DEMOGRAPHIC RESEARCH
A peer-reviewed, open-access journal of population sciences

DEMOGRAPHIC RESEARCH

VOLUME 50, ARTICLE 31, PAGES 899–928
PUBLISHED 3 MAY 2024
https://www.demographic-research.org/Volumes/Vol50/31/
DOI: 10.4054/DemRes.2024.50.31

Research Article

A new look at contraceptive prevalence plateaus in sub-Saharan Africa: A probabilistic approach

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Demographic Research: Volume 50, Article 31
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Abstract

BACKGROUND
Fertility decline in sub-Saharan Africa has been slower than in other regions, with the periods of extremely slow transitions frequently described as stalled. Lack of investment in family planning programs has been proposed as a key contributing factor. However, while there is a large literature on fertility transition stalls, similar phenomena in contraceptive prevalence trends have received less attention.

OBJECTIVE
We propose a probabilistic method for detecting plateaus in modern contraceptive prevalence (MCP) and in demand for family planning satisfied by modern methods (DS).

METHODS
We defined a contraceptive prevalence plateau in terms of level, rate, and probability conditions, each with associated thresholds for a plateau to be identified. We used probabilistic annual model-based estimates of family planning indicators and a simple smoothing approach to produce annual estimates of plateau probabilities under a variety of thresholds.

RESULTS
We applied our method to 48 countries in sub-Saharan Africa over the period 1980–2019 and found plateaus in MCP in ten countries (half in western Africa) and plateaus in DS

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in two (Niger and Nigeria). We found no indication of a temporal association between MCP plateaus and fertility transition stalls, although we observed that some fertility transition stalls occurred when MCP was low.

CONTRIBUTION
Our method provides an updated, robust way to identify plateaus in contraceptive prevalence. Moreover, it could feasibly be applied to probabilistic model-based estimates of other demographic indicators, such as total fertility.

1. Introduction

It has been well observed that fertility transitions started much later in sub-Saharan Africa than in other regions of the world, and the pace of fertility decline there remains generally slower than in Asia, Latin America, and the Caribbean (Bongaarts 2016; Dasgupta et al. 2022; Gerland, Biddlecom, and Kantorová 2017; Shapiro and Hinde 2017). Research interest in this phenomenon intensified in the 2000s, with much commentary on the purported stalling of fertility transitions, wherein fertility declines in the 1990s had slowed or halted by the turn of the millennium (Bongaarts 2006, 2008; Ezeh, Mberu, and Emina 2009; Garenne 2008; Machiyama 2010; Schoumaker 2009; Shapiro and Gebreselassie 2008). Many underlying causes for the slowdowns were proposed. They included weak government commitment, slower economic development, disruptions in investments in education of women and girls, higher infant and child mortality, and higher desired family sizes (Bongaarts and Casterline 2013; Goujon, Lutz, and KC 2015; Kebede, Goujon, and Lutz 2019; Liu and Raftery 2020). However, a lack of investment in family planning programs was frequently identified as a key contributing factor at all levels of economic development (Bongaarts 2017; Bongaarts and Sinding 2011). In this article, we consider the possibility that slowdowns analogous to fertility transition stalls in sub-Saharan Africa have also occurred in contraceptive prevalence trends.

While stalls in fertility transitions continue to be documented and debated (e.g., Grimm et al. 2022; Schoumaker 2019), less attention has been given specifically to similar phenomena in trends of contraceptive prevalence. In individual country studies, Wickstrom, Diagne, and Smith (2006) noted a slowdown in the rate of increase of modern contraceptive prevalence (MCP) in Senegal between 1997 and 2005 following a sustained period of increase in the 1990s. Similarly, Pile and Simbakalia (2006) identified a deceleration in the upward trend in MCP in Tanzania between 1999 and 2005, and Westoff and Cross (2006: 7) reported a “plateauing” in contraceptive use in Kenya between the Demographic and Health Surveys (DHSs) of 1998 and 2003. To our knowledge, though, the only multi-country, systematic analysis of unexpected slowdowns in the uptake of contraceptives was undertaken by Ross, Abel, and Abel (2004: 39), who identified plateaus or "occasional flat periods" in population-level contraceptive prevalence.

While systematic in its approach to defining plateaus, Ross, Abel, and Abel's (2004) analysis was limited to studying changes averaged over intervals between available surveys. Thus plateaus may have been missed due to averaging over long periods or because they occurred outside the range of available data. Moreover, at least three surveys per country were required, which limited analysis to 52 countries. In addition, the potential for biases and measurement errors to produce false positives or negatives was raised by Ross, Abel, and Abel (2004), but other than speculate on specific cases, they were not able to systematically address this issue. Finally, although Ross, Abel, and Abel (2004) put forward several potential explanations for the plateaus they identified, they did not discuss potential links to contemporaneous stalls in fertility transitions. Empirically, population-level indicators of contraceptive use have been found to be strongly negatively correlated with fertility indicators such as total fertility rate (TFR)[5] (Bongaarts 1978, 2006, 2015; Stover 1998). Moreover, this appears to hold across geographies and time periods for which adequate data are available (Bongaarts 2017; Choi, Short Fabic, and Adetunji 2018; Garenne 2014; United Nations 2020).

Our study, therefore, had three aims. The first was to develop a new method for detecting plateaus in contraceptive prevalence trends that was not limited to inter-survey intervals, that used all available data, and that could account for biases and measurement errors in indicator estimates. Our second aim was to use the new methodology to identify plateaus in both contraceptive prevalence and in the proportion of the need for family planning satisfied with modern methods (DS) across all sub-Saharan African countries. Finally, we aimed to compare plateaus in MCP with the fertility transition stalls identified by Schoumaker (2019), as this is informative about the role of contraceptive use as a determinant in fertility transitions. From here on we follow the literature in using the term *stall* in the context of fertility transitions and the term *plateau* in the context of contraceptive prevalence.

[5] TFR is the average number of live births that a hypothetical cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the age-specific fertility rates of a given period. TFR is expressed in the number of live births per woman.

2. Existing research on fertility transition stalls and contraceptive prevalence plateaus

2.1 Fertility transition stalls

Despite many articles on the topic, there is no standard, consistently applied definition of a fertility transition stall (Schoumaker 2019). However, from the summary of some previously proposed definitions, given in Table 1, two key commonalities can be identified. First, most authors consider the concept of a fertility transition stall to be meaningful only while a fertility transition is underway – that is, after fertility rates have begun to fall and before they settle at levels around replacement. Some authors explicitly define criteria for identifying the beginning and end of the fertility transition. We call all such criteria level conditions since they typically entail thresholds or limits on the level of fertility.

The second component common to most definitions is a set of conditions on the rate of change of fertility rates over time. We call these rate conditions. For example, Bongaarts (2008) considered periods of no statistically significant decline in TFR between successive DHS surveys to be indicative of a stall. In a recent and comprehensive analysis focusing on sub-Saharan Africa, Schoumaker (2019) adopted a criterion involving the statistical significance of inter-survey changes. Rather than use direct survey estimates, however, he used regression smoothing and indirect estimation techniques to reconstruct fertility trends from a wider range of sources over longer periods of time.

