the total number of family planning users in the baseline year by the projected number of women of reproductive age (WRA) in the same year. If the survey based CPR estimates entered into the model are based on all women, then the full WRA is used; or else, if the CPR estimates are for in union women, then the WRA is multiplied by the estimated percentage in union.

**b. Pre-existing users:**

Pre-existing users are the estimated number of users each year who were created by historic (i.e. baseline and before) LAPM service provision. These numbers are calculated by method and year from virtual cohorts of LAPM uses created the baseline year and in pre-baseline years for which service provision data was entered. The total number of women estimated to still be using during each year of the trend ( $y_1$  to  $y_n$ ) is summed across each cohort (see methodology described in sections 3.1.1 and 3.1.2). This gives a sum of the users in each year of the trend who resulted from historic service provision. The numbers will be declining each year due to discontinuation and mortality.

**c. New users created each year:**

The service provision data entered for the years covered by the trend ( $y_1$  to  $y_n$ ) are converted into the estimated number of new users created the year the services are provided. This follows a similar methodology as described earlier, but only calculating the first year user numbers for LAPMs services. First year LAPM users will be slightly lower than the number of clients served in the first year because some women may die, and some women will discontinue the method before the end of the first year.

For each long-acting method  $m$  (10 year IUD, 5 year IUD, 5 year implant, 4 year implant, 3 year implant), the number of users created in year  $y$  is calculated as follows

$$\text{New users}^m_{y_1} = \text{services provided}^m_{y_1} / \text{Average}(\text{CCR}_0, \text{CCR}_1)$$

Where  $\text{CCR}_i$  is the cumulative continuation rate in year  $i$  for the specified method. Note that  $\text{CCR}_0 = 1$ , since at the time of insertion all women are using the method (see section 3.1.2).

For male and female sterilisation, the number of users created in year  $y$  is calculated as follows

$$\text{New users}^m_{y_1} = \text{services provided}^m_{y_1} \times ({}_5p_x)^{\frac{1}{5}}$$

Where  ${}_5p_x$  is the probability of survival between ages  $x$  and  $x+5$  for the age group that contains the median age of sterilisation. The source for calculating  ${}_5p_x$  is described in section 3.1.1.

For short-term methods, the user numbers calculated by dividing services provided by the number of units needed for one year of coverage (see section 3.1.3):

$$\text{New users } y_1 = \frac{\text{services provided } y_1}{\text{Units needed for 1 year coverage }^m}$$

**d. Distributing users in the first year:**

First, an estimate is made of the total number of users needed to maintain the baseline number of users:

$$\text{Users needed to maintain } y_1 = \text{Baseline users} - \text{pre-existing users } y_1$$

Then, the model checks to see how new users should be distributed, based on the numbers needed and the client profile. This is done by first calculating the total number of programme continuers and adopters:

$$\begin{aligned} \text{New continuers } y_1 &= \text{New users } y_1 \times \% \text{ continuers} \\ \text{New adopters } y_1 &= \text{New users } y_1 \times \% \text{ adopters} \end{aligned}$$

There are three possible situations;

1. There are enough new programme continuers to maintain the baseline contribution, and all new adopters go to increasing user numbers.
2. There are not enough new programme continuers or adopters to maintain the baseline contribution, then all continuers and adopters are allocated to maintaining, and the number of users will decrease from the baseline contribution.
3. There are not enough new programme continuers to maintain the baseline number, so some adopters are allocated to maintaining the baseline contribution. The remaining adopters go to increasing user numbers.

The model checks to see which of the situations is occurring, then allocates new users accordingly into:

$$\begin{aligned} \text{Maintain users } y_1 &= \text{new users to maintain the baseline user number} \\ \text{Increase users } y_1 &= \text{new users to increase above the baseline user number} \end{aligned}$$

For situation 1, all adopters go to increasing, so:

$$\begin{aligned} \text{Maintain users } y_1 &= \text{baseline users} - \text{pre-existing users } y_1 \\ \text{Increase users } y_1 &= \text{new adopters } y_1 \end{aligned}$$

For situation 2, all adopters to go maintaining, so:

$$\begin{aligned} \text{Maintain users } y_1 &= \text{new adopters } y_1 + \text{new continuers } y_1 \\ \text{Increase users } y_1 &= 0 \end{aligned}$$

For situation 2, some adopters will be allocated to both maintaining and increasing, so:

$$\begin{aligned} \text{Maintain users } y_1 &= \text{baseline users} - \text{pre-existing users } y_1 \\ \text{Increase users } y_1 &= \text{new adopters } y_1 - [\text{baseline users} - \text{pre-existing users } y_1 - \text{new continuers } y_1] \end{aligned}$$

**e. Percent of new users counting towards CPR in first year:**

Next, the proportion of all new users counting towards CPR is estimated by dividing users maintaining the baseline contribution, and users increasing on top of the baseline by the total number of new users created in the first year:

$$\% \text{ counting in } \text{CPR}_{y_1} = \frac{\text{Maintain users } y_1 + \text{increase users } y_1}{\text{New users } y_1}$$

This proportion is applied across the number of new users of each method  $m$  to estimate the number of users of each method contributing to a CPR increase.

$$\text{New CPR users}_{y_1}^m = \% \text{ counting in } \text{CPR}_{y_1} \times \text{new users}_{y_1}^m$$

**f. Continuation of LAPM users from the first year (existing users):**

For the new LAPM users counting in CPR, an estimate is needed of how many will still be continuing to use their LAPM in each subsequent year left in the trend. These are referred to as “existing users”, which are different to pre-existing users (who were given services before the first year of the trend). For each LAPM method  $m$ , ‘existing users’ are calculated by following our cohort of users counting in CPR, applying the corresponding continuation rates (based on year) and mortality rates (based on age of cohort and life expectancy) each year as described in sections 3.1.1 and 3.1.2.

In the first year ( $y_1$ ), there are no existing users, because all clients who receive services are counted as ‘new users,’ and any past clients continuing to use their LAPMs are counted as ‘pre-existing users.’

**g. Repeating for remaining years:**

This process is repeated for each remaining year in the trend. However, rather than measuring again the baseline, calculations are done off the previous year. For example the second year in the trend ( $y_2$ ) measures increases against the total number of users contributing to increasing CPR in the first year ( $y_1$ ).

The total number of users contributing to a CPR increase in a given year ( $y_z$ ) is calculated as follows:

$$\text{Total users in CPR in year } y_z =$$

Pre-existing users in  $y_z$  + existing users in  $y_z$  + MaintainUsers  $y_z$  + IncreaseUsers  $y_z$

From here, the number of users needed to maintain this number in the following year ( $y_{z+1}$ ) is then calculated as follows:

$$\text{Users needed to maintain in } y_{z+1} = \text{Total users in CPR } y_z - \text{pre-existing users } y_{z+1} - \text{existing users } y_{z+1}$$

As described above in section 4, the three scenarios are considered based on the number of adopters and continuers, with new users then allocated accordingly into:

$$\begin{aligned} \text{MaintainUsers } y_{z+1} &= \text{new users to maintain the previous years' number} \\ \text{IncreaseUsers } y_{z+1} &= \text{new users to increase above the previous year' numbers} \end{aligned}$$

Next, as described above, the percentage of new users counting towards a organisation's contribution to increasing CPR is estimated, and this proportion of LAPM users are then put into virtual cohorts are traced out to estimate existing users in each of the remaining years of the trend. This iterative process is continued for each successive year, until the end of the trend is reached.

#### **h. Percentage point contribution to increasing CPR:**

The final result that is presented in the model is a programme's estimated percentage point contribution to increasing modern CPR. In other words, this is an estimate of how much a programme has/will increase the national CPR from their baseline contribution, assuming all other providers at least maintain their baseline contribution.

To estimate this figure, first, a programme's total percentage point contribution to increasing modern CPR is calculated by dividing the total number of users counting in CPR each year (total users in CPR in year  $y_z$ ) by the number of WRA in each year. (or in-union women of reproductive age if in-union only CPR is selected):

$$\text{Total \% point contribution } y_z = \frac{\text{Total users in CPR } y_z}{\text{WRA } y_z}$$

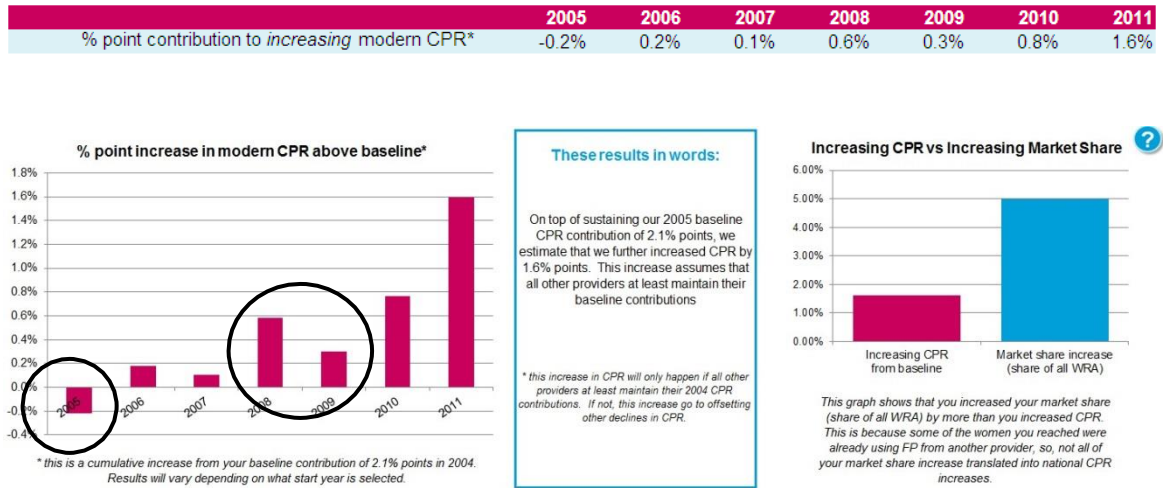
This figure includes the organisation's baseline percentage point contribution to CPR (since users maintaining the baseline are included in the total number of users counting in CPR). Therefore, to isolate the increase to CPR, the baseline percentage point contribution must be subtracted:

$$\begin{aligned} \% \text{ point contribution to increasing CPR} &= \\ \text{Total \% point contribution } y_z - \text{Baseline CPR contribution } y_0 & \end{aligned}$$

Note that the contribution is estimated relative to the baseline, not to the previous year. This means that results can be negative; this happens if a programme is unable to maintain its baseline contribution.

In the example in Figure 13, the programme has a negative contribution in 2005. This is because, when the number of users counting in CPR is considered, their contribution drops below the baseline. However, between 2008 and 2009, even though there is a *drop* from the previous year, the programme's percentage point contribution to increasing modern CPR is still positive in 2009, just smaller than in 2008.

