LONG TERM TRAJECTORIES OF FERTILITY AND CONTRACEPTIVE USE

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Preface

The Demographic and Health Surveys (DHS) Program is one of the principal sources of international data on fertility, family planning, maternal and child health, nutrition, mortality, environmental health, HIV/AIDS, malaria, and provision of health services.

One of the objectives of The DHS Program is to analyze DHS data and provide findings that will be useful to policymakers and program managers in low- and middle-income countries. DHS Analytical Studies serve this objective by providing in-depth research on a wide range of topics, typically including several countries, and applying multivariate statistical tools and models. These reports are also intended to illustrate research methods and applications of DHS data that may build the capacity of other researchers.

The topics in the DHS Analytical Studies series are selected by The DHS Program in consultation with the U.S. Agency for International Development.

It is hoped that the DHS Analytical Studies will be useful to researchers, policymakers, and survey specialists, particularly those engaged in work in low- and middle-income countries.

Sunita Kishor
Director, The DHS Program

Abstract

DHS estimates of current fertility and contraceptive use have immediate interest after the release of each survey. This report takes a long-term perspective, examining trajectories of fertility and contraception by piecing together the data from the countries that have had the most surveys. It includes 16 countries that have had five or more surveys—Bangladesh, Colombia, the Dominican Republic, Egypt, Ghana, Indonesia, Jordan, Kenya, Mali, Peru, the Philippines, Senegal, Tanzania, Uganda, Zambia, and Zimbabwe, with a total of 98 surveys. The fertility trajectories span an interval from about 1980 to about 2010. All of these countries have experienced declines in their TFR, by amounts ranging from one child in Tanzania to about four children in Jordan. The median TFR declined from 6.4 to 3.8, a reduction of 42% in about 30 years. There was a strong correlation, 0.72, between the first and last values of the TFR. In most countries the mean age at childbearing did not change but there was a greater concentration around that mean. Changes in the use of modern contraception were tracked in a subset of four of the countries that had six or seven surveys—Ghana, Indonesia, Kenya, and Senegal, with a total of 26 surveys—using time-varying coefficient models (VCMs). The interest is in whether odds ratios are moving toward one, indicating similar levels of contraceptive prevalence across sub-populations. In most countries there has been a gradual reduction in the differences between sub-populations, indicating that access to contraception has broadened as overall use has increased.

KEYWORDS: Fertility, Total Fertility Rate, mean age at childbearing, modern contraceptive prevalence, varying coefficient models, odds ratio trends

Executive Summary

One of the most important functions of Demographic and Health Surveys is to provide national estimates of the Total Fertility Rate (TFR), usually for the three years before the survey, and of the percentage of women in union who are using modern methods of contraception (the modern contraceptive prevalence rate or mCPR) at the time of the survey. Most of the countries that conduct DHS surveys have programs to increase the use of modern contraception in order to bring fertility down to replacement level. Some countries have had several DHS surveys, typically about five years apart. By pooling the birth histories from successive surveys in such countries it is possible to construct a continuous record of fertility spanning approximately 30 years, from about 1980 to about 2010. By connecting the successive snapshots of contraceptive use at the time of each survey, it is possible to produce an overview of how contraceptive use has changed and how its relationship to important determinants has changed.

The first part of this report describes changes in fertility in 16 countries that have had 5 or more DHS surveys—a total of 98 surveys. Eight of these countries are in sub-Saharan Africa (SSA). The other eight are scattered across Latin America (2), the Caribbean (1), South Asia (1), Southeast Asia (2), the Middle East (1), and North Africa (1). Long-term trajectories are derived from a pooling and smoothing of the birth histories for the ten calendar years before each survey. Except for the first five years and the final five years, each annual estimate is generally based on a pooling of the overlap in birth histories of two successive surveys. Trajectories are presented for two measures of the quantum or volume of fertility—the Total Fertility Rate and the General Fertility Rates—and for three measures of the tempo or timing of fertility—the mean age at childbearing, the standard deviation of the age at childbearing, and the ages at reaching successive integer values of the Cumulative Fertility Rate (CFR).

In these 16 countries, the median TFR fell from 6.4 around 1980 to 3.8 around 2010, a reduction of 42%. Initially, all eight SSA countries were above the median, except for Zimbabwe, which was slightly below. The highest eight were Ghana, Jordan, Kenya, Mali, Senegal, Tanzania, Uganda, and Zambia (listed in alphabetical order), all with a TFR of 7.0 or more. At the end, the eight countries above the median included all of the SSA countries, and only those countries. Jordan had a dramatic decline in fertility. Zimbabwe had only a small decline, compared to the decline in the median, and therefore was above the median at the end. The countries with the lowest fertility at the end were Colombia, Bangladesh, the Dominican Republic, Peru, Indonesia, and the Philippines (listed from lowest to highest), all with a TFR of 3.0 or less. The highest fertility countries at the end were Zambia, Tanzania, Mali, and Uganda (listed from lowest to highest), all with a TFR above 5.0. The remaining countries—Jordan, Egypt, Kenya, Ghana, Zimbabwe, and Senegal (listed from lowest to highest)—were greater than 3.0 and less than 5.0. Some countries show evidence of a recent increase in fertility, especially Tanzania and Zimbabwe. The amount of decline in the TFR ranges from about one child in Tanzania to about four children in Jordan.

For most countries, the mean age at childbearing changed very little as fertility declined. Bangladesh, the Dominican Republic, and Colombia—the three countries with the lowest fertility at the end of the series—were the only ones that had a substantial change, and for all three it was a reduction in the mean age. Their fertility reductions were mainly achieved by the elimination of births at later ages, rather than by delaying the first birth, and greater spacing between births. The standard deviation of the age at childbearing had a net decline of about half a year in most countries. Egypt, Jordan, Bangladesh, and the Dominican Republic were the only ones that had a conspicuously larger drop, that is, more concentration of age at childbearing. The SSA countries, at both the beginning and the end, have the largest standard deviations, that is, the greatest dispersion in age at childbearing. The changes in the ages at reaching successive parities were also in the direction of somewhat more concentrated distributions.

The second part of the report focuses on four of the countries that had 6 or 7 surveys—Ghana, Indonesia, Kenya, and Senegal—a total of 26 surveys. Variations in the use of modern contraception are tracked according to the woman's parity, education, work status, ideal number of children, urban/rural residence, and region. Differences in use are represented with odds ratios comparing each category with a reference category for each covariate. An innovative method in this context, varying coefficient models (VCM), is able to link the six or seven surveys together with a continuous function of time. The trajectories of the odds ratios that describe sub-population tend to show substantial variation early in a transition because early users tend to be urban women with more education who desire a smaller family size. With time, as fertility declines and overall prevalence of contraception increases, it is desirable that the odds ratios move toward 1, reflecting greater equality in contraceptive use across sub-populations.

In general, the VCM trajectories do move toward odds ratios that are closer to 1, in some cases not being significantly different from 1, and in some cases even reversing, such that higher prevalence in urban areas is replaced by higher prevalence in rural areas, for example. The finding that most subgroups are becoming more similar in their contraceptive use over time implies that family planning programs and interventions are successful in reaching various sub-populations. Further analysis when more surveys become available will determine whether these trends continue.

1. Introduction

This report describes the long-term trajectories of fertility and contraceptive use for the countries that have had the most surveys and the longest continuous intervals of DHS data. The goal is to provide an integrated overview of long-term patterns of change.

The Demographic and Health Surveys Program (DHS) has been conducting surveys since the mid-1980s. Many countries have had multiple surveys, typically about five years apart. The DHS data for countries with a long series of surveys provide researchers with an opportunity to review and integrate historical trends for many different indicators. Micro data files from all the surveys, archived with standard recodes, are publicly available.

From the beginning of DHS, two of the most important topics have been fertility and contraceptive use. Information about fertility is provided with retrospective birth histories, and is particularly rich because the histories provide a continuous record for intervals before the first survey, between successive surveys, and with many years of overlapping surveys. Information about current contraceptive use is detailed, including method. In addition to current use, the surveys include a retrospective calendar for the five years before the survey; however, this analysis uses the current status information current at the time of the surveys. Our interest is partially in trends in the use of modern methods of contraception (the modern contraceptive prevalence rate, or mCPR), but primarily in trends in the relationship of use to selected covariates—parity, level of education, work status, ideal number of children, urban/rural residence, and region.

This analysis does not attempt to articulate the correspondence between the two trajectories. Such an effort is needed, but it would require within-country and within-survey analysis that is beyond the scope of the present report. Contraceptive use and marital exposure are well known to be the principal proximate determinants of fertility. Broadly speaking, an increase in contraception will be followed by a decline in fertility, but for a variety of reasons, the correspondence is not simple, and it is difficult to observe in a single survey because the birth history is chronologically prior to current contraceptive status, the reverse of the causal sequence.

Part 1 of this report concerns the long-term trajectory of fertility in 16 countries that have had at least 5 surveys each. DHS has previously produced many reports on fertility, generally including many countries. The following lists of DHS Analytical Studies, Comparative Reports, and Methodological Reports, in chronological order, have focused on levels and trends in fertility, the relationship of fertility to covariates and proximate determinants, and methodological considerations:

Analytical Studies (AS):

AS4. The Contraception-Fertility Link in Sub-Saharan Africa and in Other Developing Countries. (Westoff and Bankole 2001)
AS21. Birth Spacing and Limiting Connections. (Westoff and Koffman 2010)
AS23. Changes in the Direct and Indirect Determinants of Fertility in Sub-Saharan Africa. (Johnson, Abderrahim, and Rutstein 2011)
AS34. Indicators of Trends in Fertility in Sub-Saharan Africa. (Westoff, Bietsch, and Koffman 2013)
AS42. Trends in Marriage and Contraception in Sub-Saharan Africa: A longitudinal perspective on factors of fertility decline. (Garenne 2014)
AS48. Religion and Reproductive Behavior in Sub-Saharan Africa. (Westoff and Bietsch 2015)

Comparative Reports (CR) and Comparative Studies (CS):

CS2. Fertility Levels and Trends (Arnold and Blanc 1990)
CS18. Men’s Fertility, Contraceptive Use, and Reproductive Preferences. (Ezeh, Seroussi, and Raggers 1996)

CS28. Fertility Levels, Trends, and Differentials. (Mboup and Saha 1998)
CR3. Fertility Levels, Trends, and Differentials 1995-1999. (Rutstein 2002)
CR16. Contraceptive trends in developing countries. (Khan et al. 2007)
CR18. Fertility Changes in Sub-Saharan Africa. (Garenne 2008)
CR23. Fertility Transition in Sub-Saharan Africa: A Comparative Analysis of Cohort Trends in 30 Countries. (Sneeringer 2009)
CR28. Trends in Birth Spacing. (Mboup and Saha 1998)

Methodological Reports (MR):
MR5. An Assessment of Age and Date Reporting in the DHS Surveys 1985-2003. (Pullum 2006)
MR11. Evidence of Omission and Displacement in DHS Birth Histories. (Pullum and Becker 2014)
MR12. Quality and Consistency of DHS Fertility Estimates, 1990 to 2012. (Schoumaker 2014)

In addition to these DHS reports, much literature is available on fertility trends in low- and middle-income countries, much of it relying heavily on DHS data. Some analysts have worked with the U.N. Population Division's estimates and projections[1], which are based on a pooling of all available data sources, including the DHS. In the literature, trajectories of the TFR are described mainly in terms of a pre-transitional level that is very high—usually in the range of 6 to 8—and relatively stable; the initiation of decline, which can be abrupt but is almost always identifiable within some interval of ten years or less; and completion, with a final value in the vicinity of replacement fertility, with a TFR of 2.1. In many countries, the last phase of the fertility decline from a TFR of about 3 to about 2.1 has been gradual. In most developed countries, the TFR is currently, or has been, below 2.1, and thus the achievement of a final value is uncertain. The lowest observed value of the TFR for the countries in this report is 2.1, seen in only one country, Colombia.

The path from the onset of decline to replacement fertility can vary considerably. Some counties experience intervals of extremely rapid decline, for example, by more than a full child in a five-year interval. Some countries experience stalls during which decline is slow. Sometimes such stalls are historical, but in others they extend to the latest date for which data are available. These kinds of trajectories—the ones that are currently stalled or are declining gradually—are of greatest concern for policy and programs. Lessons can be learned from countries that have experienced declines that are rapid and uninterrupted, or that have resumed substantial decline following a stall. Another pattern that is occasionally observed—and that is of even greater concern—is a recent non-trivial uptick in the TFR. Small reversals are not significantly distinguishable from a stall, but if the TFR is clearly increasing, it is important to understand why.

Juárez and Gayet (2015) provide an overview of long-term trends in Latin America and the Caribbean, going back to the early 1950s, well before the earliest DHS estimates, using the U.N. Population Division estimates and projections. They distinguish among countries in the Caribbean, Central America including Mexico, and South America. This report includes one country from the Caribbean, the Dominican Republic, and two from South America, Colombia and Peru. The Central American countries, when pooled, had a pre-transitional TFR of about 6.7, with a decline beginning about 1970 and reaching 2.6 by 2005–2010. As two pooled groups, the Caribbean and South American countries had lower levels throughout that entire interval, with low pre-transitional TFRs of 5.3 in the Caribbean and 5.7 in South America, a decline that began about 1965, and 2005–2010 TFRs of 2.4 in the Caribbean and 2.2 in South America. By 2010, the three sub-regions were converging and near a complete transition.

This report includes one country from North Africa, Egypt, and one from the Middle East, Jordan. In an overview of Arab countries, Eltigani (2005) described a decline from approximately the late 1970s to the late 1990s of about two children per woman, despite "continued desires for large families." Tabbarah (2009), using UN data in the 1998 Revision of World Population Prospects, looked specifically at the

[1] World Population Prospects: https://esa.un.org/unpd/wpp/

fertility transition in Jordan, Lebanon, and Syria. Jordan, in particular, appeared to have a pre-transitional TFR of 8, a decline that began around 1975, and a 1990–1995 level of 5.58. Among these three countries, Jordan had the highest initial level, the latest onset of decline, and the highest TFR in 1990–1995.

Heuveline and Hirschman (2015), looking at 11 countries in Southeast Asia, again using World Population Prospects, but the 2012 revision, describe estimated TFRs in 2010–2015 that were generally close to replacement. Our report includes two countries from Southeast Asia, Indonesia and the Philippines. In Indonesia, a relatively low pre-transitional level of 5.6—the lowest in the region—began to decline in 1970–1975, and by 2010–2015 was at 2.1. In the Philippines, the pre-transitional level was 7.42—the highest in the region—but the TFR began to decline in 1960–1965 and was estimated to be 3.05 in 2010–2015. The TFR in the Philippines was higher than Indonesia's throughout the entire interval, even though the transition began earlier in the Philippines.

An analysis of fertility decline in Asia, more broadly, using the 2004 Revision of World Population Prospects, was prepared by Gubhaju (2007). The present report includes one country in South Asia, Bangladesh, which was included in that overview. Gubhaju classified countries in five categories, based on the levels of the TFR, as of 1970–1975, 1990–1995, and 2000–2005. The five categories were high, a TFR of 5.0 or greater; transitional, 3.0 to 4.9; near-replacement, 2.2 to 2.9; low, 1.6 to 2.1; and critically low, 1.5 or less. In 1970–1975, Sri Lanka was the only South Asian country that had moved from high to transitional. By 1990–1995, Pakistan, Bhutan, and Nepal were the only South Asian countries remaining in the high category, and by 2000–2005 all South Asian countries were in the transitional category, except Sri Lanka, which was in the low category. With the exception of Sri Lanka, South Asian countries, relative to the rest of Asia, have much higher percentages of women age 20-24, and especially age 15-19, who are ever-married.

SSA has probably received more attention than any other region because of its persistent high fertility and projections of continued high population growth. This report includes eight countries from SSA: Ghana, Kenya, Mali, Senegal, Tanzania, Uganda, Zambia, and Zimbabwe.

Using DHS and World Fertility Survey data, Bongaarts and Casterline (2013) contrasted SSA with other regions. The age distribution of childbearing tends to be wider in SSA than in other regions, implying differences in timing and spacing. The second birth interval, in particular, tends to be longer in SSA than in other regions. Perhaps the most striking contrast is in the ideal number of children. In SSA, the ideal number is declining in nearly all countries, but the mean is usually above 4 in the most recent surveys.

Lesthaeghe (2014) examined the fertility transition in SSA using primarily DHS data, but without the blending approach used here, so his estimates are consistent with DHS main reports, but they will not match the numbers in the present analysis. He found that by 2010, the only countries with a TFR below 4 were in Southern Africa. Many countries still had a TFR of 6 or more, including Mali and Uganda. Several countries have actually seen net increases in fertility, attributed as "often caused by declining infertility levels" and by "the eroding of traditional birth-spacing practices (long periods of breastfeeding and postpartum abstinence." Lesthaege suggests that, "After the turn of the century, it seems that the fertility transition is picking up momentum again" in some countries, including Senegal, Ghana, and Uganda.