Table 1: A selection of criteria used previously to define fertility transition stalls

Study	Geographical coverage	Data sources	Level conditions	Rate conditions
Bongaarts (2006)	Africa, Asia, Latin America	DHS	TFR in the range 2.5–5 at the time of most recent DHS	TFR failed to decline between two DHS surveys
Bongaarts (2008)	Africa, Asia, Latin America	DHS	CP among married women above 10% and TFR above replacement	No statistically significant decline in TFR between the two most recent DHS surveys
Shapiro and Gebreselassie (2008)	Sub-Saharan Africa	DHS	At the time of most recent DHS, TFR in the range 2.5–5 (mid-transition) or 5.5–6 (early transition)	Same as Bongaarts (2006)
Garenne (2008), Garenne (2013)	Sub-Saharan Africa	DHS, WFS		Periods in which slope of TFR trend changed from negative to nil or positive. TFR trends reconstructed from WFS and DHS estimates.
Moultrie et al. (2008)	KwaZulu-Natal (partial), South Africa	Demographic surveillance site		Statistically significant difference in the rate of TFR decline over two time periods, with each period greater than or equal to five years' duration but not necessarily the same length. Preferably the slope of the line relating to the second period should not differ significantly from zero.
Ezeh, Mberu, and Emina (2009)	Eastern Africa (Kenya, Tanzania, Uganda, Zimbabwe)	DHS		Three consecutive survey observations in which third survey had a change of 0% or greater in TFR
Machiyama (2010)	Sub-Saharan Africa	DHS	TFR has dropped by more than 20% from the highest observed TFR	A trend in which the average annual pace of TFR decline during a DHS inter-survey period is less than half the pace of the previous inter-survey period
Goujon, Lutz, and KC (2015)	Sub-Saharan Africa	WIC		The ratio of a country's TFR over a ten-year period (either 2000–2005/1995–2000 or 2005–2010/2000–2005) was at or above 0.98
Schoumaker (2019)	Sub-Saharan Africa	DHS, MICS, censuses, other surveys	TFR in a given year is 10% lower than maximum number of children ever born observed in a previous DHS; mid-transition if TFR is below 5; otherwise early transition	Relative to TFR in the previous survey, current TFR is (1) equal or higher (stall) or (2) lower but the difference is not statistically significant (slight stall)

Notes: CP = contraceptive prevalence (any method); DHS = Demographic and Health Survey; MCP = modern contraceptive prevalence; MICS = Multiple Indicator Cluster Surveys; WFS = World Fertility Survey; WIC estimates compiled by the Wittgenstein Centre for Demography and Global Human Capital from various sources.

2.2 Contraceptive prevalence plateaus

There is less published research on contraceptive prevalence plateaus than on fertility transition stalls. In what has been written, the most often stated identifying feature of a contraceptive prevalence plateau was a low pace of change in contraceptive prevalence. When explicitly defined, this constituted a requirement that the annual rate of increase be below a certain threshold, typically in the range 0–0.6 percentage points (see Table 2). Allusions to conceptually similar definitions can be extracted from more qualitative statements in other studies. For instance, Jacobstein et al. (2009) labelled FP programs as "fragile" when MCP either declined or stayed the same between DHSs. Cleland, Ndugwa, and Zulu (2011: 137; 140) described an average annual increase in MCP of 0.6 percentage points per year between 1986 and 2007 in western Africa as “dismally low” when compared with an increase of 1.4 percentage points per year in eastern Africa. For context, they noted that an increase of 15 percentage points in MCP is “usually required” to bring TFR down by one birth per woman. Garenne (2013: 8) described an increase in MCP among sexually active women in Nigeria of 1.3% as “virtually no increase,” but the time period over which this was measured is not clear. Finally, Garenne (2014: 26) noted “stagnation” in ever use of modern contraception by age 40 in some sub-Saharan African countries but gave no quantitative definition.

Table 2: A selection of criteria used previously to define contraceptive prevalence plateaus

Study	Geographical coverage	Level conditions	Rate conditions
Ross, Abel, and Abel (2004)	Countries with DHS or RHS	CP or MCP between 25% and 60%	Temporary periods of hesitation after an established upward trend in prevalence Rule of 0.1: Less than 0.1 % point per year
			Rule of 0.3: Less than 0.3 % point per year
			Rule of 0.5: Less than 0.5 % point per year
Westoff and Cross (2006)	Kenya	none	0% point change in CP and MCP
Pile and Simbakalia (2006)	Tanzania	none	0.2% points CP; 0.6% points/halved MCP
Spindler et al. (2017)	Jordan	none	1% change in MCP over a ten-year period described as a stall

Notes: CP = contraceptive prevalence (any method); DHS = Demographic and Health Survey; MCP = modern contraceptive prevalence; RHS = Reproductive Health Survey.

The only multi-country, systematic analysis we are aware of was performed by Ross, Abel, and Abel (2004). They used data from all available DHSs and Reproductive Health Surveys (RHSs) conducted in countries across all regions of the world. As no accepted definition existed, the authors proposed several ways to define a plateau based on the average annual inter-survey changes (as was done by many authors for fertility transition stalls). They considered three rate conditions: 0.1, 0.3, and 0.5 percentage points per year. Modern contraceptive prevalence and contraceptive prevalence of any method (CP) were separately analysed.

Importantly, they also noted that to be analytically useful, the definition of a plateau should exclude periods during which CP was very low or very high. At very low levels, plateaus are to be expected because access is low and knowledge of contraception is just beginning to diffuse through the population. At very high levels, contraceptive use has reached a saturation point above which it is unlikely to increase. At this point, access and knowledge are high, and it is expected that the vast majority of those who want to use contraception are doing so. Ross, Abel, and Abel (2004) believed that plateaus were likely to be of substantive interest at the intermediate levels, during the transition between these two extremes, because they could feasibly signal a change in the effectiveness of family planning programs, a restriction in supply or access, or some other event worthy of further investigation. To operationalize this idea, they added a common level condition to their rate conditions, namely that CP be between 25% and 60% at the time of the plateau.

The data available to Ross, Abel, and Abel (2004) provided 152 inter-survey periods across 52 countries with at least three surveys. Each was classified as a plateau period or a non-plateau period. The number of plateau periods was noticeably affected by the choice of definition. Applying only their rate conditions, they identified 41 plateau periods using the 0.5 percentage point threshold and 18 using the 0.1 percentage point threshold. Under the 0.1 percentage point threshold and counting only cases in which the level condition was satisfied, the number of plateau periods reduced to nine. Of those nine, three were plateaus in MCP in countries in sub-Saharan Africa: South Africa (1981–1987), Rwanda (1992–2000), and Namibia (1989–1992).

3. Data and methods

3.1 Indicators

CP is the percentage of women who report themselves or their partners as currently using at least one contraceptive method of any type. MCP is the percentage of women who report themselves or their partners as currently using at least one modern contraceptive method. Modern methods of contraception include female and male sterilization, intra-uterine devices (IUDs), implants, injectables, oral contraceptive pills, male and female condoms, vaginal barrier methods (including diaphragms, cervical caps, and spermicidal foams, jellies, creams, and sponges), the lactational amenorrhea method (LAM), and emergency contraception.

