National, regional, and global rates and trends in contraceptive prevalence and unmet need for family planning between 1990 and 2015: a systematic and comprehensive analysis

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Summary

Background
Expansion of access to contraception and reduction of unmet need for family planning are key components to improve reproductive health, but scarce data and variability in data sources create difficulties in monitoring of progress for these outcomes. We estimated and projected indicators of contraceptive prevalence and unmet need for family planning from 1990 to 2015.

Methods
We obtained data from nationally representative surveys, for women aged 15–49 years who were married or in a union. Estimates were based on 930 observations of contraceptive prevalence between 1950 and 2011 from 194 countries or areas, and 306 observations of unmet need for family planning from 111 countries or areas. We used a Bayesian hierarchical model combined with country-specific time trends to yield estimates of these indicators and uncertainty assessments. The model accounted for differences by data source, sample population, and contraceptive methods included in the measure.

Findings
Worldwide, contraceptive prevalence increased from 54·8% (95% uncertainty interval 52·3–57·1) in 1990, to 63·3% (60·4–66·0) in 2010, and unmet need for family planning decreased from 15·4% (14·1–16·9) in 1990, to 12·3% (10·9–13·9) in 2010. Almost all subregions, except for those where contraceptive prevalence was already high in 1990, had an increase in contraceptive prevalence and a decrease in unmet need for family planning between 1990 and 2010, although the pace of change over time varied between countries and subregions. In 2010, 146 million (130–166 million) women worldwide aged 15–49 years who were married or in a union had an unmet need for family planning. The absolute number of married women who either use contraception or who have an unmet need for family planning is projected to grow from 900 million (876–922 million) in 2010 to 962 million (927–992 million) in 2015, and will increase in most developing countries.

Interpretation
Trends in contraceptive prevalence and unmet need for family planning, and the projected growth in the number of potential contraceptive users indicate that increased investment is necessary to meet demand for contraceptive methods and improve reproductive health worldwide.
National, regional and global rates and trends in contraceptive prevalence and unmet need for family planning between 1990 and 2015: a systematic and comprehensive analysis

Supplementary webappendix

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1 DATA

1.1 Definitions of regions and sub-regions

The definition of regions and sub-regions follows that implemented in the most recent publications of the United Nations Population Division (see supplementary table 10 for the complete list adapted from World Urbanization Prospects: The 2011 Revision[1] The terms “developed countries” and “developing countries” are used for statistical convenience and do not necessarily express a judgement about the stage reached by a particular country or area in the development process. The term “country” as used in this study also refers, as appropriate, to territories or areas. The developed countries group comprises all regions of Europe plus Northern America, Australia/New Zealand and Japan. The developing countries group comprises all regions of Africa, Asia (excluding Japan) and Latin America and the Caribbean, as well as Melanesia, Micronesia and Polynesia. Results for the total population of Melanesia, Micronesia and Polynesia combined are referred to as Mela-Micro-Polynesia.

1.2 Data on contraceptive prevalence and unmet need for family planning

Data base  Data on contraceptive prevalence and unmet need for family planning are assessed and compiled on a regular basis by the United Nations Population Division. The most recent publications based on this database are the 2012 updates for the MDG Database on contraceptive prevalence and unmet need for family planning[2, 3] and World Contraceptive Use 2012.[4] The data base presents data available as of July 2012.

Contraceptive prevalence is measured as the percentage of women who report themselves or their partners as currently using at least one contraceptive method of any type (modern or traditional). Modern methods of contraception include female and male sterilization, oral hormonal pills, the intra-uterine device (IUD), male and female condoms, injectables, the implant (including Norplant), vaginal barrier methods and emergency contraception. Traditional methods of contraception include rhythm (periodic abstinence), withdrawal, prolonged abstinence, breastfeeding, douching, lactational amenorrhoea method (LAM) and folk methods.

Unmet need for family planning is defined as the percentage of women who want to stop or delay childbearing but are not using any method of contraception to prevent pregnancy. The measurement of unmet need for family planning requires survey data on desire for another birth and its timing, pregnancy, post-partum amenorrhea, infecundity, and wantedness of a current pregnancy or last live birth.

The contraceptive prevalence indicator is generally based on nationally representative household surveys with questions on current use of contraception. Surveys that commonly include this information are: Demographic and Health Surveys (DHS), Reproductive Health Surveys (RHS), Multiple Indicator Cluster Surveys (MICS), and other national surveys. On average, surveys are undertaken every three to five years. Observations from service statistics (public and private sector facilities that provide contraception) are not used because the data tend to omit use of traditional methods and service statistics systems tend to be more variable across countries in their quality and coverage of women of reproductive-age than household-based surveys.

Generally, there is no discrepancy between estimates published by the United Nations Population Division and observations of contraceptive prevalence and unmet need for family planning published in national survey reports. However, some published observations of contraceptive prevalence (in particular contraceptive prevalence disaggregated as modern and traditional method use) have been adjusted by the United Nations Population Division to improve comparability.

The data base includes 933 observations on contraceptive prevalence (any method) for 194 countries and areas. Three observations from the data base were excluded from our study because they were not related to the current use of contraception, but pertained to “past or current use” or to “method used since the last pregnancy”. In total 930 observations were used in the model. All countries or areas that do not have any observed data on
contraceptive prevalence in the data base had total populations of less than one million people in 2010, except for Cyprus. The resulting global estimates of contraceptive prevalence and unmet need cover more than 99 per cent of all women aged 15-49 who are married or in a union.

![Table showing data availability](image)

**Figure 1: Overview of the percentage of countries with 0,1,2,3,4 or 5+ observations on total contraceptive prevalence (left) or unmet need (right), summarized for all countries, for all developed countries combined, and by region for the developing countries.** The first row (green) for each group of countries refers to the entire observation period; each cell contains the percentage of countries with 0,1,2,3,4 or 5+ observations. Similarly, subsequent rows (blue) show the percentage of countries by number of observations in the period before 1990, from 1990 to 1999, from 2000 to 2004 and from 2005 to 2011. The coloured shading visualizes the percentage of countries in each cell. The number with the subgroup refers to the total number of countries within that subgroup. “LAC” refers to Latin America and the Caribbean.

**Data availability** Figure 1 gives an overview on data availability by region and period, for observations on total prevalence and unmet need. In general, 60% of the 194 countries and areas with data on contraceptive prevalence had less than five observations (930 observations in total). The earliest observation is from 1950 survey in Japan and there are 9 observations for year 2011. Countries in Asia had the most observations on contraceptive prevalence over the full time period (57% had five or more observations and another 13% had four observations). Countries in Africa also had relatively good data coverage overall (46% had five or more observations and 17% had four observations) followed by countries in Latin America and the Caribbean.
Countries in Oceania tended to have the most limited data available overall and across the different time periods. Contraceptive use data for developed countries and Latin America and the Caribbean were more sparse in recent time periods as compared with other regions.

Out of the 194 countries with any data on contraceptive prevalence, only 111 countries had data on unmet need for family planning (306 observations in total) and for many countries the data were not very recent. In Africa, a region that has the most coverage on this indicator (only 19% of countries had no observations on unmet need over the full time period), 48% of all African countries had no observations on unmet need after 2005. Among countries in Asia, 41% had no observations on unmet need followed by 49% in Latin America and the Caribbean. The majority of developed countries and those in Oceania had no observations on unmet need for family planning.

Of the 930 observations on contraceptive prevalence, 234 observations are from DHS, 86 observations from MICS, 43 observations from World Fertility Surveys (WFS), 39 from Contraceptive Prevalence Surveys (CPS), 35 observations from RHS and 22 observations from Fertility and Family Surveys (FFS). Other international survey programs provide each less than 20 observations. National surveys, that were not conducted as part of an internationally coordinated program, account for less than half of all observations on contraceptive prevalence (414 observations, 45% of all observations). The concentration towards one international survey programme is more apparent in the case of unmet need for family planning data, where of the total 306 observations, 209 observations are from DHS.

Data comparability issues Differences in the survey design and implementation, as well as differences in the way survey questionnaires are formulated and administered can affect the comparability of data over time and between countries. Two common differences are the range of contraceptive methods included and the use of probe questions regarding the types of contraceptive methods known. An example of the former is the inclusion of folk methods in some surveys. Folk methods are generally not reported and can result in overestimating the overall level of contraceptive prevalence and traditional method use. An example of the latter is when probe questions, which help ensure that the respondent understands the meaning of the different contraceptive methods, are not included in the survey and then can result in an underestimation of the use of traditional methods as respondents assume that questions from an interviewer about contraceptive use refer to modern methods and not traditional methods that one does not have to go to a pharmacy, shop or health facility to obtain, such as withdrawal or rhythm.

The characteristics (age, sex, marital or union status) of the persons for whom contraceptive prevalence is measured can also affect the comparability of data on contraceptive prevalence. We used women who are married or in a union, between ages 15 to 49 as the base population. Illustrations of alternative samples that are sometimes used in survey-based data are: sexually active women (irrespective of marital status), ever-married women, or a combined sample of men and women who are married or in a union. The time frame used to assess contraceptive prevalence can also vary. Often it is left to the respondent to determine what is meant by “currently using” a method of contraception. Some surveys ask about use within the past month. Occasionally, when information on current use is not collected, data on use of contraceptive methods at last sexual intercourse or during the previous year are utilized. For the purpose of our study, data pertaining to “method used since the last pregnancy” or to “past or current use” were excluded.

1.3 Women of reproductive age (15-49) who are married or in a union

Estimates of contraceptive prevalence were constructed for the base population of women who are married or in a union and of reproductive age (MWRA). MWRA estimates and projections in this review were prepared for individual countries on an age-specific basis, in order to take account of the substantial changes in age structure in the reproductive ages that will occur during the projection period. Estimates and projections of the number of women of reproductive age, by five-year age groups, were provided as part of the estimates and projections (Medium variant) of population in the 2010 Revision of World Population Prospects produced by the Population Division of the Department of Economic and Social Affairs of the United Nations.[5]
For most countries, marital status data were obtained through censuses, surveys and estimates based on population registers. The proportions of women married or living in consensual union, by five-year age groups were taken from World Marriage Data 2008. For countries in Europe, where data did not report consensual unions, these data were complemented by estimates of the proportion of women aged 20-34 years living in cohabitation in or around year 2000. Marital status figures were available for about 99% of the world population.
2 METHODS

The goal of this study was the categorization of MWRA (the base population) into four groups: women who use traditional contraceptive methods, women who use modern contraceptive methods, women who have unmet need for contraceptive methods, and women who do not need any method (who are not avoiding a pregnancy). In other words, the outcome of interest was a compositional vector, here denoted by $\mathbf{p}_{c,t} = (p_{c,t,1}, p_{c,t,2}, p_{c,t,3}, p_{c,t,4})$, where $p_{c,t,m}$ denotes the proportion of women in country $c$, in year $t$, who use traditional methods ($m = 1$), modern methods ($m = 2$), have unmet need for contraceptive methods ($m = 3$), or do not use and do not need contraceptive methods ($m = 4$), see Figure 2.

![Composition of p](image)

Figure 2: Illustration of composition $\mathbf{p}_{c,t} = p_{c,t,1:4}$. Categorization of women who use traditional contraceptive methods, women who use modern contraceptive methods, women who have unmet need for contraceptive methods, and women who do not need any method (who are not avoiding a pregnancy).

Compositional vector $\mathbf{p}_{c,t}$ was not observed, instead we observed $\mathbf{y}_i = y_{i,1:4}$, where $y_{i,m}$ denotes the proportion of women in category $m$ (traditional, modern, unmet need, no need respectively) for observation $i = 1, \ldots, I$ for country $c[i]$ and year $t[i]$. The data model for an observation $y_i$ given $\mathbf{p}_{c[i],t[i]}$ is explained in detail in Section 2.3. In short, we assumed that the expected values of the log-ratios of various observed proportions in vector $\mathbf{y}_i$ are equal to the corresponding log-ratios of the vector $\mathbf{p}_{c[i],t[i]}$’s for observations from the base population, and a bias-adjusted and/or perturbed version of $\mathbf{p}_{c[i],t[i]}$ otherwise (to take into account possible errors in measuring $\mathbf{p}_{c,t}$ caused by survey characteristics). First we discuss the model for the changes over time in the compositional vector $\mathbf{p}_{c,t}$ and the hierarchical structure when estimating these time trends.

2.1 Time trends in contraceptive prevalence and unmet need

Modeling components of the compositional vector Because the components of compositional vector $\mathbf{p}_{c,t}$ are restricted to add up to one, they cannot be modelled independently; independent models for each component $p_{c,t,m}$ for $m = 1, 2, 3, 4$ would not guarantee that they add up to one. We guarantee that the components do add up to one by modelling total contraceptive method use over time, to then categorize the women who use any contraceptive method into modern and traditional methods, and the women who do not use any method into women with unmet need and women without need for contraceptive methods. Specifically, if $P_{c,t}$ denotes total contraceptive prevalence, $R_{c,t}$ the ratio of modern to total prevalence, and $Z_{c,t}$ the ratio of unmet need to no contraceptive use in country $c$, year $t$

$$P_{c,t} = p_{c,t,1} + p_{c,t,2},$$

\[1\]
for any method. The asymptotes of total contraception and the ratio of modern to total use depend on the timing, pace and asymptotes for total prevalence, and the uptake of modern methods as a ratio of any method. The asymptotes of total contraceptive use and the ratio of modern to

\[
R_{c,t} = \frac{p_{c,t,2}/(p_{c,t,1} + p_{c,t,2})}{p_{c,t,3}/(p_{c,t,3} + p_{c,t,4})},
\]

\[
Z_{c,t} = \frac{p_{c,t,3}/(p_{c,t,3} + p_{c,t,4})}{p_{c,t,4}/(1 - Z_{c,t})},
\]

with \(0 \leq P_{c,t}, R_{c,t}, Z_{c,t} \leq 1\), then the compositional vector \(p_{c,t}\) is given by:

\[
p_{c,t,1} = (1 - R_{c,t}) \cdot P_{c,t},
\]

\[
p_{c,t,2} = R_{c,t} \cdot P_{c,t},
\]

\[
p_{c,t,3} = (1 - p_{c,t}) \cdot Z_{c,t},
\]

\[
p_{c,t,4} = (1 - p_{c,t}) \cdot (1 - Z_{c,t}),
\]

with \(\sum_{m=1}^{4} p_{c,t,m} = 1\).