Shapiro and Gebreselassie (2008) write specifically about the pattern of "falling and stalling" during the fertility transition in SSA, also using the TFRs given in DHS reports. They note that virtually all of the countries that have had a DHS survey have begun a decline, but of those that have, about a third have experienced stalls, which they define as an *increase* in the TFR from one survey to the next. Of the 23 countries with two surveys in their study, 7 had an increase in the TFR, 1 had no change, 7 had a decrease but of less than 0.05 per year, and only 7 had a decrease of more than 0.05 per year. The authors consider only the countries with an increase to be stalled, but it would be possible to extend that label to countries that increased but by less than 0.05 per year—that is, by about a quarter of a child during the typical five-year interval between surveys—and to count as increasing only the seven countries with an increase of more than 0.05 per year. All of the SSA countries in the present report are in the range of -0.05 to +0.05, net annual change reported by these authors. In a multivariate analysis, the authors show that the only significant correlates of fertility decline are a decline in the percentage of women with no schooling, a decline in infant and child mortality rates, and an increase in gross domestic product per capita. Contraceptive use is the pathway to fertility reduction, allowing these factors to have their effect, but an increase in contraceptive prevalence is not significant when these other factors are in the model.

Moultrie, Sayi, and Timæus (2012) focus on the relationship between birth intervals and fertility decline in Africa, using 76 DHS surveys from 24 countries. They find that "birth intervals have lengthened in every country examined." They report, "This analysis uncovered a distinctive and previously undocumented pattern of childbearing that is prevalent across sub-Saharan Africa. After allowing for time trends in birth interval length, the lengthening of birth intervals in almost every country varies little by women's age or parity." Timing and spacing are included in the present report, as measured by the mean and standard deviation of the age at childbearing, and the ages at reaching integer values of the Cumulative Fertility Rate (CFR), rather than birth intervals.

Part 2 of this report analyzes the trajectory of modern contraceptive use in a subset of four countries—Ghana, Indonesia, Kenya, and Senegal. Increased use of contraception, especially of modern methods, is the main proximate determinant of fertility decline. The following DHS Analytical Studies and Comparative Reports have focused on levels, trends, and differentials in contraceptive use:

Analytical Studies (AS):

AS4. The Contraception-Fertility Link in Sub-Saharan Africa and in Other Developing Countries. (Westoff and Bankole 2001)
AS8. Recent Trends in Abortion and Contraception in 12 Countries. (Westoff 2005)
AS14. Contraceptive Use, Breastfeeding, Amenorrhea and Abstinence during the Postpartum Period an Analysis of Four Countries. (Gebreselassie, Rutstein, and Mishra 2008)
AS20. Levels, Trends, and Reasons for Contraceptive Discontinuation. (Bradley, Schwandt, and Khan 2009)
AS42. Trends in Marriage and Contraception in Sub-Saharan Africa: A Longitudinal Perspective on Factors of Fertility Decline. (Garenne 2014)
AS49. Men and Contraception: Trends in Attitudes and Use. (MacQuarrie et al. 2015)

Comparative Reports (CR) and Comparative Studies (CS):

CR16. Contraceptive Trends in Developing Countries. (Khan et al. 2007)
CS6. Knowledge and Use of Contraception. (Rutenberg et al. 1991)
CS18. Men's Fertility, Contraceptive Use, and Reproductive Preferences. (Ezeh, Seroussi, and Raggers 1996)
CS19. Contraceptive Knowledge, Use, and Sources. (Curtis and Neitzel 1996)

In general, modern contraceptive use in developing countries has increased (Darroch and Singh 2013; Garenne 2014; Khan et al. 2007). DHS has found increases in the mCPR in all four countries examined (Agence Nationale de la Statistique et de la Démographie and ICF International 2015; Ghana Statistical Service, Ghana Health Service, and ICF International 2015; Kenya National Bureau of Statistics and ICF International 2015; Statistics Indonesia [Badan Pusat Statistik] et al. 2013).

Typically, and especially in the early stages of a fertility transition, use of contraceptive methods—and specifically modern contraceptive methods, is not equal in all subgroups in a country. Use tends to be highest in subgroups that are wealthier, more educated, higher parity, and urban. Higher use among higher parity women is related primarily to demand, of course; other kinds of differences may be related to a combination of demand and access (Maja 2007). Differentials have previously been identified in Ghana, Indonesia, Kenya, and Senegal (Achana et al. 2015; Clements and Madise 2004; Eliason et al. 2014; Leyé et al. 2014; Nonvignon and Novignon 2014; Paskaria 2015; Widyastuti and Saikia 2011).

A high prevalence of contraception at the national level requires that contraceptive use is high in all major regions and subgroups. The focus of this analysis is not on the overall increase of modern contraceptive use but on the trends, over time, in disparities across specific subgroups. The findings can identify where interventions have been successful but also where interventions are needed, to reduce gaps between subgroups that may be unchanged or even increased. Nonvignon and Novignon (2014) studied changes in gaps, but only by comparing the odds ratios for contraceptive use in two surveys conducted in 2003 and 2008, and their methods do not allow the testing of whether the change in these odds ratios was significant. Since an odds ratio compares one group to a reference group, the approach can be used to examine equality. The further the odds ratio is from 1, the less equality exists between the comparison group and the reference group. The method used to analyze disparities in this report focuses on whether the odds ratios have changed over time and tests whether changes are statistically significant.

Part 1: Fertility Trajectories

One of the core functions of the surveys conducted by DHS is to estimate recent fertility. Every main report presents age-specific fertility rates for the three years before the survey, and the TFR by residence, region, education, and wealth quintile, also for the three years before the survey. Trends in age-specific and Total Fertility Rates are typically given for three or four five-year intervals before the survey, but they are drawn primarily from earlier DHS surveys conducted in the same country. The main report provides little description of fertility going back more than five years before the latest survey.

Part 1 of this report takes a long-term perspective on fertility in countries that have had multiple DHS surveys. The goal is to piece together the successive surveys by going back to the original data files, pooling and re-calculating rates in an integrated way, and trying to bring out patterns or trajectories that may not be clear in the analysis of only the most recent survey or even the most recent pair of surveys. The focus is on extracting as much information about fertility as possible to describe the long-term trajectories.

2. Data and Methods

2.1. DHS Data

Countries and surveys

The analysis describes levels and changes in childbearing for the 16 countries that have had five or more DHS surveys during the course of the entire DHS program and had their most recent survey in 2010 or later, a total of 98 surveys.[2]

Table 2.1. Countries included in the fertility analysis

Country	First survey	Last survey	Country ID	Number of surveys
Bangladesh	1993–1994	2014	BD	7
Colombia	1986	2010	CO	6
Dominican Republic	1986	2013	DR	7
Egypt	1988	2014	EG	7
Ghana	1988	2014	GH	6
Indonesia	1987	2012	ID	7
Jordan	1990	2012	JO	5
Kenya	1989	2014	KE	6
Mali	1987	2012–2013	ML	5
Peru	1986	2012	PE	9
Philippines	1993	2013	PH	5
Senegal	1986	2014	SN	7
Tanzania	1991–1992	2010	TZ	6
Uganda	1988–1989	2011	UG	5
Zambia	1992	2013–2014	ZM	5
Zimbabwe	1988	2010–2011	ZW	5

Eight of the countries are in SSA. The other eight represent a wide range of geographic regions—South Asia (Bangladesh), Southeast Asia (Indonesia and the Philippines), Latin America and the Caribbean (Colombia, the Dominican Republic, and Peru), North Africa (Egypt), and the Middle East (Jordan). Generally the results will be presented simply with an alphabetical listing of countries, rather than a grouping into regions.

DHS birth histories

Although the focus on fertility in most DHS reports is on recent fertility, DHS surveys obtain complete birth histories for all eligible women age 15-49 at the time of the survey. Working from the first birth to the most recent birth, interviewers ask women about the sex of the child, whether it was part of a multiple birth, the month and year of birth, and whether the child is still alive. If the child is alive, the mother is asked the current age of the child, in completed years, and whether the child lives with the mother. If the child has died, the mother is asked the age at death, with detail in days up to one month, in months up to one year, and then only in completed years.

If the month or year of birth is missing, or if, for a living child, the age and birth date are inconsistent, automated reconciliation and imputation during data processing will force the specification of a month and year. A code is added to the record to indicate the completeness of reporting of date and age. Also, during

[2] If the criterion were reduced to four surveys, rather than five, an additional set of 14 countries would qualify for inclusion. The closing date for inclusion in this report was April 1, 2016.

fieldwork, unless the child has died or is living elsewhere, the interviewer records the line number of the child in the household schedule.[3]

DHS reporting of fertility rates has virtually always been in terms of "years ago," rather than in calendar years, and refers to a window of time that depends on the date of interview. For example, "the past three years" or "0-2 [completed] years before the survey" means that the window is the 36 months before the month of interview. For a woman interviewed in March 2014, say, the time interval will be March 2011 through February 2014, inclusive. Births that occur in the month of interview are never included in the fertility rates or the child mortality rates, although they will be recorded in the interview and will be counted among the woman's number of children ever born. The justification for ignoring these births is that there is less than a full month of exposure to the month of interview.

The justification for calculating rates as "years ago" rather than as calendar years is that the number of births in the calendar year of interview can be small and statistically unstable if the interviews tend to be early in the year. Also, rates calculated for single years tend to be statistically unstable, and rates for groups of three or five calendar years can be awkward for presentation.

In this report, the concern is not with recent fertility, but with long-term trends. Calendar years are used, rather than years ago, for easier comparisons across countries and easier blending of successive surveys from the same country. Births and exposure in the year of the survey—or, for surveys that spanned two years, births and exposure in the last year of field work—are ignored.

DHS recently produced two reports on the quality of the fertility data. Schoumaker (2014) approached this issue by comparing successive surveys in the same country. The fertility data in the five years before a survey should be in approximate agreement with the fertility data five to nine years before another survey conducted five years later. Schoumaker found this kind of agreement in many countries, but in some other countries, the surveys being compared were inconsistent, with a pattern that suggests some omission or displacement of births.

Pullum and Becker (2014) examined the birth histories directly, searching for internal evidence of omission and displacement. Over time, the level of completeness of the reporting of dates in the birth histories has increased steadily, but evidence is strong that in some surveys, some children who were born inside the time interval for the health questions have been shifted to earlier dates, giving spurious evidence of recent fertility decline. In some surveys children tend to be omitted rather than displaced, although omission is much more difficult to detect. Both omission and displacement are more likely for children who have died. In this report, no explicit adjustment is made for possible omission or displacement.

2.2. Measures

Every woman in every survey contributes to the calculation of age-period-specific fertility rates for single years of age and single calendar years of time, calculated here for the 10 calendar years before the survey. Descriptions of these calculations, as well as methods for pooling surveys, imputing rates for ages that are censored, and smoothing the rates, appear in section 2.3.

Five summary measures of fertility are calculated from the long-term arrays of births, exposure, and age-period-specific rates for each country. Two measures are used for volume or quantum of fertility: the Total Fertility Rate (TFR) and the General Fertility Rate (GFR). Three measures of the timing or tempo of fertility

[3] The sequence of the questions has varied somewhat across time periods and surveys. The household line number of the child was not included in early surveys. The most recent surveys include day of birth, as well as month and year, but day is not be used in this report.

are (1) the mean age at childbearing (macb), (2) the standard deviation of the age at childbearing (sdacb), and (3) the age when women reach successive parities.

Total Fertility Rate. The TFR is a synthetic summary of births and exposure in an interval of time or a period that can be interpreted as the number of children a woman would be expected to have if she survived from exact age 15 to exact age 50 and experienced the observed age-period-specific fertility rates for the full age range. It is synthetic because period age-specific rates are used, rather than cohort age-specific rates for the births of a real cohort of women. The TFR for a specific calendar year is the sum of the age-specific rates estimated for that year.[4] It is not affected by the age distribution in the range from 15 to 49, an advantage for the analysis of trends and differentials.

General Fertility Rate. The GFR is the total number of births to women age 15-49 in an interval of time, divided by the total exposure to age 15-49 in that interval of time. In this report the interval of time is one year. The numerator of the GFR is the sum of the numerators of the age-specific rates and the denominator is the sum of the denominators of the age-specific rates.[5] We multiply this ratio by 1,000 to obtain the usual interpretation as the average number of births per year per 1,000 women age 15-49.[6] The GFR can also be interpreted as 1,000 times the average of the age-specific rates, when those rates are weighted by the exposure to each age, that is, as a weighted sum of the age-specific rates for a calendar year. The GFR is thus affected by the age-distribution of the sample, but it is perhaps more interpretable than the TFR because it is simpler and not synthetic.

Mean and standard deviation of the age at childbearing. The second group of indicators describes fertility in terms of timing. The mean and standard deviation of the age at childbearing are standard statistical measures of central tendency and dispersion. They are calculated with simple formulas in which each single year of age x is assigned the value $x+½$, which is the midpoint of the continuous range of age corresponding with age x at last birthday, and is weighted by the age-specific rate for age x. As the level of fertility declines, changes in the mean age of childbearing will be determined by the balance between delaying the first birth, with potential repercussions for the timing of all subsequent births, and avoiding high order births. It is possible for the mean to remain unchanged, even as fertility falls, if the fertility decline is due to both kinds of effects—delaying early births and avoiding later births. The standard deviation is more sensitive than the mean to changes in the lengths of birth intervals. If fertility declines and the intervals between births remain the same or become even shorter, then the standard deviation will decline. If fertility declines, but the birth intervals increase, as programs would usually encourage for the health of the children and the mother, then the standard deviation may show little change.

Trends in the ages at successive parities. A relatively innovative component of the analysis is based on simple synthetic estimates of the ages at which women achieve each successive birth order, and how these ages change over time. As stated earlier, the TFR is calculated by summing the age-specific fertility rates for single years of age 15 through 49. Incomplete sums of rates from 15 to some age before 49, such as 39, are referred to as Cumulative Fertility Rates. A CFR is normally keyed to a cutoff age (such as 39, to give the number of children born before the 40th birthday), but as an alternative, we can key it to a specific value, such as 1, 2, or 3, etc., and estimate the age when the CFR reaches that value. That age is loosely described as the age at which surviving women have their first child, second child, third child, and so on. The age at which the CFR for a synthetic cohort reaches a specific parity is not strictly the same as the mean

[4] As a sum of age-specific rates, the TFR is a compound rate. If the rates were for five-year intervals of age, which is more common, then they would be multiplied by five either before or after the summation, but this multiplier is not required when the rates are for single years of age.
[5] In the main reports and in StatCompiler, DHS uses a definition of the GFR that excludes exposure to women age 45-49 from the denominator (but includes their births in the numerator). Here we follow the standard definition in the demographic literature (see Pullum 2004) and include age 45-49 in both the numerator and the denominator.
[6] This description of the TFR and GFR assumes that the age-specific rates do not include a factor of 1,000.

age at reaching that parity, which would usually be calculated only for women who *do* reach that parity. For parities greater than the TFR, the age when the CFR reaches that age is undefined, and thus, when the TFR goes below 5, for example, the age at reaching parity 5 can no longer be tracked with this approach, although some women will still have five children, and their mean age at the birth of the fifth child could be calculated.

2.3. Methods

Arrays of births, exposure, and fertility rates

In the original definition of an age-specific fertility rate, say for women age 20-24 in calendar year 2000, the numerator is the number of births in 2000 to women who were age 20-24 at the time of birth, and the denominator is the number of women age 20-24 at the midpoint of the year, that is, on July 1, 2000. The numerator comes from a vital statistics system and the denominator is estimated from a completely different source, such as censuses or a civil registration system. In developed countries, official statistics on fertility are calculated in this way. (See, for example, Pullum 2004.)

By contrast, when age-specific fertility rates are calculated from retrospective birth histories collected in a survey, the denominators are *not* the number of women in an age group, but rather they are the number of woman-years of exposure to the specified age interval in a specified time interval. All women in the survey whose lives included any time (“exposure”) in the combination of age and time, not just those who had a birth, contribute something to the denominators. Each woman’s month and year of birth are used to calculate her age in the time interval. The standard five-year age intervals are 15-19, 20-24…45-49, but in this report age is disaggregated into single years 15, 16…49.

The procedures to calculate fertility rates will not be described here in detail because they are consistent with standard DHS procedures, described in Pullum 2004. The only modification when using calendar years, rather than “years ago,” is with the specification of the window within which births and exposure are calculated. For example, the intervals for a woman interviewed in March of 2014, say, would not be the three-year window from March 2011 through February 2014, inclusive; instead, the intervals would be January 2012 through December 2012, inclusive, for calendar year 2012. Otherwise, the arbitrary demographic decisions that are required because we know the month and year of the mother’s birth and the child’s birth, but not the day, are handled in exactly the same way here as for the standard rates in DHS reports.