DS is the ratio of the number of women who are currently using, or whose sexual partner is currently using, at least one modern contraceptive method to the number of women who prefer not to have any (more) children. This ratio is Indicator 3.7.1 of the Global Indicator Framework of the 2030 Agenda for Sustainable Development (United Nations 2015, 2017). The indicator reflects at the population level the gap between fertility intentions and modern contraception coverage, thus taking into account population-level changes in fertility intentions. We studied plateaus in both MCP and DS. Further details on the indicators are available in United Nations (2022c).

The population of interest for plateaus in MCP was married or in-union women of reproductive age (MWRA). This ensured greater comparability with this indicator's use in existing research. Moreover, it avoided the potential confounding of results due to changes in the proportion married or in union. The study population for plateaus in DS was women of reproductive age (WRA; age 15–49) to align with its definition in the Global Indicator Framework. We restricted our analysis to 48 countries in sub-Saharan Africa (as defined by United Nations 2021) and the period 1980–2019. These locations and times matched those used by Schoumaker (2019) and yielded a total of 1,920 country-years of observation.

3.2 Data

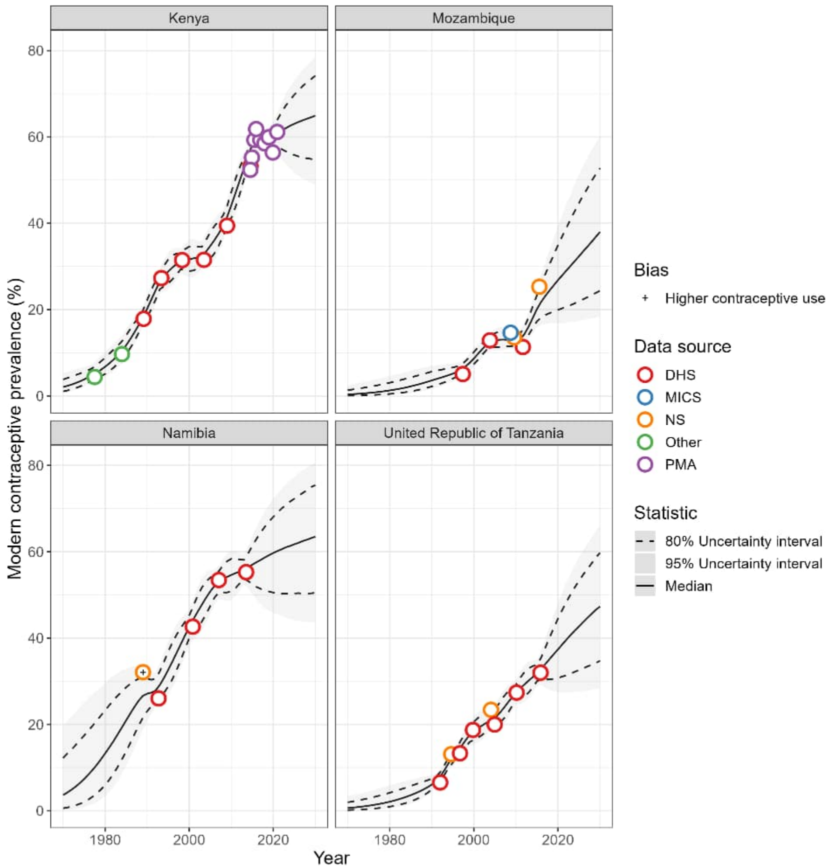
Data came from World Contraceptive Use (United Nations 2022b, 2022c), a data compilation containing estimates of contraceptive use calculated from nationally representative surveys. The entire compilation consisted of 1,404 observations in total from 186 countries or areas of the world for the period from 1950 to 2020. The source surveys were from multi-country survey programs that routinely collect the necessary data, including the DHS, the Multiple Indicators Cluster Survey (MICS), and national surveys.

3.3 Model-based estimates of family planning indicators

The basis of all analyses was the set of model-based estimates of family planning indicators available from the United Nations (2022a; see also United Nations 2022c). The model-based estimates were obtained by applying the Global Family Planning Estimation Model (FPEMglobal) to data from World Contraceptive Use. FPEMglobal is a Bayesian hierarchical mode that produces a Markov chain Monte Carlo (MCMC) sample from the joint posterior distribution over a set of family planning indicators. This was transformed into a pair of univariate marginal posterior distributions for each country, one for MCP and the other for DS. We worked directly with individual trajectories from the MCMC sample to produce probabilistic plateau indicators.

Examples of the model-based estimates and projections of MCP for four countries are shown in Figure 1 along with the data used to fit the model. Marginal posterior distributions for MCP are summarized in the plot using medians and central 80% and 95% probability intervals. The intervals indicate uncertainty, which, as intuition would suggest, is lower in periods when data are abundant and of good quality and higher when data are sparse or have known biases.

Figure 1: Model-based estimates of modern contraceptive prevalence for married/in-union women aged 15–49 for selected countries in sub-Saharan Africa



Notes: The + sign indicates an additional bias parameter added to account for an expected upward bias in any particular survey (see Kantorová et al. 2020 for details). Key: DHS = Demographic and Health Survey; MICS = Multiple Indicator Cluster Survey; NS = national survey; Other = other survey; PMA = Performance Monitoring and Accountability Survey.
Source: United Nations (2022a).

A comprehensive description of FPEMglobal is available elsewhere (Alkema et al. 2013; Cahill et al. 2017; Kantorová et al. 2020). Briefly, it is a flexible model for contraceptive prevalence trends wherein the time trends of CP and the ratio of MCP to CP are the combination of two country-specific components. The first component consists of systemic trends modelled using logistic curves. A separate pair of curves is estimated for each country, with their exact shapes determined by the available data. The second component comprises deviations from the smooth logistic trend modelled by auto-correlated error processes. Biases due to factors including geographic coverage discrepancies, systematic misreporting, and measurement errors are accounted for with additional adjustment parameters. Sampling and non-sampling errors are accounted for through additional model parameters, which are informed by data where available.

The outcome is a set of unique country-specific time trends that are not constrained to follow the stylized logistic function but can deviate from it where the data indicate. Critically, this feature allows the model-based estimates to pick up any contraceptive prevalence plateaus – periods that by definition do not conform to the monotonically increasing logistic trend.

The model is implemented in the R package FPEMglobal, version 1.3.0 (Wheldon et al. 2022). Appropriately formatted source data are included in the package.

3.4 A probabilistic approach to determining contraceptive prevalence plateaus

3.4.1 Condition thresholds

We adopted the framework of Ross, Abel, and Abel (2004) and used level and rate conditions to define contraceptive prevalence plateaus. Working with probabilistic estimates allowed us to add a third condition, which we call a probability condition, indicating the probability that a plateau occurred. We investigated sensitivity to the plateau definition by varying the thresholds in the rate and probability conditions. (Level condition thresholds were fixed.) Three rate condition thresholds and three probability condition thresholds were investigated, resulting in nine variants. We applied the same set of thresholds to all countries, indicators, and marital groups. A summary of the thresholds for each condition is given in Table 3.