We modelled \(\{P_{c,t}, R_{c,t}, Z_{c,t}\}\) on the logit-scale to restrict the outcomes to be between 0 and 1. Each of the quantities is modelled by systematic (latent) trends, with autoregressed distortions added to it:

\[
P_{c,t} = \logit^{-1} \left( \logit(p_{c,t}^{*}) + \varepsilon_{c,t} \right),
\]

\[
R_{c,t} = \logit^{-1} \left( \logit(R_{c,t}^{*}) + \eta_{c,t} \right),
\]

\[
Z_{c,t} = \logit^{-1} \left( \logit(Z_{c,t}^{*}) + \theta_{c,t} \right),
\]

where the country-specific systematic trends are denoted by \(\{P_{c,t}^{*}, R_{c,t}^{*}, Z_{c,t}^{*}\}\) and the autoregressed distortions by \(\{\varepsilon_{c,t}, \eta_{c,t}, \theta_{c,t}\}\) for \(\{P_{c,t}, R_{c,t}, Z_{c,t}\}\) respectively. The distortions were modelled by autoregressive processes of order 1 (AR(1)-models):

\[
\varepsilon_{c,t} \sim N(\rho \varepsilon_{c,t-1}, \tau_{v}^{2}),
\]

\[
\eta_{c,t} \sim N(\rho \eta_{c,t-1}, \tau_{\eta}^{2}),
\]

\[
\theta_{c,t} \sim N(\rho \theta_{c,t-1}, \tau_{\theta}^{2}),
\]

with autoregressive parameter \(0 < \rho < 1\) and variance \(\tau^{2}\). The distributions for the distortions in the first observation year \(t_{c,1}\) in country \(c\) are given by:

\[
\varepsilon_{c,t_{c,1}} \sim N(0, \frac{\tau_{v}^{2}}{1 - \rho^{2}}),
\]

\[
\eta_{c,t_{c,1}} \sim N(0, \frac{\tau_{\eta}^{2}}{1 - \rho^{2}}),
\]

\[
\theta_{c,t_{c,1}} \sim N(0, \frac{\tau_{\theta}^{2}}{1 - \rho^{2}}),
\]

Systematic trends in contraceptive use The systematic trends in total contraceptive prevalence \(P_{c}^{*}\) and the ratio of modern to total use \(R_{c}^{*}\) are given by logistic curves from 0 to asymptotes \(\tilde{P}_{c}\) and \(\tilde{R}_{c}\), increasing at pace \(\omega_{c}\) and \(\psi_{c}\) and centred in year \(\Omega_{c}\) and \(\Psi_{c}\) respectively:

\[
P_{c,t}^{*} = \frac{\tilde{P}_{c}}{1 + \exp(-\omega_{c}(t - \Omega_{c}))},
\]

\[
R_{c,t}^{*} = \frac{\tilde{R}_{c}}{1 + \exp(-\psi_{c}(t - \Psi_{c}))},
\]

The systematic trends in total prevalence, its break-down into modern and traditional method use, and example trajectories after adding the autoregressed distortion terms are illustrated in Figure 3 (panel a). Note that the trend in traditional method use (the inverted U-shape in the illustration) is not modelled explicitly, it follows from the logistic curves for total prevalence and for the ratio of modern to total prevalence. The actual trend in a country of interest depends on the timing, pace and asymptotes for total prevalence, and the uptake of modern methods as a ratio of any method. The asymptotes of total contraceptive use and the ratio of modern to
total prevalence in a country may vary for a number of reasons, in part due to restrictions on the availability of modern methods or the extent to which induced abortion is practised. We do not take into account these other factors.

Examples of different segments of different “contraceptive prevalence transitions” are given in panel b for Bangladesh and France. In Bangladesh, the increase of total contraceptive prevalence is driven almost entirely by the uptake of modern methods, and the start of the contraceptive prevalence transition is within the observation period. France is at the end of its contraceptive prevalence transition. From 1970 onwards, the use of modern contraceptive methods increased, while the use of traditional methods declined.

**Systematic trends in unmet need** The country-specific systematic trend in the ratio of unmet need to no contraceptive use, $Z^*_c,t$, was modelled as a function of total prevalence $P_{c,t}$. We chose to model the ratio as a function of total contraceptive prevalence, as opposed to unmet need as a function of total contraceptive prevalence for two reasons. Firstly, modelling the ratio of unmet need to no contraceptive use guarantees that the percentage of women with unmet need does not exceed the percentage of women who do not use any methods. Secondly, unmet need and total contraceptive use are dependent (because they refer to the elements of the same compositional vector), while the ratio is not dependent on total contraceptive use. The model for the ratio is given by:

$$Z^*_c,t = \frac{1}{1 + \exp(z_c + \beta_1 (P_{c,t} - 0.4) + \beta_2 \cdot (P_{c,t} - 0.4)^2)}, \quad (19)$$

with country-specific “intercept” $z_c$ and world-level parameters $\{\beta_1, \beta_2\}$. (Note that 0.4 was subtracted from $P_{c,t}$ to reduce correlation between the $z_c$’s and the $\beta$’s, this does not affect the fitted trend line). This model was motivated by observed trends on the world and country level, as illustrated in Figure 4 The observed world pattern (illustrated by a loess fit to the data) corresponds closely with the fit of the parametric function.

**Note on the inclusion of covariates for estimating contraceptive prevalence and unmet need** Given the lack of data on contraceptive prevalence and in particular, unmet need for several countries, covariates that are deemed to be associated with the outcomes of interest, such as the wanted total fertility rate or women’s educational attainment, could be considered for inclusion in the model as predictors. We chose not to include covariates because for most candidates, data are limited and additional model assumptions would be required to construct estimates and short-term projections of the covariate for all country-years of interest. Gains of including a covariate may be limited if there is considerable uncertainty associated with it. Instead, our approach was to focus on developing a parsimonious and internally consistent model of family planning indicators. The advantage of this approach is that modeled estimates can be used in further analyses to examine the ways that family planning behaviour is associated with covariates of interest without the pitfall of “rediscovering” covariates that were used to estimate the family planning indicators in the first place.
Figure 3: Theoretical model of contraceptive prevalence (total, modern and traditional methods) over time. (a) Model representation: simulated examples of systematic trends (smooth lines, modelled by parametric functions on contraceptive prevalence and the ratio of modern use to any method use), and simulated trajectories (non-smooth lines, modelled by the systematic trends with autocorrelated distortions) of total, modern and traditional prevalence. (b) Trajectories of contraceptive prevalence for Bangladesh and France illustrate segments of different examples of the “contraceptive prevalence transition”.

a: Model representation.

b: Illustrations.
Figure 4: Illustration of the model for the ratio of unmet need to no contraceptive use. (a) The ratio of unmet need for contraceptives to no contraceptive use plotted versus total contraceptive prevalence. Observations are highlighted for selected countries, observations for remaining countries are plotted in black. A loess smoother fit to the data (dashed red line) suggests the “observed world pattern”, which corresponds closely to the parametric function used in our model (solid orange line). (b) The ratio of the percentage change in unmet need to a one percentage point increase in contraceptive prevalence plotted versus total contraceptive prevalence. The solid orange line illustrates the estimated relation between the rate of change ratios and the level of contraceptive prevalence, showing that for a trajectory of increasing contraceptive prevalence, unmet need is first estimated to increase (until a contraceptive prevalence level of around 20%) before the decrease sets in. Subsequently, the rate of decrease in unmet need accelerates until contraceptive prevalence is around 60%. Dots represent the observed ratios from subsequent surveys in countries, plotted versus the average of reported contraceptive prevalence in the two surveys. A loess smoother fit to the data (dashed red line) suggests a similar trajectory of changes in the rate of change in unmet need, as compared to changes in contraceptive prevalence.

a: Model representation.  
b: Rate of change.

2.2 Bayesian hierarchical model

Estimating the country-specific parameters of the systematic trends presented a challenge because of the limited number of observations for each country. We used a Bayesian hierarchical model [8, 9] to estimate the parameters in each country, such that the estimates are based on the observations in the country of interest, as well as on the (sub)-regional and/or global experience. For classifying countries into (sub)-regions, we used the United Nations Population Division classification described earlier.

Different levels of hierarchy were used for different sets of country parameters to best incorporate expected differences and similarities across countries and (sub)-regions. Country-specific asymptotes $\tilde{P}_c$ and $\tilde{R}_c$ for total contraceptive prevalence and the ratio of modern to total contraceptive use, were estimated with a hierarchical model with one level (world-country):

$$\log \left( \frac{\tilde{P}_c - 0.5}{1 - \tilde{P}_c} \right) \sim N(\tilde{P}_w, \kappa^{(c)}_P),$$
\[
\log \left( \frac{\hat{R}_c - 0.5}{1 - \hat{R}_c} \right) \sim N(\hat{R}_w, \kappa_R^{(c)}),
\]
where both asymptotes were restricted to be between 50% and 100% (based on expert opinion), and \(\hat{P}_w\) is world mean and \(\kappa_R^{(c)}\) the variance of \(\hat{P}_c\)'s, and \(\hat{R}_w\) is world mean and \(\kappa_R^{(c)}\) the variance of \(\hat{R}_c\)'s.

For pace parameters \(\omega_c\) and \(\psi_c\), three-level hierarchical models were used because these parameters are expected to vary across countries, sub-regions and regions. For pace parameter \(\omega_c\) for the uptake of any method, the transformation
\[
\omega_c^* = \log \left( \frac{\omega_c - 0.01}{0.5 - \omega_c} \right)
\]
is used, such that \(\omega_c\) is restricted to be between 0.01 and 0.5 (a reasonable range, corresponding to the transition from 10% to 90% of \(\hat{P}_c\) taking at least 10 years, and at most 4 centuries), and the hierarchical distributions are given by:
\[
\begin{align*}
\omega_c^* & \sim N(\omega_c^*|c], \kappa_c^{(c)}), \\
\omega_s^* & \sim N(\omega_s^*|s], \kappa_c^{(s)}), \\
\omega_r^* & \sim N(\omega_r^*|r], \kappa_c^{(r)}),
\end{align*}
\]
such that the (logit-transformed) \(\omega_c\)'s are distributed around a sub-regional mean \(\omega_c^*|c]\) (\(s[c]\) refers to the sub-region of country \(c\)), and the sub-regional means are distributed around a regional mean \(\omega_s^*|s]\) (\(r|s]\) is the region of sub-region \(s\)). The variances on the country, sub-regional and regional level are expected and again a three-level model is used: \(\psi_c\), three-level hierarchical models were used because these parameters are expected to vary across countries, sub-regions and regions. For pace parameter \(\psi_c\) for the uptake of any method, the transformation
\[
\psi_c^* = \log \left( \frac{\psi_c - 0.01}{0.5 - \psi_c} \right),
\]
is used, such that \(\psi_c\) is restricted to be between 0.01 and 0.5 (a reasonable range, corresponding to the transition from 10% to 90% of \(\hat{P}_c\) taking at least 10 years, and at most 4 centuries), and the hierarchical distributions are given by:
\[
\begin{align*}
\psi_c^* & \sim N(\psi_c^*|c], \kappa_c^{(c)}), \\
\psi_s^* & \sim N(\psi_s^*|s], \kappa_c^{(s)}), \\
\psi_r^* & \sim N(\psi_r^*|r], \kappa_c^{(r)}),
\end{align*}
\]
For the timing of the uptake of modern methods (as a proportion of any method), \(\Psi_c\), differences in (sub)-regional means are expected and again a three-level model is used:
\[
\begin{align*}
\Psi_c & \sim N_T(\Psi|c], \kappa_\Psi^{(c)}), \\
\Psi_s & \sim N(\Psi|s], \kappa_\Psi^{(s)}), \\
\Psi_r & \sim N(\Psi|r], \kappa_\Psi^{(r)}),
\end{align*}
\]
where the country-specific timings are restricted to be later than 1800 (a non-informative lower bound). Similarly, for the timing of the uptake of any method, \(\Omega_c\), the model for the developing countries (denoted by \(c \in L\)) is again a three-level hierarchical model:
\[
\begin{align*}
\Omega_c & \sim N_T(\Omega|c], \kappa_\Omega^{(c)}), \quad c \in L \\
\Omega_s & \sim N(\Omega|s], \kappa_\Omega^{(s)}), \\
\Omega_r & \sim N(\Omega|r], \kappa_\Omega^{(r)}),
\end{align*}
\]
while for all developed countries there is no distinction between regions; we do not expect differences in (sub-)regional means across developed countries:
\[
\begin{align*}
\Omega_c & \sim N_T(\Omega|D], \kappa_\Omega^{(D)}), \quad c \in D.
\end{align*}
\]
Finally, the country-specific “intercept” $z_c$ for the proportion of women with unmet need among all women who do not use any contraceptive methods is modelled with a two-level model (given the variability across sub-regions within regions, subregional means are not assumed to be distributed around a regional mean):

$$
\begin{align*}
  z_c & \sim N(z_{s[c]}, \kappa_{z}^{(c)}), \\
  z_s & \sim N(z_{w}, \kappa_{z}^{(r)}).
\end{align*}
$$

### 2.3 Data model

As before, let $y_{i,m}$ denote the proportion of women in category $m$ for observation $i = 1, \ldots, I$, where $m$ refers to 1) women using a modern method, 2) women using a traditional method, 3) women with unmet need and 4) women without need for contraceptive methods ($m = 1, 2, 3, 4$). We used the Logistic-normal distribution for compositional data.\(^{[10, 11]}\) This corresponds to assuming a multivariate normal distribution for the log-ratios of all-but-one of the categories in a compositional vector with respect to a left-out category. Because unmet need was missing for many observations (only the sum of women who do not use any method was known), the data model was set up sequentially; we first considered the log-ratios of traditional to no contraceptive method use and modern to no contraceptive method use (or total to no method use if the break-down into traditional and modern method use was missing), and then considered the log-ratio of unmet need to no need for contraceptive methods for observations with information on this break-down.

Specifically, with $y_{i,3+4} = y_{i,3} + y_{i,4}$, the data model for categorization of all women into categories (1), (2) and (3+4) is given by:

$$
\begin{bmatrix}
  \log \left( \frac{y_{i,1}}{y_{i,3+4}} \right) \\
  \log \left( \frac{y_{i,2}}{y_{i,3+4}} \right)
\end{bmatrix} \sim N\left( \begin{bmatrix}
  \log \left( \frac{q_{i,1}}{q_{i,3+4}} \right) \\
  \log \left( \frac{q_{i,2}}{q_{i,3+4}} \right)
\end{bmatrix}, \Sigma_S[i] \right),
$$

where $q_{i,m}$ is the perturbed and bias-adjusted proportion of women in category $m$ for observation $i$ ($p_{c[i],t[i],m}$ for non-biased observations from the base population, and the perturbed and bias-adjusted version of that proportion for other observations, explained in detail in Sections \([2.3.2]\) and \([2.3.3]\) and summarized in Section \([2.3.4]\). $S[i]$ refers to the source of observation $i$ (the categorization of sources is explained in Section \([2.3.1]\), and covariance matrix $\Sigma_S$ is given by:

$$
\Sigma_S = \begin{bmatrix}
  \sigma_{S,1}^2 & \rho_S \sigma_{S,1} \sigma_{S,2} \\
  \rho_S \sigma_{S,1} \sigma_{S,2} & \sigma_{S,2}^2
\end{bmatrix},
$$

where $\sigma_{S,k}^2$ is the error variance of source $S$ for the log-ratios $k = 1$ (traditional) and $k = 2$ (modern), and $\rho_S$ is correlation in the log-ratios. For observations with outcomes on all methods only (traditional and modern combined, 13 observations), the data model is given by:

$$
\log \left( \frac{y_{i,1+2}}{1 - y_{i,1+2}} \right) \sim N\left( \log \left( \frac{q_{i,1+2}}{1 - q_{i,1+2}} \right), \sigma_T^2 \right),
$$

where $\sigma_T^2$ is the error variance for total prevalence on the logit-transformed scale. Because of the limited number of observations, this error variance is assumed to be the same across all sources.

The data model for the break-down of women who do not use any method (categories 3 and 4) into the categories unmet/no need is given by:

$$
\logit \left( \frac{y_{i,3}}{y_{i,3+4}} \right) = \log \left( \frac{y_{i,3}}{y_{i,4}} \right) \sim N\left( \log \left( \frac{q_{i,3}}{q_{i,4}} \right), \sigma_{S,i,3}^2 \right),
$$

where $\sigma_{S,3}^2$ is the error variance of source $S$ for the log-ratios of unmet need to no need. To avoid difficulties with undefined ratios, observed proportions $y_m$ smaller than 1% were rounded upwards to 1%. 

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2.3.1 Data categorization based on source types

We categorized the different data sources for contraceptive use into four categories: 1) DHS (234 observations), 2) MICS (86 observations), 3) other international survey programmes (196 observations), and 4) National surveys (414 observations), see Table 1. For each source category, we estimated a variance-covariance matrix ($\Sigma_S$ in Eq. 20) to allow for differences in average errors across observations of the different source types.