Figure 13 Example results for contribution to increasing CPR

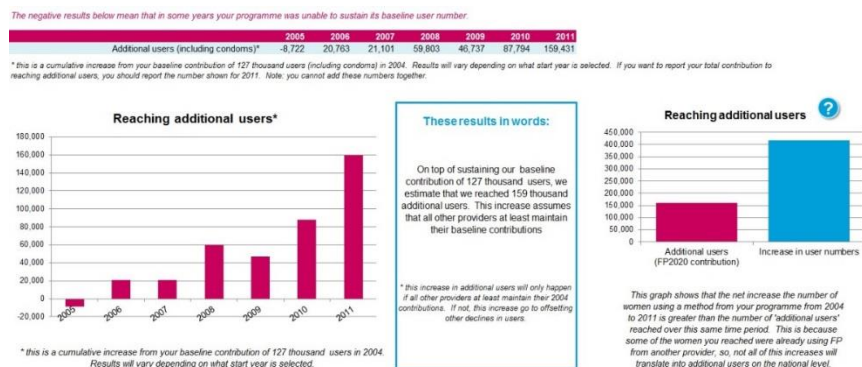


#### 4.3.3 Reaching additional users (in support of FP2020)

A second result is presented in the model to show an organisations contribution to reaching additional users. FP2020 is a global initiative that aims to expand access to 120 million additional women in the poorest countries by 2020. This reach is in addition to sustaining existing contraceptive use in these countries. This is similar to the above the concept of contribution to an increasing CPR. However, reaching additional users does not account for the need to keep up with population growth as is done for the increasing CPR calculations. Therefore, the above methodology is repeated, only, population *is held constant from the baseline year*. This measures the contribution to a national increase in the number of contraceptive users—regardless if this increase is sustaining existing CPR (to offset population growth), or, increasing CPR. The client profile is still used, so that only adopters can contribute to an organisation's contribution to national level increases in contraceptive use.

The results are displayed in a similar way, only, the focus on absolute numbers of additional users rather than % point contributions to increasing CPR.

Figure 14 Example results for reaching additional users





#### 4.3.4 National contributions towards health and demographic impacts

National contributions are estimated for all health and demographic impacts. They are estimated based on unintended pregnancies averted to women increasing CPR.

**a. Calculating women increasing CPR**

The number of women increasing CPR each year is calculated by multiplying the percentage point contribution to increasing modern CPR by WRA for each year included in the trend.

**b. Average pregnancy rate of users**

The average number of pregnancies per user is calculated each year by multiplying users by method by the appropriate pregnancy rates (following the methodology described in section 3.3). The total number of pregnancies is divided by the number of users to estimate the ratio of pregnancies per user each year.

**c. Calculating national contribution to pregnancies averted**

The ratio of pregnancies per user each year is then multiplied by the total number of women increasing CPR each year to estimate the total number of pregnancies counting towards a national contribution.

**d. Calculating other impacts**

From here, the remaining calculations follow the same methodology (and use the same data and assumptions) described in section 3.3 to section 3.3.7 to translate pregnancies into the other national reduction health and demographic impacts.

#### Reducing numbers v reducing ratios

By reducing the number of unintended pregnancies and subsequent births, family planning services play a direct role in reducing the absolute number of abortions, unsafe abortions and maternal deaths.

Understanding the impact of family planning services on the abortion ratio and the MMR is less straightforward. These ratios present a risk of abortion, unsafe abortion or maternal death *per birth*, so there is no direct relationship between reducing the number of births and reducing these ratios. However, evidence has shown that indirect relationships exist that affect the risk per birth. In terms of the MMR, family planning services reduce the proportion of births that are high risk (ie very young, very old, high parity, short birth spacing)<sup>21</sup>. By reducing the proportion of all unintended pregnancies, family planning services may also have an indirect relationship to the abortion ratio, although this relationship is not well understood.

Impact 2 is unable to account for the intricacies of the indirect relationship between family planning services and the abortion ratio and MMR. Rather, impacts are based on the absolute numbers of abortions, unsafe abortions and maternal deaths averted.

## 5 National level contraceptive use and additional users (*whole country mode only*)

Impact 2 has been updated to include a whole country mode, so that the benefits of the model can be harnessed for national-level analysis. In some cases, the calculations and results are identical for both organisation and national model. But, there are some special considerations and differences when using national mode that are outlined in this section. Total impacts and users are calculated in the same way when in whole country mode, so the methodology as outlined in section 3 applies for this model more.

### 5.1 Establishing baseline services

Impact 2 results are driven by service data. To get an accurate picture of national level use, historic service numbers are needed to (1) establish baseline level of contraceptive use, and (2) account for continuation of past LAPM clients. There are two options given for how this historic service data can be entered:

- Estimate historic services from baseline CPR and method mix
- Enter historic service data

This section covers both of these options. Establishing historic services is needed whether entering services for the specified time period, or, setting a goal for CPR or reaching additional users (see section 6).

#### 5.1.1 Estimate historic services from baseline CPR and method mix

##### a. Entering CPR and method mix

The user is asked to input modern CPR, by method, for the baseline year. This can be done for all women, or married women. The latest CPR by method is pre-loaded, but should be updated to reflect what the user thinks the CPR is in the baseline year selected.

##### b. Convert to users by method

The CPR for each method is then multiplied by the number of WRA in the baseline year (a model input); or MWRA if a married-only CPR is entered (WRA x % married; also a model input). This gives an estimate of the number of users, by method, in the baseline year.

$$\text{Users}_{\text{method } x} = \text{WRA} * \% \text{ WRA using method } x$$

##### c. Convert users into services

Next the user numbers are used to estimate the number of services provided in the baseline year, as well as in previous years (for LAPMs only).

**Short-term methods:** For short term methods, this calculation is straightforward. The total number of users is simply multiplied by the number of units needed for 1 year of coverage (a model input) to get the number of services needed to generate these user numbers.

For each short-term method x:

$$\text{Services}_{\text{method } x} = \text{Users}_{\text{method } x} \times \text{Units needed for 1 year coverage}_{\text{method } x}$$

**Long-acting and permanent methods:** For LAPMs, the calculations are more complex because they must account for services provided in the baseline year, as well as services provided in past years (e.g. women who are still using the method received before the baseline year). A methodology has been developed to create a set of historic LAPM services which will result in the specified baseline number of users for each method.

To do this, a “dummy table” of LAPM continuation was developed for each method. This table is used to calibrate the historic trend of services. This creates a trend of service provision that can be scaled to actual levels of provision needed to reach baseline use for each method. This created trend may not accurately reflect how historic services were scaled up in the country; but in the absence of historic nationally representative HMIS data, this approach is the best option available. It will produce the correct number of users in the baseline year, and give estimates of continuation of LAPM users from pre-baseline into future years.

**Creating dummy tables:** Each dummy table covers the total duration of the method (e.g. 5 years for a 5-year IUD) to account for all potential continuation of use into the baseline year. For sterilisation, the duration is based on average age of sterilisation, as described in section 3.1.2. The dummy table is based on a linear scale up of services; with a slope of 1 (e.g. an increase of “1 dummy unit” each year). For each year the dummy services are traced forward, using cumulative continuation rates for LARC, and mortality rates for sterilisation, as described in section 3.1.2. This is shown in the example table below. The numbers in the light grey boxes represent the first year of use. These are lower than the annual service numbers (1, 2, 3, 4, 5, 6) because they account for first year discontinuation.

Table X: Sample LAPM “Dummy” Acceptors Table, Five-year IUD

		Year of Analysis									Services provided
		Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8	Y9	
Year of Insertion	Y1	0.92	0.77	0.65	0.54	0.46					1
	Y2		1.84	1.55	1.30	1.09	0.9				2
	Y3			2.76	2.32	1.95	1.6	1.4			3
	Y4				3.68	3.09	2.6	2.2	1.8		4
	Y5					4.60	3.9	3.2	2.7	2.3	5
Total						11.18					15

*In Impact 2, the dummy table is adjusted so that the final year of insertion = baseline year.*

Next, a calculation is needed of the total dummy users in baseline year. This is done by taking the sum of the column that matches the baseline year. In the example above the baseline year is Y5, since this is the final year of provision for 5 year IUDs (e.g. you need to count 5 years of services to capture all continuation into the baseline year). In the example above, the dummy table scale up of services produces 11.18 users.

Next, the number of users needed in the baseline year is divided by the number of dummy users in the baseline year; this gives the scale factor, or,

the number of services per “unit” of increase in the dummy table. For example, if the scale factor is 53, rather than services increasing by 1, 2, 3 as in the dummy table, the annual service numbers would be 53, 106, 159. Therefore for each LAPM method, the services per unit are calculated as:

$$S_{u \text{ method } x} = \frac{\text{Baseline Users}_{\text{method } x}}{\text{Baseline Dummy Users}_{\text{method } x}}$$

Finally, a table of historical LAPM services is created using this “services per unit” figure. The first historic year (based on the furthest number of years to go back in order to account for full continuation into the baseline year) has a service number of  $S_u$ , the following year has a service number of  $2 \times S_u$ , the third year has a service number of  $3 \times S_u$ , etc.

This trend is created for each LAPM method.

#### d. Create table of historic services

The service number calculations from above are then populated into a table of historic services. For LAPMs, this table will include services for multiple years before the selected baseline year. For STMs, it will only include services in the baseline year.

#### 5.1.2 Enter historic services

When the user chooses to enter historic services, they are given a blank table where services by method can be entered from 1982 onwards. This inputted data then becomes the table of historic services used for all calculations within the model.

### 5.2 Modelled modern CPR

When looking at an entire country, the concept of estimating a contribution to increasing CPR does not exist since there are not issues of substitution at the national level. Any year on year increase in users will equate to a national increase in contraceptive use. Therefore calculations in whole country mode are straight forward, and can simply be based on annual user number calculations.

The annual user numbers, by method is calculated as described in section 3.1. These user estimates can be compared to WRA each year to estimate modern CPR for each year  $y$ :

$$\text{CPR}_{\text{method } x} = \frac{\text{Users}_{\text{method } x}}{\text{WRA}}$$

This calculation is done by method, and for all users to give an overall estimate of modern CPR.

#### Tracking progress between surveys

This feature of Impact 2 can be used to track national CPR changes in-between DHS surveys, or other national surveys. To do this, the last surveyed CPR should be used as the “baseline”- with historic services created by Impact 2 based on this survey. Then, nationally representative service data (e.g. HMIS and private sector data) can be entered into the selected trend years to establish CPR estimates for years subsequent to the last survey. This can give an indication of how CPR is trending, and how method mix may be changing. Estimates will only be as good as the data that is entered— in countries with limited or incomplete HMIS data, or heavy reliance on the short-term methods sold through the public sector, this approach may not be as robust.

### 5.3 Additional users

When looking at the entire country, additional users simply refer to any increase in contraceptive users from year to year. Therefore, the calculation of additional users just captures year on year increases in national contraceptive users:

$$\text{Additional users year}_x = \text{Total users year}_x - \text{Total users year}_{x-1}$$

This result can be used to track progress towards countries FP2020 goals of reaching additional users.

## 6 From goal to services

The calculations for goals are simply a reverse of those described in the preceding sections. Rather than starting with services, you start with an impact goal, and work backwards to the service provision needed to achieve the specified goal. From there, resulting impacts are also calculated, using the methodologies explained previously.

The follow goals can be set using Impact 2:

- Market share increase (organisation mode only)
- Increase CPR (organisation mode & whole country mode)
- Reach additional users (organisation mode & whole country mode)

### 6.1 Method mix to reach goal

In order to work back to service provision data, a method mix is needed to convert expanded reach into services. Therefore, a method mix must be provided in order for the goal setting units to work.