Table 3: Conditions and thresholds underlying the definition of a contraceptive prevalence plateau in a single year

Condition	Indicator	Threshold description	Threshold variants	Basis
Level	MCP	10%–60%	(fixed)	Posterior median
	DS	20%–80%		
Rate	Both	Less than δ percentage points per year	δ = 0.1,0.3,0.5	MCMC trajectories
Probability	Both	Exceeds γ percent	γ = 80,90,95	MCMC trajectories

Notes: These conditions pertain to plateaus in MCP and DS. Level condition thresholds were fixed, but rate and probability condition thresholds were varied. All combinations of the rate and probability condition thresholds were investigated, resulting in nine variants.

The MCP level condition meant that plateaus were declared only in years when the country-specific posterior median estimate of MCP was between 10% and 60%. Similarly, plateaus in DS were identified only in years when the posterior median estimate of DS itself was between 20% and 80%. Across all countries of interest, these values were found to reasonably capture the periods in which contraceptive prevalence was generally increasing. Although the thresholds themselves were constant, the time windows they defined varied across countries with the values of the respective indicators.

Once the respective posterior median estimate exceeded the lower threshold, the condition was considered satisfied from that year onward until the upper threshold was reached (if at all). Thus, in the event the indicator exceeded the lower threshold but then oscillated around it, the level condition was maintained and any plateaus during such periods were counted.

For both indicators, we used the same rate condition thresholds as Ross, Abel, and Abel (2004). These values were found to adequately identify years in which change was atypically slow while not being so strict as to eliminate the possibility of any meaningful plateaus. This assessment was based on an analysis of the distributions of the annual rates of change in posterior medians, restricted to years in which the level conditions were satisfied.

Ross, Abel, and Abel (2004: 40) described the 0.5 percentage point threshold as “rather lax,” as they found it was roughly equal to the average rate of increase observed in many countries in their dataset. However, in the context of our analysis, this threshold was more conservative. The median of our annual change distributions was 0.95 percentage points for MCP and 1.2 percentage points for DS. More specifically, 0.5 percentage points marked the 26th percentile of the distribution of annual percentage point changes in MCP and the 16th percentile in DS. The 0.1 percentage point threshold marked the tenth percentile for MCP and the seventh percentile for DS. Further details are in Supplement A, Section 1.1.

While this investigation was useful for comparative purposes, we eventually applied the rate condition to locally smoothed versions of the underlying indicators rather than the median annual changes themselves (explained further below). We also applied an additional condition, a probability condition with thresholds of 80%, 90%, and 95%, reflecting the range of probabilities commonly used in statistical demography to quantify uncertainty. Since smoothing generally attenuates annual differences and our probability condition filtered out plateaus with low posterior probability, the overall plateau identification method we propose is more conservative than the simple analysis of annual changes would indicate.

3.4.2 Estimation of plateau probabilities via local linear smoothing

Each trajectory in each of the posterior MCMC samples for MCP and DS is a time series of indicator values. To construct an estimate of the probability of a plateau in each year, these real-valued series were transformed into series of binary plateau indicators with each element taking the value 1 if the year was a plateau year and 0 otherwise. The probability of a plateau in each year was estimated as the proportion of trajectory elements having a binary indicator value of 1 in that year.

The transformation of each trajectory from a real-valued to a binary time series was done as follows. To robustly identify plateaus, we fitted ordinary linear least squares (OLS) regressions to the trajectories within moving windows of width three years, centered at each year. From these local linear regression fits we extracted the slope coefficients, one for each trajectory in each year, and applied the rate condition to the resulting regression-based estimates of annual change. More details can be found in Supplement A, Section 1.2.

4. Results

4.1 Contraceptive prevalence plateaus by country

Under the rate and probability threshold combination of 0.5 percentage points and 80%, ten countries across all four sub-Saharan Africa subregions had at least one MCP plateau year (Table 4 and Figure 2). Gambia had the longest plateau at 11 years, followed by Rwanda with 8 years. Comoros had a plateau that lasted one year. The average plateau length was 4.2 years (standard deviation three years). No country had more than one contiguous plateau period. Plots of MCP plateaus for all countries in sub-Saharan Africa are in Supplement B, Section 1.1.

The MCP plateaus in Gambia (2002–2012), Nigeria (2010–2012), and Rwanda (1993–2000) occurred at MCP levels close to the level condition thresholds of 10%. In all three cases, MCP oscillated around the thresholds after having exceeded it some years earlier.

The MCP plateaus in Cameroon (2015–2016), Comoros (2007), Ghana (2004–2006), Mauritania (2016–2018), Mozambique (2007–2009), and Niger (2017–2019) all occurred at relatively higher levels of MCP. In South Africa (2009–2013), the plateau occurred close to the level condition thresholds of 60%.

Figure 2: MCP and probability of a contraceptive prevalence plateau in MCP among married/in-union women of reproductive age