For estimating the error variance in the data model for unmet need (Eq. 21, observations from all sources other than DHS were combined. That is, we estimated the error variance of observations on unmet need from DHS based on 209 observations, and the error variance for other sources based on 97 observations.

<table>
<thead>
<tr>
<th>Data</th>
<th>DHS</th>
<th>MICS</th>
<th>Other</th>
<th>National Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contraceptive Use</td>
<td>234</td>
<td>86</td>
<td>196</td>
<td>414</td>
</tr>
<tr>
<td>Unmet need</td>
<td>209</td>
<td></td>
<td></td>
<td>97</td>
</tr>
</tbody>
</table>

Table 1: Number of observations by source for contraceptive prevalence and unmet need.

2.3.2 Data categorization based on characteristics of the population sampled

Overview of population characteristics  Characteristics of sampled populations that were different from the base population of MWRA were summarized into eight categories, see Table 2. The first three categories are given by: 1) samples limited to specific geographical areas of a country or specific population groups (57 observations), 2) samples covering ever-married or all women (53 observations), 3) samples including both men and women or husbands and wives (7 observations). These three categories have potentially different effects on estimated contraceptive prevalence and it is left unspecified whether the effect is in a positive or negative direction. Examples of samples from only a specific geographical area of a country covered are the survey for Armenia in 1991, that took place only in Yerevan, or the survey in Sri Lanka in 2006, that excluded the Northern Province. Examples of specific samples that differ from the base population are the surveys for the United States of America in 1955, 1960, 1965 and 1970 in which only white women were surveyed, or the surveys in Belgium in 1966, 1975, 1982 and 1991 with data pertaining to the Flemish population only. In the second category of ever-married or all women are, for example, data from the surveys in China in 1982, 1988 and 1992 pertaining to ever-married women or data from 2006 survey in Cuba pertaining to all women. Examples for the third category are surveys from India for years 1970, 1980 and 1988 that included samples of both men and women.

Categories 4 and 5 in Table 2 refer to samples from populations with additional information related to fertility, absence of pregnancy and sexual activity (66 observations in total). Fertile, sexually active or non-pregnant women are a theoretically higher risk group for pregnancy as compared with the base population and, therefore, higher contraceptive prevalence levels are expected. Surveys pertaining to all sexually active women (25 observations) were mostly from developed countries. Sexually active women who are not in union generally have higher levels of condom use than women in marital unions. Therefore, for all sexually active women, the use of modern contraceptive methods is expected to be higher, while traditional method use is expected to be potentially different (without assuming whether higher or lower) compared to the base population.

The 41 observations in category 5 refer to populations that are expected to have higher contraceptive prevalence (higher use of both modern and traditional methods) compared to the base population. Their characteristics are described in Table 3. For example, data from a 2002 survey in Iran pertaining to non-pregnant women or data from a 1983 survey in Rwanda pertaining to fertile women.

Lastly, categories 6, 7 and 8 in Table 2 refer to differences in age groups of the sampled populations. Age groups were categorized based on the magnitude of difference and expected implications for contraceptive prevalence in the baseline age group. We classified reported age groups that started at ages 13–17 and ended at ages 47–51 as base line age groups (based on a negligible difference with the 15 to 49 years old age group).
<table>
<thead>
<tr>
<th>Group</th>
<th>Characteristics of sampled population</th>
<th># obs.</th>
<th>Contraceptive use compared to base population of MWRA?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Specific geographical region or population group</td>
<td>57</td>
<td>Potentially different</td>
</tr>
<tr>
<td>2</td>
<td>Ever-married or all women</td>
<td>53</td>
<td>Potentially different</td>
</tr>
<tr>
<td>3</td>
<td>Husband and wives or both sexes</td>
<td>7</td>
<td>Potentially different</td>
</tr>
<tr>
<td>4</td>
<td>All sexually active women</td>
<td>25</td>
<td>Modern use is expected to be higher, traditional use is potentially different</td>
</tr>
<tr>
<td>5</td>
<td>Non-pregnant women, married sexually active and/or fertile women (Table [3])</td>
<td>41</td>
<td>Traditional and modern use are expected to be higher</td>
</tr>
<tr>
<td>6</td>
<td>Age group starts at ages 13-17 but ends after age 51</td>
<td>2</td>
<td>Traditional and modern use are expected to be lower</td>
</tr>
<tr>
<td>7</td>
<td>Women married in last 12 years before survey (age unknown)</td>
<td>3</td>
<td>Traditional and modern use are expected to be higher</td>
</tr>
<tr>
<td>8</td>
<td>Other age group (not described by groups 6 and 7)</td>
<td>253</td>
<td>Potentially different</td>
</tr>
</tbody>
</table>

Table 2: **Categorization of non-base population samples, number of observations in each category and comparison of the expected prevalence levels in the non-base category compared to the base category of MWRA (women of ages 15 to 49 years, who are currently married or in a union).**

<table>
<thead>
<tr>
<th>Description of characteristics</th>
<th># obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertile women</td>
<td>1</td>
</tr>
<tr>
<td>Non-pregnant women</td>
<td>13</td>
</tr>
<tr>
<td>Sexually active, married women</td>
<td>1</td>
</tr>
<tr>
<td>Sexually active, non-pregnant women</td>
<td>4</td>
</tr>
<tr>
<td>Women exposed to the risk of pregnancy</td>
<td>17</td>
</tr>
<tr>
<td>Women who were sexually active during the month prior to the interview</td>
<td>3</td>
</tr>
<tr>
<td>Women who were sexually active during the three months prior to the interview</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 3: **Overview of characteristics of sampled populations that were expected to have higher contraceptive prevalence compared to the base population of MWRA because of additional information related to fertility, absence of pregnancy and sexual activity.**
Perturbation multipliers  We modelled expected differences in prevalence between non-baseline groups and MWRA through the inclusion of perturbation multipliers. We first introduce what “perturbing a compositional vector” using perturbation multipliers refers to, and then explain how it was applied in our study.

The result of perturbing a baseline compositional vector $p = (p_1, p_2, p_3, p_4)$ by perturbation vector $V = (V_1, V_2, V_3, V_4) > 0$ is denoted by $q = (\hat{q}_1, \hat{q}_2, \hat{q}_3, \hat{q}_4)$ and given by:

$$\hat{q}_m = \frac{p_m \cdot V_m}{\sum_{n=1}^{4} p_n \cdot V_n},$$

where $V_m$ denotes the perturbation multiplier for category $m$. Examples of two perturbations are given in Figure 5. In the first example, multiplier $V_2 > 1$, while the other multipliers are all equal to one. The perturbation results in an increase in the proportion of women in category 2 (who use modern methods); instead of $p_2 \cdot 100$ women that use modern methods, compared to $(1 - p_2) \cdot 100$ women in the other categories (which we would expect for the base population), there are $V_2 \cdot p_2 \cdot 100$ women for every $(1 - p_2) \cdot 100$ women in the other categories in the perturbed composition. If multipliers $V_2 > 1$ and $V_1 > 1$, while the other multipliers are all equal to one (second example), we find that instead of $p_2 \cdot 100$ women who use modern methods and $p_1 \cdot 100$ women that use traditional methods, compared to $(1 - p_1 - p_2) \cdot 100$ women who do not use any methods (which we would expect for the base population), there are $V_2 \cdot p_2 \cdot 100$ women who use modern, and $V_1 \cdot p_1 \cdot 100$ women who use traditional methods for every $(1 - p_1 - p_2) \cdot 100$ women who do not use any methods in the perturbed composition. If a multiplier for a given category is less than 1, the opposite reasoning holds true and that category will be smaller than expected.

![Illustrations of compositions and perturbations](image)

Figure 5: Illustrations of compositions and perturbations. Left: Baseline composition $p$ of categories 1) women using a modern method, 2) women using a traditional method, 3) women with unmet need and 4) women without need for contraceptive methods ($m = 1, 2, 3, 4$). Centre: Illustration of the perturbation of $p$ when the relative proportion of women in category 2 (using modern methods) is twice larger than in the baseline composition ($V_2 = 2, V_{1,3,4} = 1$). Right: Illustration of the perturbation of $p$ when categories 1 and 2 are twice as large compared to the baseline outcomes ($V_{1,2} = 2, V_{3,4} = 1$).

In our study, if the sampled population in observation $i$ was part of group $g$ in Table 2, multiplier $V^{(g)}_{j[i], 1}$ was included to perturb traditional use, and multiplier $V^{(g)}_{j[i], 2}$ was included to perturb modern use, where $j[i]$ refers to the multiplier index assigned to observation $i$. If there were repeated observation from the same category within a country, one multiplier was assigned for all such observations in the country. Table 4 provides an
overview of the number of multipliers assigned in each group and lists the restrictions on the $V$’s based on the expected differences.

<table>
<thead>
<tr>
<th>$g$</th>
<th>Non-baseline group</th>
<th>$# V^{(g)}_{j,m}$</th>
<th>Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Geographical region</td>
<td>23</td>
<td>$V_{j,1} &gt; 0$</td>
</tr>
<tr>
<td>2</td>
<td>Ever-married/all women</td>
<td>41</td>
<td>$V_{j,2} &gt; 0$</td>
</tr>
<tr>
<td>3</td>
<td>Husband/wives, both sexes</td>
<td>3</td>
<td>$V_{j,3} &gt; 0$</td>
</tr>
<tr>
<td>4</td>
<td>All sexually active women</td>
<td>17</td>
<td>$V_{j,4,1} &gt; 0, V_{j,4,2} &gt; 1$</td>
</tr>
<tr>
<td>5</td>
<td>Non-pregnant/fertile/married sexually active women</td>
<td>33</td>
<td>$V_{j,5} &gt; 1$</td>
</tr>
<tr>
<td>6</td>
<td>Age group with - bias</td>
<td>2</td>
<td>$V_{j,6} &lt; 1$</td>
</tr>
<tr>
<td>7</td>
<td>Age group with + bias</td>
<td>2</td>
<td>$V_{j,7} &gt; 1$</td>
</tr>
<tr>
<td>8</td>
<td>Age group different</td>
<td>96</td>
<td>$V_{j,8} &gt; 0$</td>
</tr>
</tbody>
</table>

Table 4: *Summary of non-baseline categories and assigned perturbation vectors.*

**Estimation of perturbation multipliers** Because of the limited number of observations within each country, estimating the multipliers independently in each country is not possible. Instead, perturbation parameters were grouped based on the expected average outcome across countries, and the estimation procedure is group-specific. The three groups (A, B, and C) are given by:

A: Group of multipliers for traditional and/or modern use in sampled populations where use could be different from the base population, but where it is not clear whether use would be lower or higher. This group refers to traditional and modern use among women from different geographical regions within a country, women of age groups that differ from 15-49 years old leading to an unknown change in use, husband/wives, both sexes, ever-married/all women, as well as traditional use among all sexually active women, who are not necessarily married or in union ($g = 1, 2, 3, 8, m = 1, 2$ and $g = 4, m = 1$). A multi-level model was used to estimate the $V^{(g)}_{j,m}$’s in this group, to allow the multipliers to differ across countries while shrinking multipliers towards the group average for countries with little information. The multi-level model is given by:

$$\log(V^{(g)}_{j,m}) \sim N(0, \delta^2_m),$$

such that the $V$’s are restricted to be positive but not necessarily larger than 1. $\delta^2_m$ is the variance of the multipliers on the log-scale (for traditional use, $m=1$, and modern use, $m=2$).

B: Group of multipliers for modern use in population groups where use is believed to be higher or lower than in the base population. The “higher-use” group includes non-pregnant women or married sexually active women, women from age groups that are believed to have higher contraceptive prevalence, and all sexually active women ($g = 4, 5, 7$). The “lower-use” group includes the women from a different age group deemed to have lower contraceptive prevalence ($g = 6$). For these multipliers, a multi-level model was used:

$$V^{(g)}_{j,2} = 1 + W^{(g)}_{j,2}, \quad g = 4, 5, 7$$

$$V^{(g)}_{j,2} = 1/(1 + W^{(g)}_{j,2}), \quad g = 6$$

$$\log(W^{(g)}_{j,2}) \sim N(\mu_2, \lambda^2_2),$$

such that the $V$’s are restricted to be larger (smaller) than 1 for the “higher-use” (“lower-use”) group. Information about the multipliers is exchanged across countries through the hierarchical distribution for the multipliers on the transformed scale, with mean $\mu_2$ and variance $\lambda^2_2$.

C: Group of multipliers for traditional use in population groups where use is believed to be higher or lower than in the base population. The “higher-use” group includes non-pregnant women or married sexually
active women and women from age groups that are believed to have higher contraceptive prevalence 
($g = 5, 7$). The “lower-use” group includes the women from a different age group deemed to have lower 
contraceptive prevalence ($g = 6$). The multipliers in this group are determined by parameter $\mu_1$, with
\[
V_{j,1}^{(g)} = 1 + \exp(\mu_1), \quad g = 5, 7
\]
\[
V_{j,1}^{(g)} = 1/(1 + \exp(\mu_1)), \quad g = 6,
\]
such that the $V$’s are restricted to be larger (smaller) than 1 for the “higher-use” (“lower-use”) group. 
(A multi-level approach for estimating the multipliers was not used because it led to convergence issues 
and multiplier estimates which were equal to 1 with high posterior probability, thus contradicting expert 
knowledge).

After applying all permutations, the resulting compositional vector is denoted by $\tilde{q}_{i,m}$ with 
\[
\tilde{q}_{i,m} = \frac{p_{c[i],t[i],m} \cdot v_{i,m}}{\sum_{n=1}^{4} p_{i,n} \cdot v_{i,n}},
\]
where $v_{i,m}$ denotes the product of all multipliers for observation $i$, for contraceptive use category $m$: 
\[
v_{i,m} = \prod_{g=1}^{8} \tilde{V}_{i,m}^{(g)},
\]
$\tilde{V}_{i,m}^{(g)}$ is the multiplier for observation $i$, for contraceptive use category $m$, with respect to non-baseline category $g$: 
\[
\tilde{V}_{i,m}^{(g)} = \begin{cases} 
1 & \text{if } m = 3, 4 \text{ or if } i \notin S^{(g)}, \\
V_{j[i],m}^{(g)} & \text{if } m = 1, 2 \text{ and if } i \in S^{(g)},
\end{cases}
\]
where $V_{j[i],m}^{(g)}$ is the $j$-th assigned multiplier to non-baseline observation $i$ for category $g$ and $S^{(g)}$ is the set of 
al non-baseline observations $i$ in category $g$.

### 2.3.3 Misclassification biases

Four types of misclassification errors (leading to misclassification biases) were identified in the surveys in the data base:

1. Exclusion of sterilization from modern method use, regardless of the reason of the sterilization, is expected to lead to under-reporting of total and modern method use (6 observations). For example, in a 1975 survey in Denmark male and female sterilization were excluded from method use.
2. Inclusion of sterilization for non-contraceptive reasons in modern method use, is expected to lead to over-reporting of total and modern method use (10 observations). For example, surveys in 2000 and 2004 in France included some cases of sterilization for non-contraceptive reasons.
3. Inclusion of folk methods in traditional method use (136 observations) is expected to lead to higher overall reporting, as well as higher reporting of traditional methods. Folk methods are local methods and spiritual methods of unproven effectiveness, like herbs or amulets.\[^{[12]}\] For example, folk methods are included in traditional method use in Bolivia in 1998 survey or in Paraguay in surveys in years 1979, 1987, 1990, 1995 and 1998.
4. The absence of probing questions about knowledge of specific methods is expected to lead to under-reporting by women of traditional method use (86 observations). This is reported for data source MICS, a cross-national survey programme that has not systematically implemented a set of probe questions about contraceptive method knowledge.
We estimated the proportion of women that was misclassified from category $n$ into category $m$ (e.g., from having unmet need into using traditional methods in 3) as a proportion $\gamma_{n,m}$ of the expected (potentially perturbed) proportion of women in category $n$ for observation $i$ such that (1) $\tilde{q}_{i,2}\gamma_{2,4}$ refers to the misclassification bias when sterilization is excluded from modern contraceptive use, (2) $\tilde{q}_{i,4}\gamma_{4,2}$ refers to the misclassification bias when sterilization is included in modern contraceptive use, (3) $\tilde{q}_{i,3}\gamma_{3,1}$ to the misclassification bias when folk methods are included in traditional methods, and finally, (4) $\tilde{q}_{i,1}\gamma_{1,3}$ to the misclassification bias in absence of probing (signified by data source being from MICS).