Conceptually, age-period specific fertility rates for each survey are calculated from two arrays, one with numerators (births) and the other with denominators (exposure). In each array or matrix, the rows are the 35 single years of age from 15 through 49. The columns are calendar years. From each survey, we restrict to the 10 calendar years before the survey, with each year treated separately. For example, if the survey was done in 2014, or if it was done in 2013–2014, the 10 years would be 2004 through 2013, inclusive. We thus have a 35 × 10 array of births and a separately calculated 35 × 10 array of woman-years of exposure. Each birth and each contribution of exposure is multiplied by the sampling weight before calculating the totals in the cells. If the number in each cell of the births array is divided by the number in the corresponding cell of the exposure array, we obtain a third array, the age-period specific rates.[7]

Some cells in the arrays will be empty or extremely small because of the upper age cutoff for the sample. In the example of a survey conducted in 2014, there will be little exposure in 2013 to age 49, none in 2012

[7] The actual calculation of rates uses poisson regression, in which the outcome is the number of births, with an offset for the natural logarithm of the exposure. Adjustments for weights are included so that the point estimates are unbiased. Adjustments for clusters and strata are made so that robust standard errors can be estimated analytically. The description in the text is more conceptual.

to age 49, and little to age 48, and so on. The women who would have contributed to those combinations of years and ages would have been older than 49 at the date of the survey and, therefore, they were not interviewed. We fill in missing cells for ages 40+ with an empirically based procedure. Exposure and births in single-years of age from 40 through 49 are imputed as needed for the 10 years before the survey, simply by maintaining constant rates and proportional exposure as observed in the years immediately prior to the surveys. The results will have low sensitivity to how this is done because these are ages in which fertility is generally low, relative to earlier ages.

The surveys from Egypt and Jordan were limited to ever-married women. Unbiased estimates for the national population of all women age 15-49 living in households, regardless of marital status, require that the exposure for every woman in a survey be inflated with "all-woman factors" (awfactt). DHS calculates these factors during the preparation of the main data files, as the inverse of the proportion of all women age *x* in the household survey who are ever-married, with *x* measured in single years of age.

The next step, after calculating the births and exposure arrays for each survey, is to combine fertility data from the successive surveys in each country. This is done by expanding the number of columns in the arrays of births and exposure, and consolidating or adding the contributions from each survey. For example, suppose that we have surveys from 2009 and 2014 for a specific country. Each survey produces 35 x 10 arrays of births and exposure. The 10 columns from the 2014 survey, as described earlier, refer to calendar years 2004 through 2013. The 10 columns from the 2009 survey refer to calendar years 1999 through 2008. Both surveys provide information about births and exposure in five overlapping years, 2004 through 2008. In the consolidated arrays, the births and exposure for 2008 coming from the 2009 survey and the 2014 survey are added, cell by cell. The combined array has 35 rows, for each age 15 through 49, and 15 columns, for each year 1999 through 2013. The most recent columns include data from only the most recent survey. The earliest columns include data from only the earliest survey. The middle columns contain a pooling of the births and exposure from both surveys. The array of age-period-specific fertility rates is again obtained by dividing the births array by the exposure array, cell by cell.

As earlier surveys are added, the arrays for each country become wider. This study includes all countries that have had five or more DHS surveys. Typically, the most recent five years come only from the most recent survey; the earliest five years come only from the earliest survey. Otherwise, depending on the spacing between surveys, contributions for each year usually come from two successive surveys, but sometimes three surveys and sometimes only one.

In the consolidation of births and exposure from successive surveys, no adjustment is made for the sizes of the surveys. The general trend has been toward increasingly large samples over the course of the DHS program. When births and exposure from two surveys of unequal size are pooled, the resulting pooled rate is intermediate to the separate rates from the two surveys, but it is closer to the one with more exposure, and typically, more births.

It might seem desirable to re-scale the sampling weights in successive surveys, which could give equal weight to both surveys or give weight in proportion to the changing population of the country. This analysis, however, does not do this. Estimates of the fertility rate for a specific year of age and year of time, coming from two successive surveys, are generally unbiased.[8] The optimal way to pool two unbiased rates is to add the numerators, add the denominators, and then divide, without any re-weighting.

[8] A statistical association is possible between fertility and survival. For example, women who had more births by some specific age may be more likely to have died before the survey. An association is possible between fertility and recall. For example, women who had more births may be more likely to have children who died, and those children may be more likely to be omitted from the birth history. Either association could lead to downward bias in retrospective estimates; otherwise, the estimates from each survey are believed to be unbiased.

We briefly expand on the description in section 2.2 of how age at successive parities is estimated. In this calculation, cumulative fertility at age 20, for example, is interpreted as the number of children born by the 20th birthday and, therefore, it is the sum of the age-specific rates up to and including age 19, and excluding the rate for age 20. Suppose that this sum up to and including age 19 is less than or equal to 1.00, but the next sum, for age 21—the previous sum plus the age-specific rate for age 20—is greater than 1.00. The mean age when achieving parity 1 is then estimated to be in the interval between age 20.00 and 21.00, but not including 21.00. The specific value of age in that one-year age interval is calculated by linear interpolation.

Single-year estimates are shown in the figures for each country. The figures show some year-to-year fluctuation or jaggedness, resulting from a combination of sampling error and genuine fluctuation in the underlying population values.[9] The observed outcomes—TFR, GFR, mean age at childbearing, standard deviation of the age at childbearing, and ages when the CFR reached integer values—have been smoothed with 4-year linear splines. The knots are at calendar years that are divisible by 4, such as 2000. The selection of 4 is largely arbitrary (alternatives were tried, with little apparent effect), but it is important to avoid 5 because of the typical 5-year spacing of surveys. Alternatives, such as cubic splines, which is another option with Stata, higher-degree polynomials, and lowess smoothing, would give similar results. The estimates given in the text and tables for specific calendar years are the smoothed values, not the observed values.

Substantial sampling variability can occur in the cells of the arrays of births, exposure, and rates. The calculation of age-specific rates for single years of age or time, or the calculation of the TFR and GFR for single years of time, departs from standard DHS practice. The standard error of a rate based on single years of age and time will be approximately four times as large as a rate based on five years of age and three years of time given in a DHS report.[10] However, this more granular approach, followed by smoothing, seems preferable to alternatives, such as arbitrarily wide multiyear intervals of age or time, or both, or moving averages, etc.

Graphs of the TFR and GFR include approximate 95% confidence intervals.[11] The figures generally show a widening of the intervals for the five years in the beginning of the series and the five years at the end, because those estimates are based on only one survey, rather than the overlap of two surveys. Confidence intervals are not calculated for the other measures, but it can be seen from the figures that those estimates do not change much from one year to the next, indicating statistical stability, and the intervals would be narrow.

The next chapter reports the results of our analyses for the 16 countries covered in this report, organized alphabetically. The figures show the survey dates for the Total Fertility Rate, the General Fertility Rate, the mean and standard deviations for the age at childbearing, and the age at reaching successive number of children. The last section is an overview of all the countries.

[9] There is, undoubtedly, some measurement error, apart from sampling error, but we do not attempt to assess its direction or magnitude and we made no adjustments for it.

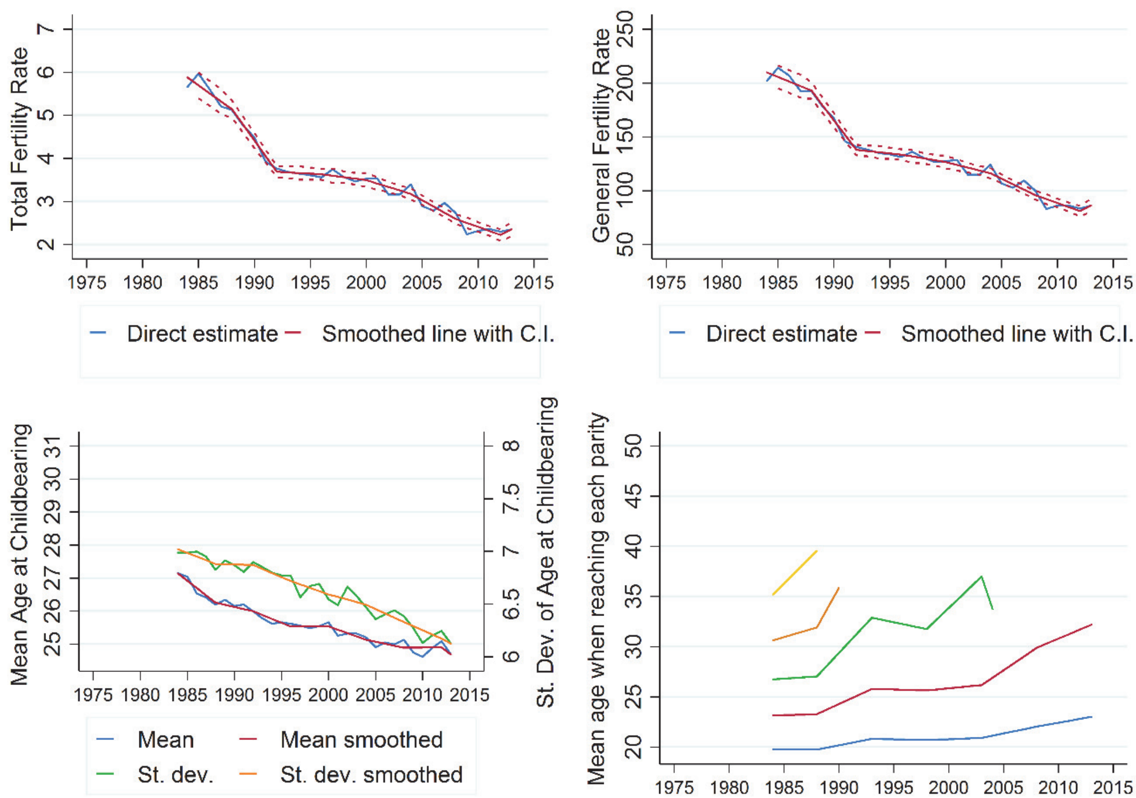
[10] In the comparison of a rate for 1 year of age and 1 year of time with a rate for 5 years of age and 3 years of time, the approximate factor for the standard error is the square root of 5×3, or 3.9.

[11] Robust confidence intervals are much easier to calculate for the General Fertility Rate (GFR) than for the Total Fertility Rate (TFR), although they are just re-arrangements of the same births and exposure, because the TFR is a compound rate. To arrive at an approximation, our strategy was to calculate the confidence interval for the GFR, then express the lower and upper ends as percentages of the GFR, and then apply those percentages to the TFR to get lower and upper bounds for the TFR.

3. Results

3.1. Bangladesh

Figure 3.1. Fertility trajectory for Bangladesh, estimated from seven DHS surveys for calendar years from 1984 to 2013. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

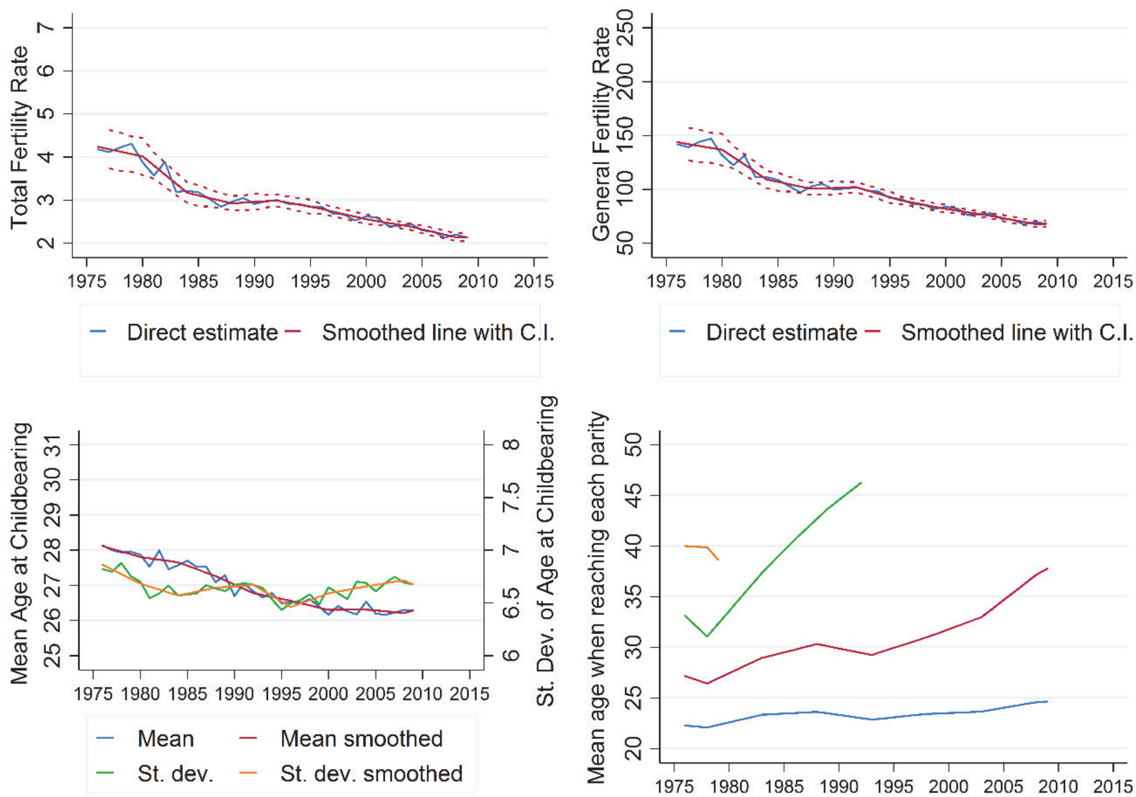


Bangladesh underwent a truly remarkable fertility transition during the time interval, with an estimated TFR of 5.9 in 1984, declining to 2.4 in 2013. The decline in the TFR and GFR was especially abrupt in the first 10 years, when the TFR dropped by about two children. It is clear that this rapid initial decline began before 1984. The most recent survey suggests that the rate of decline is slowing as replacement fertility is being approached.

The decline in the number of children has been accompanied by a continuous and steady decline in both the mean and the standard deviation of the age at childbearing. Fewer women have proceeded to parities above 2, and the age at having the first and second births has increased substantially; the age at the second birth has increased by nearly 10 years during the time interval. The interval between the first and second births has steadily increased. The reduction in family size has come about through a combination of not progressing to higher parities, having the first child later, and increasing the intervals between births.

3.2. Colombia

Figure 3.2. Fertility trajectory for Colombia, estimated from six DHS surveys for calendar years from 1976 to 2009. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

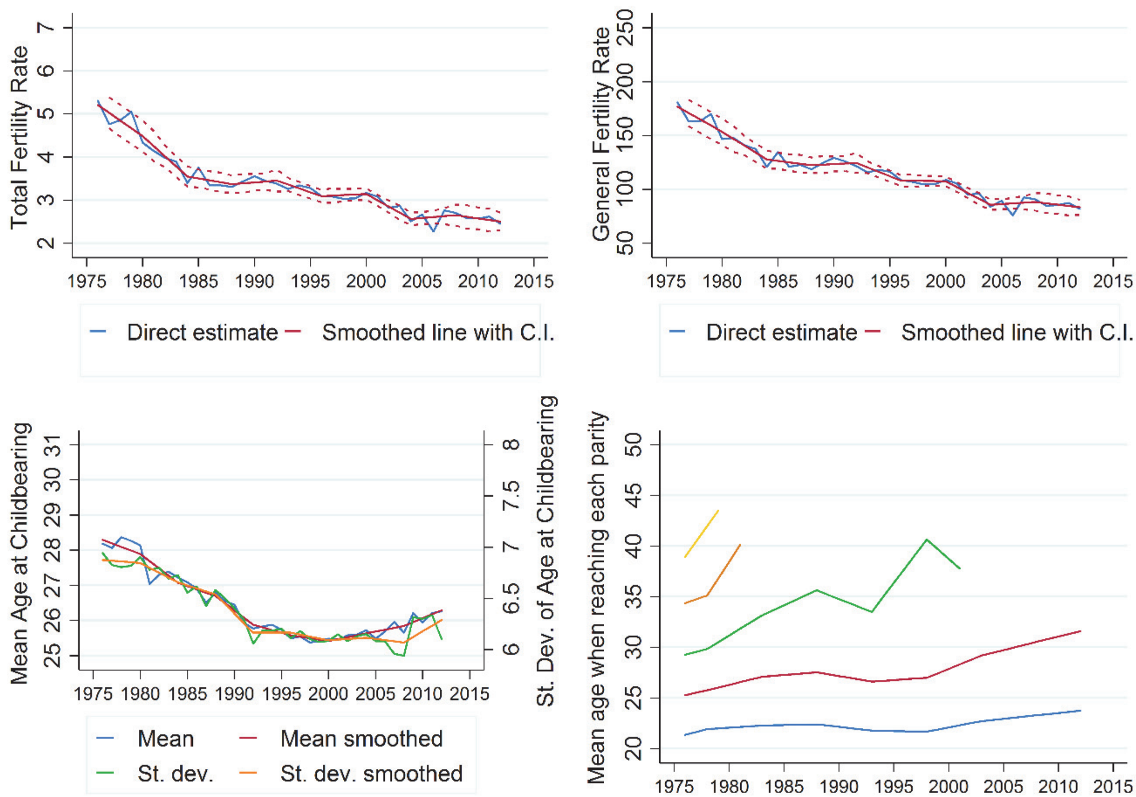


Colombia had completed its fertility transition by the end of the time interval, reaching a replacement-level TFR of 2.1 in 2009. At the beginning of the interval, in 1976, its TFR was 4.2, twice replacement level, but already well into a fertility transition as a consequence of several years of decline before 1976. It appears that the TFR trajectory leveled at about three children from the mid-1980s to the mid-1990s, but declined steadily since then.