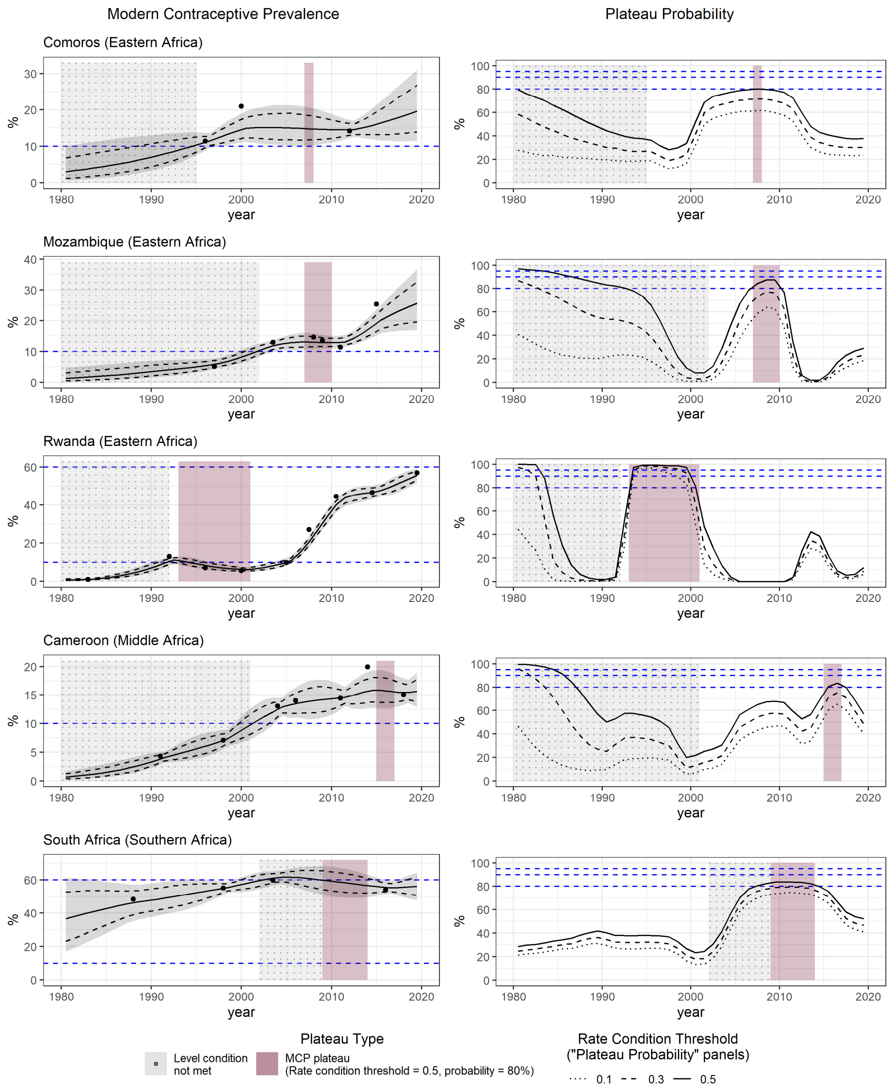
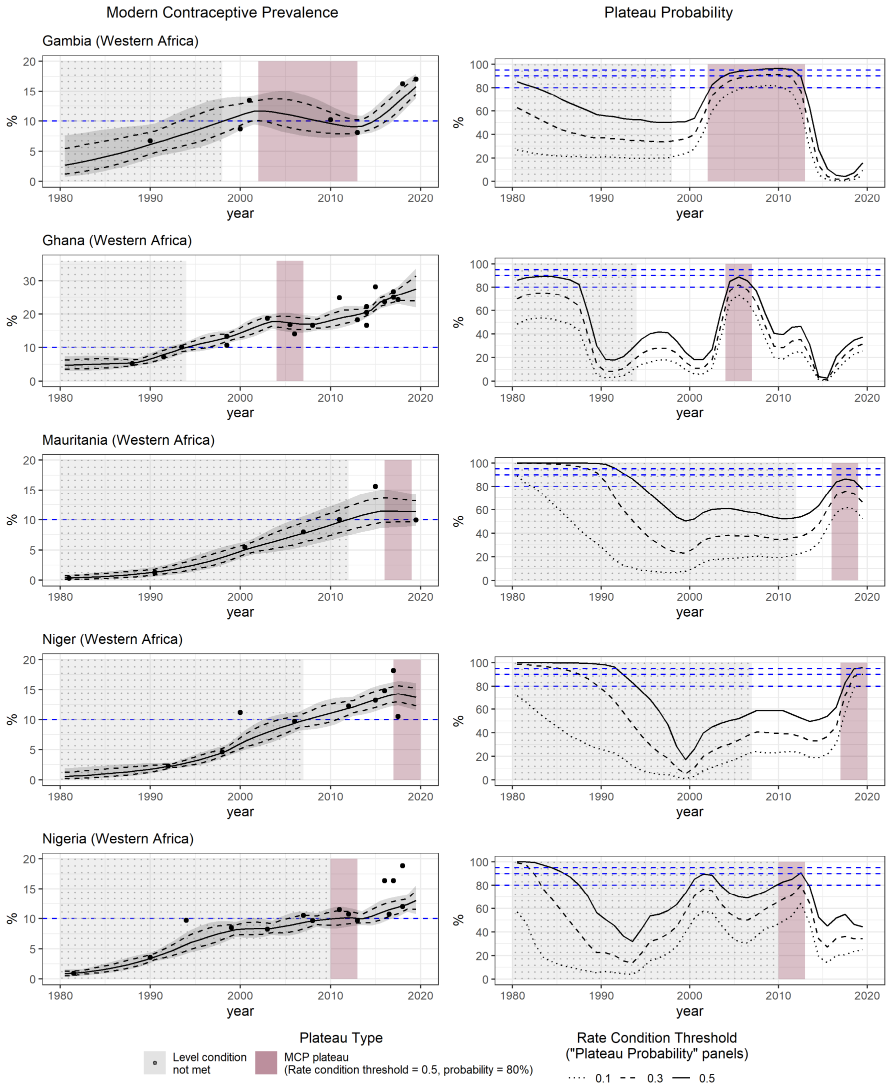


Figure 2: (Continued)



Notes: Only countries with at least one plateau year using a rate condition threshold of 0.5 percentage points and a probability condition threshold of 80% are shown. Countries are grouped by subregion, which appear in alphabetical order; countries appear alphabetically within subregion. Panels in the left column show posterior median MCP (solid lines), posterior central 80% uncertainty intervals (UIs; dashed lines), and posterior central 95% UIs (grey ribbons). The underlying survey data (DHS, MICS, etc.) are shown as filled black circles. Panels in the right column show the plateau probabilities under different rate condition thresholds. Years where the probability of a plateau reached or exceeded 80% under the rate condition threshold of 0.5 are highlighted.

Table 4: Contraceptive prevalence plateaus: plateaus in MCP among married/in-union women of reproductive age and in DS among all women of reproductive age, by country, using the rate condition threshold 0.5 and the probability condition threshold 80%

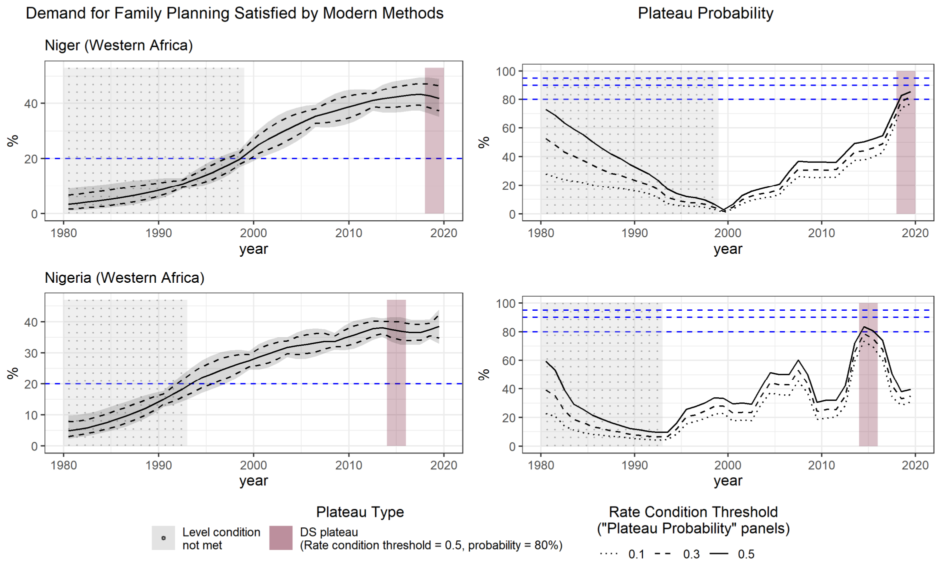
Marital group	Indicator	Subregion	Country	Period	Duration (years)	Indicator mean (%)
MWRA	MCP	Eastern Africa	Comoros	2007	1	15
			Mozambique	2007–2009	3	13
			Rwanda	1993–2000	8	8
		Middle Africa	Cameroon	2015–2016	2	16
		Southern Africa	South Africa	2009–2013	5	58
		Western Africa	Gambia	2002–2012	11	10
			Ghana	2004–2006	3	17
			Mauritania	2016–2018	3	11
			Niger	2017–2019	3	14
			Nigeria	2010–2012	3	10
WRA	DS		Niger	2018–2019	2	42
			Nigeria	2014–2015	2	37

Notes: Mean levels of the respective indicator (MCP or DS) during the plateau period are also shown. Countries are grouped by subregion, which appear in alphabetical order; countries appear alphabetically within subregions.