The resulting perturbed and bias-adjusted compositional vector $q_i$ is given by:

\[
q_{i,1} = \tilde{q}_{i,1}(1 - \gamma_{1,3}) + \tilde{q}_{i,3}\gamma_{3,1}, \\
q_{i,2} = \tilde{q}_{i,2}(1 - \gamma_{2,4}) + \tilde{q}_{i,4}\gamma_{4,2}, \\
q_{i,3} = \tilde{q}_{i,3}(1 - \gamma_{3,1}) + \tilde{q}_{i,1}\gamma_{1,3}, \\
q_{i,4} = \tilde{q}_{i,4}(1 - \gamma_{4,2}) + \tilde{q}_{i,2}\gamma_{2,4}.
\]

To avoid numerical problems with logarithms of proportions that are zero, perturbed estimated probabilities that were less than 1% were rounded upwards to 1% (same approach as for observed proportions).

### 2.3.4 Example-based explanation of bias and perturbation parameters

Bias parameters were included in the model to account for survey misclassification errors. For example, women who use traditional methods may not report this use in a survey interview without probe questions about traditional method use and thus may be identified as having unmet need for contraceptives. Based on all surveys without probing questions, we estimated the average proportion of traditional method users that are misclassified. This proportion is referred to as the misclassification bias parameter.

Perturbation parameters were included to account for differences in method use and unmet need for sampled populations that differ from MWRA. For example, we expect modern method use to be higher among all sexually active women as compared to MWRA. In other words, if there are 50 modern method users for every 100 non-modern-method users among MWRA, we expect that among sexually active women only, there will be more than 50 modern method users for every 100 non-modern-method users, i.e. $V \cdot 50$ users with $V > 1$. Multiplier $V$ is referred to as the perturbation parameter for modern use among sexually active women, and estimated for all surveys that sample sexually active women only. If the sampled population refers to a specific geographical region, we assume in the illustration above that there are $V' \cdot 50$ modern method users with $V' > 0$ such that modern use could be higher or lower than in the baseline population.

The full list of bias and perturbation parameters, for both modern as well as traditional methods, and their estimated values, are given in the results graphs in section 3.2. The interpretation of the parameters follows the examples described above.
2.4 Full model specification and prior distributions

2.4.1 List of main symbols

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$p_{c,t,m}$</td>
<td>Unobserved proportion of MWRA in country $c$, year $t$ in category $m$ (referring to traditional and modern use, unmet need and no need respectively)</td>
</tr>
<tr>
<td>$P_{c,t}$</td>
<td>Total contraceptive prevalence in country $c$, year $t$</td>
</tr>
<tr>
<td>$R_{c,t}$</td>
<td>Ratio of modern to total prevalence in country $c$, year $t$</td>
</tr>
<tr>
<td>$Z_{c,t}$</td>
<td>Ratio of unmet need to no method in country $c$, year $t$</td>
</tr>
<tr>
<td>$B_{c,t}$</td>
<td>Demand satisfied, $B_{c,t} = \frac{p_{c,t,1} + p_{c,t,2} + p_{c,t,3}}{p_{c,t,1} + p_{c,t,2} + p_{c,t,3}}$</td>
</tr>
<tr>
<td>$P_{c,t}^{*}$</td>
<td>Systematic trend in $P_{c,t}$</td>
</tr>
<tr>
<td>$R_{c,t}^{*}$</td>
<td>Systematic trend in $R_{c,t}$</td>
</tr>
<tr>
<td>$Z_{c,t}^{*}$</td>
<td>Systematic trend in $Z_{c,t}$</td>
</tr>
<tr>
<td>$P_{c}$</td>
<td>Asymptote of $P_{c,t}^{*}$</td>
</tr>
<tr>
<td>$R_{c}$</td>
<td>Asymptote of $R_{c,t}^{*}$</td>
</tr>
<tr>
<td>$\psi_{c}$</td>
<td>Pace parameter for increase in $R_{c,t}^{*}$</td>
</tr>
<tr>
<td>$\omega_{c}$</td>
<td>Pace parameter for increase in $P_{c,t}^{*}$</td>
</tr>
<tr>
<td>$\Psi_{c}$</td>
<td>Midpoint for increase in $R_{c,t}^{*}$</td>
</tr>
<tr>
<td>$\Omega_{c}$</td>
<td>Midpoint for increase in $P_{c,t}^{*}$</td>
</tr>
<tr>
<td>$\tilde{Z}_{c,t}$</td>
<td>“Intercept” parametric model for $Z_{c,t}^{*}$</td>
</tr>
<tr>
<td>${ \beta_{1}, \beta_{2} }$</td>
<td>Coefficients of parametric model for $Z_{c,t}^{*}$</td>
</tr>
<tr>
<td>$\varepsilon_{c,t}$</td>
<td>AR(1) distortion for $P_{c,t}$</td>
</tr>
<tr>
<td>$\eta_{c,t}$</td>
<td>AR(1) distortion for $R_{c,t}$</td>
</tr>
<tr>
<td>$\theta_{c,t}$</td>
<td>AR(1) distortion for $Z_{c,t}$</td>
</tr>
<tr>
<td>${ \rho_{\varepsilon}, \rho_{\eta}, \rho_{\theta} }$</td>
<td>Autoregressive coefficients for the AR(1) distortions</td>
</tr>
<tr>
<td>${ \tau_{\varepsilon}, \tau_{\eta}, \tau_{\theta} }$</td>
<td>Variance parameters of the AR(1) distortions</td>
</tr>
<tr>
<td>$q_{i,m}$</td>
<td>Perturbed and bias-adjusted proportion of women for observation $i$</td>
</tr>
<tr>
<td>$y_{i,m}$</td>
<td>Observed proportion of women in observation $i$</td>
</tr>
<tr>
<td>$\gamma_{n,m}$</td>
<td>Misclassification bias parameter (from category $n$ to $m$)</td>
</tr>
<tr>
<td>$V_{j,m}$</td>
<td>$j$-th Multiplier for perturbation category $g$, contraceptive use category $m$</td>
</tr>
</tbody>
</table>

2.4.2 Full model specification

\[
\begin{align*}
    p_{c,t,1} &= (1 - R_{c,t}) \cdot P_{c,t}, \\
    p_{c,t,2} &= R_{c,t} \cdot P_{c,t}, \\
    p_{c,t,3} &= (1 - P_{c,t}) \cdot Z_{c,t}, \\
    p_{c,t,4} &= (1 - P_{c,t}) \cdot (1 - Z_{c,t}), \\
    P_{c,t} &= \logit^{-1} \left( \logit(P_{c,t}^{*}) + \varepsilon_{c,t} \right), \\
    R_{c,t} &= \logit^{-1} \left( \logit(R_{c,t}^{*}) + \eta_{c,t} \right), \\
    Z_{c,t} &= \logit^{-1} \left( \logit(Z_{c,t}^{*}) + \theta_{c,t} \right), \\
    \varepsilon_{c,t} &\sim N(\rho_{\varepsilon} \cdot \varepsilon_{c,t-1}, \tau_{\varepsilon}^2), \\
    \eta_{c,t} &\sim N(\rho_{\eta} \cdot \eta_{c,t-1}, \tau_{\eta}^2), \\
    \theta_{c,t} &\sim N(\rho_{\theta} \cdot \theta_{c,t-1}, \tau_{\theta}^2), \\
    \varepsilon_{c,t-1} &\sim N \left( 0, \frac{\tau_{\varepsilon}^2}{1 - \rho_{\varepsilon}^2} \right),
\end{align*}
\]
\( \eta_{c,t,1} \sim N \left( 0, \frac{\tau_{\eta}^2}{1 - \rho_{\eta}^2} \right) \),

\( \theta_{c,t,1} \sim N \left( 0, \frac{\tau_{\theta}^2}{1 - \rho_{\theta}^2} \right) \),

\[ P_{c,t}^* = \frac{\tilde{P}_c}{1 + \exp(-\omega_c(t - \Omega_c))}, \]

\[ R_{c,t}^* = \frac{\tilde{R}_c}{1 + \exp(-\psi_c(t - \Psi_c))}, \]

\[ Z_{c,t}^* = \frac{1}{1 + \exp(z_c + \beta_1(P_{c,t} - 0.4) + \beta_2 \cdot (P_{c,t} - 0.4)^2)} \]

\[ \log \left( \frac{\tilde{P}_c - 0.5}{1 - \tilde{P}_c} \right) \sim N(\tilde{P}_w, \kappa_P^{(c)}), \]

\[ \log \left( \frac{\tilde{R}_c - 0.5}{1 - \tilde{R}_c} \right) \sim N(\tilde{R}_w, \kappa_R^{(c)}), \]

\[ \omega_c^* = \log \left( \frac{\omega_c - 0.01}{0.5 - \omega_c} \right), \]

\[ \omega_s^* \sim N(\omega_{s,c}^*, \kappa_{\omega}^{(c)}), \]

\[ \omega_r^* \sim N(\omega_{r,s}^*, \kappa_{\omega}^{(s)}), \]

\[ \psi_c^* = \log \left( \frac{\psi_c - 0.01}{0.5 - \psi_c} \right), \]

\[ \psi_s^* \sim N(\psi_{s,c}^*, \kappa_{\psi}^{(c)}), \]

\[ \psi_r^* \sim N(\psi_{r,s}^*, \kappa_{\psi}^{(s)}), \]

\[ \Omega_c \sim \begin{cases} N(\Omega_{s,c}, \kappa_{\Omega}^{(c)}), & c \in L, \\ N(\Omega_{D}, \kappa_{\Omega}^{(D)}), & c \in D, \end{cases} \]

\[ \Omega_s \sim N(\Omega_{r,s}, \kappa_{\Omega}^{(s)}), \]

\[ \Omega_r \sim N(\Omega_{L}, \kappa_{\Omega}^{(L)}), \]

\[ z_c \sim N(z_{s,c}, \kappa_{z}^{(c)}), \]

\[ z_s \sim N(z_{w}, \kappa_{z}^{(r)}). \]

Data model

\[ \begin{bmatrix} \log \left( \frac{q_{1,t}}{q_{1,t + 4}} \right) \\ \log \left( \frac{q_{2,t}}{q_{2,t + 4}} \right) \end{bmatrix} \sim N \left( \begin{bmatrix} \log \left( \frac{q_{1,t}}{q_{1,t + 4}} \right) \\ \log \left( \frac{q_{2,t}}{q_{2,t + 4}} \right) \end{bmatrix}, \Sigma_S[i] \right), \]

\[ \Sigma_S = \begin{bmatrix} \sigma_{S,1}^2 & \rho_{SS1}\sigma_{S,1}\sigma_{S,2} \\ \rho_{SS1}\sigma_{S,1}\sigma_{S,2} & \sigma_{S,2}^2 \end{bmatrix}, \]

23
\[
\log \left( \frac{y_{i,1+2}}{1 - y_{i,1+2}} \right) \sim N \left( \log \left( \frac{q_{i,1+2}}{1 - q_{i,1+2}} \right), \sigma^2 \right) \quad (\text{for observations without break-down}),
\]

\[
\log \left( \frac{y_{i,3}}{y_{i,4}} \right) \sim N \left( \log \left( \frac{q_{i,3}}{q_{i,4}} \right), \sigma^2_s \right),
\]

where

\[
\hat{q}_{i,m} = \frac{\sum_{n=1}^{4} p_{i,n} \cdot v_{i,n}}{G}
\]

\[
v_{i,m} = \prod_{g=1}^{G} V_{i,m}^{(g)}
\]

\[
V_{i,m}^{(g)} = \begin{cases} 
1 & \text{if } m = 3, 4 \text{ or if } i \notin S^{(g)}, \\
V_{j[1,g],m}^{(g)} & \text{if } m = 1, 2 \text{ and if } i \in S^{(g)},
\end{cases}
\]

\[
W_{j,m}^{(g)} = \begin{cases} 
\log N(0, \delta^2_{\nu}), & \text{for } g = 1, 2, 3, 6, m = 1, 2 \text{ and for } g = 4, m = 1, \\
1/(1 + W_{j,m}^{(g)}), & \text{for } g = 8, m = 1, 2, \\
1 + W_{j,m}^{(g)}, & \text{otherwise,}
\end{cases}
\]

\[
\log(W_{j,m}^{(g)}) = \begin{cases} 
\mu_1, & \text{for } m = 1, \\
\sim N(\mu_2, \lambda^2_2), & \text{for } m = 2,
\end{cases}
\]

\[
q_{i,1} = \tilde{q}_{i,1}(1 - \gamma_{1,3}) + \tilde{q}_{i,3} \gamma_{3,1}, \\
q_{i,2} = \tilde{q}_{i,2}(1 - \gamma_{2,4}) + \tilde{q}_{i,4} \gamma_{4,2}, \\
q_{i,3} = \tilde{q}_{i,3}(1 - \gamma_{3,1}) + \tilde{q}_{i,1} \gamma_{1,3}, \\
q_{i,4} = \tilde{q}_{i,4}(1 - \gamma_{4,2}) + \tilde{q}_{i,2} \gamma_{2,4}.
\]

### 2.4.3 Prior distributions

Spread-out prior distributions were used for the world-level mean parameters of the logistic curves and parametric function for unmet need (some centred at least-squares estimates):

\[
\hat{P}_w \sim N(0, 10^2), \\
\hat{R}_w \sim N(0, 10^2), \\
\omega_w^* \sim N(-1, 10^2), \\
\phi_w^* \sim N(-1, 10^2), \\
\Phi_w \sim N(1980, 50^2), \\
\Omega_D \sim N(1920, 50^2), \\
\Omega_L \sim N(1980, 50^2), \\
z_w \sim N(-0.38, 1), \\
\beta_1 \sim N(0.12, 1), \\
\beta_2 \sim U(0, 10).
\]

For the AR(1) distortion terms:

\[
\tau^{-1/2} \sim U(0.01, 1), \\
\rho \sim U(0, 1). \quad (22)
\]

Inverse-Gamma prior distributions were used for the across-countries variance parameters \(\kappa^{(c)}\)’s:

\[
1/\kappa^{(c)} \sim \Gamma(\nu_0/2, \nu_0/2 \cdot \kappa_0), \quad (24)
\]

such that

\[
E\{\kappa\} = \frac{\nu_0/2}{\nu_0/2 - 1} \kappa_0. \quad (25)
\]
mode\{\kappa\} = \frac{\nu_0/2}{\nu_0/2 + 1}\kappa_0, \quad (26)

with mode\{\kappa\} < \kappa_0 < E\{\kappa\}. The prior variance parameters \kappa_0 were estimated based on a model fit without AR-terms (systematic curves only) to the data. For unmet need intercept \(z_c\), “prior sample size” \(\nu_0\) was set to 1. For the parameters of the logistic functions, the total prior sample size \(\nu_0\) was set to 10 (with a prior sample size of 8 for \(\kappa_0^{(c)}\) and 2 for \(\kappa_0^{(D)}\) to reflect the relative break-down into developing and developed countries). These somewhat informative prior distributions for the across-country variance of the logistic parameters were chosen to rule out complete shrinkage (after including the AR-terms) of the country-specific parameters to the sub-regional or world means based on the assumption that underlying trends and “long-term asymptotes” differ between countries.