The mean age at childbearing declined moderately across the interval, and the standard deviation fluctuated, but with little net change. The timing of the first birth has been relatively stable, typically being reached in the mid 20s, but the second birth has been typically delayed to the late 30s.

3.3. Dominican Republic

Figure 3.3. Fertility trajectory for Dominican Republic, estimated from seven DHS surveys for calendar years from 1976 to 2012. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

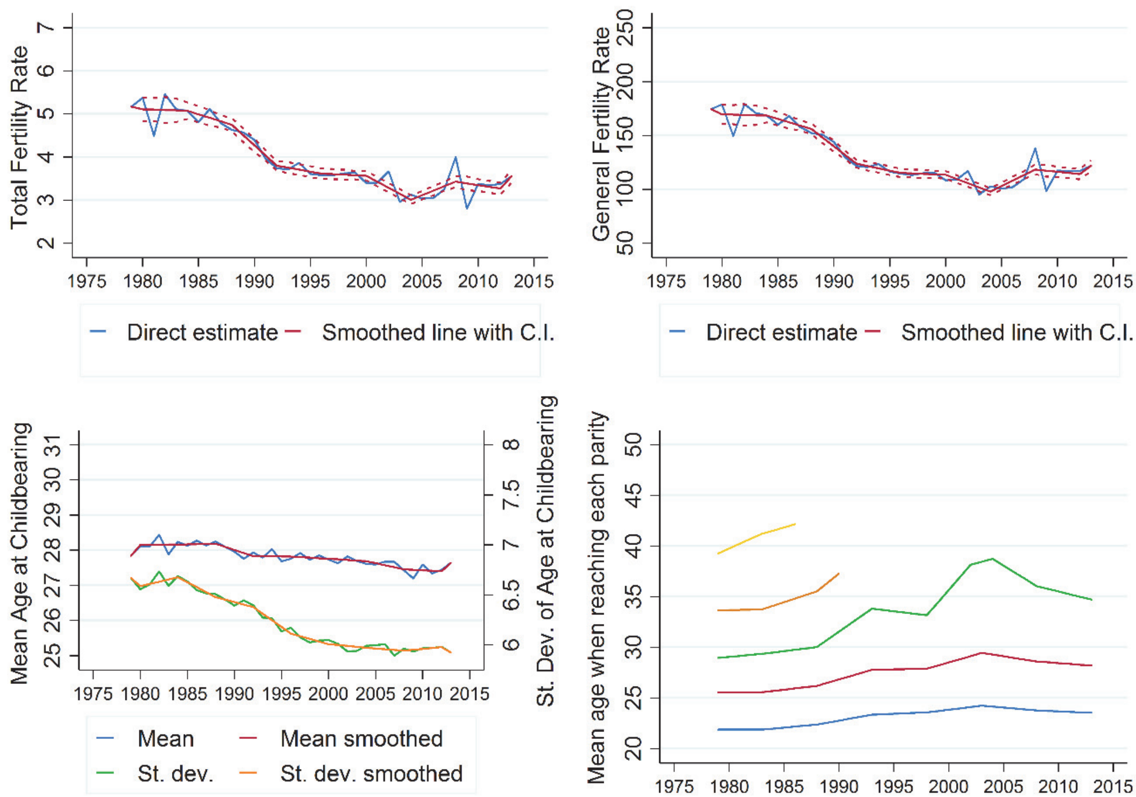


The trajectories of the TFR and GFR for the Dominican Republic are similar to those for Colombia, although at a slightly higher level. The TFR declined by about half, moving from 5.2 in 1976 to 2.5 in 2012. The decline was clearly well underway before 1976. The rates plateaued between the mid-1980s and the mid-1990s, but then the decline resumed, with some evidence of another plateau around 2000 and another one in the past decade or so.

The mean and standard deviation of the age at childbearing declined steadily until the late 1990s but have been flat or slightly increasing since then. The scales for these indicators, shown in the third graph of Figure 3.3, are different, given by the left and right vertical axes, and the apparent overlap of the trajectories is a coincidence. The ages at reaching parity 1 and parity 2 have increased, but not as dramatically as in Colombia, and the most recent age at the second birth is much earlier than in Colombia, despite a difference of only 0.3 in the TFR.

3.4. Egypt

Figure 3.4. Fertility trajectory for Egypt, estimated from seven DHS surveys for calendar years from 1979 to 2013. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

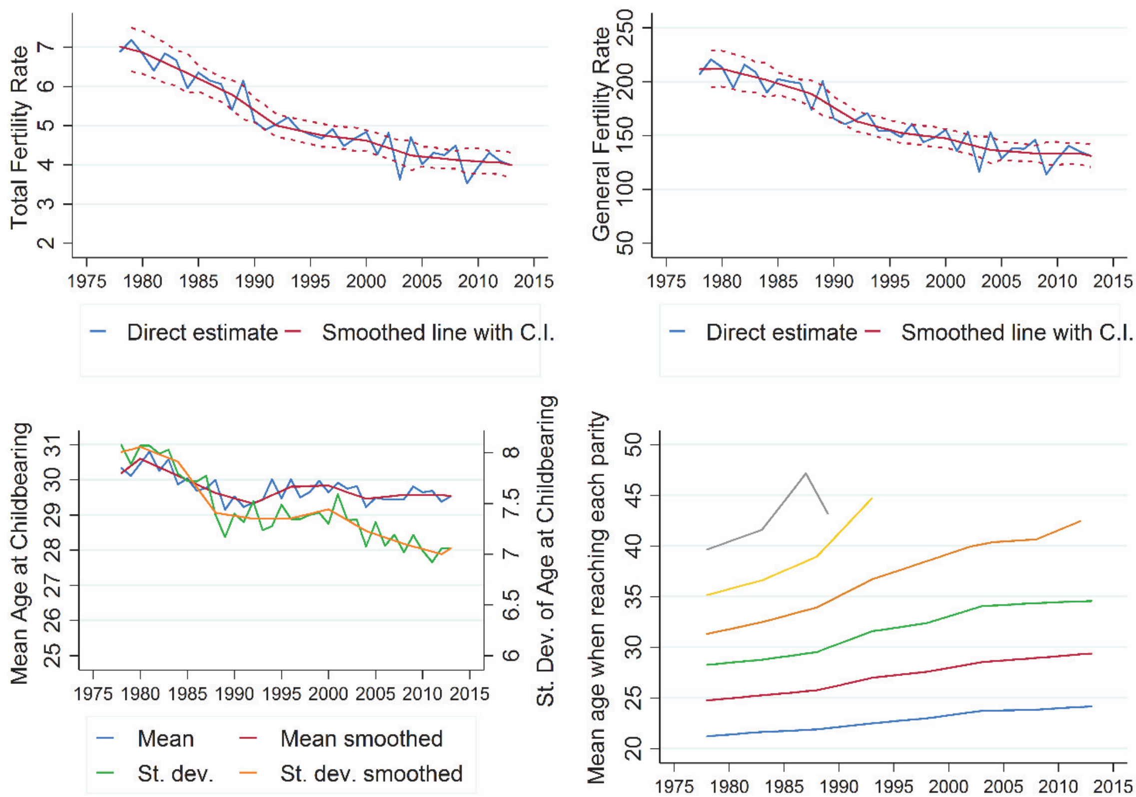


The TFR in Egypt has declined, from an initial value of 5.2 in 1979 to a final value of 3.6 in 2013. Compared with many other countries, however, the decline in Egypt has been only moderate. During the final 10 years or so, the TFR was essentially flat, and the GFR increased slightly to about the same level as 20 years earlier. Because of the lack of change in the first few years after 1979, it appears that the fertility transition had barely started, but the initial level of 5.2 is below the typical pre-transition TFR.

The mean age at childbearing has remained relatively constant for the full interval, around 28.0 years, but the degree of concentration increased (that is, the standard deviation decreased) between 1985 and 2000 and then became flat. The most recent standard deviation, about 6.0 years, is among the lowest in all the countries. Finally, the ages at reaching successive parities increased gradually until about 2003, and since then have returned to earlier levels.

3.5. Ghana

Figure 3.5. Fertility trajectory for Ghana, estimated from six DHS surveys for calendar years from 1978 to 2013. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

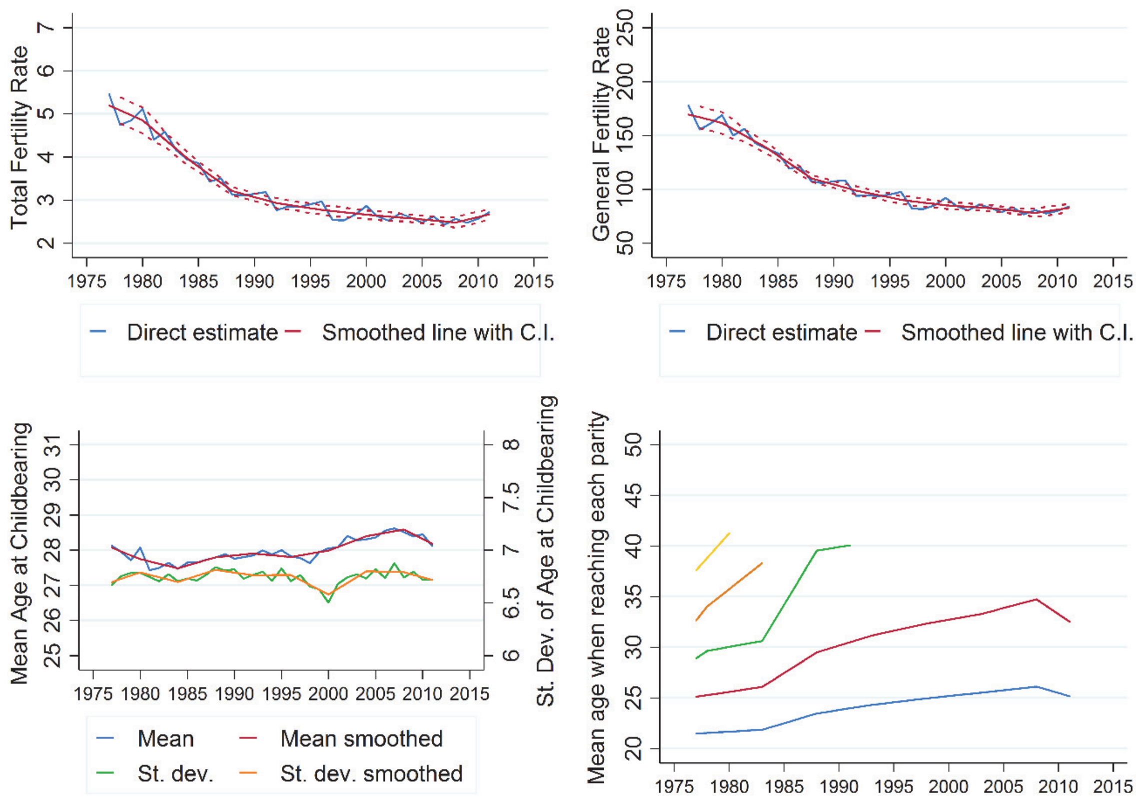


The decline in the TFR in Ghana has been monotonic and steady, from 7.0 in 1978 to 4.0 in 2013, the same final value as Kenya. The initial TFR was high, but the immediate decline suggests that the transition had already begun, which suggests an inflection point soon after 1990, such that the rapid decline up to that point became gradual, up to the present. The decline in recent years has been slow, as measured with the TFR and negligible with the GFR.

The mean age at childbearing was initially high, nearly 31.0. It declined until about 1990, and it has been essentially unchanged since then, somewhat below 30.0, but still one of the highest levels of all countries. The standard deviation also was initially high, near 8.0. It declined until 1990, then was flat for about 10 years, and has been in decline since about 2000. The timing of each parity has been steadily increasing, despite the recent flatness in the TFR and GFR, a pattern that is consistent with the increasing concentration of the age at childbearing. The intervals between the first and second, the second and third, and the third and fourth births have continued to be about equal to one another, but have gradually increased. As a result, the increase in age at reaching successive parities has moved progressively more steeply. The continuing decrease in the standard deviation and increases in the ages at successive parities show that the TFR and GFR do not completely capture the changing pattern of childbearing.

3.6. Indonesia

Figure 3.6. Fertility trajectory for Indonesia, estimated from seven DHS surveys for calendar years from 1977 to 2011. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.



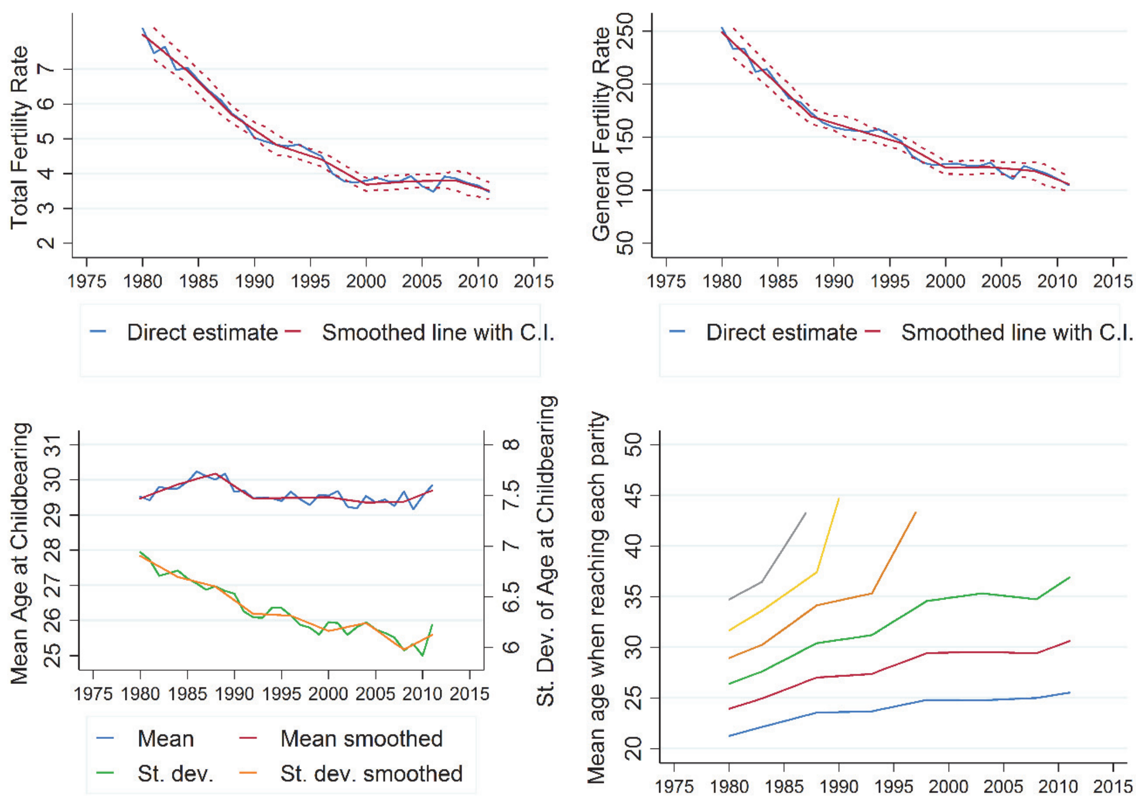
Indonesia moved from a TFR of 5.2 in 1977 to 2.7 in 2011, so now it is only a little more than half a child above replacement level, but most of that decline was before approximately 1990. Since then, the trajectory has been relatively flat, and the most recent survey suggests a possible increase, with the TFR and GFR in 2011 being at approximately the same level as in 2000.