For family planning, the user must enter the method mix of *clients served each year*. If historic service provision is included in the model, the method mix is set automatically based on the method mix of the baseline year service provision. This method mix is *not* the same as the CPR by method, since this includes past LAPM clients who are continuing to use their method. Rather, this is the method mix of clients actually served (e.g. if 100 clients are served in 2015, how many will receive an IUD?).

For safe abortion and PAC services, the user can choose to enter a method mix to distribute total safe abortion and PAC services into categories by type (ie medical client service, medical product sale, surgical client service). Again, if historic service provision is included in the model, the method mix is set automatically, based on the method mix of the baseline year service provision.

### 6.2 Market share goal (organisation mode)

A goal can be set for any of the family planning market shares, the safe abortion market share or the PAC market share.

#### 6.2.1 Family planning market share goals

The methodology described in section 3.2 to estimate market shares is used here. In addition, the methodology used to estimate user numbers described in section 3.1 is applied in reverse to get to an estimate of the total number of services needed in order to produce the required user numbers.

The projected changes to the size of market (based on the linear trends created for market share estimates) are used as a default. However, the user is given the option to override this projection. A new estimated size of the market in the final year of the trend can be entered; then, a new linear trend from the size of the market at baseline to this new estimate is created.

A goal is set for a percentage point increase over the period of the trend. This increase is distributed as linear growth across the years in the trend; producing annual estimates for market share. From here, the total number of users needed each year can be estimated. Then, by accounting for continuation of historic and new (ie created during the trend) LAPM users, the number of users reached can be estimated each year. The set method mix is applied to these users to work backwards to service provision numbers.

### 6.2.2 Safe abortion and PAC market share goals

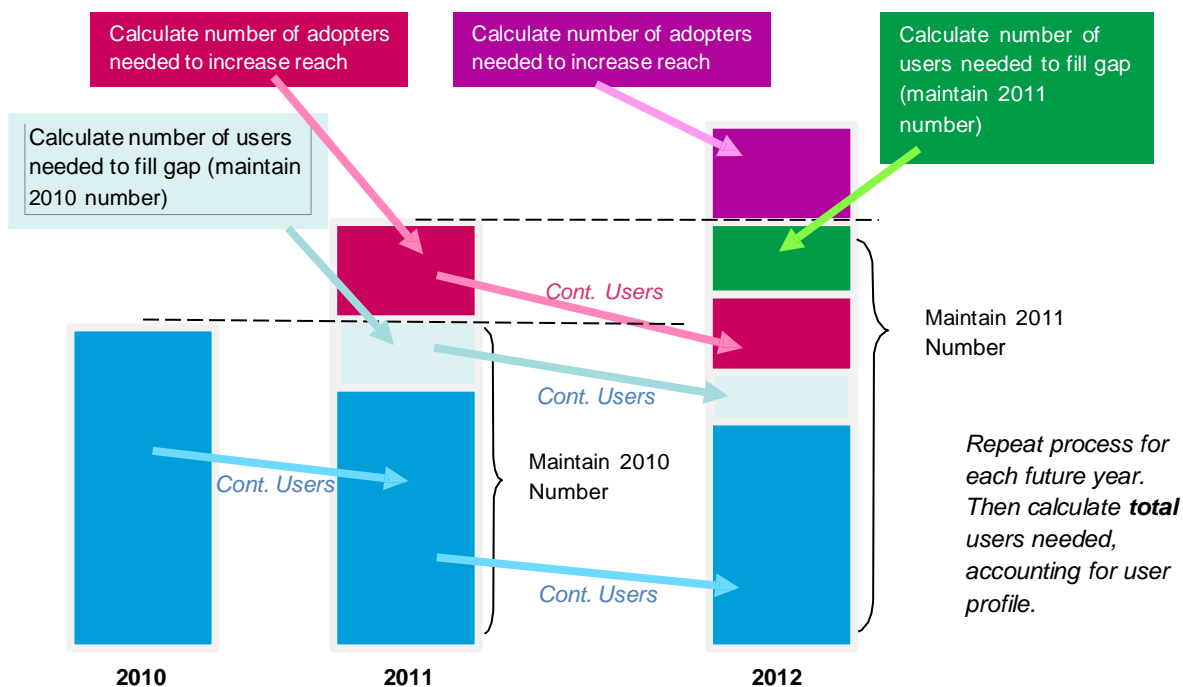
Both of these goals rely on the estimated number of abortions nationally. A goal is set for a percentage point increase over the period of the trend. This increase is distributed in a linear way across the years in the trend; producing annual estimates for market share. From here, the total number of safe abortion or PAC services needed to meet the goal in each year is calculated. Then the method mix is applied to distribute these services by type.

### 6.3 Increasing CPR goal in organisation mode

The increasing CPR goal reverses the methodology used to estimate an organisations contribution to increasing CPR, described in section 4.3.2. A goal is set for a percentage point increase in a programme's CPR contribution above the baseline over the period of the trend. This increase is distributed in a linear way across the years in the trend; producing annual estimates for CPR contribution. By comparing these estimates to WRA (all or in union depending on CPR data), the total number of users counting in an organisation's contribution to increasing CPR each year can be estimated. These users are then divided into:

- users increasing the previous year's number: these can only be adopters
- users maintaining the previous year's number: this includes pre-existing and existing LAPM users and new users who are adopters or programme continuers.

Figure 15 Illustration of allocating users to reach increasing CPR goal



From here, the model works backwards to estimate the number of new users needed each year to (1) fill any gaps in maintaining the previous year's number, and (2) increase in order to meet the goal. This gives an estimate of new users counting in CPR each year. There are two possible scenarios:

- There are enough programme continuers to maintain the previous year's contribution, and all adopters can count towards increasing the contribution.



- There are not enough programme continuers to maintain the previous year's contribution, and so some adopters must go towards maintaining the previous year's contribution.

The model determines the total number of new users needed, by inflating the client profile, depending on which scenario will occur. This total number of new users each year is then translated into service provision numbers by reversing the steps described in section 3.1.

#### 6.4 Increasing CPR goal in whole country mode

When in whole country mode, the increasing CPR goal is more straight forward since issues of substitution and the client profile is not relevant. A linear trend in CPR growth from the baseline CPR to the goal CPR is created. Then, for each year in the trend, this is converted into the number of annual users needed, based on WRA or mWRA (depending on which CPR is selected):

$$\text{Users}_y = \text{CPR}_y \times \text{WRA}_y$$

The number of LAPM users continuing from historic services is calculated for each year of the trend following the methodology described in section 3.1. Then for the first year of the trend, the gap between these continuing users and the total users needed is equal of the number of users that must be served in that year.

$$\text{UsersServe}_y = \text{Users}_y - \text{PreExistingUsers}_y$$

Using the method mix entered, the users served in the first year of the trend are then converted into service numbers. For the second year of the trend, the model accounts for both continuation of pre-existing users and continuation of users from the first year. This process is repeated in each subsequent year, giving the total number of services needed to reach the CPR goal.

#### 6.5 Reaching additional users in organisation mode

The reaching additional users goal follows the same methodology as the increasing CPR goal. However, because this result is concerned with absolute numbers of additional users, rather than CPR, the trend of users created does not account for population growth. This goal reverses the methodology described in section 4.3.3, follow the same approach described in section 6.3.

#### 6.6 Reaching additional users in whole country mode

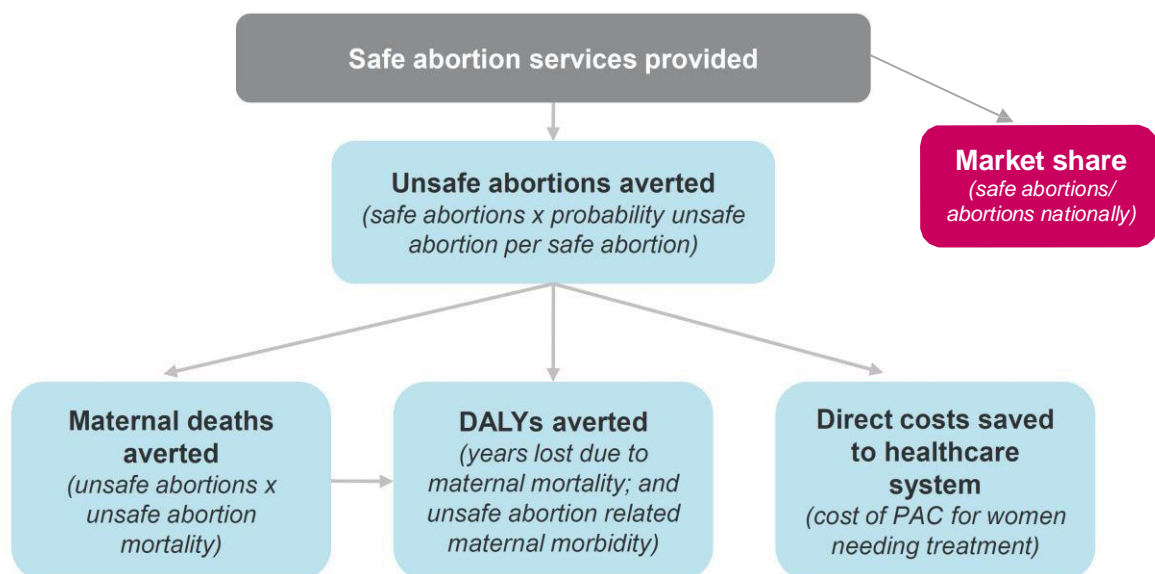
The reaching additional users goal follows the same methodology as the increasing CPR goal. However, because this result is concerned with absolute numbers of additional users, rather than CPR, the trend of users created does not account for population growth. This goal reverses the methodology described in section 5.3, following the same approach described in section 6.4.

## 7 Safe abortion services to impact

### 7.1 Background

The impacts resulting from safe abortion services are shown in Figure 16. All of the impacts flow from unsafe abortions that are averted by providing a woman with a safe abortion. This means that providing a safe abortion in an environment with no unsafe abortions will not avert any impacts in the model.

Figure 16 Impacts from safe abortion services



In a previous model, Impact Estimator 1.2, safe abortion services also averted live births. For Impact 2, we decided that we would no longer attribute live births averted to safe abortion services. The model attempts to estimate the outcomes that would have happened if the women had not received a safe abortion from the specified programme. Since a pregnancy can only end in one outcome (ie birth or abortion), it would be double counting impacts to count both the number of unsafe abortions averted and number of births averted.

The number of safe abortions provided is an input in the model; a programme can enter the total number of safe abortions provided, or they can enter service data by the type of safe abortion service provided:<sup>xiv</sup>

- Medical client service
  - Medical product sale
  - Surgical client service
- } It is up to the programme to determine what regiment of product sales equates to one safe abortion service. The input in the model is the number of safe abortions, not the number of products distributed/sold.

The calculations to estimate various impacts are outlined below.

<sup>xiv</sup> Safe abortion and PAC data are entered jointly in the model to reflect that many organisations do not separate these procedures when collecting data. A programme estimates what proportion of services provided are PAC and what proportion are safe abortions in the single country set up. This proportion is then applied to the data to get separate safe abortion and PAC service numbers.