Uniform priors were used for the standard deviations on the sub-regional and regional level:

\[
\sqrt{\kappa^{(s,r,L,D)}} \sim U(0, K_{\kappa^{(s,r,L,D)}}), \quad (27)
\]

where \(K_{\kappa^{(s,r,L,D)}}\) is the upper bound for \(\sqrt{\kappa^{(s,r,L,D)}}\), set a large value such that its prior distribution did not restrict posterior outcomes.

Spread-out inverse-Wishart distributions were used for the covariance matrices \(\Sigma_S\) for sources \(S = 1, \ldots, 4\):

\[
\Sigma_S \sim IW(Diag(0.1), 2).
\]

Because of the limited number of observations, the error variance parameter for observed total prevalence (on the logit-scale) was assigned a somewhat informative prior based on an estimate for the observations where the break-down was available:

\[
\sigma_T^2 \sim IGamma(0.5, 0.5 \cdot 0.15^2).
\]

The prior for the variance parameter related to unmet need was again spread out:

\[
\sigma_{S,3} \sim U(0.01, 2), \quad \text{for } S = 1, 2,
\]

and \(\sigma_{3,3} = \sigma_{4,3} = \sigma_{2,3}\).

We used uniform prior distributions for all (four) misclassification bias parameters, and spread out distributions for the mean and variance of the perturbation multipliers:

\[
\gamma_{m,n} \sim U(0, 1),
\mu_m \sim N(-2, 1.25^2),
\delta_m \sim U(0, 2),
\lambda_2 \sim U(0.01, 2).
\]

2.5 Computation and inference

We obtained samples from the posterior distributions of all model parameters using a Markov chain Monte Carlo (MCMC) algorithm, implemented in open source software packages R\textsuperscript{\textregistered} 2.14\textsuperscript{\textregistered} and JAGS (Just Another Gibbs Sampler\textsuperscript{\textregistered}), using R-packages R2jags\textsuperscript{\textregistered} (version 0.03-07) and rjags.\textsuperscript{\textregistered} Results were obtained from 5 chains; the total number of iterations in each chain was 150,000, keeping every 50th iteration, and discarding the first 50,000 iterations as burn-in. Convergence of the MCMC algorithm and the sufficiency of the number of samples obtained was checked through visual inspection of trace plots and convergence diagnostics of Raftery and Lewis\textsuperscript{\textregistered} and Gelman and Rubin\textsuperscript{\textregistered}, both implemented in the coda R-package.\textsuperscript{\textregistered}
For each posterior sample of the model parameters, trajectories of contraceptive prevalence and unmet need were constructed for all countries. Specifically, for a country of interest $c$, the $j$-th posterior sample of the model parameters of its logistic curves for total prevalence and the ratio of modern to total prevalence was used to construct the logistic curves $P^*_c(t)$ and $R^*_c(t)$ from 1990 to 2015. Posterior samples of the AR(1) distortion terms $\epsilon_{c,t}^{(j)}$ and $\eta_{c,t}^{(j)}$ from 1990 to 2015 were obtained by sampling these distortions conditional on the posterior sample for the observation years in the country. E.g. to obtain a “future distortion” term after the last observation year $t_{c,n}$ in country $c$, we sampled

$$\epsilon_{c,t}^{(j)} \sim N(\rho^{(j)}_c \epsilon_{c,t}^{(j)}, \tau^{2(j)}_c).$$

Back-projections from the first observation year $t_{c,1}$ were obtained by sampling

$$\epsilon_{c,t,0}^{(j)} \sim N(\rho^{(j)}_c \epsilon_{c,t,1}^{(j)}, \tau^{2(j)}_c).$$

The logistic curves and the distortion terms were combined to obtain the posterior sample of country-specific trajectories of traditional and modern prevalence from 1990 to 2015.

Similarly, to obtain the trajectories of unmet need for countries with unmet need data, the $j$-th posterior sample of the model parameters for the expected ratio of unmet need to no use of contraceptive methods was used to construct that ratio $Z^*_c(t)$ for 1990 to 2015. Distortions $\theta_c^{(j)}$ were sampled for all years of interest, conditional on the posterior samples in the observation years.

For countries without data on unmet need, the country-specific parameter $z_c^{(j)}$ in the ratio $Z^*_c(t)$ was sampled from its hierarchical distribution,

$$z_c^{(j)} \sim N(z_s^{(j)}, \kappa^{(j)}_c),$$

using the $j$-th posterior sample $\{z_s^{(j)}, \kappa^{(j)}_c\}$ for the subregional mean and the variance parameter. The distortion term in the first observation year $t_{c,1}$ for contraceptive prevalence was sampled from its respective distribution:

$$\theta_{c,t,1} \sim N\left(0, \frac{\tau^{2(j)}_c}{1 - \rho^{2(j)}_c}\right),$$

and the distortions for the remaining years were obtained in the same way as discussed for the $\epsilon_{c,t}^{(j)}$s.

Uncertainty intervals (UIs) were based on the 2.5 and 97.5 percentiles of the posterior sample of estimates for each country, for each year from 1990 to 2015, and reflect the uncertainty in the country-year estimates. The “best” estimates were given by the median outcome in each year.

## 2.5.1 Subregional estimates

Aggregate estimates (e.g., for (sub)-regions) were constructed by taking into account the number of MWRA in each country (see [1,3]), denoted by $W_{c,t}$ for country $c$, year $t$. The aggregate estimate for the subset of countries $C_S = \{c_1, \ldots, c_n\}$ is given by

$$p_t^{[C_S]} = \frac{1}{\sum_{c \in C_S} W_{c,t}} \sum_{c \in C_S} W_{c,t} \cdot p_{c,t}.$$

When constructing the aggregate estimates, future/past distortions of the time trends were assumed to be uncorrelated.

Aggregate estimates of demand satisfied, denoted by $B_t^{[C_S]}$ for subset $C_S$, were constructed as follows:

$$B_t^{[C_S]} = \frac{\sum_{c \in C_S} W_{c,t} \cdot p_{1+2,c,t}}{\sum_{c \in C_S} W_{c,t} \cdot p_{1+2+3,c,t}}.$$
The model-based estimate for an outcome of interest in a given year (e.g., total, modern or traditional contraceptive prevalence) for a country or aggregate group (e.g., region) is given by the median value of all trajectories for the outcome in that year. As a result, the model-based estimates of modern and traditional prevalence for a country or aggregate group do not always sum exactly to the estimated total contraceptive prevalence for the country or aggregate group because the trajectory that gives the median for total prevalence does not have to correspond to the median trajectory for traditional and/or modern method prevalence.

### 2.5.2 Inference on changes

We estimated changes in various indicators over time. For example, given the $j$-th posterior sample of total prevalence $p_{1+2,c,t}^{(j)}$ for country $c$, years $t_1$ and $t_2$, sample $j = 1, \ldots, J$, the $j$-th posterior sample for the change in prevalence is given by

$$p_{1+2,c,t}^{(j)} = p_{1+2,c,t_2}^{(j)} - p_{1+2,c,t_1}^{(j)}.$$

The median estimate for the change, and its 95% uncertainty interval were based on the corresponding sample percentiles. The probability that a change was positive (e.g., whether an increase in total prevalence has occurred, referred to as the posterior probability of an increase, PPI) is given by

$$P(p_{1+2,c,t_2}^{(j)} > p_{1+2,c,t_1}^{(j)}) \approx \frac{1}{J} \sum_j I(p_{1+2,c,t_2}^{(j)} > p_{1+2,c,t_1}^{(j)}),$$

where $I$ refers to the index function $I(p_{1+2,c,t_2}^{(j)} > p_{1+2,c,t_1}^{(j)}) = 1$ if $p_{1+2,c,t_2}^{(j)} > p_{1+2,c,t_1}^{(j)}$, 0 otherwise. The same procedure was used for other indicators as well as well as for aggregate outcomes.

Lastly, to examine whether the change from $t_1$ to $t_2$ was bigger/smaller than the change from $t_2$ to $t_3$ (e.g., did contraceptive prevalence increase more slowly from 2000 to 2010, than from 1990 to 2000?), we constructed posterior samples of those differences and calculated posterior probabilities of either a positive or a negative change. E.g., for contraceptive prevalence $p_{1+2,c,t}$ in country $c$, the posterior probability that the change in (2000-2010) was bigger than the change in (1990-2000), is given by:

$$P((p_{1+2,c,t_3} - p_{1+2,c,t_2}) > (p_{1+2,c,t_2} - p_{1+2,c,t_1})) \approx \frac{1}{J} \sum_j I((p_{1+2,c,t_3} - p_{1+2,c,t_2})^{(j)} > (p_{1+2,c,t_2} - p_{1+2,c,t_1})^{(j)}),$$

where $t_1 = 1990, t_2 = 2000, t_3 = 2010$. Again, the same procedure was used for other indicators as well as well as for aggregate outcomes.

### 2.6 Model validation

Cross-validation was used to validate model performance, in which some observations were excluded while the model was fitted to the remaining observations (the training set).

We carried out three validation exercises. In the first exercise, 20% of the observations within each country were left out at random, such that the training set consisted of 80% of all observations. In the second validation exercise, all data with observation years after (and including) 2005 were left out (17% of all observations, 23% of the observations with information on unmet need) to check the predictive performance of the model. In the third validation exercise we left out all observations on unmet need for a random subset of 22 countries with data on unmet need (20% of the countries), to check how well the model predicts unmet need for countries without observations.

Out-of-sample performance was assessed using three measures, based on the left-out observations and their predictive posterior distributions:
(1) Median prediction error and median absolute prediction error.
A prediction error was defined as the difference between the left-out observation and its posterior predictive median estimate. I.e., the error in predicting total prevalence for left-out observation $i$ was given by

$$e_{i,1+2} = y_{i,1+2} - \hat{y}_{i,1+2},$$

where $\hat{y}_{i,1+2}$ is the predictive posterior median of $y_{i,1+2}$ (taking into account perturbations and biases).

(2) Proportion of the left-out observations that fell below their respective posterior predictive median estimate. This proportion is expected to be around 50%.

(3) Coverage of 95% prediction intervals for the left-out observations.
Calibration of the predictive distributions of the excluded observations was assessed by checking that the prediction intervals contained the left-out observations the right proportion of the time. If left-out observations are independent from one another, we expect that around 5% of the left-out observations fall outside their respective predictions intervals. Higher proportions suggest that the uncertainty intervals for true prevalence are too narrow, while smaller proportions suggest that they are too wide.

Because left-out observations within one country are expected to be dependent (to err in the same direction if prevalence was under- or over-estimated for several years within countries under consideration), only one left-out observation within a country was included when calculating the performance measures. When leaving out data at random, one observation was selected at random within each country. When leaving out data after/in 2005 or all unmet data in a subset of countries, the most recent left-out observation within each country was selected.

To assess how confident one can be about the current estimates and projections, we also compared the current estimates and projections (based on the full data set) to the estimates and uncertainty bounds based on the training set. The goal is to check that additional data did not change the estimates and projections significantly; as more data become available, we expect the current (updated) estimates to lie well within the previously constructed uncertainty intervals. The smaller the proportion of estimates and projections that fall outside their respective uncertainty intervals, the better (contrary to the previously described measure of calibration).

Changes in estimates and bounds were summarized for a year of interest, here 2008 was chosen. Reported outcomes measures were based on the difference between an updated and “old” median estimate (where the latter is based on the training set) and the proportion of countries in which the updated median estimate for a specific year was outside the previously constructed 95% UI for the year of interest.
3 RESULTS

Supplementary tables (an overview of selected subregional and country estimates of contraceptive prevalence and satisfied demand for family planning, and country estimates for changes in demand satisfied) and figures (estimates for all countries) are provided in Sections 5 and 6.

3.1 Error variance parameters

As described in Eq. 20, the observed log-ratios of traditional and modern contraceptive use to no contraceptive use were assumed to be drawn from a multivariate normal distribution. The estimates for the standard deviations for both ratios, as well as the estimated correlation between the ratios, are shown in Figure 6 (top row) for the four source categories (DHS, MICS, Other international survey programmes and National surveys). Errors tend to be smaller for the log-ratio of modern to no contraceptive prevalence compared to traditional to no contraceptive use (the average median posterior estimate for all 4 sources combined is 0.13 for modern use, compared to 0.34 for traditional use). A comparison across sources shows that MICS tends to have higher error for both log-ratios as compared to the other 3 source categories, especially for the log-ratio of traditional to no contraceptive use. The correlation is small but positive for all source categories, suggesting that if a survey overestimates (underestimates) the ratio of modern to no contraceptive use, the ratio of traditional to no contraceptive use also tends to be overestimated (underestimated).

Estimates of the error standard deviation of the log-ratio of unmet need for contraceptives to no need for observations from a DHS, and observations from other sources are shown in Figure 6 (bottom row). The standard deviation is much smaller for observations from DHS compared to other sources (0.09 with 95% UI (0.03, 0.14) for DHS compared to 0.63 with 95% UI (0.53, 0.76) for other sources) and moreover, the error variance of other sources is very large, suggesting that these log-ratios are subject to substantial sampling and/or non-sampling errors.
Figure 6: Overview of estimates of standard deviations by source of observed contraceptive prevalence log-ratios. Top row: Estimated standard deviations (sigma) and correlation (rho) for the log-ratios of traditional and modern contraceptive use to no use, by source. Bottom graph: Estimated standard deviations (sigma) for the log-ratio of unmet need to no need for contraceptive methods, by source (“Other” here refers to any source other than DHS). Vertical lines display 95% uncertainty intervals.
3.2 Misclassification biases and perturbation multipliers

The estimated misclassification bias parameters are shown in Figure 7 and refer to the estimated proportion of women who were misclassified from one category to another category: (1) the estimated proportion of women who use modern methods but are misclassified as having unmet need if sterilization is excluded from modern method use, (2) the estimated proportion of women who do not have a need for contraceptive methods but are misclassified as using modern methods if sterilization for non-contraceptive reasons is included among modern method use, (3) the estimated proportion of women who have an unmet need for effective contraceptive methods but are misclassified as using traditional methods if folk methods are included as traditional methods, and (4) the estimated proportion of women who use traditional methods but are misclassified as having unmet need if the survey does not include probing questions.

For all but the folk misclassification bias, the median estimate for the proportion of misclassified women is at least 5% and there is considerable uncertainty about the extent of the misclassification bias. For folk biases, the proportion of women that is misclassified (the proportion of women that uses folk methods among the total number of women with unmet need) was small (4.2% with 95% UI (3.1, 5.4%)).

The estimates of the perturbation multipliers and corresponding uncertainty bounds are summarized in Figure 8. While the median posterior estimates (dots) tend to be close to 1 for most multipliers, the UIs tend to be wide (e.g., covering outcomes from around 0.5 to 1.5 for a large subset of multipliers), suggesting substantial uncertainty about the measured ratios of contraceptive prevalence.