The mean age at childbearing increased slightly, from an initial value of about 28.0 years, but after a slight decline in the past few years, it was back to almost exactly the initial value in 2011. The standard deviation in 2011 was also almost exactly at the initial level. The ages at reaching parities 1 and 2 increased steadily until about 2008, and the interval between those two ages also increased steadily, but with a possible reduction in the years just before the 2012 survey.

East Timor was included in the data collection for the early surveys of Indonesia, but after Indonesia relinquished control in 1999, East Timor was not included. The present analysis omitted East Timor from the early surveys, so that the entire trajectory presented here is exclusive of East Timor.

3.7. Jordan

Figure 3.7. Fertility trajectory for Jordan, estimated from five DHS surveys for calendar years from 1980 to 2011. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.



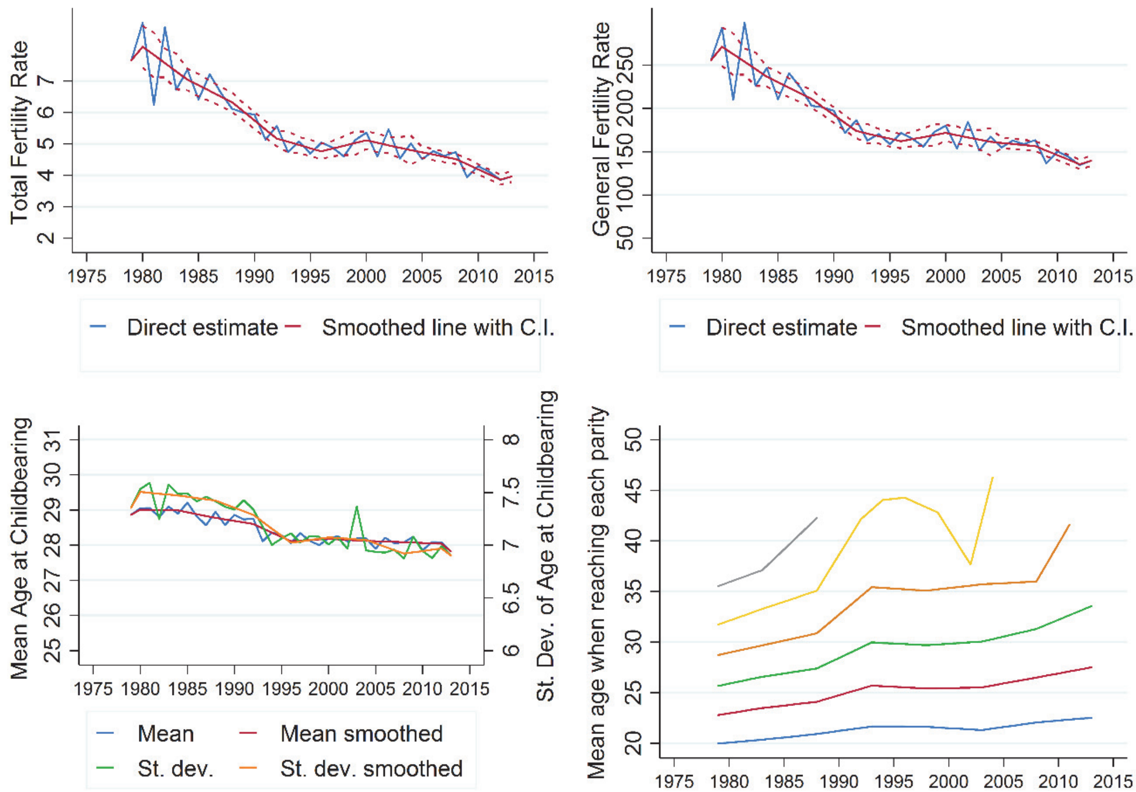
In Jordan, the TFR in the starting year, 1980, was calculated to be 8.0. There is other evidence that Jordan's pre-transitional TFR was about 8, but a more plausible estimate for 1980 would be about 7.5. Our estimates of the TFR and GFR in the early 1980s are almost certainly too high. As described earlier, the all-woman factors from the 1990 survey were used to inflate exposure for the 10 years 1980 through 1989, but during the 1980s age at marriage was rising, and it appears that the application of 1990 factors led to an exaggeration of the rates for single years of age 15 through 24 in the early 1980s. This distortion is not observed for later surveys of Jordan or for Egypt.

At any rate, Jordan began with one of the highest initial TFRs of all 16 countries, and the highest outside of SSA. By 1990 the TFR had declined to 5.3, and by 2000 to 3.7, that is, by about four children in the span of 20 years. Since 2000, however, there has been a plateau, such that the estimated TFR in the final year, 2011, is 3.5.

The mean age at childbearing has remained relatively steady, about 29.5 years, during most of the interval. The standard deviation has dropped steadily by about one year, from 7 to 6 years, but most of that decline was before 2000. The age at reaching successive parities has increased steadily, but again, most of that increase was before 2000. The data from the 2012 survey, for the years just before that survey, suggests a possible resumption of the downward trend in the TFR.

3.8. Kenya

Figure 3.8. Fertility trajectory for Kenya, estimated from six DHS surveys for calendar years from 1979 to 2013. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

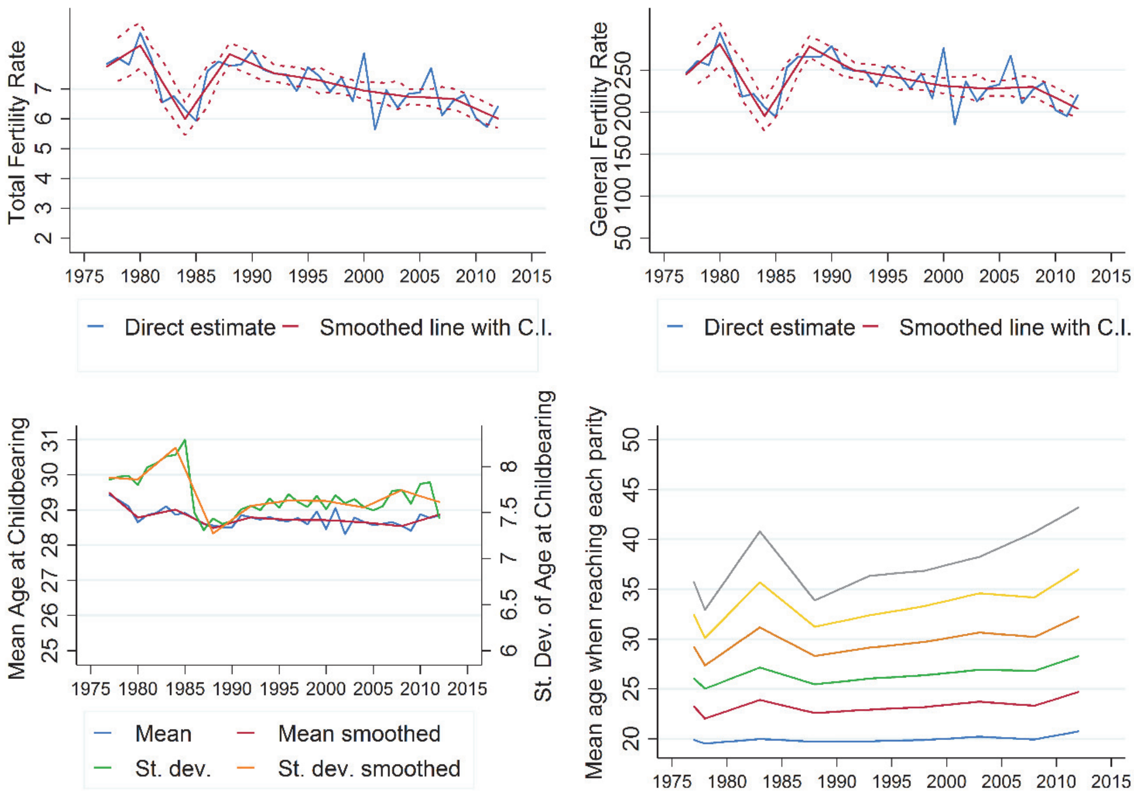


Kenya had high initial fertility, with a TFR of 7.7 in 1977, the first year of the series. The trajectory from then to about 1995 was steeply downward, with a reduction of about one child every five years. The TFR increased slightly from 1995 to 2000, when it was 5.1, and then declined to 4.0 in the most recent year, 2013, with a rate of decline that was about half what it had been during the earlier phase. The final TFR, for the same year, matched that of Ghana.

Both the mean and the standard deviation of the age at childbearing declined before 1995, and since then have been relatively flat. The apparent overlap in the figure is a coincidence resulting from the scales. The ages at reaching successive parities have increased slowly, with nearly the same intervals from one birth to the next, although those intervals are wider in recent years than they were at the beginning of the interval.

3.9. Mali

Figure 3.9. Fertility trajectory for Mali, estimated from five DHS surveys for calendar years from 1977 to 2012. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.



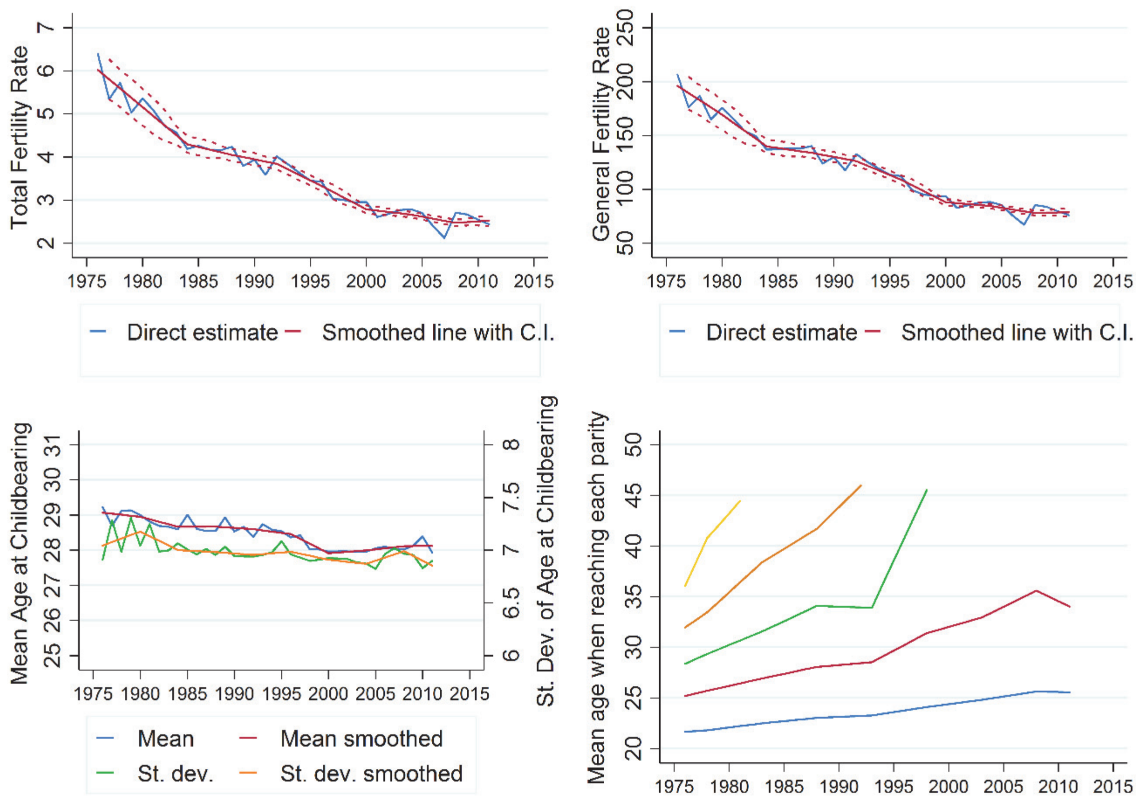
Mali had one of the highest TFRs at the beginning of the series, 7.7 in 1977. The TFR and GFR showed a substantial dip, and then a return to previous levels between 1980 and 1990, with consistent alterations to the other indicators. It is likely that this evidence of a dip is spurious. Apart from that dip, the decline has been gradual, to a TFR of 6.0 in 2012, one of the highest, and the same as Uganda in its last year, 2010.

The mean and standard deviation of the age at childbearing have also been relatively unchanged since about 1990. The intervals between successive births have been remarkably uniform, with only slight increases in age and corresponding slight increases in the intervals between parities.

Most of the surveys in Mali have omitted some geographic areas because they are sparsely populated or because of difficult field conditions. These areas have differed from one survey to the next. The pooling of surveys in this report has not taken those irregularities into account.

3.10. Peru

Figure 3.10. Fertility trajectory for Peru, estimated from nine DHS surveys for calendar years from 1976 to 2011. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.



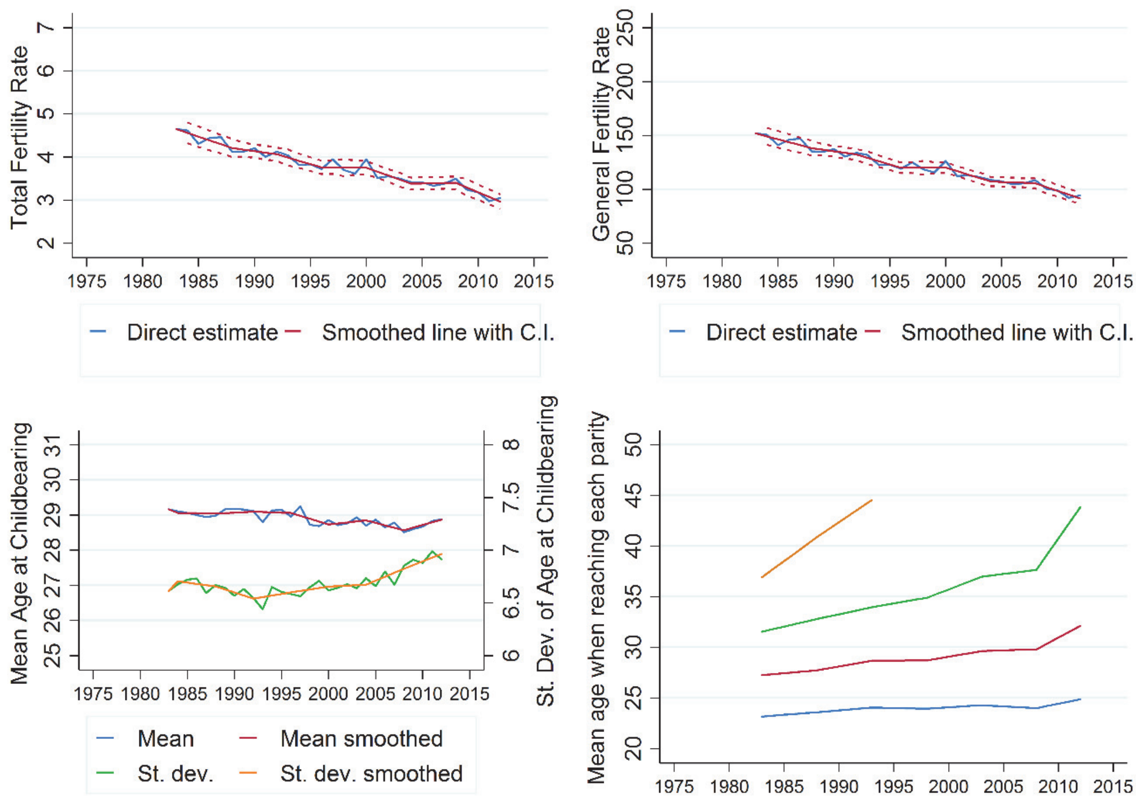
Peru's TFR declined from 6.0 in 1976 to 2.5 in 2011, similar to the decline in the Dominican Republic but somewhat steeper overall. The TFR is approaching replacement level. The reduction in the final 10 years has been only about 0.3 of a child, with virtually no reduction in the past 5 years.

The mean age at childbearing declined gradually from about 29 to about 28, with little change since 2000 and little change in the standard deviation during the entire interval. The reduction in fertility was clearly due to a combination of eliminating high-order births and increasing the age at earlier births, particularly the age at the second birth, which rose by about 10 years during the full interval. The age at the first birth increased by about four years and the interval to the second birth increased by about six years.

Peru had its last standard DHS survey in 2000, and since 2004 has had a continuous survey, with data collection every year and a rolling sample design. The years of the continuous survey have been grouped together (as in the data files DHS makes available) to reach a nominal total of nine surveys.

3.11. Philippines

Figure 3.11. Fertility trajectory for the Philippines, estimated from five DHS surveys for calendar years from 1983 to 2012. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.