## 7.2 Market share

Abortion market shares show what proportion of all abortions nationally (safe and unsafe) were provided by a specific provider. An overall market share is estimated based on the total number of safe abortion services, and separate market shares are estimated for the three segmentations listed above. These sub-group market shares still have the same denominator, all abortions nationally, meaning they will add together to the total safe abortion market share. This is because data does not exist to distribute the estimated number of abortions nationally by type.

In order to estimate this market share, we need to estimate the total number of abortions nationally. There are many challenges in estimating this number, given the limitations of abortion data. These are discussed in more detail in section 3.3.3.

The market shares are calculated as follows:

$$\frac{\text{Number of safe abortions provided by the programme in year } y}{\text{Number of abortions nationally in year } y}$$

The numerator is an input by the user, and the denominator is estimated as follows:

- Estimate the number of pregnancies nationally<sup>xv</sup>:

$$((\text{WRA} \times \text{TFR})/31.1) \times \text{live birth to pregnancy ratio})$$

- Multiply this by the estimated number of abortions per pregnancy:

$$\text{Abortions nationally in year } y =$$

$$\text{Pregnancies nationally in year } y \times \left( \frac{\text{abortion ratio}}{100 \text{ live births}} \times \text{live birth to pregnancy ratio} \right)$$

See section 3.3.2 for calculation of the live birth to pregnancy ratio.

## 7.3 Total and incremental impacts

### 7.3.1 Unsafe abortions

The percent of all abortions that are unsafe nationally is used to estimate what proportion of safe abortions provided avert an unsafe abortion. This ratio is used as a proxy for the likelihood that, had the women not received a safe abortion, she would have had an unsafe abortion.

The limitations of abortion data were discussed earlier (see section 3.3.3). For many regions, especially regions where most countries have highly restrictive abortion laws, the overall and unsafe abortion ratios are the same. When this happens, the model assumes that every safe abortion averts an unsafe abortion. This likely overestimates the impact of safe abortion services; however, unless better data is available, there is no way around this issue.

$$\text{Unsafe abortions averted} = \text{safe abortions provided} \times \left( \frac{\text{unsafe abortion ratio}}{\text{abortion ratio}} \right)$$

Unsafe abortions averted are calculated for each year included in the trend.

### 7.3.2 Maternal deaths

The maternal deaths averted that can be attributed to a safe abortion service are maternal deaths that may have occurred as a result of an unsafe abortion. These

<sup>xv</sup> Birth to pregnancy ratio described in section 3.3.2, estimation of pregnancies nationally described in section 0

are estimated using the unsafe abortion case fatality (maternal deaths per 100,000 unsafe abortions). The default assumptions in the model are based on regional and sub-regional estimates from the WHO report on unsafe abortion in 2017<sup>12</sup>.

$$\text{Maternal deaths averted} = \text{unsafe abortions averted} \times \left( \frac{\text{maternal deaths}}{100,000 \text{ unsafe abortions}} \right)$$

Abortion related maternal deaths averted are calculated for each year included in the trend.

### 7.3.3 Maternal DALYs

Maternal DALYs are estimated using a similar methodology to estimating maternal DALYs averted from family planning services. Years of life lost (YLL) and years lost to disability (YLD) are calculated separately.

#### a. Estimating YLLs

Years of life lost are calculated directly from the above estimate of maternal deaths averted. YLLs per maternal death from an abortion is an input to the model. The default data are sub-regional estimates from Global Burden of Disease 2016. Therefore, YLL are calculated as follows:

$$\text{Safe abortion related YLL averted} = \text{maternal deaths averted} \times \text{YLL per abortion-related maternal death}$$

Abortion related YLLs averted are calculated for each year included in the trend.

#### b. Estimating YLDs

For YLDs, calculations are based on the ratio of YLLs to YLDs for abortion related maternal conditions only to reflect the morbidity associated specifically with unsafe abortions.<sup>xvi</sup> An estimation of YLD per unsafe abortion is calculated as outlined below:

$$\text{YLD averted} = \text{YLL averted} \times \text{abortion-related YLD/YLL}$$

Abortion related YLD averted are estimated for each year included in the trend.

#### c. Total maternal DALYs averted

The above estimates of abortion related maternal YLD and YLL averted can then be summed to give the total abortion related maternal DALYs averted.

### 7.3.4 Direct cost savings

The direct costs savings associated with a safe abortion are those costs related to an unsafe abortion, namely PAC. The estimated cost of PAC uses the same approach as described in section 3.3.8. The cost of PAC is converted into the currency and year of interest specified by the user, as described earlier, so it will be comparable to other cost outputs from the model.

<sup>xvi</sup> Maternal DALYs are broken down by condition, including DALYs related to abortions. There is no split between safe and unsafe abortions. However, it is assumed all of the mortality and morbidity is associated with unsafe abortions. While there is a very small level of mortality and morbidity associated with safe abortions, it is assumed to be negligible.

Next, this cost is multiplied by the percent of unsafe abortions requiring PAC. This is an input in the model, and a global value of 42% is used as the default, in line with *Adding it Up*.<sup>7</sup> This gives an approximation of the costs averted per unsafe abortion.

Direct cost savings =

Unsafe abortions averted x [cost per PAC x (% unsafe abortions requiring PAC)]

This estimation is done for every year included in the trend.

## 7.4 National contribution

For safe abortion services, Impact 2 considers a national contribution to be impacts to safe abortions provided that are above and beyond maintaining the previous year's safe abortion market share. This calculates how population growth and fertility trends will change the estimated number of pregnancies each year, requiring a programme to maintain a relative contribution in relationship to these changes.

### 7.4.1 Proportion of safe abortion services having a national contribution

The percentage of services having a national contribution is estimated by subtracting the abortion market share in the year of interest (year y) from the market share in the previous year (year y-1). The market shares are calculated in section 7.2.

If historic services are included, a baseline is set using the safe abortion market share in the year before the first year of the trend. If historic services are not included, the baseline is set at 0%, meaning all services in the first year of the trend count towards a national contribution.

Proportion in national contribution<sub>y</sub> = market share<sub>y</sub> - market share<sub>y-1</sub>

### 7.4.2 National contribution impacts

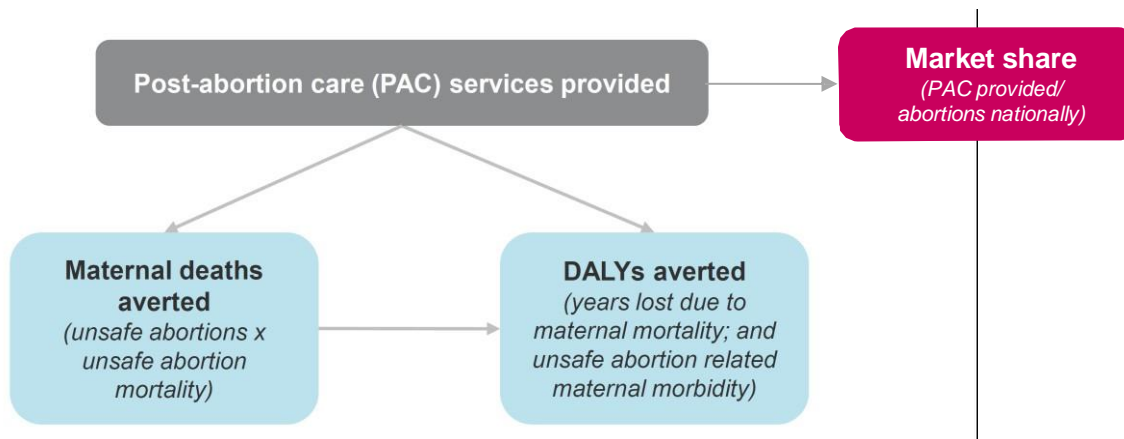
Next, each of the impacts calculated above (unsafe abortions averted, maternal deaths averted, maternal DALYs averted and costs averted) are multiplied by this percent to calculate national contribution impacts.

## 8 PAC services to impact

### 8.1 Background

The term post-abortion care (PAC) refers to a comprehensive approach that goes beyond just treating abortion related complications. However, the impact quantified by the model is focused on the provision of treatment (see Figure 17). The impact of post-abortion family planning would be captured under the family planning services section of the model.

Figure 17 Impact from post-abortion care (PAC) services



### 8.2 Market share

This calculation shows the total number of PAC services provided by a programme in a given year as a proportion of all abortions in that year. This is useful in countries with restrictive abortion laws for determining what proportion of all abortions arrive at a programme for PAC. Please note it does not calculate a programme's PAC services as a proportion of all these services nationally. The denominator includes both safe and unsafe abortions, as described in section 8.2.

The market share is calculated as:

$$\frac{\text{PAC services provided}}{\text{Abortions nationally}}$$

Market shares are calculated for each year included in the trend.

### 8.3 Total and incremental impacts

#### 8.3.1 Maternal deaths

According to the PAC Consortium, the treatment element of PAC refers to treatment of “incomplete and unsafe abortions and complications that are potentially life-threatening”<sup>22</sup>. In some cases, PAC is provided as emergency treatment where the threat of death is imminent; in other cases, PAC may be provided in a non-emergency situation where there is no immediate risk of death. In emergency situations, PAC has a very large impact because the likelihood that the women would have died if PAC was not provided is high. For the latter, had PAC not been provided, the situation could have become life threatening. In non-emergency situations, there is no data to estimate the proportion of women who would have

gone on to face life-threatening conditions had they not received this early intervention. Given these complexities, it is difficult to assess the risk of mortality and morbidity that would be averted by providing PAC.

In addition, service providers suggest that, in some cases, services recorded as PAC are provided to women who may not have really needed them; either because the abortion was already complete, or because the body would have naturally completed the abortion. In these cases, some morbidity may be averted, but the risk of mortality would be similar to a safe abortion, which is negligible (around 0.6 per 100,000<sup>12</sup>).

Given these limitations, it was decided that a general risk (ie the risk of death per unsafe abortion) would be used as a proxy of the risk of death faced by women receiving PAC. This assumes that the distribution of risk among women seeking PAC is similar to all women having an unsafe abortion.

Therefore, maternal deaths averted are estimated as follows:

$$\# \text{ women receiving PAC} \times \left( \frac{\text{maternal deaths}}{100,000 \text{ unsafe abortions}} \right)$$

Maternal deaths averted by PAC are calculated for each year included in the trend.

### 8.3.2 Maternal DALYs

The estimation of maternal DALYs follows the same methodology used for estimating DALYs averted by safe abortion services (see section 7.3.3). The abortion related YLD and YLL are used, since the mortality and morbidity averted by PAC results from an unsafe abortion.

#### a. Estimating YLLs

YLLs are calculated from the above estimate of maternal deaths averted in exactly the same way:

$$\text{PAC related YLL averted} = \text{maternal deaths averted} \times \text{YLL per abortion-related maternal death}$$

Abortion related YLLs averted are calculated for each year included in the trend.

#### d. Estimating YLDs

For YLDs, calculations are based on the ratio of YLLs to YLDs for abortion related maternal conditions only to reflect the morbidity associated specifically with unsafe abortions.<sup>xvii</sup> An estimation of YLD per unsafe abortion is calculated as outlined below:

$$\text{YLD averted} = \text{YLL averted} \times \text{abortion-related YLD/YLL}$$

PAC-related YLD averted are estimated for each year included in the trend.