![Figure 7: Estimates and uncertainty intervals for the misclassification bias parameters.](image)

The parameters refer to biases resulting from exclusion of sterilization from modern method use regardless of the reason of the sterilization, inclusion of sterilization for non-contraceptive reasons in modern method use, inclusion of folk methods in traditional method use, and the absence of probing questions about knowledge of specific methods (signified by data source being from MICS). Horizontal lines display 95% uncertainty intervals.
Figure 8: Estimates of the perturbation multipliers with uncertainty bounds. The detailed description of each multiplier (country, category, traditional or modern use, number of observations) can be read when zooming in on the figure. Horizontal lines display 95% uncertainty intervals.
3.3 Model validation

The results related to the left-out observations for the three validation exercises are summarized in Table 5. For exercise (1), when leaving out 20% of all observations at random, the calibration results suggested that the model is well calibrated for all countries combined. The coverage probabilities for all categories were around 95% as expected, albeit slightly higher for unmet need, and slightly lower for traditional use. The median error (difference between the left-out observation and the predictive median posterior estimate) was negative for unmet need but small (-2%) and negligible for the other categories. The maximum median absolute error was 4% for left-out observations of total contraceptive prevalence. The validation results related to the changes in estimates are summarized in Table 6 (note that changes in unmet need estimates included changes in countries where no data on unmet need were left out because changes in total prevalence could also have affected the estimates of unmet need). Changes in estimates were small in this validation exercise and the maximum percentage of estimates that fell outside the bounds that were constructed based on the training set was 6.8% for contraceptive use, and 2.9% for unmet need.

For exercise (2), when leaving out all observations starting in 2005, coverage probabilities were again reasonable and errors were small: the maximum median absolute error is 4% in the four categories. Changes in estimates are small as well, and the updated estimate is within the uncertainty interval (UI) that would have been constructed in 2005 for at least 95.4% of the countries with left-out observations for all categories.

Lastly, also when leaving out all data on unmet need in a random subset of 22 countries with data on unmet need, the validation exercise suggested the model was well calibrated. The median difference between the training and updated estimate for 2008 in the 22 countries was close to 0%, and the median absolute difference was 3%. The updated median estimate for 2008 was within the previously constructed 95% UI for all but one country.

![Table 5: Summary of model validation results for the left-out observations.](image)

For each exercise, for each category of contraceptive prevalence, the reported outcomes are: number of left-out observations (countries), percentage of left-out observations that fall below/in/above the respective 95% prediction intervals based on the training set and below their posterior predictive median estimate, and their median error (ME) and the median absolute error (MAE).
Table 6: Summary of model validation results: changes in estimates for 2008. For each exercise, for each category of contraceptive prevalence, the reported outcomes are: number of countries with excluded observations, the percentage of countries for which the estimate based on the full data set falls below/above the uncertainty interval based on the training set, and the differences between the updated estimates and the estimates constructed based on the training set.

### Exercise 1 (20%)

<table>
<thead>
<tr>
<th>Category</th>
<th># Countries</th>
<th>% Below</th>
<th>% Above</th>
<th>Differences Median</th>
<th>Median abs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>103</td>
<td>2.9</td>
<td>3.9</td>
<td>0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Modern</td>
<td>103</td>
<td>1.9</td>
<td>4.9</td>
<td>0.00</td>
<td>0.02</td>
</tr>
<tr>
<td>Total</td>
<td>103</td>
<td>2.9</td>
<td>3.9</td>
<td>0.01</td>
<td>0.02</td>
</tr>
<tr>
<td>Unmet</td>
<td>103</td>
<td>2.9</td>
<td>0.0</td>
<td>-0.00</td>
<td>0.01</td>
</tr>
</tbody>
</table>

### Exercise 2 (end)

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<tr>
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<th># Countries</th>
<th>% Below</th>
<th>% Above</th>
<th>Differences Median</th>
<th>Median abs.</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.9</td>
<td>0.9</td>
<td>-0.00</td>
<td>0.01</td>
</tr>
<tr>
<td>Modern</td>
<td>107</td>
<td>1.9</td>
<td>1.9</td>
<td>-0.01</td>
<td>0.03</td>
</tr>
<tr>
<td>Total</td>
<td>107</td>
<td>1.9</td>
<td>1.9</td>
<td>-0.01</td>
<td>0.03</td>
</tr>
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<td>Unmet</td>
<td>107</td>
<td>0.9</td>
<td>3.7</td>
<td>0.01</td>
<td>0.02</td>
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</tbody>
</table>

### Exercise 3 (unmet)

<table>
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<th># Countries</th>
<th>% Below</th>
<th>% Above</th>
<th>Differences Median</th>
<th>Median abs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unmet</td>
<td>22.00</td>
<td>0.00</td>
<td>4.6</td>
<td>0.00</td>
<td>0.03</td>
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</table>

**Expected**

<table>
<thead>
<tr>
<th></th>
<th>≤ 2.5</th>
<th>≤ 2.5</th>
</tr>
</thead>
</table>

#### 3.4 Differences between model-based estimates and observations

The model-based point estimates do not necessarily duplicate the observations since the model draws on all available data for a country, accounts for differences among survey data sources, differences in sample populations and how contraceptive prevalence was measured and is informed by sub-regional, regional and global patterns.

To investigate differences, we compared our model-based point estimates from 1990 to 2012 with observations for total and modern contraceptive prevalence and unmet need and selected all observations where absolute differences with the model-based estimates were more than 5 percentage points. Differences of this magnitude occurred in a small proportion of observations: 7.1% for total contraceptive prevalence, 4.2% for modern use and 6.9% for unmet need for family planning (corresponding to 45, 26 and 19 observations, respectively). Of the cases where differences are more than 5 percentage points, the majority are observations with a sampled population that differs from MWRA or with misclassification issues (see Table 7). For these observations, differences in reported prevalence as compared to prevalence in the baseline population are not surprising and are accounted for in our model, so the resulting differences are as expected.

The observations without special characteristics that differ more than 5 percentage points from the model-based estimate are listed in Table 8. Only 5 observations for total contraceptive prevalence and 1 observation for modern method prevalence do not have any special characteristics that were accounted for in the model. An investigation of the data for these countries suggested that discrepancies arise because of conflicting information from data sources in the country. For example, 4 observations on total prevalence in Pakistan that are more than 5 percentage points different from the model-based point estimates are also quite different from observations from other national surveys that show higher levels of contraceptive prevalence. Another example is Viet Nam, where the DHS in 2002 reports 56.7% modern method use while most other observations in Viet Nam are from a consistent time series of national surveys with higher modern method prevalence, explaining the higher model-based estimate of 61.7% for 2002.

For unmet need for family planning, we find that all 9 observations without special characteristics that differ more than 5 percentage points from the model-based estimate are from data sources other than the Demographic and Health Survey (DHS). As discussed in Section 3.1 we estimated that the error variance for DHS observations on unmet need is much lower than for observations from all other non-DHS sources. In other words, observations on unmet need from non-DHS data sources are estimated to be less informative than DHS observations. As a result, larger differences between observations from non-DHS sources and model-based es-
estimates are not unlikely, especially if the non-DHS observation contradicts information on the expected unmet need level from DHS data. For example, in India, the model-based estimate of unmet need in 2007 is 15.1%, which is much lower than the 20.5% as reported in a national survey in that year, but in line with the lower observations on unmet need from DHS.

This analysis of differences between model-based estimates and observations pinpoints to country-years with conflicting sources of information, that may warrant further investigation into data quality of the observations.

<table>
<thead>
<tr>
<th># Observations in/after 1990</th>
<th>Any method</th>
<th>Modern methods</th>
<th>Unmet need</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>636</td>
<td>622</td>
<td>277</td>
</tr>
<tr>
<td>More than ±5 percentage points difference with model-based estimate</td>
<td>45</td>
<td>26</td>
<td>19</td>
</tr>
<tr>
<td>AND special characteristics</td>
<td>40</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>Among selected observations with special characteristics</td>
<td>16</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Other than MWRA</td>
<td>18</td>
<td>15</td>
<td>5</td>
</tr>
<tr>
<td>Different age group</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Not nationally representative</td>
<td>12</td>
<td>13</td>
<td>5</td>
</tr>
<tr>
<td>Misclassification bias</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 7: Summary of comparison of model-based point estimates with observed data for total and modern contraceptive prevalence and unmet need. Additional information on special characteristics (such as biases or samples from a non-baseline population) and source are listed for selected observations with more than 5 percentage points difference from the model-based estimates. Note that listing totals of special characteristics can add to more than the number of observations because observations can belong to more than one category.

Table 8: Overview of observations without special characteristics for which the difference between the model-based estimate and the observation is more than 5 percentage points. Source “NS” refers to a national survey.
3.5 A note on the width of uncertainty intervals

For countries where regular DHS surveys show a smooth trend in prevalence, such as Kenya and Bangladesh, UIs may be wider than expected; based on the data from those two countries alone, there is a reason to be confident in the DHS observations and dramatic changes during the period from one survey to the next seem unlikely. However, the width of the UIs is based on (i) the estimate of the uncertainty in (or error variance of) a DHS observation, and (ii) the assessment of possible changes in prevalence from one year to the next, from all available data sources in all countries. There are several countries (i.e., Egypt, Senegal and Tanzania) with substantial drops in prevalence between two DHS surveys that are only one or two years apart, suggesting either a large error in one of the two DHSs or an (unexpected) decline in prevalence from one year to the next. As a result, the error variance of the DHS and the variability in prevalence from one year to the next are informed by both data and trends in Kenya and Bangladesh, as well as data and trends in countries like Egypt, Senegal and Tanzania. The resulting UIs in years with DHSs in Kenya and Bangladesh are thus informed by the estimated magnitude of DHS errors, and the widths of the UIs increase during years without observations and during the projection period to allow for possible changes in prevalence levels.

3.6 Comparison of estimates across studies

Sub-regional estimates of MWRA’s use of modern contraception using other approaches are generally within the uncertainty intervals of our estimates. A comparison of our estimates with the estimates by Singh and Darroch (2012) is shown in Figure 9. At the sub-regional level, modern contraceptive prevalence estimates based on a constant extrapolation from the most recent survey observation are generally lower than estimates from our approach but still within the 95% uncertainty intervals for most subregions. The exceptions are Middle Africa and Western Africa (estimates from Singh and Darroch are at the lower bound of the 95% uncertainty interval) and Eastern Asia (the estimate from Singh and Darroch is outside the upper bound of the 95% uncertainty interval, likely due to a higher estimate of modern contraceptive prevalence used for China by the latter study). Point estimates for unmet need for modern methods are comparable across the studies for all subregions except Eastern Asia (the estimate from Singh and Darroch is at the lower bound of the 95% uncertainty interval, and, again, likely due to a higher estimate of modern contraceptive prevalence used for China by the latter study).

Table 9 shows comparisons of the absolute number of married or in-union women in 2012 in developing regions using modern methods or with an unmet need for modern methods from this study and those from Singh and Darroch (2012). Since there is not an equivalent estimate for married or in-union women with an unmet need for modern methods from Singh and Darroch (2012), we multiplied the percentage given in that study (56.7% using modern methods and 18% with an unmet need for modern methods) to the number of married or in-union women from our study. The differences are small despite the different models and populations of married or in-union women. The number of married or in-union women using modern contraceptive methods is 0.2% lower in our estimate compared to the adjusted Singh and Darroch (2012) estimate and the number of married or in-union women with an unmet need for modern methods is 2.6% higher. The absolute numbers based on the Singh and Darroch (2012) study are within the uncertainty intervals of our modeled estimates and are very close to our point estimates.
Figure 9: Comparison of the percentage of married or in-union women aged 15 to 49 years (MWRA) who use modern methods or have an unmet need for modern methods in 2012 in selected sub-regions based on the current study and the study by Singh and Darroch (2012). 95% uncertainty intervals from the current study are presented in blue.

<table>
<thead>
<tr>
<th></th>
<th>Estimated number of MWRA in developing countries:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Using modern methods</td>
</tr>
<tr>
<td>Current study (95% UI)</td>
<td>600,000 (559,000–638,000)</td>
</tr>
<tr>
<td>Singh &amp; Darroch (2012)</td>
<td>596,000</td>
</tr>
<tr>
<td>MWRA prevalence estimates from Singh &amp; Darroch (2012) applied to estimated number of MWRA used in current study</td>
<td>601,000</td>
</tr>
</tbody>
</table>

Table 9: Comparison of the number of married or in-union women aged 15 to 49 years (MWRA) in 2012 in developing regions who use modern methods or have an unmet need for modern methods based on the current study and the study by Singh and Darroch (2012).
4 REFERENCES

References


4 United Nations, Department of Economic and Social Affairs, Population Division. World Contraceptive Use 2012; Forthcoming.


Table 10: **Classification of countries and areas by regions and sub-regions.** The names of countries or areas refer to their short form as presented in the United Nations Multilingual Terminology Database (http://unterm.un.org/).

<table>
<thead>
<tr>
<th>Region</th>
<th>Countries</th>
<th>Sub-region</th>
<th>Countries</th>
</tr>
</thead>
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<tr>
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</tr>
<tr>
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<tr>
<td>Country</td>
<td>CP (any)</td>
<td>CP (modern)</td>
<td>Cono real</td>
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<td>-------------------------</td>
<td>----------</td>
<td>-------------</td>
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Continued on next page
Table 11: Estimates of median increase in the absolute percentage points change in the period (1990-2000) to (2000-2010) and (2000-2005) to (2005-2010) in contraceptive prevalence (any method and modern methods) and unmet need, for the world, developed countries, developing countries (incl. and excl. China), and all subregions and the world, with 95% uncertainty intervals. Symbols: Probability that the change was positive: * >0.9, ** >0.95, *** >0.99. Probability that the change was negative: ′ <0.9, ′′ <0.95, ′′′ <0.99.

<table>
<thead>
<tr>
<th>Region</th>
<th>CP (any)</th>
<th>Unmet need</th>
<th>CP (modern)</th>
<th>Unmet need</th>
</tr>
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<tr>
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Table 11: continued from previous page

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<th>Unmet need</th>
<th>CP (modern)</th>
<th>Unmet need</th>
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<td>[1.1, 0.5]</td>
<td>[0.5, 0.6]</td>
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<tr>
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<td>[0.5, 0.6]</td>
<td>[1.1, 0.5]</td>
<td>[0.5, 0.6]</td>
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<td>Federated States of Micronesia</td>
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<td>[1.1, 0.5]</td>
<td>[0.5, 0.6]</td>
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<tr>
<td>Cook Islands</td>
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<td>[0.5, 0.6]</td>
<td>[1.1, 0.5]</td>
<td>[0.5, 0.6]</td>
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<td>[1.1, 0.5]</td>
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<tr>
<td>Region</td>
<td>1990</td>
<td>2010</td>
<td>Change 1990–2010</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>------</td>
<td>------</td>
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<td></td>
</tr>
<tr>
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<tr>
<td>Africa</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Asia (cont.)</td>
<td>12.7</td>
<td>13.9</td>
<td><strong>1.2 (1.6; 2.6)</strong></td>
<td></td>
</tr>
<tr>
<td>Brazil–Caribbean</td>
<td>22</td>
<td>26</td>
<td><strong>4 (3.2; 5.4)</strong></td>
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<tr>
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<td>61.4</td>
<td><strong>1.9 (1.8; 2.2)</strong></td>
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<td>63.5</td>
<td><strong>1.1 (0.9; 1.4)</strong></td>
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<td>China</td>
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<td>10.9</td>
<td><strong>0.8 (0.7; 1.0)</strong></td>
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<td><strong>5.3 (4.1; 6.5)</strong></td>
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<td><strong>2.8 (2.4; 3.3)</strong></td>
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<tr>
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<td>127.8</td>
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<tr>
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<td>29.3</td>
<td><strong>0.8 (0.7; 1.0)</strong></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>40.5</td>
<td>43.7</td>
<td><strong>3.2 (2.9; 3.6)</strong></td>
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</tr>
<tr>
<td>Southeast Asia</td>
<td>106.9</td>
<td>111.6</td>
<td><strong>4.7 (4.1; 5.4)</strong></td>
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</table>
| *Note: Values in parentheses represent the 90% confidence interval.*