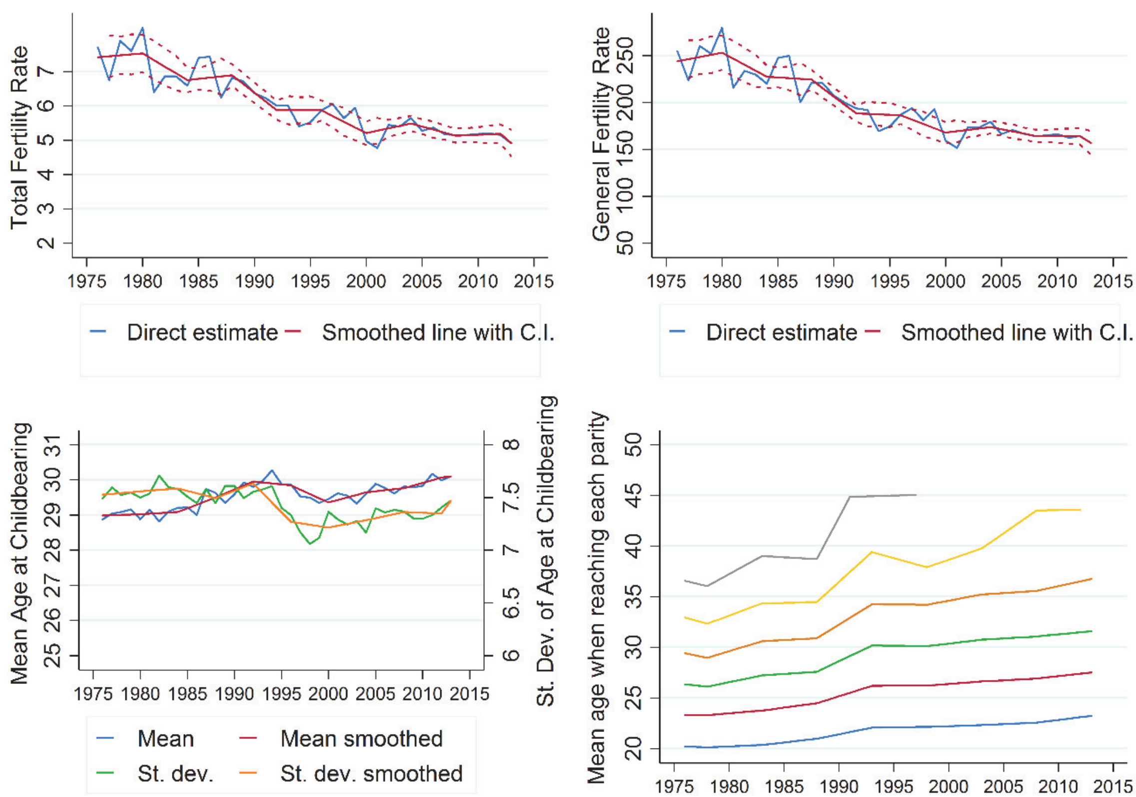
The trajectory for the Philippines has been close to linear throughout the interval from 1983 to 2012. The initial value of the TFR was 4.7 and the final value was 3.0, with an average reduction of 0.06 of a child per year. No plateau is indicated between 1983 or 2012, and not at the end, but this gradual pattern would need to be projected for another 15 years or so to reach replacement fertility.

The mean age at childbearing has been steady. The standard deviation has steadily increased since the early 1990s. The timing of the first birth has been flat, between approximately ages 23 and 25. The ages at the second and third births show a faster rise, particularly the third birth, in the most recent years.

The Philippines had its first National Demographic Survey in 1968, and other surveys at five-year intervals between then and the first DHS survey in 1988. It would be possible to extend this series back by 20 years.

3.12. Senegal

Figure 3.12. Fertility trajectory for Senegal, estimated from seven DHS surveys for calendar years from 1976 to 2013. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

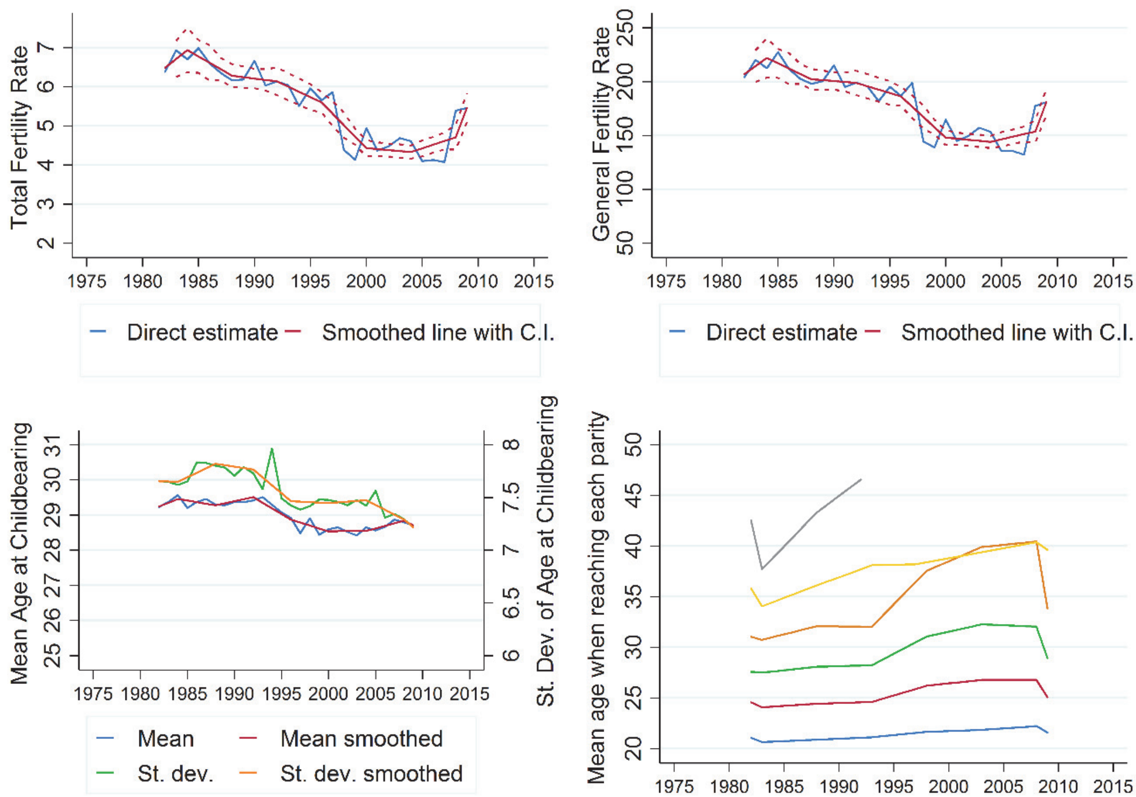


Senegal appears to have begun its fertility transition near the beginning of the series, in 1976, when the TFR was high at 7.4, with a fairly steady decline until 1995, and then a plateau, with just a gradual decline from 5.2 in 2000 to the final value of 4.9 in 2013.

The mean age at childbearing increased by about a year, from age 29 in 1976 to age 30 in 1995, and it has been increasing since about 2000. The standard deviation went from a higher level to a lower level, with most of the change happening in the late 1990s, about the same time as the plateau in the TFR and GFR. The ages at reaching successive parities have increased gradually, mostly before 1995, but steadily since then as well. The age at the fifth child remains on the figure until just before 2012, because that is when the TFR finally decreased below 5.0, but it increased by about 10 years of age during the time interval.

3.13. Tanzania

Figure 3.13. Fertility trajectory for Tanzania, estimated from six DHS surveys for calendar years from 1982 to 2009. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.



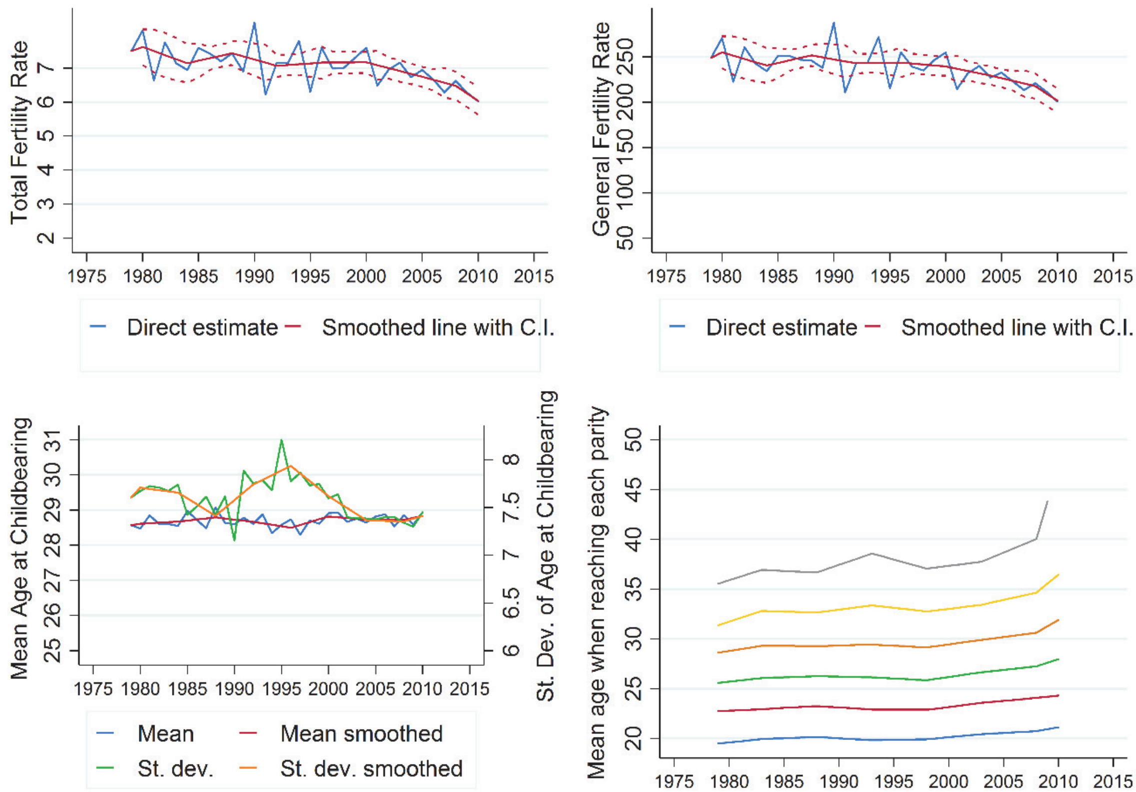
Tanzania had a TFR of 6.5 in 1982 and 5.5 in 2009, a decline of one child across a span of 27 years. In SSA, a pre-transition level of 6.5 would be relatively low, so it is possible that some decline had already occurred, despite the early pattern for the TFR and GFR, which is not compatible with a previous decline. The decline to about 4.5 in 2000, and then a plateau, is a familiar pattern from other countries in SSA, but the 2010 survey shows an increase of about one child after about 2005, a conspicuous difference from the other countries in this report, with the exception of Zimbabwe.

Both the mean and standard deviation of the age at childbearing had a net decline over the time interval, but most of the change was before 2000. The initial standard deviation for Tanzania, about 7.5, was also high—as is typical for the initial values of countries in SSA. The initial and final values of the ages at reaching successive parities are nearly the same, another manifestation of the apparent recent uptick in the TFR and GFR.

A more recent survey, conducted in 2015, but not available in time to be included here, will clarify whether the apparent increase before the 2010 survey was real.

3.14. Uganda

Figure 3.14. Fertility trajectory for Uganda, estimated from five DHS surveys for calendar years from 1979 to 2010. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

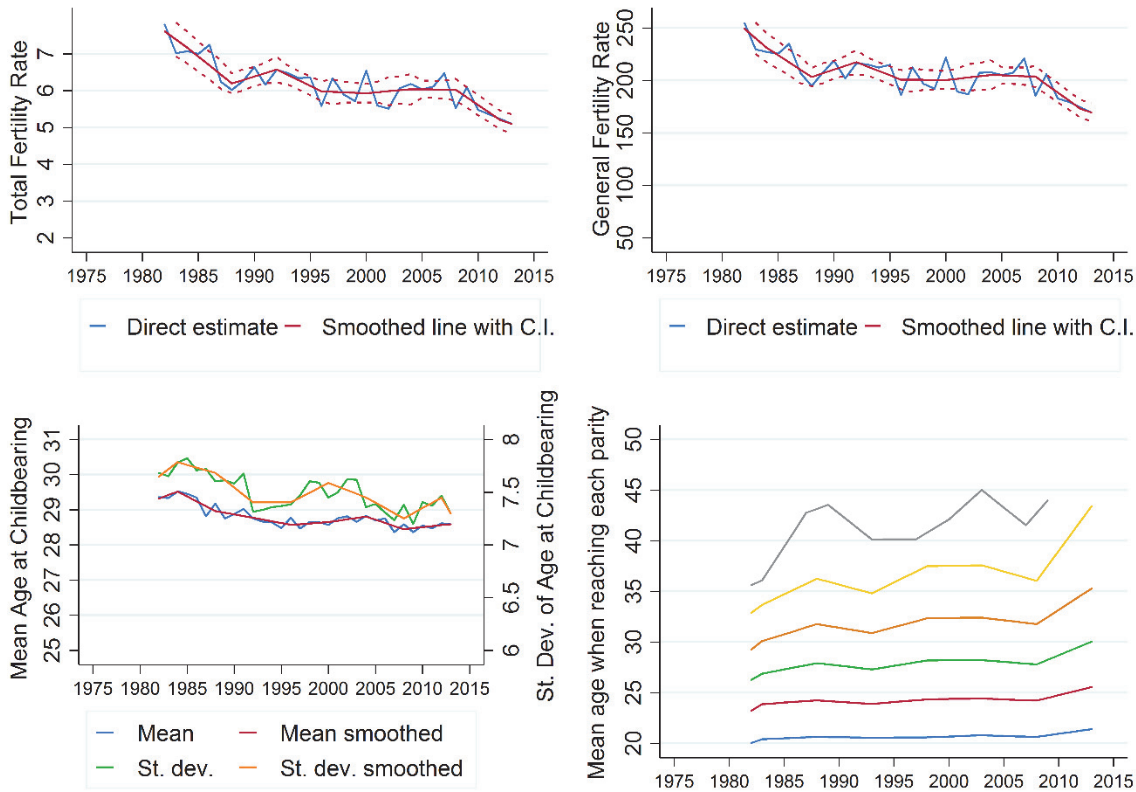


After Tanzania, Uganda shows the least net change in fertility of all the countries. Its TFR in 1982 was 7.4, a high pre-transitional level, and in 2010 it had reached was 6.0, which matches the final value in Mali and is higher than the initial value in several other countries. Most of the net decline of 1.4 births occurred after 2000, when the estimated TFR was 7.2. After 2000, the decline has been gradual but steady and may well continue.

Virtually no change in the mean age at childbearing took place during the entire interval. The standard deviation moved irregularly before 2000, but it was steady during the period of decline after 2000. The ages at reaching successive parities were consistently and uniformly spaced for the entire interval, with gradual and parallel increases after about 2000, suggesting a slight delay in the timing of the first birth, but with no or only small additional delays in later births apart from that.

3.15. Zambia

Figure 3.15. Fertility trajectory for Zambia, estimated from five DHS surveys for calendar years from 1982 to 2013. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.

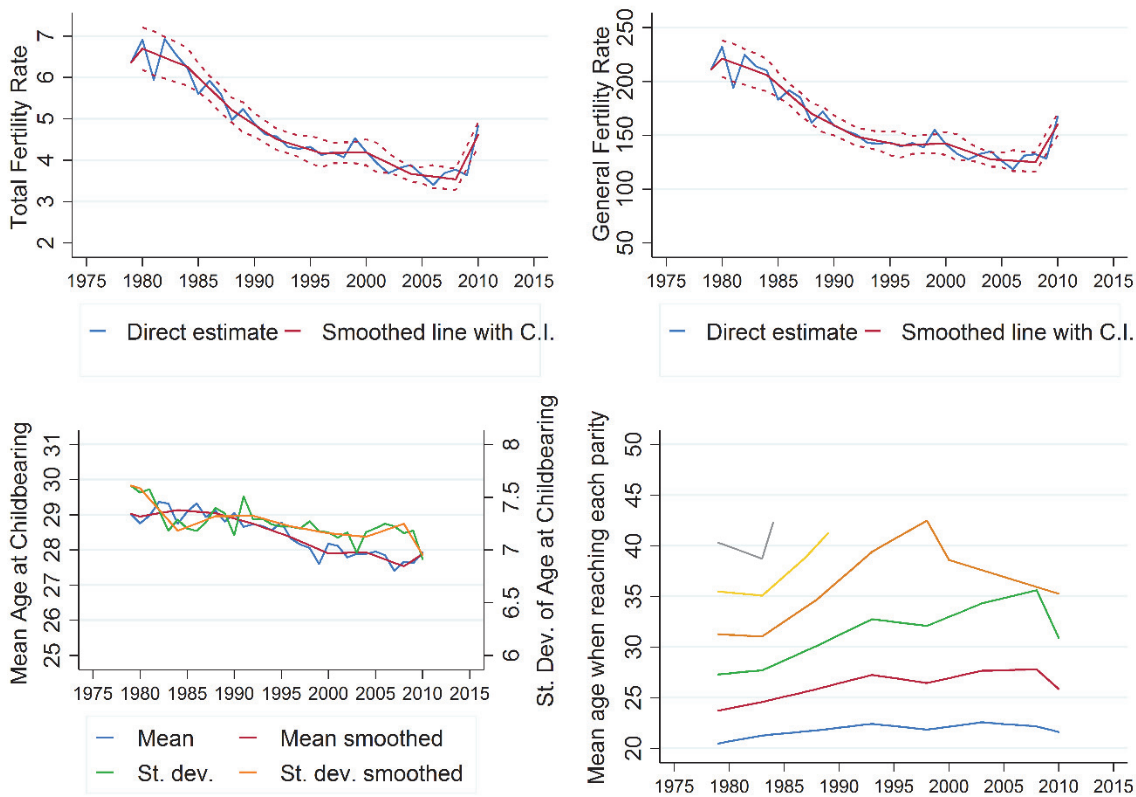


Zambia began with a high TFR, 7.6, in 1982, and ended with a TFR of 5.1 in 2013. An initial rapid decline is apparent, followed by an interval of about 20 years during which the TFR hovered near 6. The recent decline in TFR and GFR suggested in the 2014 survey is encouraging.