<sup>xvii</sup> Maternal DALYs are broken down by condition, including DALYs related to abortions. There is no split between safe and unsafe abortions. However, it is assumed all of the mortality and morbidity is associated with unsafe abortions. While there is a very small level of mortality and morbidity associated with safe abortions, it is assumed to be negligible.



## 8.4 National contribution

For PAC services, Impact 2 considers a national contribution to be impacts to PAC services provided that are above and beyond maintaining the previous year's PAC market share. This calculates how population growth and fertility trends will change the estimated number of pregnancies each year, requiring a programme to maintain a relative contribution in relationship to these changes.

### 8.4.1 Proportion of PAC services having a national contribution

The percentage of services having a national contribution is estimated by subtracting the PAC market share in the year of interest (year  $y$ ) from the market share in the previous year (year  $y-1$ ). The market shares are calculated in section 8.27.2.

If historic services are included, a baseline is set using the PAC market share in the year before the first year of the trend. If historic services are not included, the baseline is set a 0%, meaning all services in the first year of the trend count towards a national contribution.

$$\text{Proportion in national contribution}_y = \text{market share}_y - \text{market share}_{y-1}$$

### 8.4.2 National contribution impacts

Next, each of the impacts calculated above (maternal deaths averted and maternal DALYs averted) are multiplied by this percent to calculate national contribution impacts.

## 9 Limitations

Throughout this paper, limitations either pertaining to the availability of data, or the methodological approaches taken have been highlighted. The main limitations and their implications for using results from the model are summarised below:

- **Market shares** are the only results in the model that rely on an estimate of CPR, or abortions nationally. Both of these national level estimates have significant limitations. The methodology used to project CPR changes (linear increases with some adjustments) is not very robust, especially for countries with out of date CPR estimates. The model also cannot account for how a programme's service provision is affecting CPR. Abortion data is very limited, and abortion ratios are held constant over time, meaning it is very difficult to estimate the number of abortions nationally. Therefore, this is one of the weaker results in the model.
- **Direct costs averted** use fairly crude default cost data, based on global commodity costs, and regional personnel costs. It is highly recommended that, when available, country-specific cost data is used instead of the default cost estimates.
- **Short term method users** rely on estimates of the number of commodities needed per year of protection. For coitus based methods such as condoms, the number needed for a year of coverage is particularly difficult to estimate.
- **Abortion data** is very limited; for most countries, default assumptions are based on sub-regional estimates. Within sub-regions, countries have different levels of restriction and there is wide variation between the proportion of abortions that are safe and unsafe.

In summary, results from Impact 2 are only estimates and should always be reported as such. Therefore, while estimates from Impact 2 are important, due to these limitations and others, results should only be used to tell part of the story. Many of the benefits of family planning programmes are not, and cannot, be quantified. These other important issues should be considered and addressed alongside quantitative results from the model.

## 10 Conclusion and next steps

This paper has presented the methodology used in MSI's Impact 2 model version 5. Impact 2 plays an important role in improving service delivery organisations' ability to estimate the impact their services are having. By introducing the concepts on incremental impacts and national contributions, Impact 2 allows programmes to consider how who they are reaching (adopters, provider changers, continuing users) affects the role they are playing. While the estimated total impact of a programme should still be reported, comparing this with incremental impacts and national reductions allows programmes to see the importance of reaching clients who do not already have access to services.

The "whole country" feature of Impact 2 allows the model to be harnessed for national level analysis. It is especially useful where strong national HMIS data exists; allowing for an estimate of how service provision has influences the CPR and method mix since the last survey. This use of the model is fully dependent on the quality and coverage of HMIS data, and so should be used with caution when data is incomplete (e.g. if private sector data is not included).

MSI has developed this model in consultation with other partners in the field in hopes that, as much as possible; the methodology is in line with existing work. Throughout the document, blue "looking for alternatives" boxes highlight areas where the choices were made that diverge from existing methodologies, or, areas where MSI attempted to strengthen or expand the methodology but found limitations due to available data. These are areas that MSI will strive to continue to improve and strengthen in the future.

This paper has focused on the methodology of the model; however, another important feature of Impact 2 is that it has been pre-loaded with data for almost all countries in the world. The Annexes of this report outline the methods used to estimate these data sources (when not directly available) and sources used for the pre-loaded default data available in the model. The actual data used can be found in the model itself (under single-country set up, clicking the "click to view default data" button). The default data will be updated annually to incorporate any new data releases, or more recent DHS surveys.

Supporting training materials are also being developed to support programmes to use Impact 2. These will be published at [www.maristopes.org/impact-2](http://www.maristopes.org/impact-2) as they become available.

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## Annex 1 Key terminology

### Timeframe:

- **Annual:** snapshot of impacts that *happen in a given year* (ie impact from services provided in that year and impact from LAPM clients who received services in past years, but are estimated to still be using the method)
  - *including historic:* includes services provided prior to the start year of your trend
  - *without historic:* does not include services provided prior to the start year of your trend.
- **Service lifespan:** impacts that *will happen over multiple future years*, from services provided in a given year (ie impacts from services provided in that year, and future impacts from LAPMs over the duration of their use).

### Types of result:

- **Total:** counts the full impact of a programme (ie includes impacts to all clients, regardless of their previous use).
- **Incremental:** counts impacts for which a programme is responsible, or impacts that would not exist without a programme, unless other providers increased their service levels (ie excludes impacts to clients who were ‘taken’ from another provider.
- **National contribution:** counts impacts that contribute to a national reduction in burden (ie only includes impacts to women increasing CPR).

### Family planning use:

- **Services:** products provided (these come from our partnership statistics). They only count the number of commodities distributed, not the number of clients served.
- **Client visits:** refers to the number of interactions between a programme and a client; three different women coming to the clinic is counted in the same way as one women coming three times; client visit numbers are **not** used in Impact 2.
- **Clients:** refers to women *served* each year (ie provided an FP method or other service).
- **Users:** estimate of the number of women using an FP method each year
  - converts service provision data into number of women ‘using’ each method
  - counts LAPM clients who received methods in previous years still using the method.

## Annex 2 Assigning countries to families of model life tables

### General concept:

Each country is assigned to a family of model life tables.<sup>xviii</sup> Then, using female life expectancy at birth – ( $e_0$ ) estimated (pre-2011) and projected (post-2010) as part of the UN Population Prospects (2017 Revision) – age specific mortality rates are calculated for each country, for each year, from 1980 to 2045.

This allows the model to account for changes in mortality over time. These rates are then applied to sterilisation clients to estimate how many are still alive in future years.

### Choosing a model life table (MLT):

WHO publishes country specific life tables that provide estimates of age specific female mortality rates ( ${}_5q_x$ ) for 1990, 2000 and 2009. This data was matched to age specific mortality rates from each family of model life tables corresponding to estimated female life for each of the three years.

The Impact 2 model uses female age specific survival rates ( ${}_5p_x$ ) for five year age groups, from 15–19 to 45–49.

For each year and each age group, the  ${}_5p_x$  value from the WHO country specific life table is compared to each of the corresponding  ${}_5p_x$  values from the nine families of model life tables. The closeness of fit was evaluated, with the closest four families of life tables identified (based on  $|\text{WHO}_5p_x - \text{MLT}_5p_x|$ ).

First, the top three matches were considered for each country, across each year, and each age group. Analysis was done to count the number of times each MLT appeared in the top three fits across each age group.

For countries where at least one MLT matched across all age groups: If an MLT was not in the top three for one or more age groups, this MLT was then ruled out for the country. Next, among the remaining MLTs, the one that occurred most often (mode) was selected.

For countries where no MLT appeared in the top three across all age groups: There were 40 countries that fell into this category (22%). For these countries, analysis was repeated, but extending to the top four closest matching life tables.

Only two countries did not have at least one MLT that matched across all age groups, when considering the four closest matches. For these countries, the most common MLT (mode) among the top three closest matches was used.

### Other options considered:

- ratio of infant to adult mortality
- overall mortality from 15 to 49 (probability of dying between ages 15 and 49)
- only match based on 2009 – but need to fit data from 1982 to 2045, so makes sense to consider older data as well, to get better ‘overall’ fit.

<sup>xviii</sup> There are nine families of model life tables: four developed by Coale-Demery (CD East, CD North, CD South, CD West), and five developed by the UN (UN Chilean, UN Far East Asian, UN General, UN Latin, UN South Asian).



## Annex 3 Countries/regions with missing CPR data

The following countries or regions have no CPR data available:

Aruba	Luxembourg
Brunei Darussalam	Martinique
Channel Islands	Mayotte
China, Macao SAR	Micronesia (Fed. States of)
Cyprus	Netherlands Antilles
French Guiana	New Caledonia
French Polynesia	Tonga
Guadeloupe	Western Sahara
Iceland	
Less developed regions, ex. China	
Less developed regions, ex. least developed countries	

For these countries/regions, no CPR estimates are made. Given how many factors affect contraceptive use, we decided it is not appropriate to ‘match’ CPR to other similar countries. This means that market shares cannot be calculated unless the user enters their own CPR estimates.

The following countries or regions have only one CPR estimate available:

Argentina	Israel
Austria	Latvia
Bahamas	Least developed countries
Central Asia	Libyan Arab Jamahiriya
Congo	Lithuania
Croatia	Micronesia
Dem. People’s Republic of Korea	Polynesia
Equatorial Guinea	Solomon Islands
Estonia	South-Central Asia
Fiji	Southern Asia
Gabon	TFYR Macedonia
Gambia	Turkmenistan
Guam	United Arab Emirates
	United States Virgin Islands

The UN 2011 contraceptive wall chart publishes estimated annual increases in CPR for some countries/regions that can be used to create a ‘hypothetical’ second CPR estimate. However, only three countries (Gambia, Democratic People’s Republic of Korea and Macedonia) have published rates of change available.

For these three countries, a second CPR estimate is created by applying the UN average annual rate of change to the overall CPR to get to a new CPR estimate. The method mix (between LAPMs, short term methods and traditional methods) was kept the same. For the remaining countries and regions, CPR is held constant across the model.

## **Annex 4 Annualising UN TFR and life expectancy estimates**

Data on total fertility rates and life expectancy is published by the UN Population Prospects<sup>4</sup> in five year averages (ie the average TFR between 2005 and 2009). The Impact 2 model requires annual data; therefore, the data was annualised as follows:

The published five year average is assumed to be the midpoint of the interval (ie for 2005–2009, the average value is assigned to 2007.5). From here, annual estimates are calculated by assuming a linear trend between each successive estimate.

## Annex 5 Median age of sterilisation

The below are weighted sub-regional averages based on DHS data, weighted by the number of sterilised women in each country. When a DHS survey is based on a sample size of >30, then a country specific estimate is used. If no DHS survey exists, or the sample of sterilised women is less than 30, the sub-regional average below is used.

Two alternative estimates are used for developed countries based on a UK study, and a study based on Europe and Australia.

<b>Region</b>	<b>Weighted average</b>
Eastern Africa	32
Middle Africa	31
Northern Africa	34
Western Africa	32
Central Asia	32
South-Eastern Asia	32
Southern Asia	27
Western Asia	33
Eastern Europe	28
Caribbean	31
Central America	31
South America	30
United Kingdom <sup>24</sup>	33
Developed countries <sup>25</sup>	35

## Annex 6 Estimating age specific fertility discounts

It is known that a woman's fertility varies with age. However, there is limited evidence available to quantify the relative differences in fertility across age groups. For the purposes of the Impact 2 model, age specific fertility data from Hutterites has been used to construct these discounts. The Hutterite, a community living in North America, keep detailed birth records, have high and unchanging rates of marriage, low migration and practice no contraception<sup>9</sup>. Data from this community have been used by demographers to understand possible levels of human fertility in absence of these limiting factors.