**continued on next page**
<table>
<thead>
<tr>
<th>Region</th>
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<th>2010</th>
<th>Change 1990-2010</th>
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</thead>
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<td>59</td>
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</tr>
<tr>
<td>Asia</td>
<td>112</td>
<td>146</td>
<td>+34</td>
</tr>
<tr>
<td>Europe</td>
<td>60</td>
<td>75</td>
<td>+15</td>
</tr>
<tr>
<td>The Americas</td>
<td>34</td>
<td>46</td>
<td>+12</td>
</tr>
<tr>
<td>Oceania</td>
<td>50</td>
<td>86</td>
<td>+36</td>
</tr>
<tr>
<td>World</td>
<td>221</td>
<td>289</td>
<td>+68</td>
</tr>
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</table>

**Note:** Continues on next page.
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Solomon Islands</td>
<td>21.1 [8.5; 38.6]</td>
<td>29.9 [20.3; 41.2]</td>
<td>8.8 [ -10.4 ; 25.6 ]</td>
<td>5.3 [1.2; 16.5]</td>
<td>6 [2.4; 13.2]</td>
<td>0.6 [ -10.2 ; 8.1 ]</td>
</tr>
<tr>
<td>Vanuatu</td>
<td>27.2 [18.3; 36.4]</td>
<td>38.7 [27.9; 50.9]</td>
<td>11.5 [ -2.6 ; 26 ]</td>
<td>3.6 [1.8; 7.9]</td>
<td>2.7 [0.9; 9.7]</td>
<td>0.9 [ -5.2 ; 3.6 ]</td>
</tr>
<tr>
<td>Micronesia</td>
<td>50.1 [20.4; 82.4]</td>
<td>42.7 [20.2; 75.7]</td>
<td>11.7 [ -1.5 ; 25.2 ]</td>
<td>8.8 [2.9; 15.7]</td>
<td>8.3 [2.8; 13.9]</td>
<td>0.5 [ -8.1 ; 6.7 ]</td>
</tr>
<tr>
<td>Palau</td>
<td>29.8 [19.9; 41.3]</td>
<td>37.9 [27.8; 51.4]</td>
<td>8.1 [ -6.9 ; 24.8 ]</td>
<td>5 [2.6; 9.1]</td>
<td>5.3 [2.6; 9.9]</td>
<td>0.3 [ -7.9 ; 6.7 ]</td>
</tr>
<tr>
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<td>26.4 [18.1; 38.8]</td>
<td>32.9 [22.5; 45.1]</td>
<td>6.5 [ -10.9 ; 26.2 ]</td>
<td>4.5 [2.6; 6.5]</td>
<td>4.6 [2.7; 6.4]</td>
<td>0.1 [ -8.6 ; 5.4 ]</td>
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<tr>
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<td>27.9 [17.9; 41.3]</td>
<td>9.3 [ -11.4 ; 30.8 ]</td>
<td>8.2 [3.6; 12.8]</td>
<td>10.4 [4.7; 18.4]</td>
<td>2.2 [ -11.2 ; 13.3 ]</td>
</tr>
<tr>
<td>Northern Mariana Islands</td>
<td>26.2 [12.1; 47.5]</td>
<td>36.3 [16.7; 65.3]</td>
<td>9.1 [ -6.4 ; 30.7 ]</td>
<td>5.8 [0.6; 15.2]</td>
<td>4.9 [0.5; 15.2]</td>
<td>1.1 [ -6.0 ; 10.3 ]</td>
</tr>
<tr>
<td>Palau</td>
<td>24.2 [10.2; 48.3]</td>
<td>34.1 [19.7; 61.9]</td>
<td>9.9 [ -10.2 ; 28.7 ]</td>
<td>5.6 [0.7; 12.7]</td>
<td>3.5 [0.9; 11.6]</td>
<td>2.1 [ -7.9 ; 6.7 ]</td>
</tr>
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<td>22.9 [13.5; 36.3]</td>
<td>30.8 [22.4; 50.2]</td>
<td>7.9 [ -11.6 ; 31.7 ]</td>
<td>7.3 [2.9; 15.3]</td>
<td>4 [1.9; 13.4]</td>
<td>3.1 [ -7.4 ; 13.7 ]</td>
</tr>
<tr>
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<td>50.1 [18.7; 77.1]</td>
<td>52.7 [19.5; 80.5]</td>
<td>2.6 [ -5.1 ; 21.6 ]</td>
<td>5.2 [2.3; 10.1]</td>
<td>4.5 [2.0; 15.3]</td>
<td>0.7 [ -6.2 ; 7.6 ]</td>
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<td>28.3 [17.2; 43.5]</td>
<td>7.5 [ -8.3 ; 20.7 ]</td>
<td>4.8 [0.1; 11.6]</td>
<td>6.5 [2.0; 15.7]</td>
<td>1.3 [ -4.6 ; 6.6 ]</td>
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Table 12: Estimates (%) and 95% uncertainty intervals of contraceptive prevalence (CP) for modern and traditional methods, for the world, developed countries, developing countries (incl. and excl. China), all subregions and all countries, for 1990 and 2010.
<table>
<thead>
<tr>
<th>Region</th>
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<th>2000</th>
<th>2010</th>
<th>Change 1990-2010</th>
</tr>
</thead>
<tbody>
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<td>World</td>
<td>197.0</td>
<td>220.0</td>
<td>249.0</td>
<td>52.0 (27.2%)</td>
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<tr>
<td>Developed countries</td>
<td>86.4</td>
<td>88.5</td>
<td>90.9</td>
<td>2.1 (2.4%)</td>
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<tr>
<td>Developing countries</td>
<td>110.6</td>
<td>131.5</td>
<td>158.1</td>
<td>27.9 (25.4%)</td>
</tr>
<tr>
<td>Developing (ex. China)</td>
<td>65.8</td>
<td>62.6</td>
<td>60.6</td>
<td>-3.2 (5.0%)</td>
</tr>
<tr>
<td>Eastern Africa</td>
<td>37.0</td>
<td>37.6</td>
<td>40.7</td>
<td>3.7 (10.3%)</td>
</tr>
<tr>
<td>Latvia</td>
<td>22.8</td>
<td>25.5</td>
<td>26.7</td>
<td>3.2 (12.9%)</td>
</tr>
<tr>
<td>others</td>
<td>20.5</td>
<td>21.6</td>
<td>24.0</td>
<td>3.5 (15.7%)</td>
</tr>
<tr>
<td>Middle East</td>
<td>30.2</td>
<td>42.7</td>
<td>48.9</td>
<td>18.7 (54.8%)</td>
</tr>
<tr>
<td>others</td>
<td>31.4</td>
<td>32.0</td>
<td>36.1</td>
<td>4.6 (14.5%)</td>
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<tr>
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<td>173.0</td>
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<tr>
<td>Africa</td>
<td>17.9</td>
<td>18.5</td>
<td>20.2</td>
<td>2.3 (13.4%)</td>
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<tr>
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<td>84.8</td>
<td>88.4</td>
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<tr>
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<td>67.2</td>
<td>8.6 (21.7%)</td>
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continued on next page
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<th>Country</th>
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<th>Change 1990-2010</th>
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<tr>
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<td>61</td>
<td>-0.00</td>
</tr>
<tr>
<td>Oman</td>
<td>28</td>
<td>40</td>
<td>12.0</td>
</tr>
<tr>
<td>Qatar</td>
<td>52</td>
<td>71</td>
<td>19.0</td>
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<td>40</td>
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<td>20.0</td>
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<td>22.0</td>
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<tr>
<td>Latin America and the Caribbean</td>
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**Table 13 – continued from previous page**

**Continued on next page**
Table 13: Estimates of satisfied demand for family planning for 1990 and 2010, and the median absolute percentage point change (1990-2010) for the world, developed countries, developing countries (incl. and excl. China), all subregions and all countries, with 95% uncertainty intervals. Symbols with the median absolute percentage point change: Probability that the change was positive: * >0.9, ** >0.95, *** >0.99. Probability that the change was negative: ′ <0.9, ′′ <0.95, ′′′ <0.99.

<table>
<thead>
<tr>
<th>Country</th>
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<th>2010</th>
<th>Change 1990-2010</th>
</tr>
</thead>
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<tr>
<td>Micronesia</td>
<td>61.4 [46.7; 75.1]</td>
<td>72.2 [59.1; 82.6]</td>
<td>10.4 [-3.9; 25.5]</td>
</tr>
<tr>
<td>Guam</td>
<td>66.1 [42.9; 85.7]</td>
<td>77.2 [56.2; 95.5]</td>
<td>10.1 [-1.6; 35.0]</td>
</tr>
<tr>
<td>Kiribati</td>
<td>54.1 [33.6; 74.4]</td>
<td>64.5 [44.3; 83.1]</td>
<td>10.4 [-13.1; 34.6]</td>
</tr>
<tr>
<td>Marshall Islands</td>
<td>57.1 [41.3; 73.2]</td>
<td>71.5 [57.5; 83.4]</td>
<td>13.4 [-3.5; 30.9]</td>
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<td>49.7 [27.3; 72.7]</td>
<td>86.6 [43.7; 75.8]</td>
<td>8.7 [-14.3; 32.6]</td>
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<td>53.7 [23.2; 73.5]</td>
<td>66.6 [38.9; 86.7]</td>
<td>10.5 [-10.0; 31.8]</td>
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<td>4.8 [-14.1; 21.6]</td>
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<td>Tonga</td>
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<td>58.7 [35.9; 66.2]</td>
<td>8.5 [-13.1; 33.4]</td>
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Table 13 – continued from previous page
<table>
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<tr>
<th>Year</th>
<th>Total contraceptive use</th>
<th>Unmet need</th>
<th>Total Demand</th>
<th>Unmet need for modern methods</th>
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<tbody>
<tr>
<td>2015</td>
<td>26,800 [19.9; 30.8]</td>
<td>5,100 [4.99; 6.02]</td>
<td>31,900 [25.0; 36.9]</td>
<td>1,200 [1.14; 1.27]</td>
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<td>2014</td>
<td>26,700 [19.8; 30.7]</td>
<td>5,000 [4.9; 6.0]</td>
<td>31,700 [25.0; 36.9]</td>
<td>1,200 [1.13; 1.27]</td>
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<td>2013</td>
<td>26,700 [19.8; 30.7]</td>
<td>5,000 [4.9; 6.0]</td>
<td>31,700 [25.0; 36.9]</td>
<td>1,200 [1.13; 1.27]</td>
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<td>2012</td>
<td>26,800 [19.9; 30.8]</td>
<td>5,100 [4.99; 6.02]</td>
<td>31,900 [25.0; 36.9]</td>
<td>1,200 [1.14; 1.27]</td>
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<td>26,800 [19.9; 30.8]</td>
<td>5,100 [4.99; 6.02]</td>
<td>31,900 [25.0; 36.9]</td>
<td>1,200 [1.14; 1.27]</td>
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<td>2010</td>
<td>26,500 [18.9; 28.7]</td>
<td>4,900 [4.3; 5.6]</td>
<td>31,400 [24.3; 36.9]</td>
<td>1,100 [1.03; 1.21]</td>
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<td>2009</td>
<td>26,600 [18.9; 28.7]</td>
<td>4,900 [4.3; 5.6]</td>
<td>31,500 [24.3; 36.9]</td>
<td>1,100 [1.03; 1.21]</td>
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<td>2008</td>
<td>26,600 [18.9; 28.7]</td>
<td>4,900 [4.3; 5.6]</td>
<td>31,500 [24.3; 36.9]</td>
<td>1,100 [1.03; 1.21]</td>
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<td>2007</td>
<td>26,700 [19.8; 30.7]</td>
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<td>31,700 [25.0; 36.9]</td>
<td>1,200 [1.13; 1.27]</td>
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<td>2006</td>
<td>26,700 [19.8; 30.7]</td>
<td>5,000 [4.9; 6.0]</td>
<td>31,700 [25.0; 36.9]</td>
<td>1,200 [1.13; 1.27]</td>
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<td>2005</td>
<td>26,600 [19.8; 30.7]</td>
<td>5,000 [4.9; 6.0]</td>
<td>31,600 [25.0; 36.9]</td>
<td>1,100 [1.03; 1.21]</td>
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<table>
<thead>
<tr>
<th>Year</th>
<th>Total contraceptive users</th>
<th>Unmet need</th>
<th>Total Demand</th>
<th>Unmet need for modern methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>413 [297; 549]</td>
<td>32.1 [20.3; 49.3]</td>
<td>1,442 [1,060; 1,890]</td>
<td>526 [250; 947]</td>
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<tr>
<td>2011</td>
<td>417 [317; 517]</td>
<td>32.8 [20.9; 49.8]</td>
<td>1,153 [895; 1,400]</td>
<td>415 [215; 681]</td>
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<tr>
<td>2012</td>
<td>421 [313; 529]</td>
<td>33.6 [21.3; 52.7]</td>
<td>1,021 [781; 1,240]</td>
<td>372 [224; 485]</td>
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<tr>
<td>2013</td>
<td>425 [316; 530]</td>
<td>34.5 [22.1; 53.8]</td>
<td>932 [700; 1,170]</td>
<td>322 [204; 428]</td>
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<tr>
<td>2014</td>
<td>429 [319; 531]</td>
<td>35.4 [22.9; 54.0]</td>
<td>853 [621; 1,080]</td>
<td>273 [189; 398]</td>
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<tr>
<td>2015</td>
<td>433 [322; 532]</td>
<td>36.3 [23.7; 55.1]</td>
<td>784 [579; 994]</td>
<td>225 [161; 294]</td>
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Table 14 – continued from previous page

...Continued on next page...
<table>
<thead>
<tr>
<th>Year</th>
<th>Total Consumption</th>
<th>Unmet Need</th>
<th>Total Demand</th>
<th>Unmet need for medium method</th>
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<tr>
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<td>3,020,560</td>
<td>29,200</td>
<td>3,050,000</td>
<td>120,000</td>
</tr>
<tr>
<td>2015</td>
<td>3,020,560</td>
<td>29,200</td>
<td>3,050,000</td>
<td>120,000</td>
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**Table 14 – continued from previous page**

Spain

Slovenia

Serbia

Portugal

Malta

Italy

Bosnia and Herzegovina

United Kingdom

Sweden

Lithuania

Latvia

Ireland

Estonia

Denmark

Slovakia

Russian Federation

Republic of Moldova

Poland

Belarus

Europe

Turkey

Saudi Arabia

Qatar

Jordan

Iraq

Continued on next page
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<th>Country or Region</th>
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<th>2015</th>
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<tr>
<td>Argentina</td>
<td>4,090 (3,800, 4,590)</td>
<td>5,070 (4,890, 5,370)</td>
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<tr>
<td>Belize</td>
<td>254 (17, 31)</td>
<td>120.0 (10.3, 203.0)</td>
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<td>Bolivia (Plasmalgetic State of)</td>
<td>591 (214, 790)</td>
<td>629 (214, 790)</td>
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<td>Brazil</td>
<td>2,200 (2,100, 2,300)</td>
<td>2,530 (2,400, 2,630)</td>
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<td>862 (542, 600)</td>
<td>862 (542, 600)</td>
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<tr>
<td>Colombia</td>
<td>551 (370, 550)</td>
<td>653 (370, 590)</td>
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<tr>
<td>Costa Rica</td>
<td>334 (269, 410)</td>
<td>438 (269, 470)</td>
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<tr>
<td>Dominica</td>
<td>656 (501, 850)</td>
<td>810 (501, 850)</td>
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<tr>
<td>Ecuador</td>
<td>280 (245, 310)</td>
<td>430 (245, 310)</td>
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<td>El Salvador</td>
<td>551 (370, 550)</td>
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<td>Guatemala</td>
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<td>736 (586, 840)</td>
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<td>749 (535, 775)</td>
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<td>Niger</td>
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Table 14 – continued from previous page

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<thead>
<tr>
<th>Year</th>
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<th>Unmet need</th>
<th>Total Demand</th>
<th>Unmet need for modern methods</th>
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<tr>
<td>2010</td>
<td>1,090[1,020; 1,160]</td>
<td>15</td>
<td>960[870; 1,050]</td>
<td>1,240[1,180; 1,300]</td>
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<td>2015</td>
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<td>15</td>
<td>960[870; 1,050]</td>
<td>1,240[1,180; 1,300]</td>
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</table>

Numbers are reported in 3 significant digits.