The mean age at childbearing declined during the first few years, and then remained virtually unchanged. The standard deviation appears to have had a long-term net decline of half a year, but with fluctuations. The ages at reaching successive parities have been steady and equally spaced. The age parity 1, just slightly above age 20, is one of the earliest in all the countries. The uptick in age from the 2014 survey is seen for all parities, including parity 1.

3.16. Zimbabwe

Figure 3.16. Fertility trajectory for Zimbabwe, estimated from five DHS surveys for calendar years from 1979 to 2010. Figures show the Total Fertility Rate, the General Fertility Rate, the mean and standard deviation of the age at childbearing, and the age at reaching successive numbers of children.



The TFR in Zimbabwe is estimated at 6.4 in the first year, 1979, and 4.6 in the final year, 2010. There was an initial rapid decline to 4.9 in 1990 and 4.2 in 2000, but with a levelling in approximately 2003 to 2007. The TFR increased abruptly in the years just before the 2011 survey, returning to approximately 1990 levels. Tanzania is the only other country in this report that shows such an abrupt increase in the most recent survey.

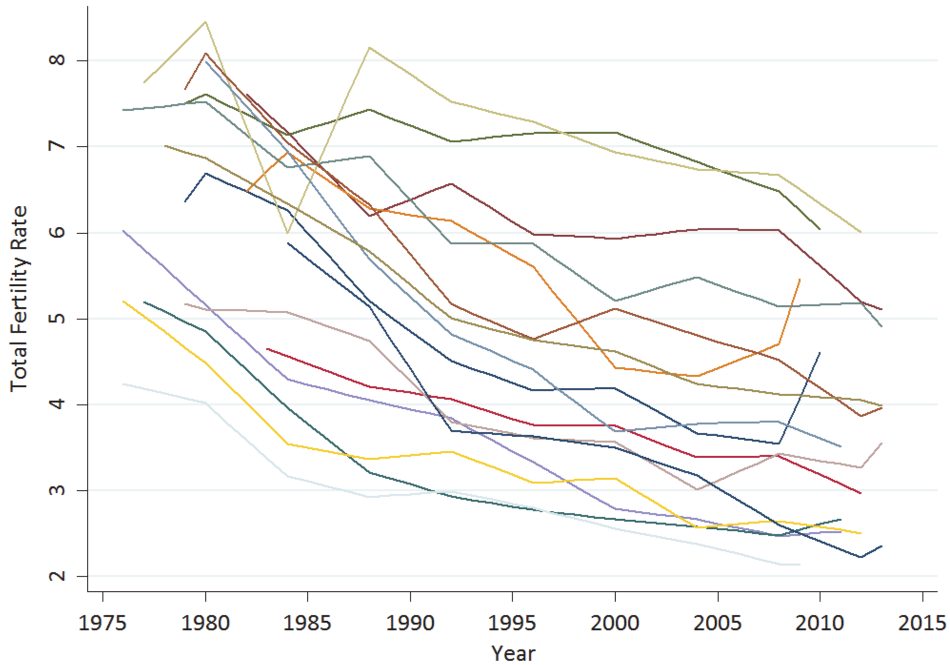
The mean age at childbearing was unchanged during the first 10 years or so, but then it declined gradually. The standard deviation was also steady for the initial 10 years, and then it declined even more gradually. The overlap of lines for the mean and standard deviation is a coincidence that results from the scales on the figure. The ages at successive parities increased throughout most of the time interval, but it declined abruptly in the final five years, to the levels of the late 1990s. Another DHS survey of Zimbabwe will be released soon.

3.17. Summary of Results

This section reviews and summarizes the changes for all 16 countries for the TFR, GFR, mean age at childbearing, standard deviation of the age at childbearing, and the ages at reaching successive parities. Results for all countries are illustrated in figures, supplemented by a table listing the estimated values by years, and a table comparing the changes across selected years.

Total Fertility Rate

Figure 3.17. Trajectory of the Total Fertility Rate for all 16 countries, based on pooled data from 98 DHS surveys for the 10 calendar years before each survey.



The TFR for the 16 countries covered in this analysis has declined substantially, overall. The median initial level was 6.43, and the median final value was 3.76, a reduction of 42%.[12] Every country showed a decline. Despite the various fluctuations and, for several countries, upticks or downticks at the end, the consistency across countries was high. The correlation between the initial and final TFRs was 0.72. Squaring this number, fully half of the variation in the final TFR was statistically explained by the initial value. In a comparison of the countries above or below the medians at the initial and final values, only two countries that did not remain in the same half. Jordan is exceptional for being above the initial median but below the final median. Zimbabwe is exceptional for being below the initial median, although only slightly, but above the final median.

[12] Each median was calculated as the midpoint between the eighth and ninth values of the TFR, when the countries are ranked by their initial TFR and then by their final TFR.

Table 3.1 gives the TFR for all countries in the initial year; in 1980, if the initial year was before 1980; in 1990; in 2000; in 2010, if the last year was after 2010; and in the last year. The first three columns also identify the first year, last year, and the length of the interval.[13] TFR values are given with two decimal places, but in the text they are usually rounded to the nearest tenth.

Table 3.1. Smoothed values of the Total Fertility Rate in the 16 countries. Includes smoothed values for the first year and last year, 1990, and 2010. If the first year was before 1980, smoothed values for 1980 are also included. If the last year was after 2010, smoothed values for 2010 are also included.

Country	First year	Last year	Interval	TFR in first year	1980	1990	2000	2010	TFR in last year
Bangladesh	1984	2013	29	5.88		4.42	3.50	2.41	2.35
Colombia	1976	2009	33	4.24	4.02	2.96	2.56		2.14
Dominican Republic	1976	2012	36	5.21	4.49	3.41	3.14	2.58	2.50
Egypt	1979	2013	34	5.17	5.11	4.27	3.57	3.35	3.55
Ghana	1978	2013	35	7.01	6.87	5.40	4.62	4.09	3.99
Indonesia	1977	2011	34	5.20	4.85	3.07	2.66	2.61	2.67
Jordan*	1980	2011	31	7.99	7.99	5.26	3.68	3.61	3.51
Kenya	1979	2013	34	7.67	8.09	5.75	5.12	4.19	3.96
Mali	1977	2012	35	7.74	8.46	7.84	6.94	6.34	6.01
Peru	1976	2011	35	6.02	5.16	3.95	2.79	2.51	2.53
Philippines	1983	2012	29	4.65		4.14	3.75	3.18	2.97
Senegal	1976	2013	37	7.42	7.53	6.39	5.21	5.16	4.91
Tanzania	1982	2009	27	6.49		6.21	4.43		5.46
Uganda	1979	2010	31	7.50	7.62	7.25	7.17	6.04	6.04
Zambia	1982	2013	31	7.61		6.39	5.93	5.61	5.10
Zimbabwe	1979	2010	31	6.37	6.70	4.86	4.19	4.61	4.61

*As described in the text, the initial TFR for Jordan is distorted; a suggested approximation would be 7.5.

Colombia is the only country that could be said to have achieved replacement-level fertility by the end of the time interval, but five other countries had a final TFR value below 3: Bangladesh, the Dominican Republic, Peru, Indonesia, and the Philippines. These six lowest-fertility countries are all in Latin America and the Caribbean or in Asia. The next lowest countries are Jordan and Egypt, from the Middle East and North Africa, respectively. All of the remaining countries are above the median and are in SSA. Of these eight, Kenya and Ghana are just barely below 4 (to the nearest tenth, their TFR is 4.0). Senegal is just below 5 (at 4.9); Zambia is just above 5 (at 5.1); Tanzania has a TFR of 5.5, Mali and Uganda have a TFR of 6.0.

[13] The interval is calculated as the last year minus the first year. To get the total number of calendar years for which an estimate is provided, 1 should be added.

Table 3.2 describes the change between the TFR values given in the columns of Table 3.1. It is important to recognize that changes here, as throughout the text, are expressed as arithmetic differences between the values at two time points, and not as, say, annual rates of reduction, which are relative changes. Time 1 refers to 1980 or to the initial value in Table 3.1, if the first time point is after 1980; Time 2 is always 1990; Time 3 is always 2000; Time 4 refers to 2010 or to the final value in Table 3.1, if the last time point is before 2010. The arithmetic differences in the TFR are divided by the elapsed number of years, to express change on an annualized scale.[14] The goal is to describe, as nearly as possible, the decadal changes between 1980 and 2010. The last column of Table 3.2 can be interpreted as the average annual change from approximately 1980 to approximately 2010.

Table 3.2. Changes in the smoothed values of the Total Fertility Rate in the 16 countries

Country	First year	Last year	Interval	Change 12 annual	Change 23 annual	Change 34 annual	Change 14	Change 14 annual
Bangladesh	1984	2013	29	−0.2441	−0.0921	−0.0881	−3.5296	−0.1217
Colombia	1976	2009	33	−0.0913	−0.0402	−0.0469	−2.1026	−0.0637
Dominican Republic	1976	2012	36	−0.1283	−0.0270	−0.0533	−2.7051	−0.0751
Egypt	1979	2013	34	−0.0817	−0.0705	−0.0011	−1.6188	−0.0476
Ghana	1978	2013	35	−0.1347	−0.0775	−0.0486	−3.0227	−0.0864
Indonesia	1977	2011	34	−0.1637	−0.0411	0.0008	−2.5296	−0.0744
Jordan*	1980	2011	31	−0.2735	−0.1573	−0.0159	−4.4838	−0.1446
Kenya	1979	2013	34	−0.1744	−0.0633	−0.0886	−3.7036	−0.1089
Mali	1977	2012	35	0.0078	−0.0902	−0.0778	−1.7338	−0.0495
Peru	1976	2011	35	−0.1483	−0.1158	−0.0238	−3.4961	−0.0999
Philippines	1983	2012	29	−0.0731	−0.0385	−0.0657	−1.6851	−0.0581
Senegal	1976	2013	37	−0.0739	−0.1179	−0.0229	−2.5112	−0.0679
Tanzania	1982	2009	27	−0.0345	−0.1778	0.1145	−1.0242	−0.0379
Uganda	1979	2010	31	−0.0229	−0.0082	−0.1132	−1.4653	−0.0473
Zambia	1982	2013	31	−0.1532	−0.0454	−0.0637	−2.5086	−0.0809
Zimbabwe	1979	2010	31	−0.1372	−0.0667	0.0418	−1.7573	−0.0567

Note: “Change 14” is the change from the first smoothed value to the last smoothed value. “Change 14 annual” is “Change 14” divided by the number of years in the full interval, which ranges between 27 and 37 years. “Change 12 annual” is the annualized change from the first smoothed value to 1990; “Change 23 annual” is the annualized change from 1990 to 2000; “Change 34 annual” is the annualized change from 2000 to the last smoothed value.

*Using 7.5 as the initial value for Jordan, Change 12 annual is −0.2240, Change 14 is −3.99, and Change 14 annual is −0.1287.

To assess whether the annual reduction was large or small, it is important to keep in mind the actual levels, particularly the initial distance from replacement level. The greatest annual reductions are for Jordan (0.13, if the initial value is replaced with 7.5), Bangladesh (0.12), Kenya (.11), and Peru (.10). Even if the initial TFR for Jordan is replaced with 7.5, the decline for Jordan remains the largest of all countries. The smallest annual reductions are for Tanzania (.04), Uganda, Egypt, and Mali (.05), and Zimbabwe and the Philippines (.06). The other eight countries had intermediate changes (.07, .08, or .09). Except for Jordan, the country with the greatest change, and Tanzania, the country with the least change, the other 14 countries are in a range from 0.05 to 0.12 in their annualized decline in the TFR, from about 1980 to about 2010.

[14] For example, the change from Time 1 to Time 2 for Bangladesh, with the first estimate for 1984, is expressed as the 1990 estimate, minus the 1984 estimate, divided by 6. Calculations were done with more decimal places than are shown in Table 3.1. Table 3.2 gives four digits to the right of the decimal place because often the first digit is 0, and sometimes also the second and even the third. Small differences from one date or country to another should not be over-interpreted.

General Fertility Rate

Figure 3.18. Trajectory of the General Fertility Rate for all 16 countries, based on pooled data from 98 DHS surveys for the 10 calendar years before each survey.

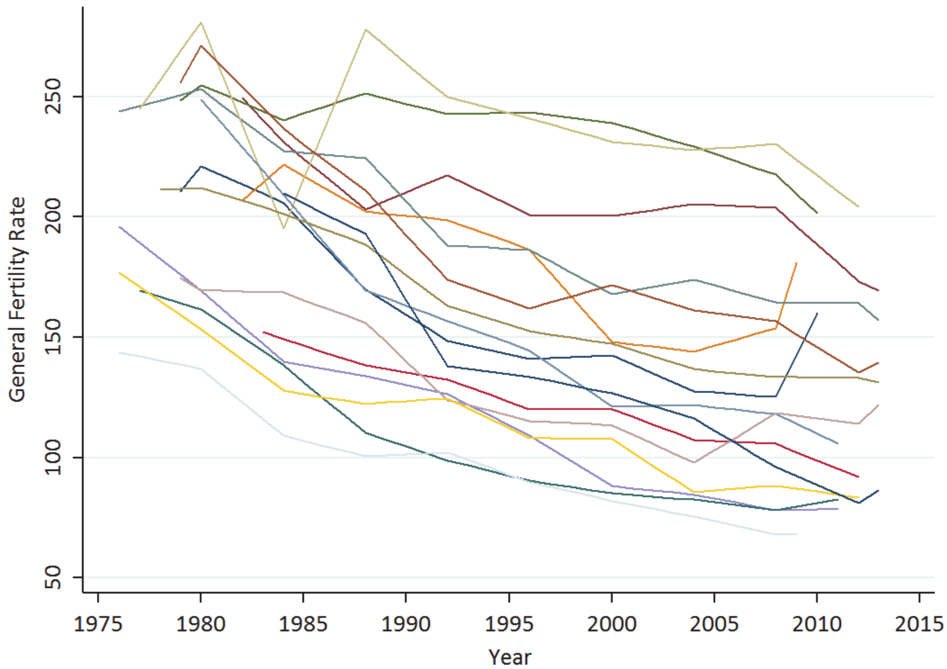


Figure 3.18 and Tables 4.3 and 4.4, are analogous to Figure 3.17 and Tables 4.1 and 4.2, for the GFR for all 16 countries.

Although the TFR and GFR show similar patterns, they are conceptually different, and that is the reason for including both of them throughout this analysis. The TFR is a synthetic measure, with an interpretation that depends on an obviously false assumption that there is no mortality for women between the exact ages 15 and 50. The interpretation of the GFR requires no such assumption, and it can be interpreted simply as the annual number of births per 1,000 women of childbearing age.

The early period covered by this report had few years and countries for which the GFR exceeded 250. By the end of the observations, no countries exceeded a GFR of 250, and six countries had a GFR below 100: Colombia (68), Peru (79), Indonesia and the Dominican Republic (both 83), Bangladesh (86), and the Philippines (92).

Targets are generally specified in terms of the TFR because it is not affected by the age distribution and can be considered a pure measure of fertility. As is well known, a TFR of 2.1 can be interpreted as replacement fertility, although the exact replacement value depends on the level of mortality. The GFR does not have a specific value that corresponds with replacement fertility, but the value of 68 for Colombia, which has a final TFR of 2.14, is close to replacement. The estimated initial TFR for Jordan is too high, by 5% to 10%, but will not be adjusted downward.