The data in columns A to C of Table 5 are from Eaton and Meyer<sup>9</sup> and show numbers of Hutterite women and births from 1946 to 1950. In order to calculate annual estimates of births, the total number of births over five years is divided by five (column D). This assumes there is an equal distribution of births across a five year period. In trying to ascertain differences in fertility, it is important to have comparable estimates across each age group. Because the median age of marriage among this group of women was 22, it means that, for the first two age groups, the marital fertility rates are skewed by the fact that few women were married, and that they were likely not married (and therefore exposed to the risk of childbirth) across all five years of the age group.

**Table 5 Estimating fertility discount factors Hurrerite data**

	A	B	C	D	E	F	G	H
	Women	Married women	Births over 5 yrs	Annual births <sup>1</sup>	Married birth rates	Adjusted annual births <sup>2</sup>	Adjusted married birth rates	Age specific fertility discounts
15–19	301	39	18	3.6	9.2%			1.0
20–24	252	173	291	58.2	33.6%	97	56.1%	1.5
25–29	220	169	421	84.2	49.8%	84.2	49.8%	1.3
30–34	180	159	352	70.4	44.3%	70.4	44.3%	1.1
35–39	130	121	224	44.8	37.0%	44.8	37%	1.0
40–44	96	93	100	20	21.5%	20	21.5%	0.6
45–49	76	74	16	3.2	4.3%	3.2	4.3%	0.1
<b>Total</b>	<b>1,255</b>	<b>828</b>	<b>1,422</b>	<b>284.4</b>	<b>34.3%</b>	<b>319.6</b>	<b>38.6%</b>	

<sup>1</sup> Annual births assumes an even distribution of births across the five years.

<sup>2</sup> Adjusted annual births takes account of the fact that exposure to marriage is lower in younger women; many of the married women giving birth in these age groups were not married for the entire five years.

Adjusted birth and fertility rates were calculated to account for this (columns F and G). For the 15–19 year old age group, no adjusted estimates are made because it was felt the sample of married women was too small and skewed to make an accurate estimate of fertility among these women. Therefore, a fertility discount of 1 (ie applying the average pregnancy rate) is used. Because Impact 2 follows cohorts from the median age of receiving an LAPM forward, there are unlikely to be any instances where this estimate is used.

For the 20–24 year old age group, the 291 births were distributed over three years, rather than five, to reflect that with a median age of marriage of 22, most women would be exposed to three years of marital childbearing. The fertility discount was then calculated by dividing the age specific fertility rate by the estimated average fertility rate across all ages. This provides an indication of how

fertility varies *relative* to the average. The comparison pregnancy rate used in Impact 2 represents an average fertility rate across all age groups, so this is the appropriate adjustment to calculate.

The fertility discounts are shown in column H. The calculations are in line with other findings reported by Eaton and Meyer that showed a peak in population fecundity at age 20, with a slow and steady decline into older ages<sup>9</sup>.

## Annex 7 Estimating miscarriages

The first three columns Table 6 are taken from Hammerslough<sup>11</sup>, and represents the probability of foetal survival by week (column A), a distribution of when induced abortions occur during pregnancy (column B), and an estimate of the number of pregnancies required initially (ie at four weeks) to have one pregnancy at each week (column C). This is calculated as:

$$1 + ((1 - \text{prob survival at week } x) / \text{probability survival at week } x)$$

For the purposes of Impact 2, these calculations were adjusted (columns D and E) to represent probabilities starting from the sixth week of pregnancy, rather than the fourth week. This slight adjustment is to look at the probability from when most pregnancies will be recognised to different pregnancy outcomes. Column D is calculated by dividing the proportion of induced abortions in a given week (column B) by .9755, the sum of the proportion of induced abortions taking place from week six onwards. Similarly, column E is calculated by adjusting the probabilities of survival to look at survival from week six onwards (.953):

$$1 + ((.953 - \text{prob survival at week } x) / \text{probability survival at week } x)$$

**Table 6 Life table of foetal survival and induced abortion**

Week	A Probability of survival	B Proportion of induced abortions	C Pregnancies required	D Proportion of induced abortions	E Pregnancies required
4	1	0.007	1		
5	0.975	0.0174	1.026		
6	0.953	0.0827	1.049	0.084777	1
7	0.934	0.1595	1.071	0.163506	1.020343
8	0.919	0.188	1.088	0.192722	1.036997
9	0.903	0.1595	1.107	0.163506	1.055371
10	0.884	0.1268	1.131	0.129985	1.078054
11	0.864	0.0917	1.157	0.094003	1.103009
12	0.845	0.0545	1.183	0.055869	1.127811
13	0.832	0.0282	1.202	0.028908	1.145433
14	0.823	0.0172	1.215	0.017632	1.157959
15	0.816	0.0117	1.225	0.011994	1.167892
16	0.811	0.0106	1.233	0.010866	1.175092
17	0.808	0.0095	1.238	0.009739	1.179455
18	0.804	0.0096	1.244	0.009841	1.185323
19	0.802	0.0076	1.247	0.007791	1.188279
20	0.8	0.0062	1.250	0.006356	1.19125
21	0.798	0.004	1.253	0.0041	1.194236
22	0.797	0.0033	1.255	0.003383	1.195734
23	0.796	0.0021	1.256	0.002153	1.197236
24	0.795	0.0014	1.258	0.001435	1.198742
25	0.794	0.0006	1.259	0.000615	1.200252

26	0.793	0.0003	1.261	0.000308	1.201765
27	0.793	0.0002	1.261	0.000205	1.201765
28	0.792	0.0001	1.263	0.000103	1.203283
29	0.791	0.0001	1.264	0.000103	1.204804
30	0.791	0.0001	1.264	0.000103	1.204804
31	0.79	0	1.266	0	1.206329
32	0.79	0	1.266	0	1.206329
33	0.789	0	1.267	0	1.207858
34	0.789	0	1.267	0	1.207858
35	0.788	0	1.269	0	1.209391
36	0.787	0	1.271	0	1.210928
37	0.786	0	1.272	0	1.212468
38	0.785	0	1.274	0	1.214013
39	0.785	0	1.274	0	1.214013
40	0.784	0	1.276	0	1.215561
41	0.783	0	1.277	0	1.217114
42	0.783	0	1.277	0	1.217114
43	0.782	0	1.279	0	1.21867
44	0.782	0	1.279	0	1.21867

Pregnancies per abortion:	<b>1.116</b>	<b>1.066</b>
Pregnancies per preg to 27 weeks:	<b>1.261</b>	

Using this data, Hammerlough<sup>11</sup> estimates how many pregnancies are required to ‘produce’ an observed number of births or abortions.

For abortions, the number of pregnancies required each week is weighted by the distribution of induced abortions by week to produce an average number of pregnancies per induced abortion. For the calculations adjusted to start at six weeks, this produces a figure of 1.066. In other words, for every induced abortion, there were an additional 0.07 pregnancies that ended in miscarriage.

Because Impact 2 accounts for stillbirths separately, an estimate is needed of miscarriages that occur between week six of pregnancy and week 27. This can be found in Column E; the figure of 1.202 means that for each pregnancy reaching week 27, there are an additional .2 pregnancies that ended in miscarriage.

These two figures (.07 miscarriages per abortion; and .2 miscarriages per pregnancy reaching 27 weeks) are used in Impact 2 to account for miscarriage as a potential pregnancy outcome. See section 3.3.2 for more details.



## Annex 8 Filling in missing data

**Country level:** matched (where applicable), or weighted.

When countries were missing data, estimates were filled in based on matching or weighting. A country was identified for matching based on being in the same geographic region with similar levels of development, and preferably similar levels and trends for the missing variable from historical comparisons. If such a country did not exist within the same region, countries outside of the region were considered. In several instances, variables may be missing for different countries, and thus the matched country may vary depending on variable.

Indicator	Matching/weighting
% married	WRA * regional average % married
Pregnancy outcomes	Matched to similar country
MMR	Matched to similar country
CO <sub>2</sub> emissions per capita	Matched to similar country
Model life table	Matched to similar country

**Regional level:** weighted (where applicable) by appropriate measure

Indicator	Matching/Weighting
Abortion ratio/unsafe abortion ratio	Weighted by number of births for: <ul style="list-style-type: none"> <li>• more developed regions</li> <li>• less developed regions</li> <li>• least developed countries</li> <li>• less developed regions, excluding least developed countries</li> <li>• less developed regions, excluding China</li> </ul>
Unsafe abortion case fatality	Weighted by number of births for: <ul style="list-style-type: none"> <li>• more developed regions</li> <li>• less developed regions</li> <li>• least developed countries</li> <li>• less developed regions, excluding least developed countries</li> <li>• less developed regions, excluding China</li> </ul>
MMR	Regional and sub-regional figures weighted by number of births when not published for geographic area needed
Unmet need	Weighted by WRA for: <ul style="list-style-type: none"> <li>• less developed regions, excluding least developed countries</li> <li>• less developed regions, excluding China</li> <li>• South-Central Asia</li> </ul> <p>* regional averages left blank for regions where more than 50% of the population did not have an estimate</p>
% Married	Weighted by WRA for: <ul style="list-style-type: none"> <li>• least developed countries</li> <li>• less developed regions, excluding least developed countries</li> <li>• less developed regions, excluding China</li> <li>• regions</li> <li>• sub-regions</li> </ul>
Pregnancy outcomes	Regions and sub-regions weighted by number births
Model life table	Regions and sub-regions based on MLT that applies to the most number of women in the region/sub-region (weighted by population).

## Annex 9 Data and sources

When a country/region is selected, the appropriate data and sources will be shown in the model. This gives a general reference for which data sources were used. To check particular country/regional data and sources, the actual Impact 2 model should be consulted.

Blanks indicate where regional or country data is preloaded. Global assumptions are shown below.

Trend data		1982 to 2055							
Population projections		1982 to 2055							
Women of reproductive age (15-49)*									
FWRATotal fertility rate (TFR)									
Female life expectancy at birth (e0)									
<i>Source: UN Population Prospects 2017 Revision (by country)</i>									
Maternal mortality		1985	1990	1995	2000	2005	2010	2015	
Maternal Mortality Ratio (MMR) per 100,000 live births									
		<i>Source: Trends in Maternal Mortality: 1990 to 2015; WHO, UNICEF, UNFPA, and The World Bank (by country)</i>							
Contraceptive prevalence rate (CPR) - <i>this is only used to estimate market shares</i>									
CPR data is for							women	<i>You should use all-wome</i>	
		Survey 1 (newest)	Survey 2 (older)						
Year of Survey				<i>Source: last 2 DHS surveys</i>					
Survey Type									
Any method									
Any LAPM									
Any short-term method									
Any traditional/folk method									

These two assumptions are used to model CPR trends, and, set the size of the long-  
 The default values (75% max CPR, and 3% max annual increase) are in line with the  
 Futures Institute to project CPR for the Hand2Hand Campaign.