4.2 Plateaus in the proportion of family planning needs satisfied by modern methods

Under rate and probability condition thresholds of 0.5 percentage points and 80%, plateaus in the DS indicator were rarer, occurring in only two cases: Niger (2017–2019) and Nigeria (2010–2012) (Table 4 and Figure 3); both coincided with, or closely followed, contraceptive prevalence plateaus. Average levels of DS during both plateaus were well within the level condition threshold bounds (Niger, 42%; Nigeria, 37%). The plateau in Niger began 19 years after the level condition was met, while the gap before plateau onset in Nigeria was 21 years. Plots of DS for all countries in sub-Saharan Africa are in Supplement B, Section 1.2.

Figure 3: DS and probability of a contraceptive transition plateau in DS among all women of reproductive age



Notes: Only countries with at least one plateau year using a rate condition threshold of 0.5 percentage points and a probability condition threshold of 80% are shown. Countries are grouped by subregion, which appear in alphabetical order; countries appear alphabetically within subregions. Panels in the left column show posterior medians (solid lines), posterior central 80% uncertainty intervals (UIs; dashed lines), and posterior central 95% UIs (grey ribbons). Underlying survey data for WRA are not shown because they were not used to produce the model-based estimates of DS (Kantorová et al. 2020). Panels in the right column show the plateau probabilities under different rate condition thresholds. Years where the probability of a plateau reached or exceeded 80% under the rate condition threshold of 0.5 are highlighted.

4.3 Plateaus under different thresholds

When we tested the sensitivity to plateau definitions, the number and length of plateaus dropped quickly with the increasing stringency of the definition (see Supplement A, Section 2.2; Supplement B, Section 2). A single-step tightening of just one of the rate or probability condition thresholds reduced the number of plateau years by roughly half. The most unambiguously identified plateaus were MCP plateaus in Rwanda (1994–1995), Gambia (2007–2010), and Niger (2019).

4.4 Contraceptive prevalence plateaus and fertility transition stalls

Schoumaker (2019) identified 32 distinct fertility transition stalls in 19 countries, lasting on average six years each. Evidence for 18 of those periods, spread over 12 countries, was found to be moderate or very strong. Most countries with a stall had only one such period, but a few had two periods or had one period during which the strength of evidence changed.

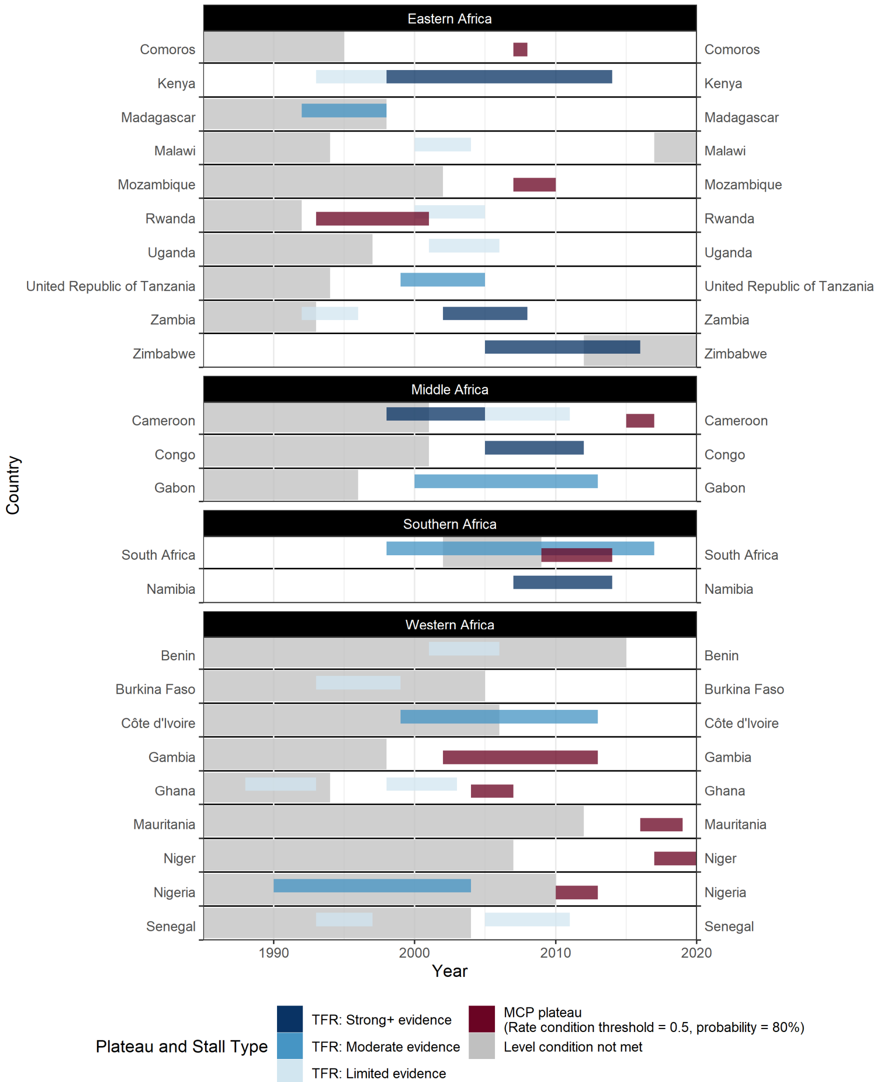
The coincidence of fertility transition stalls and MCP plateaus using a rate condition threshold of 0.5 percentage points and a probability condition threshold of 80% is displayed in Figure 4 (see also Supplement A, Table 2.4; Supplement B, Section 1). Among the 48 countries, 24 had an MCP plateau, a fertility transition stall, or both. Five countries had both, but only in Rwanda and South Africa did the two overlap. In Cameroon, Ghana, and Nigeria, MCP plateaus occurred after fertility transition stalls.

Fourteen countries experienced at least one fertility transition stall but no MCP plateau, while five countries (Comoros, Gambia, Mauritania, Mozambique, and Niger) experienced an MCP plateau without a fertility transition stall. The remaining 24 countries had neither a plateau nor a stall.

An analysis of the strength of association between MCP plateaus and fertility transition stalls at the country level was conducted by cross-tabulating countries according to the occurrence of a stall or plateau during the observation period. Using Fisher's exact test, the estimate of the odds ratio was 1.69 with a 95% confidence interval (0.327, 8.85), suggesting no difference between the odds of a fertility transition stall in a country with a plateau and one without (see Supplement A, Table 2.5).

Fertility transition stalls in nine countries – six countries in western Africa (Benin, Burkina Faso, Côte d'Ivoire, Ghana, Nigeria, and Senegal) and Cameroon, Madagascar and Zambia – occurred wholly or partially during periods when MCP among MWRA was below 10% – in other words, when the level condition for identifying MCP plateaus was not satisfied. Fertility transition stalls in South Africa and Zimbabwe happened at levels of MCP above 60%.