Table 14: Estimates and uncertainty intervals of the number of women (1,000) aged 15-49, who are married or in a union for total contraceptive use (any method), unmet need, total demand (total contraceptive use (any method) and unmet need combined), and unmet need for modern methods (unmet need and traditional method use combined), for 2010 and 2015, for the world, developed countries, developing countries (incl. and excl. China), all subregions and all countries, with 95% uncertainty intervals. Numbers are reported in 3 significant digits.
6 SUPPLEMENTARY FIGURES

Figure 10: Overview of country estimates of family planning indicators for married or in-union women aged 15-49. Contraceptive prevalence (CP) for any method, modern and traditional methods; ratio of modern contraceptive use over total contraceptive use. Bottom row: unmet need; total demand (the sum of contraceptive prevalence and unmet need for family planning); and satisfied demand for family planning. Observed data points are categorized by source type, characteristics of the populations sampled and misclassification biases. 95% uncertainty intervals are displayed with the shaded areas. The median estimates and 80% uncertainty intervals are presented with black solid lines.
Algeria (Northern Africa)

**CP (any)**

- **1990**: 40%
- **1995**: 50%
- **2000**: 60%
- **2005**: 70%
- **2010**: 80%
- **2015**: 90%

**CP (modern)**

- **1990**: 30%
- **1995**: 40%
- **2000**: 50%
- **2005**: 60%
- **2010**: 70%
- **2015**: 80%

**CP (traditional)**

- **1990**: 20%
- **1995**: 30%
- **2000**: 40%
- **2005**: 50%
- **2010**: 60%
- **2015**: 70%

**Ratio (modern/any method)**

- **1990**: 0.5
- **1995**: 0.6
- **2000**: 0.7
- **2005**: 0.8
- **2010**: 0.9
- **2015**: 1.0

**Unmet need**

- **1990**: 20%
- **1995**: 30%
- **2000**: 40%
- **2005**: 50%
- **2010**: 60%
- **2015**: 70%

**Total demand**

- **1990**: 80%
- **1995**: 90%
- **2000**: 100%
- **2005**: 100%
- **2010**: 100%
- **2015**: 100%

**Demand satisfied**

- **1990**: 70%
- **1995**: 80%
- **2000**: 90%
- **2005**: 100%
- **2010**: 100%
- **2015**: 100%

Color Key:
- **DHS**: Demographic and Health Survey
- **MICS**: Multiple Indicator Cluster Survey
- **Other international survey**: Other international surveys
- **National survey**: National surveys

Subpopulation:
- **Married women**
- **Sexually active women**
- **Ever married/All women**
- **Both sexes and husband/wives**

Legend:
- **+**: Higher contraceptive use
- **−**: Lower contraceptive use
- **A**: Other age group
- **F**: Folk methods included
- **S−**: Sterilization included
- **S+**: Sterilization excluded
Chad (Middle Africa)

CP (any)

CP (modern)

CP (traditional)

Ratio (modern/any method)

Unmet need

Total demand

Demand satisfied

- DHS
- MICS
- Other international survey
- National survey

Subpopulation
- : Higher contraceptive use
- : Lower contraceptive use
- A: Other age group
- F: Folk methods included
- S: Sterilization included
- S+: Sterilization excluded

Married women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives
Cook Islands (Polynesia)

CP (any)

CP (modern)

CP (traditional)

Ratio (modern/any method)

Unmet need

Total demand

Demand satisfied

- DHS
- MICS
- Other international survey
- National survey
- Subpopulation
  +: Higher contraceptive use
  -: Lower contraceptive use
  A: Other age group
  F: Folk methods included
  S−: Sterilization included
  S+: Sterilization excluded

Married women
Sexually active women
Ever married/All women
Both sexes and husband/wives
Costa Rica (Central America)

### CP (any)

- Data incl. before 1990

### CP (modern)

- Data incl. before 1990

### CP (traditional)

- Data incl. before 1990

### Ratio (modern/any method)

- Data incl. before 1990

---

### Unmet need

### Total demand

### Demand satisfied

- DHS
- MICS
- Other international survey
- National survey

- Subpopulation:
  - : Higher contraceptive use
  - –: Lower contraceptive use
  - A: Other age group
  - F: Folk methods included
  - S−: Sterilization included
  - S+: Sterilization excluded

- Markers:
  - Married women
  - Sexually active women
  - Ever married/All women
  - Both sexes and husband/wives
Croatia (Southern Europe)

Graphs showing trends in contraceptive prevalence (CP) and unmet need from 1990 to 2015.

- **CP (any)**: Data includes before 1990.
- **CP (modern)**: Data includes before 1990.
- **CP (traditional)**: Data includes before 1990.
- **Ratio (modern/any method)**: Data includes before 1990.

- **Unmet need**
- **Total demand**
- **Demand satisfied**

Legends:
- DHS
- MICS
- Other international survey
- National survey
- Subpopulation
- +: Higher contraceptive use
- -: Lower contraceptive use
- A: Other age group
- F: Folk methods included
- S−: Sterilization included
- S+: Sterilization excluded

Data sources and subpopulations:
- Married women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives
Egypt (Northern Africa)

CP (any)  

CP (modern)  

CP (traditional)  

Ratio (modern/any method)  

Unmet need  

Total demand  

Demand satisfied  

*Data incl. before 1990  

DHS  

MICS  

Other international survey  

National survey  

Subpopulation  

+: Higher contraceptive use  

- : Lower contraceptive use  

A: Other age group  

F: Folk methods included  

S−: Sterilization included  

S+: Sterilization excluded  

Married women  

Sexually active women  

Ever married/All women  

Both sexes and husband/wives
Finland (Northern Europe)

**CP (any)**

- 1990: 60%
- 2015: 40%

**CP (modern)**

- 1990: 80%
- 2015: 60%

**CP (traditional)**

- 1990: 80%
- 2015: 60%

**Ratio (modern/any method)**

- 1990: 100%
- 2015: 100%

**Unmet need**

- 1990: 20%
- 2015: 20%

**Total demand**

- 1990: 100%
- 2015: 100%

**Demand satisfied**

- 1990: 100%
- 2015: 100%
Honduras (Central America)

**CP (any)**

- 1990: A
- 1995: A
- 2000: A
- 2005: A
- 2010: A
- 2015: A

- *Data incl. before 1990

**CP (modern)**

- 1990: A
- 1995: A
- 2000: A
- 2005: A
- 2010: A
- 2015: A

- *Data incl. before 1990

**CP (traditional)**

- 1990: A
- 1995: A
- 2000: A
- 2005: A
- 2010: A
- 2015: A

- *Data incl. before 1990

**Ratio (modern/any method)**

- 1990: A
- 1995: A
- 2000: A
- 2005: A
- 2010: A
- 2015: A

- *Data incl. before 1990

**Unmet need**

- 1990: A
- 1995: A
- 2000: A
- 2005: A
- 2010: A
- 2015: A

- *Data incl. before 1990

**Total demand**

- 1990: A
- 1995: A
- 2000: A
- 2005: A
- 2010: A
- 2015: A

- *Data incl. before 1990

**Demand satisfied**

- 1990: A
- 1995: A
- 2000: A
- 2005: A
- 2010: A
- 2015: A

- *Data incl. before 1990

**Legend**

- DHS
- MICS
- Other international survey
- National survey
- Subpopulation
  +: Higher contraceptive use
  -: Lower contraceptive use
  A: Other age group
  F: Folk methods included
  S−: Sterilization included
  S+: Sterilization excluded

**Population Groups**

- Married women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives
India (Southern Asia)

### CP (any)
- Data incl. before 1990

### CP (modern)
- Data incl. before 1990

### CP (traditional)
- Data incl. before 1990

### Ratio (modern/any method)
- Data incl. before 1990

---

### Unmet need

### Total demand

### Demand satisfied

- DHS
- MICS
- Other international survey
- National survey

- Subpopulation
  - +: Higher contraceptive use
  - -: Lower contraceptive use
  - A: Other age group
  - F: Folk methods included
  - S−: Sterilization included
  - S+: Sterilization excluded

- Subpopulations:
  - Married women
  - Sexually active women
  - Ever married/All women
  - Both sexes and husband/wives
Iran (Islamic Republic of) (Southern Asia)

CP (any)

CP (modern)

CP (traditional)

Ratio (modern/any method)

Unmet need

Total demand

Demand satisfied

*Data incl. before 1990

DHS
MICS
Other international survey
National survey
Subpopulation

+: Higher contraceptive use
−: Lower contraceptive use
A: Other age group
F: Folk methods included
S−: Sterilization included
S+: Sterilization excluded

Married women
Sexually active women
Ever married/All women
Both sexes and husband/wives
Iraq (Western Asia)

**CP (any)**

*Data incl. before 1990

**CP (modern)**

*Data incl. before 1990

**CP (traditional)**

*Data incl. before 1990

**Ratio (modern/any method)**

*Data incl. before 1990

**Unmet need**

**Total demand**

**Demand satisfied**

- DHS
- MICS
- Other international survey
- National survey

● Subpopulation

+: Higher contraceptive use
−: Lower contraceptive use
A: Other age group
F: Folk methods included
S−: Sterilization included
S+: Sterilization excluded

Married women
Sexually active women
Ever married/All women
Both sexes and husband/wives
Ireland (Northern Europe)

**CP (any)**

- **1990**
- **1995**
- **2000**
- **2005**
- **2010**
- **2015**

**CP (modern)**

- **1990**
- **1995**
- **2000**
- **2005**
- **2010**
- **2015**

**CP (traditional)**

- **1990**
- **1995**
- **2000**
- **2005**
- **2010**
- **2015**

**Ratio (modern/any method)**

- **1990**
- **1995**
- **2000**
- **2005**
- **2010**
- **2015**

**Unmet need**

- **1990**
- **1995**
- **2000**
- **2005**
- **2010**
- **2015**

**Total demand**

- **1990**
- **1995**
- **2000**
- **2005**
- **2010**
- **2015**

**Demand satisfied**

- **1990**
- **1995**
- **2000**
- **2005**
- **2010**
- **2015**

**Legend:**
- Red: DHS
- Green: MICS
- Black: Other international survey
- Blue: National survey
- Orange: Subpopulation
  - +: Higher contraceptive use
  - -: Lower contraceptive use
  - A: Other age group
  - F: Folk methods included
  - S-: Sterilization included
  - S+: Sterilization excluded
- Gray: Married women
- Light gray: Sexually active women
- Light orange: Ever married/All women
- White: Both sexes and husband/wives
Israel (Western Asia)

**CP (any)**
- Data incl. before 1990

**CP (modern)**
- Data incl. before 1990

**CP (traditional)**
- Data incl. before 1990

**Ratio (modern/any method)**
- Data incl. before 1990

**Unmet need**

**Total demand**

**Demand satisfied**

**Legend:**
- DHS
- MICS
- Other international survey
- National survey
- Subpopulation
  - +: Higher contraceptive use
  - -: Lower contraceptive use
  - A: Other age group
  - F: Folk methods included
  - S−: Sterilization included
  - S+: Sterilization excluded

**Population groups:**
- Married women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives
Japan (Eastern Asia)

**CP (any)**

- 1990: 60%
- 2010: 80%

**CP (modern)**

- 1990: 60%
- 2010: 80%

**CP (traditional)**

- 1990: 60%
- 2010: 80%

**Ratio (modern/any method)**

- 1990: 80%
- 2010: 80%

**Unmet need**

- 1990: 20%
- 2010: 20%

**Total demand**

- 1990: 80%
- 2010: 80%

**Demand satisfied**

- 1990: 80%
- 2010: 80%

---

- Data incl. before 1990

- DHS
- MICS
- Other international survey
- National survey

- Subpopulation
    - +: Higher contraceptive use
    - -: Lower contraceptive use
    - A: Other age group
    - F: Folk methods included
    - S: Sterilization included
    - S+: Sterilization excluded

- Maried women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives
Liberia (Western Africa)

**CP (any)**
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

**CP (modern)**
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

**CP (traditional)**
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

**Ratio (modern/any method)**
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

**Unmet need**
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

**Total demand**
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

**Demand satisfied**
- 1990
- 1995
- 2000
- 2005
- 2010
- 2015

*Data incl. before 1990

- ●: DHS
- ●: MICS
- ●: Other international survey
- ●: National survey
- ●: Subpopulation
- +: Higher contraceptive use
- -: Lower contraceptive use
- A: Other age group
- F: Folk methods included
- S−: Sterilization included
- S+: Sterilization excluded

- Married women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives
Papua New Guinea (Melanesia)

CP (any)

CP (modern)

CP (traditional)

Ratio (modern/any method)

Unmet need

Total demand

Demand satisfied

- DHS
- MICS
- Other international survey
- National survey

- Subpopulation
  +: Higher contraceptive use
  -: Lower contraceptive use
  A: Other age group
  F: Folk methods included
  S-: Sterilization included
  S+: Sterilization excluded

- Marital status
  Married women
  Sexually active women
  Ever married/All women
  Both sexes and husband/wives
Rwanda (Eastern Africa)

**CP (any)**

- Data incl. before 1990

**CP (modern)**

- Data incl. before 1990

**CP (traditional)**

- Data incl. before 1990

**Ratio (modern/any method)**

- Data incl. before 1990

**Unmet need**

**Total demand**

**Demand satisfied**

- DHS
- MICS
- Other international survey
- National survey
- Subpopulation
- Married women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives

Note: +: Higher contraceptive use; -: Lower contraceptive use; A: Other age group; F: Folk methods included; S−: Sterilization included; S+: Sterilization excluded.
Turkmenistan (Central Asia)

CP (any)

CP (modern)

CP (traditional)

Ratio (modern/any method)

Unmet need

Total demand

Demand satisfied

- DHS
- MICS
- Other international survey
- National survey
- Subpopulation
  +: Higher contraceptive use
  -: Lower contraceptive use
  A: Other age group
  F: Folk methods included
  S−: Sterilization included
  S+: Sterilization excluded

Married women
Sexually active women
Ever married/All women
Both sexes and husband/wives
Viet Nam (South-Eastern Asia)

CP (any)

CP (modern)

CP (traditional)

Ratio (modern/any method)

Unmet need

Total demand

Demand satisfied

*Data incl. before 1990

● DHS

● MICS

● Other international survey

● National survey

● Subpopulation

+: Higher contraceptive use

−: Lower contraceptive use

A: Other age group

F: Folk methods included

S−: Sterilization included

S+: Sterilization excluded

Married women

Sexually active women

Ever married/All women

Both sexes and husband/wives
Zimbabwe (Eastern Africa)

**CP (any)**

- Data incl. before 1990

**CP (modern)**

- Data incl. before 1990

**CP (traditional)**

- Data incl. before 1990

**Ratio (modern/any method)**

- Data incl. before 1990

**Unmet need**

**Total demand**

**Demand satisfied**

- DHS
- MICS
- Other international survey
- National survey
- Subpopulation
  - +: Higher contraceptive use
  - -: Lower contraceptive use
  - A: Other age group
  - F: Folk methods included
  - S−: Sterilization included
  - S+: Sterilization excluded

- Married women
- Sexually active women
- Ever married/All women
- Both sexes and husband/wives