Maximum future CPR	75%
Maximum average annual CPR increase	3%

## Non-trend data (held constant over time)

### Pregnancy outcomes

Abortion ratio (per 100 live births)		Source:	Calculated from abortion estimates from Ganatra, et al, (2017) and birth rates from UNPD (UN, 2017)
% of unintended pregnancies that end in abortion		Source:	Sedgh et al. <i>Intended and Unintended Pregnancies Worldwide in 2012 and Recent Trends. Studies in Family Planning</i> 2014; 45[3]: 301-314; regional estimates
% abortions that are unsafe		Source:	Ganatra, et al, 2017. <i>Global, regional, and sub-regional classifications of abortions by safety, 2010-2014: estimates from a Bayesian hierarchical model</i>
Unsafe abortion to MMR ratio		Source:	Calculated based on WHO unsafe abortion mortality, and regional MMRs; regional estimates
Percent of unsafe abortions needing post-abortion care (PAC)	42%	Source:	Adding it Up Methodology (note: not all of these cases go on to receive care); global
Unsafe abortion case-fatality (maternal deaths per 100,000 unsafe abortions)		Source:	WHO <i>Unsafe abortion: global and regional estimates of the incidence of unsafe abortion and associated mortality in 2008</i> ; regional estimates
% of your PAC/safe abortion services which are post-abortion care	0%	Note:	Default set to 0%, must be updated based on programme services.
# miscarriages for every pregnancy that reaches 28 weeks	0.20	Source:	Calculations based on Hammerslough (1992); global
# miscarriages per every abortion	0.07	Source:	Calculations based on Hammerslough (1992); global
Stillbirth rate (per 1,000 births)		Source:	Cousens et al (2011) <i>National, regional, and worldwide estimates of stillbirth rates in 2009 with trends since 1995</i> ; country specific estimates

### Women related

Source:	DHS or UN Marital Status Wall Chart	Source:	UN Population Division; 2017 estimate based on projected # married WRA/projected # WRA
	Unmet need (married women)	Source:	UN 2014 Revision Model-Based Estimates and Projections for FP Indicators

Annual pregnancy rate of non-FP users	41%	Source:	Guttmacher, Adding it Up, global assumptions
Mortality from model life table family			Source: MSI analysis, see methodology paper
<b>DALYs</b>			
DALY ratio (YLD/YLL) all maternal conditions		Source:	Global Burden of Disease 2016 ratio sub-regional estimate
DALY ratio (YLD/YLL) abortion-related maternal conditions		Source:	Global Burden of Disease 2016 ratio sub-regional estimate
YLL per maternal death (all causes)		Source:	Global Burden of Disease 2016 ratio sub-regional estimate
YLL per maternal death (abortion-related)		Source:	Global Burden of Disease 2016 ratio sub-regional estimate
Previous birth interval (PBI) deaths averted per birth		Source:	Warren Stevens & David Jeffries, analysis for MSI, August 2011
YLL per PBI death averted	84.55	Source:	Global Burden of Disease 2016; life expectancy at age 1.8 (avg global a

Method-specific data		Typical use effectiveness (Trussell 2011)	Units needed for 1 year of use	Supply Chain wastage (% wasted)	CYP factor (USAID 2011)	
<b>Long-acting and permanent methods</b>						
Female Sterilisation		99.50%			10.0	Or 13
Male Sterilisation		99.85%			10.0	Or 13
Implants- 5 year		99.95%			3.8	
Implant- 4 year		99.95%			3.2	
Implants- 3 year		99.95%			2.5	
IUD- 10 year		99.20%			4.6	
IUD- 5 year		99.80%			3.3	
<b>Short-term methods</b>						
Condoms- free		82%	98	0%	0.01	
Condoms- paid		82%	98	0%	0.01	
Female condoms- free		79%	98	0%	0.01	

Female condoms- paid	79%	98	0%	0.01
Pills	91%	13	0%	0.07
Diaphragm	88%	1	0%	1.00
Foam tablets	82%	98	0%	0.01
1-month injectables	94%	12	0%	0.08
2-month injectables	94%	6	0%	0.17
3-month injectables	94%	4	0%	0.25
Vaginal ring	91%	13	0%	0.07
Contraceptive Patch	91%	13	0%	0.07
Standard Days Method (SDM)	76%		0%	1.50
Lactational Amenorrhea Method (LAM)	78%	1	0%	0.25
Emergency contraception (EC)	75%	12	0%	0.05
Country-specific method 1	0%	1	0%	0.00
Country-specific method 2	0%	1	0%	0.00
<b>PAC/safe abortion services</b>				
Total PAC/safe abortion services			0%	
Medical- in clinic			0%	
Medical- out of clinic			0%	
Surgical			0%	

*If you do not separate your safe abortion and PAC data, then, put supply chain wastage under "total"*

Non-resupply method data		Median Age							
Female Sterilisation		<i>source: Sub-regional estimate note: this is also used for vasectomy</i>							
Implant	30	<i>source: global average</i>							
IUD	30	<i>source: global average</i>							
Standard Days Method (SDM)	30	<i>source: global average</i>							
<b>Cumulative continuation rates</b>		<b>yr 1</b>	<b>yr 2</b>	<b>yr 3</b>	<b>yr 4</b>	<b>yr 5</b>	<b>yr 6</b>	<b>yr 7</b>	<b>yr 8</b>
<i>Based on continuation curves</i>	IUD - 10 yr	87%	72%	59%	48%	40%	33%	27%	22%

for the USAID 2011 CYP update

IUD - 5 yr	87%	72%	59%	48%	40%			
Implant - 5 yr	89%	79%	71%	63%	56%			
Implant - 4 yr	89%	79%	71%	63%				
Implant - 3 yr	89%	79%	71%					
Standard Days Method (SDM)	54%	29%	16%	9%	5%	3%	1%	1%

Note: IUS assumed to have the same continuation rates as IUD

## Costs averted

Source: All cost data from the UNFPA Reproductive Health Costing Tool (RHCT)<sup>20</sup>, incidence data from RCHT and Adding it Up<sup>7</sup>

Default data is based on 'full care' – ie all women who need care receive it.

This will not reflect current cost savings if not all women currently receive care.

	Total Cost in 2011 USD	% preg incurring cost	% births incurring cost	Notes on incidence:
<b>Antenatal Care and Delivery Care</b>				
Antenatal care (ANC)		100%		100%; assumes all pregnant women receive care
Treatment of severe anaemia				Sub-regional estimate based on RHCT
Hypertensive disorders of pregnancy				Sub-regional estimate based on RHCT
Malaria prevention within ANC				Sub-regional estimate based on RHCT
Malaria treatment within ANC		0%		Assume all women receive ANC malaria prevention, so none need treatment. If not all women receive ANC malaria prevention, %ANC x malaria preg
Delivery care			100%	100%; assumes all pregnant women receive care
Postpartum care			100%	100%; assumes all pregnant women receive care
<b>Obstetric Complications</b>				
Emergency pre-referral care			20%	20%; global assumption used in Adding it up
Prelabour rupture of membranes			10%	10%; global assumption from RHCT
Prolonged labour (>18 hours)				Sub-regional estimate based on RHCT

Forceps or vacuum-assisted delivery				Sub-regional estimate based on RHCT (50% of prolonged labour)
Caesarean section (C-Section)				Sub-regional estimate based on RHCT
Antepartum haemorrhage				Sub-regional estimate based on RHCT
Postpartum haemorrhage				Sub-regional estimate based on RHCT
Puerperal sepsis				Sub-regional estimate based on RHCT
Eclampsia/severe pre-eclampsia				Sub-regional estimate based on RHCT

### Unsafe abortion related costs

Management of post-abortion complications (PAC)				Calculated based on % of unsafe abortions need PAC
-------------------------------------------------	--	--	--	----------------------------------------------------

### Other maternal conditions

Obstetric fistula				Calculated as 1% x % obstructed labour cases (based on RHCT)
Urinary tract infection		25%		25%; global assumption
Mastitis			15%	15%; global assumption

### Newborn interventions

Routine newborn care			100%	100%; assumes all newborns receive care
Newborn sepsis/infections			5%	5%; global assumption
Birth asphyxia/Breathing difficulties			3%	3%; global assumption
Low birth weight				Sub-regional estimate based on RHCT

### Total cost per pregnancy averted

Currency of cost data	USD
Year of cost data	2011

## Annex 10 Previous birth spacing (PBI) coefficient methodology

### Generation of Preceding Birth Interval Relative Risk child mortality and DALY coefficients for CYP, pregnancies and births averted for 198 countries in the MSI Impact model.

*Warren Stevens & David Jeffries August 2011*

Recently we developed a model that used demographic health surveillance study data sets to estimate the impact of below optimal birth spacing on the relative risk of death in children in a select group of countries for which PSI had an active family planning program. These models were computationally intense and were limited by the size, quality and availability of appropriate data sets. As a result MSI requested that we develop a 'proxy' version of the model, which is less reliant on data and uses self-generated probability distribution functions around measured summary statistics for the 198 countries collated within their Impact model.

What follows are descriptions of the methods used, the source data of inputs and a summary of the outputs.

There are three stages to the development of a function that estimates PBI RR deaths averted;

1. Determine a functional non-linear relationship between a universal proxy and median PBI
2. Generation of a 'generalized' Probability Distribution Function (PDF) for PBI
3. Application of child death relative risk to assumed 'shifts' in PBI due to intervention

Once we have these PDFs and functions for each of the 198 countries we can translate this data into deaths averted coefficients per CYP, pregnancy averted and birth averted. These in turn can be translated into DALY averted using the recognized YLL formula from DCP, and these are described in;

4. Summary of outputs and source data
5. Finally we compared the resulting 'coefficient method' to the non-linear effect of 'shifting' probability distributions and then estimating the impact on mortality.

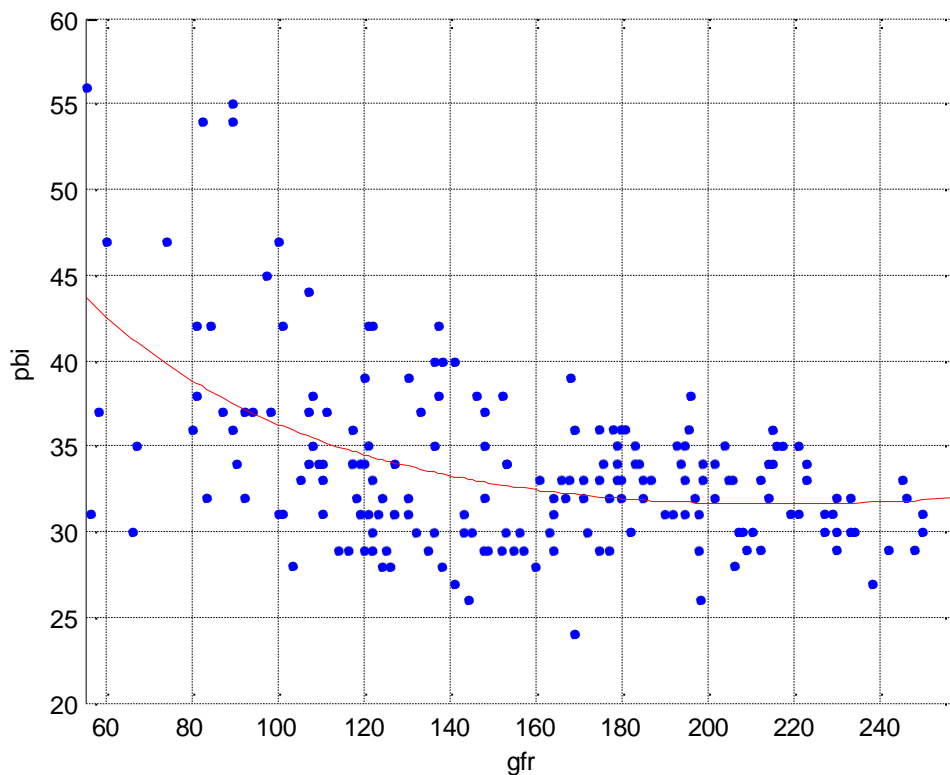


**1. Using a Fractional polynomial fit to estimate a functional relationship between PBI vs. GFR data**

Best fit, giving a highly significant ( $p < 0.0001$ ) is:

$$\text{PBI} = 32.55342 - 76.17437 \cdot (G^{0.5} - 1.250193702) + 32.55342 \cdot (G^{0.5} \cdot \log_e(G) - 0.5583327597), \text{ where } G = \text{GFR}/100.$$

Figure 1 Non-linear fit of GFR vs PBI (median).