Figure 4: Fertility transition stalls and contraceptive prevalence plateaus compared



Notes: Grid plot of Schoumaker's (2019) fertility transition stalls by strength of evidence and MCP plateaus among MWRA using a rate condition threshold of 0.5 and a probability condition threshold of 80%. Only countries with at least one plateau or stall year are included; an additional 24 countries had neither a plateau nor a stall.

5. Discussion

We proposed a framework for detecting plateaus in contraceptive prevalence based on probabilistic annual model-based estimates and projections of family planning indicators (United Nations 2022a) and applied it to 48 countries in sub-Saharan Africa over the period 1980–2019. Similar to fertility transition stalls, contraceptive prevalence plateaus are periods of very low or negative increase in key indicators during the periods in which prevalence would otherwise be expected to increase. We studied plateaus in modern contraceptive prevalence among married/in-union women of reproductive age and, for the first time, the proportion of all women of reproductive age who had their need for family planning satisfied with modern methods, the indicator that considers the underlying trends in population-level fertility intentions and is used for the global monitoring of progress toward universal access to reproductive health care services within the 2030 Agenda for Sustainable Development, Indicator 3.7.1 (United Nations 2017).

5.1 Discussion of results

Overall, contraceptive prevalence plateaus were not common. Under the rate and probability threshold combination of 0.5 percentage points and 80%, MCP plateaus were found in ten countries, half of which were in western Africa. They lasted an average of four years each. In all but a single case (South Africa), plateaus occurred when MCP was relatively low, on average less than 18%.

In the analysis of the proportion of women of reproductive age who have their need for family planning satisfied with modern methods, which takes into account changes in fertility intentions at the population level, plateaus were less frequent still, occurring in only two countries: Niger and Nigeria. These were also the only countries to experience plateaus in both MCP and DS.

Plateaus in MCP among MWRA were identified in previous studies in Senegal (1997–2005; Wickstrom, Diagne, and Smith 2006), Kenya (1998–2003; Westoff and Cross 2006), and Tanzania (1999–2005; Pile and Simbakalia 2006) and in the following countries by Ross, Abel, and Abel (2004): South Africa (1981–1987), Rwanda (1992–2000), and Namibia (1989–1992). Of these, only the period 1993–2000 in Rwanda satisfied all conditions for a plateau under our approach. Of the remaining cases, our estimated plateau probabilities were elevated in the respective periods in Senegal, Kenya, Tanzania, and Namibia but did not reach the threshold level of 80%. Moreover, Senegal MCP did not exceed the 10% threshold until 2004. The plateau in South Africa was apparently informed by a survey conducted in 1981 that was not in our database. While a national fertility survey was conducted in South Africa over the period 1981–1982, we excluded it because it was not nationally representative (Mostert and Hofmeyr, 1988). As a result, our estimates prior to 1987 were model-based, and these did not indicate a plateau.

While a large body of research shows the strong negative correlation between TFR and contraceptive use, there have been no comparative studies of the association between fertility transition stalls and contraceptive prevalence plateaus specifically. We filled this gap by comparing MCP plateau periods with periods of fertility transition stall identified by Schoumaker (2019). We found no indication of an association between MCP plateaus and TFR stalls. There was no obvious temporal relation either; in five countries where both occurred, MCP plateaus variously preceded, followed, and coincided with a fertility transition stall.

Notably, we found that the fertility transition stalls identified by Schoumaker (2019) occurred almost exclusively in countries with very low MCP. In nine countries, including six countries in western Africa, a fertility stall occurred when MCP among married women was below 10%, indicating that sustained very low MCP can be one of the factors that hinder continuation of fertility transitions once they start. This was the case in Benin, Burkina Faso, Cameroon, Côte d’Ivoire, Ghana, Madagascar, Nigeria, Senegal, and Zambia. In seven countries, these fertility transition stalls were indeed classified by Schoumaker (2019) as early-transition fertility transition stalls.

The lack of association between MCP plateaus and TFR stalls is not entirely surprising for a number of reasons. First, the elasticity of TFR with respect to contraceptive use is relatively low and tends to be lower in high-fertility settings. Choi, Short Fabic, and Adetunji (2018) estimate that an increase in CPR of about 15–17 percentage points would be required to reduce TFR by one birth on average, but in sub-Saharan Africa, an increase of 20 percentage points would be required to achieve the same reduction in TFR, suggesting that a short-term MCP plateau may not be sufficient to lead to a TFR stall.

Second and related, contraceptive use is just one of several proximate determinants of fertility (Bongaarts 1978, 2015; Stover 1998), and changes in MCP do not necessarily equate to changes in TFR, particularly if those changes in MCP are small or not sustained. Bongaarts (2006) found no evidence of a deterioration of family planning program quality during fertility transition stalls in several countries. Regarding other proximate determinants, changes in the incidence of abortion, the duration of postpartum insusceptibility due to breastfeeding, sexual abstinence, the prevalence of secondary sterility, the proportion of women who are married or in a union, and sexual activity among unmarried women all play roles in fertility changes at the population level (Bongaarts 1978, 2015; Stover 1998). For example, results from the analysis by Rogers and Stephenson (2018) indicated a universal decrease in the duration of breastfeeding and postpartum abstinence in 33 low- and middle-income countries between 2000 and 2016. It contributed to stalling fertility rates in countries of Central Africa, while in other countries, increased contraceptive use and increased age at marriage or sexual debut were able to offset this, still leading to substantial decreases in fertility rates.

In Cameroon, reductions in the duration of breastfeeding were found to be the greatest contributor to stalled fertility rates in the early 2000s (Rogers and Stephenson 2018). Furthermore, the fertility stall actually coincided with an increase in wanted fertility in Cameroon, from 4.3 children per woman in the 1998 DHS to 4.5 children in the 2004 and 2011 DHSs (ICF 2012). So the TFR stall in Cameroon in the 2000s was caused likely by a change in fertility preferences and a reduction in the duration of postpartum insusceptibility due to breastfeeding. At the same time, the increase in MCP was slow between 2005 and 2019; the probability of a plateau was above 50% over the whole period, but only in 2016–2017 did it exceed 80% (Figure 2). Despite the MCP plateau in the mid-2010s, fertility rates declined, likely due to other factors, such as a decline in the proportion of women aged 15–49 who were married or living in a union, from 67% in 2004 to 57% in 2018, with an especially strong decline among those aged 15–19 and 20–24 (ICF 2012).

In Ghana, the fertility stall between 1998 and 2003 occurred despite continued increases in modern contraceptive use (see also Garenne 2013), as the period coincided with increases in marriage rates, sexual activity, and wanted fertility rates (Askew, Maggwa, and Obare 2017). The subsequent plateau of MCP in the first decade of the 2000s, however, may have been related to increasing concern about the health effects of hormonal contraception (Machiyama and Cleland 2014), which had begun to see rapid growth in use in the years prior (United Nations 2022c). Machiyama and Cleland (2014) suggested that the enduring resistance to hormonal methods, much of it based on prior experience of side effects, led to the use of periodic abstinence or reduced coital frequency as an alternative to modern contraception. This, together with decreases in marriage rates and the wanted fertility rate after 2003 (ICF 2012), contributed to continuing fertility declines.