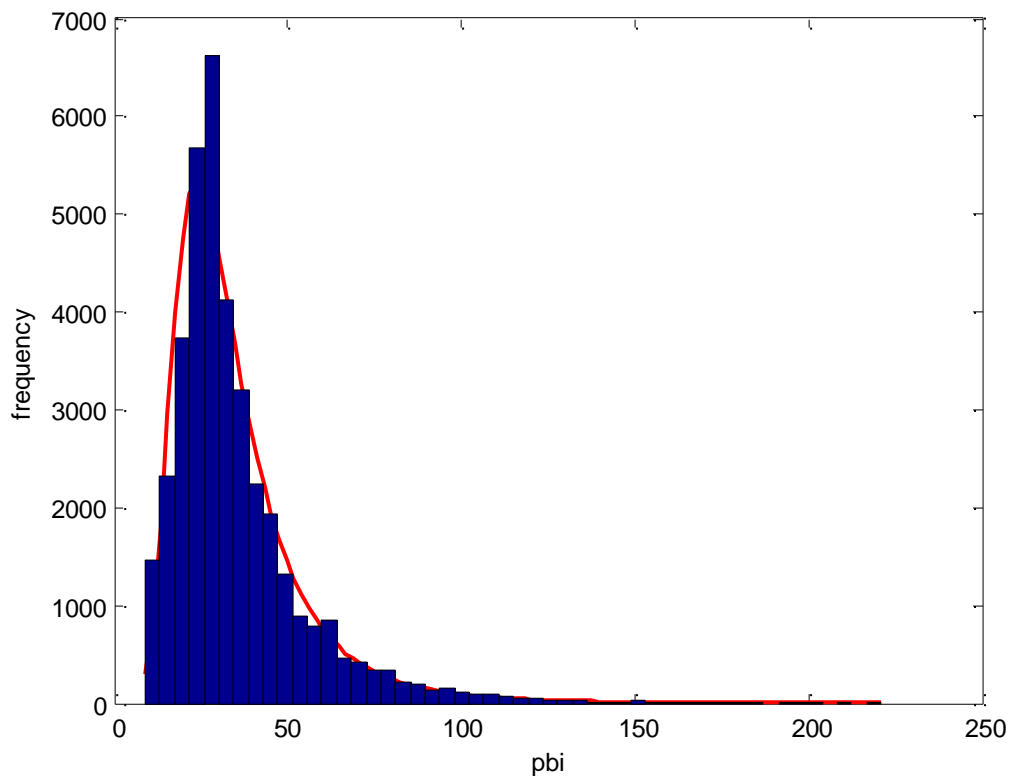
This relationship can be used to predict any PBI, given a GFR

## 2. Using Generalized Extreme Value (GEV) distribution to generate country specific PDFs for PBI

Fitting a GEV distribution to the combined three country (Tanzania, Vietnam and Uzbekistan) PBI data, gives, the following maximum likelihood estimates for the 3 distributional parameters as:

- Shape = 0.2044
- Scale = 11.2951
- Location = 25.9789

Figure 2 Fitted and actual data



Note the GEV distribution is truncated at the minimum pbi.

Median of GEV distribution = Location + scale<sup>X</sup>, where  $X = ((\log_e 2)^{-\text{shape}} - 1) / \text{shape}$

If  $M_p$  = predicted median, then assuming the same shape and scale parameters:

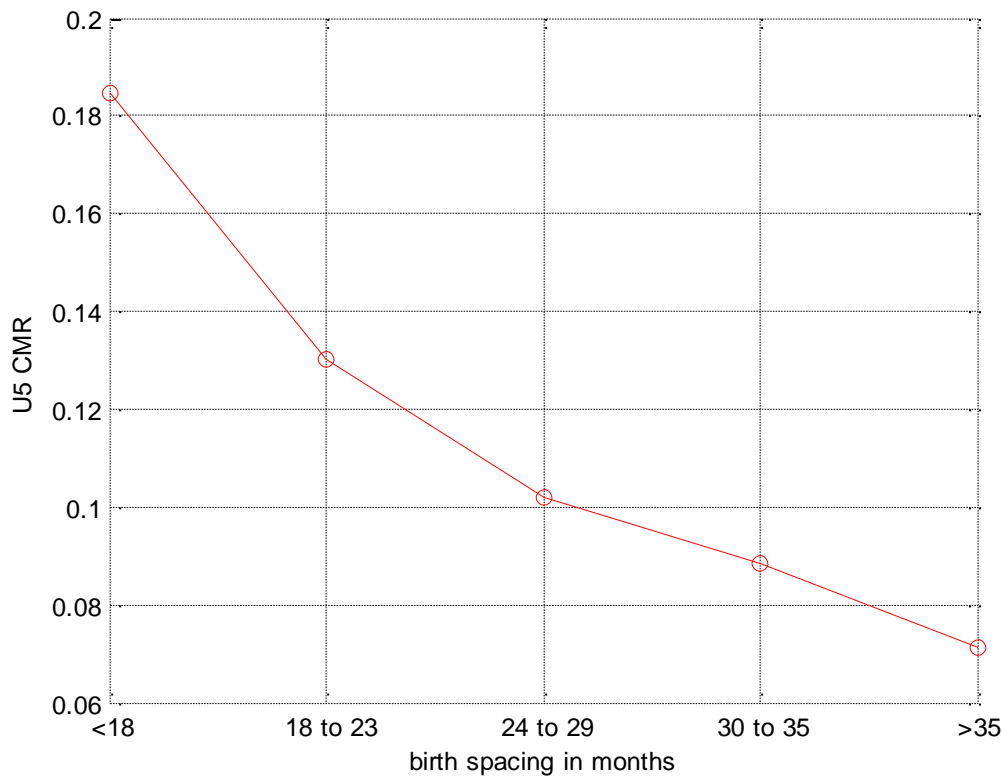
location change =  $M_p - (\text{Location} + \text{scale}^X)$

For any predicted median PBI, the GEV distribution, for the specific country predicted median PBI can then be calculated, from which any PBI regional service lifespan probabilities can be derived.

### 3. Applying Child Mortality rates to PBI shifts to estimate impact on mortality

Combining the three country birth spacing data gives:

**Figure 3** u5MR versus birth spacing (PBI)



Assume that the birth spacing class that contains the median birth spacing from Figure 1, has the country wide u5MR level. The relative risks from Figure 3 can then be used to u5MR's for each birth spacing group for each country.

The mortality change caused by shifts in birth spacing, by moving the distribution in Figure 2 to the right can then be estimated.

#### Algorithm

1. Estimate PBI given the GFR using the regression model in Figure 1.
2. Assume this represents the median PBI and use the GEV parameters to estimate the distribution of birth spaces.
3. For 1 CYP, the change in birth spacing is  $12 * 1 / (15-44 \text{ female population})$  months
4. Using the GEV distribution and the u5MR's estimate proportion of mortality this averts
5. Multiply by country level 15-44 female population \* GFR to estimate deaths averted by increase in birth spacing.

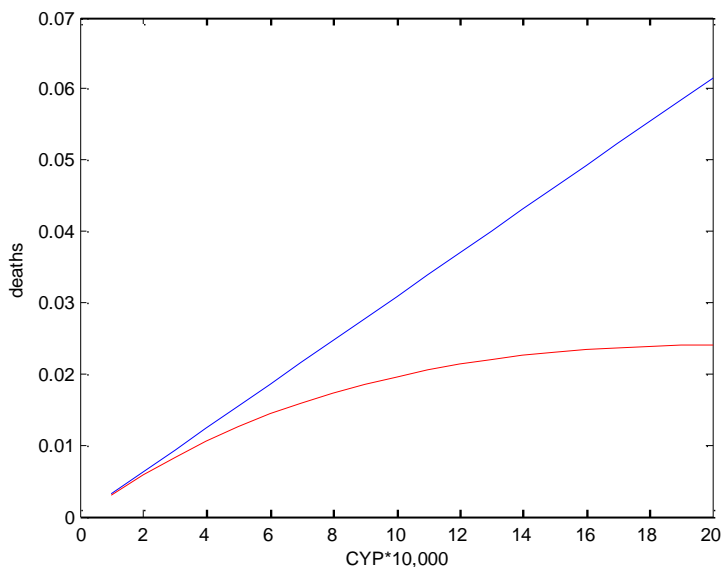
#### 4. Summary data sources

Abortions per 100 live births	Incidence of abortion worldwide (2007)
Unsafe abortions per 100 live births	Incidence of abortion worldwide (2007)
15-44 (female)	country pop of women aged 15-44 years (2010) UNPOP
TFR UN	Total Fertility rate UN
GFR UN	General Fertility rate UN
MMR UN	Maternal Mortality rate (per 1000 live births) UN
Neonatal Mortality	Neonatal Mortality Rate IHME 2010
Post Neonatal Mortality	Post Neonatal Mortality Rate IHME 2010
Age 1 to 5 Mortality	Child Mortality Rate IHME 2010
Under 5 Mortality	U5MR IHME 2010

#### 6. Comparison of coefficient method and the original non-linear model

One of the concerns we had with using single coefficients generated from a non-linear model (that estimates impact by shifting a non-linear distribution) is that significant scale changes would mean a worsening fit between the model itself and any representative (proxy) coefficients. It seems that indeed this is the case. Even though the impact of using the coefficients isn't terrible there is likely to be a tendency to over-estimation of the coefficient over the actual model. Its recommended you should move towards the full model whenever it becomes convenient to do so.

**Figure 4 PBI deaths averted against CYP: comparison of single coefficient against non-linear model**



Blue line is 'coefficient' based method i.e. CYPs \* coefficient.

Red line is using CYPs \* coefficient to calculate spacing and then estimating deaths averted as a result

This shows that coefficient based method is not a good estimate of the non-linear effect of shifting distributions and in big programs it may act as an overestimation of the true impact from the original model.

Marie Stopes International

1 Conway Street  
Fitzroy Square  
London W1T 6LP

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