Studies of other countries not considered in our analysis have also found that fertility stalls are not necessarily accompanied by contraceptive plateaus or declines. In Jordan and Bangladesh, for example, fertility stalls occurred even as modern contraceptive prevalence continued to increase; in the former case, fertility began to decrease again even as contraceptive use decreased at the same time (Krafft, Kula, and Sieverding 2021; Saha and Bairagi 2007).

Additionally, at the country level, broader socioeconomic factors, including migration patterns, economic trends, and education, may further complicate the relationship between national-level indicators of contraceptive use and fertility (Bongaarts 2006; Garenne 2013, 2014; Goujon, Lutz, and KC 2015).

Finally, part of the discrepancy between MCP plateaus and TFR stalls can be explained by our adoption of a more conservative definition of what constitutes a stall – that the probability of a stall must exceed 80% rather than only 50%, as is common practice in classification problems. In several cases, such as in Nigeria, Cameroon, and South Africa, the probability of an MCP plateau increased and exceeded 50% during the fertility stall periods identified by Schoumaker (2019) but either did not reach a probability of 80% or MCP did not fall within the range of 10%–60%.

5.2 Discussion of methodology

Using model-based estimates of family planning indicators provided three major benefits. First, because these estimates consisted of a complete annual time series of estimates for all countries, we were not forced to limit our plateau analysis to specific inter-survey intervals, which are often irregular and sparse, and we could take into account a wider range of survey data. Second, specific biases and measurement error in the underlying survey data, as well as non-sampling errors, were directly accounted for through model parameters and the uncertainty in resulting estimates coherently summarized by probability intervals. Finally, we were able to produce continuous annual estimates of the probabilities of plateaus. This continuous measure is more informative than the simple binary indicators used in previous research and incorporates uncertainty due to measurement error into the plateau definition.

These features, which provide additional robustness, are likely to be the reason our method did not identify many of the plateaus reported in previous studies. The plateau reported by Ross, Abel, and Abel (2004) in Namibia (1989–1992) is illustrative. Surveys conducted in 1989 and 1992 yielded MCP estimates of 32.1% and 26.0%, respectively (United Nations 2022b), an average decline of two percentage points per year. However, our method was not limited to this simple inter-survey difference. Rather, the model-based estimates we used were based on all available data, which resulted in a more robust and wholistic estimate of the underlying trend. Furthermore, bias and uncertainty due to measurement error were coherently accounted for. This is particularly relevant here, as the 1989 survey estimates were calculated and presented in the report only for non-pregnant women, thus overestimating MCP relative to the 1992 survey (Mostert and van Tonder 1989; United Nations 2022b). This potential bias was explicitly accounted for in our model-based estimates through a special bias parameter. Our continuous plateau probability measure was able to reflect the trade-off between the substantial inter-survey decline and the uncertainty associated with it, as the plateau probabilities in 1990 and 1991 were elevated but remained below the threshold of 80%.

To our knowledge, this is the first time a probabilistic measure of contraceptive prevalence plateaus has appeared in the literature. Furthermore, we put forth the suggestion that our probabilistic approach to determining stalls or plateaus in processes that can be described by a transition from one stable level to another (e.g., fertility transition or child mortality declines) is an advance over purely descriptive approaches and could be applied to existing probabilistic models for such processes, especially for the indicators with many data available from various data sources (surveys, censuses, or sample registration), using various calculation methods (direct and indirect methods).

It is important to note that plateau identification will be affected by any assumptions built into the model-based estimates used as the basis for analysis. In our case this was the FPEMglobal model, which includes a systematic component consisting of a smooth logistic curve. This is a monotonically increasing function that cannot itself accommodate plateaus. Deviations from the logistic trend are allowed for where the data indicate by the inclusion of a second component, namely an auto-correlated error process. Therefore, in the periods where data were lacking for a long time span and in the periods before the first observation and after the last observation, plateau occurrences may have been underestimated. However, those periods where plateaus were identified were necessarily well supported by the underlying data, even after the biases and measurement errors were taken into account. The performance of the plateau identification method when applied to the output of a different model will be dependent on the assumptions built into that model.

6. Conclusion

Our study had three aims. First, we proposed a new method for detecting plateaus in contraceptive prevalence trends and used probabilistic annual model-based estimates, which avoided any need to limit the analysis to specific inter-survey intervals.

Second, we applied our method to 48 countries in sub-Saharan Africa over the period 1980–2019 and identified MCP plateaus in ten countries. Almost all MCP plateaus were observed in periods where MCP itself was low (below 18%, on average).

Third, we compared the MCP plateau periods with periods of fertility transition stall identified by Schoumaker (2019) but found no indication of an association between MCP plateaus and TFR stalls. We concluded that the lack of evidence for a link between contraceptive prevalence plateaus and fertility transition stalls reflected the multitude of other factors that also influence fertility trends. These include composition effects, trends in fertility intentions, changes in attitudes and beliefs, health sector reorganization, poor coordination among family planning providers, lack of support from national leadership, changes in education provision, and reductions in overall family planning program quality (Bongaarts 2006; Bongaarts and Hardee 2019; Cleland, Ndugwa, and Zulu 2011; Mekonnen and Telake 2019; Pile and Simbakalia 2006).

7. Acknowledgments

This work was supported, in whole or in part, by the Bill and Melinda Gates Foundation (INV-033016 and INV-009900). Under the grant conditions of the foundation, a Creative Commons Attribution 4.0 generic license has already been assigned to the author-accepted manuscript version that might arise from this submission. The authors thank Philipp Ueffing and Niamh Cahill for helpful suggestions on early drafts. The views expressed herein are those of the authors and do not necessarily reflect the views of the United Nations.

8. Data availability statement

The data underlying this study are freely available online: United Nations (2022b). World contraceptive use 2022. New York: United Nations, Department of Economic; Social Affairs, Population Division. https://www.un.org/development/desa/pd/data/world-contraceptive-use.

The estimates of family planning indicators upon which the analysis was based were derived from the World Contraceptive Use 2022 data compilation using FPEMglobal, a software package written in the R and JAGS languages. FPEMglobal is freely available in the repository below. This repository also contains the input data needed to generate the MCMC trajectories used in the paper: Wheldon, M.C., New, J.R., Cahill, N., Gu, G., Tait, A., Hertog, S., and Alkema, L. (2022). *FPEMglobal* (Version 1.3.0) [Computer software]. https://github.com/FPcounts/FPEMglobal.

Pre-computed summaries of the family planning indicators are published here: United Nations (2022a). *Model-based estimates and projections of family planning indicators 2022*. United Nations, Department of Economic and Social Affairs, Population Division. https://www.un.org/development/desa/pd/data/family-planning-indicators.

Computer code in the R language implementing the proposed method of contraceptive prevalence plateau identification is freely available online at: Wheldon, M.C. *FPPlateaus* [Computer software]. https://github.com/markalava/FPPlateaus.

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