The remainder of the figures and tables for the GFR will not be discussed because of the similarity to the TFR.

Table 3.3. Smoothed values of the General Fertility Rate in the 16 countries. Includes smoothed values for the first year and last year, 1990, and 2010. If the first year was before 1980, smoothed values for 1980 are also included. If the last year was after 2010, smoothed values for 2010 are also included.

Country	First year	Last year	Interval	GFR in first year	1980	1990	2000	2010	GFR in last year
Bangladesh	1984	2013	29	209.94		165.50	126.69	88.60	86.37
Colombia	1976	2009	33	143.82	136.86	101.31	81.98		68.03
Dominican Republic	1976	2012	36	176.82	153.50	123.54	107.57	85.89	83.38
Egypt	1979	2013	34	174.65	169.58	140.05	113.47	116.33	121.95
Ghana	1978	2013	35	211.53	212.08	175.99	147.39	133.33	131.20
Indonesia	1977	2011	34	169.55	161.66	104.54	85.20	81.20	82.71
Jordan	1980	2011	31	248.83	248.83	163.20	121.14	110.00	105.98
Kenya	1979	2013	34	255.80	271.47	192.47	171.70	145.99	139.51
Mali	1977	2012	35	245.07	281.13	263.96	231.33	217.25	204.17
Peru	1976	2011	35	196.08	169.34	130.12	88.05	78.54	78.79
Philippines	1983	2012	29	152.16		135.41	120.21	98.72	91.78
Senegal	1976	2013	37	243.81	253.18	206.37	167.87	164.31	157.03
Tanzania	1982	2009	27	207.02		200.58	148.07		180.94
Uganda	1979	2010	31	248.64	254.97	247.17	239.28	201.54	201.54
Zambia	1982	2013	31	249.46		210.45	200.52	188.56	169.66
Zimbabwe	1979	2010	31	210.82	221.18	159.34	142.45	160.09	160.09

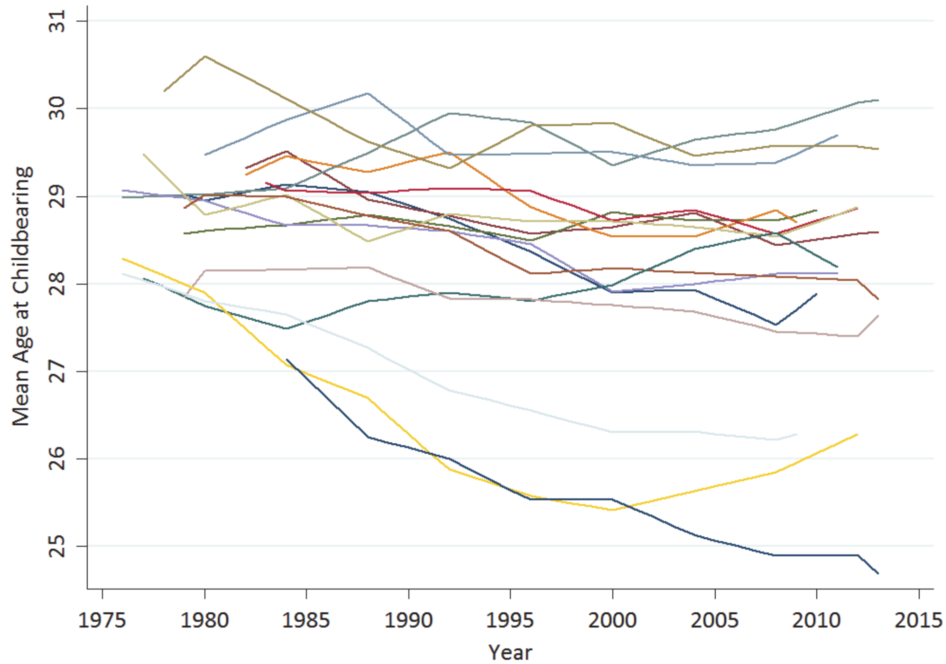
Table 3.4. Changes in the smoothed values of the General Fertility Rate in the 16 countries.

Country	First year	Last year	Interval	Change 12 annual	Change 23 annual	Change 34 annual	Change 14	Change 14 annual
Bangladesh	1984	2013	29	−7.4069	−3.8807	−3.1014	−123.5670	−4.2609
Colombia	1976	2009	33	−3.0364	−1.9330	−1.5498	−75.7876	−2.2966
Dominican Republic	1976	2012	36	−3.8060	−1.5966	−2.0162	−93.4437	−2.5957
Egypt	1979	2013	34	−3.1454	−2.6577	0.6522	−52.6973	−1.5499
Ghana	1978	2013	35	−2.9623	−2.8593	−1.2458	−80.3360	−2.2953
Indonesia	1977	2011	34	−5.0008	−1.9345	−0.2258	−86.8396	−2.5541
Jordan	1980	2011	31	−8.5632	−4.2058	−1.3787	−142.8563	−4.6083
Kenya	1979	2013	34	−5.7570	−2.0764	−2.4764	−116.2837	−3.4201
Mali	1977	2012	35	1.4531	−3.2630	−2.2636	−40.9020	−1.1686
Peru	1976	2011	35	−4.7114	−4.2071	−0.8423	−117.2948	−3.3513
Philippines	1983	2012	29	−2.3925	−1.5199	−2.3687	−60.3706	−2.0817
Senegal	1976	2013	37	−2.6749	−3.8495	−0.8343	−86.7883	−2.3456
Tanzania	1982	2009	27	−0.8043	−5.2511	3.6526	−26.0716	−0.9656
Uganda	1979	2010	31	−0.1329	−0.7891	−3.7745	−47.0983	−1.5193
Zambia	1982	2013	31	−4.8765	−0.9931	−2.3741	−79.8065	−2.5744
Zimbabwe	1979	2010	31	−4.6802	−1.6887	1.7636	−50.7323	−1.6365

Note: “Change 14” is the change from the first smoothed value to the last smoothed value. “Change 14 annual” is “Change 14” divided by the number of years in the full interval, which ranges between 27 and 37 years. “Change 12 annual” is the annualized change from the first smoothed value to 1990; “Change 23 annual” is the annualized change from 1990 to 2000; “Change 34 annual” is the annualized change from 2000 to the last smoothed value.

Mean age at childbearing

Figure 3.19. Trajectory of the mean age at childbearing for all 16 countries, using pooled data from 98 DHS surveys for the 10 calendar years before each survey



The trajectories of the mean age at childbearing are described in Figure 3.19 and Tables 3.5 and 3.6, which are discussed together. Virtually all of the initial values of the mean age at childbearing were in the range of 28.0 to 30.0 years. Ghana was a little higher and Egypt was a little lower. The initial value for Bangladesh, in 1984, was nearly a full year below that range, but possibly would have been in that range in 1980 if there had been an earlier survey. For most countries, the mean age at the end of the series was also in that range, and if the range is widened to, say, 27.5 to 30.1, in the final year only three countries—Bangladesh (24.7) and Colombia and the Dominican Republic (26.3 for both)—would be outside that range, and they would be substantially below it. These three countries had a steadily declining mean age at the same time that the TFR and GFR were dropping rapidly; otherwise, the countries with declining fertility did not show nearly such large declines in their mean age at childbearing. Four countries, however, did show a change of approximately a year, up or down, in their mean age: Zimbabwe declined by 1.14 years, Kenya by 1.04 years, and Peru by 0.95 of a year; Senegal increased by 1.11 years.

A relationship that is not reflected in the figures or tables in this report is that the TFR and the mean age at childbearing across all countries are positively and significantly correlated. At the initial year, if the mean age is regressed on the TFR, the regression coefficient is 0.35, and at the final year it is 0.62. In general, countries with a lower TFR also have a lower mean age at childbearing. That is, a reduction of about 1.6 in the TFR corresponds with a reduction of about one full year in the mean age at childbearing. This pattern probably reflects the dominant role of the omission of high parities, rather than the delay of the early parities, during the transition to lower fertility.

No adjustment is made to the estimates of the mean and standard deviation of the age at childbearing in Jordan in the early 1980s. The mistiming of the all-woman factors, described earlier, slightly exaggerated the rates for ages 15-24, probably producing a slight downward bias in the mean and upward bias in the standard deviation, but only for 1980.

Table 3.5. Smoothed values of the mean age at childbearing in the 16 countries. Includes smoothed values for the first year and last year, 1990, and 2010. If the first year was before 1980, smoothed values for 1980 are also included. If the last year was after 2010, smoothed values for 2010 are also included.

Country	First year	Last year	Interval	Mean age in first year	1980	1990	2000	2010	Mean age in last year
Bangladesh	1984	2013	29	27.14		26.13	25.54	24.90	24.69
Colombia	1976	2009	33	28.12	27.81	27.03	26.30		26.28
Dominican Republic	1976	2012	36	28.29	27.90	26.29	25.42	26.07	26.29
Egypt	1979	2013	34	27.84	28.15	28.01	27.76	27.43	27.64
Ghana	1978	2013	35	30.20	30.60	29.47	29.84	29.57	29.54
Indonesia	1977	2011	34	28.07	27.75	27.85	27.99	28.32	28.19
Jordan	1980	2011	31	29.47	29.47	29.83	29.51	29.59	29.70
Kenya	1979	2013	34	28.87	29.01	28.69	28.18	28.07	27.82
Mali	1977	2012	35	29.48	28.78	28.64	28.71	28.71	28.87
Peru	1976	2011	35	29.07	28.95	28.64	27.91	28.12	28.12
Philippines	1983	2012	29	29.16		29.07	28.73	28.72	28.87
Senegal	1976	2013	37	28.99	29.02	29.73	29.36	29.92	30.10
Tanzania	1982	2009	27	29.24		29.39	28.54		28.71
Uganda	1979	2010	31	28.57	28.61	28.73	28.82	28.84	28.84
Zambia	1982	2013	31	29.32		28.87	28.65	28.51	28.59
Zimbabwe	1979	2010	31	29.03	28.95	28.90	27.90	27.88	27.88

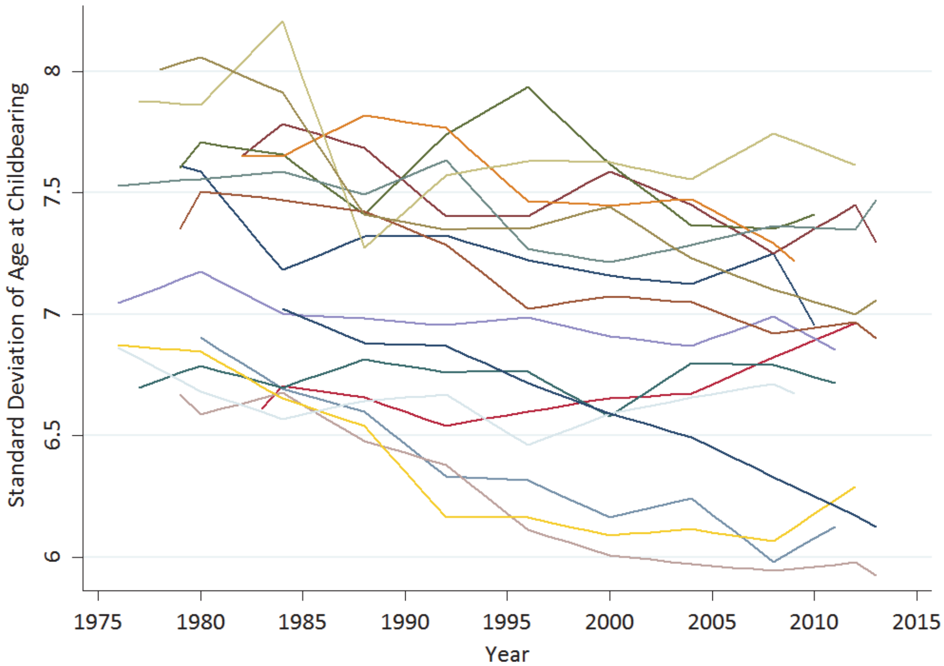
Table 3.6. Changes in the smoothed values of the mean age at childbearing in the 16 countries

Country	First year	Last year	Interval	Change 12 annual	Change 23 annual	Change 34 annual	Change 14	Change 14 annual
Bangladesh	1984	2013	29	−0.1692	−0.0589	−0.0654	−2.4547	−0.0846
Colombia	1976	2009	33	−0.0781	−0.0724	−0.0019	−1.8335	−0.0556
Dominican Republic	1976	2012	36	−0.1433	−0.0872	0.0728	−2.0050	−0.0557
Egypt	1979	2013	34	0.0153	−0.0251	−0.0092	−0.2024	−0.0060
Ghana	1978	2013	35	−0.0602	0.0367	−0.0232	−0.6565	−0.0188
Indonesia	1977	2011	34	−0.0165	0.0138	0.0180	0.1204	0.0035
Jordan	1980	2011	31	0.0354	−0.0318	0.0172	0.2251	0.0073
Kenya	1979	2013	34	−0.0158	−0.0510	−0.0274	−1.0412	−0.0306
Mali	1977	2012	35	−0.0644	0.0071	0.0133	−0.6065	−0.0173
Peru	1976	2011	35	−0.0309	−0.0723	0.0189	−0.9483	−0.0271
Philippines	1983	2012	29	−0.0137	−0.0337	0.0117	−0.2927	−0.0101
Senegal	1976	2013	37	0.0527	−0.0369	0.0571	1.1116	0.0300
Tanzania	1982	2009	27	0.0186	−0.0857	0.0189	−0.5377	−0.0199
Uganda	1979	2010	31	0.0146	0.0090	0.0021	0.2714	0.0088
Zambia	1982	2013	31	−0.0563	−0.0221	−0.0043	−0.7284	−0.0235
Zimbabwe	1979	2010	31	−0.0116	−0.0999	−0.0014	−1.1410	−0.0368

Note: “Change 14” is the change from the first smoothed value to the last smoothed value. “Change 14 annual” is “Change 14” divided by the number of years in the full interval, which ranges between 27 and 37 years. “Change 12 annual” is the annualized change from the first smoothed value to 1990; “Change 23 annual” is the annualized change from 1990 to 2000; “Change 34 annual” is the annualized change from 2000 to the last smoothed value.

Standard deviation of the age at childbearing

Figure 3.20. Trajectory of the standard deviation of the age at childbearing for all 16 countries, using pooled data from 98 DHS surveys for the 10 calendar years before each survey.



The trajectories of the standard deviation of the age at childbearing, shown in Figure 3.20 and listed in Tables 3.7 and 3.8, are discussed together. The scale of Figure 3.20 is compressed because the variation in the standard deviation is relatively narrow. It is almost never outside a range of six to eight years.

The distribution of age at childbearing (not shown, but summarized with the mean and standard deviation) is well-known to be asymmetric, with more births in, say the 10 years before the mean age than in the 10 years after the mean age. Nevertheless, as with a normal distribution, nearly all births will be in the range from the mean age minus two standard deviations to the mean plus two standard deviations, and the full range in age at childbearing, with few exceptions, is 35 years.

In the initial year, the standard deviation is almost always in a range from 6.5 years to 8.0 years. In the final year, it is almost always in a range from 6.0 years to 7.5. Four countries had the most concentrated values, around 6.0, in the final year: Egypt (5.93), Bangladesh (6.12), Jordan (6.13), and the Dominican Republic (6.29). These countries were also among the ones with the lowest initial values of the standard deviation.

The standard deviation tends to decline as the TFR declines; the two are positively and significantly correlated. When the standard deviation in the initial year is regressed on the TFR in that year, the regression coefficient is 0.27. In the final year, it is almost unchanged at 0.29. Thus, if one country has a TFR that is 1.74 less than another country, its standard deviation will tend to be half a year less than the other country, but the relationship between the TFR and the standard deviation is not as strong as the relationship between the TFR and the mean of the age at childbearing.

Table 3.7. Smoothed values of the standard deviation of the age at childbearing in the 16 countries. Includes smoothed values for the first year and last year, 1990, and 2010. If the first year was before 1980, smoothed values for 1980 are also included. If the last year was after 2010, smoothed values for 2010 are also included.

Country	First year	Last year	Interval	SD of age in first year	1980	1990	2000	2010	SD of age in last year
Bangladesh	1984	2013	29	7.02		6.88	6.59	6.25	6.12
Colombia	1976	2009	33	6.86	6.68	6.66	6.59		6.68
Dominican Republic	1976	2012	36	6.87	6.85	6.35	6.09	6.18	6.29
Egypt	1979	2013	34	6.67	6.59	6.43	6.01	5.96	5.93
Ghana	1978	2013	35	8.01	8.06	7.38	7.44	7.05	7.06
Indonesia	1977	2011	34	6.70	6.79	6.79	6.58	6.74	6.72
Jordan	1980	2011	31	6.90	6.90	6.47	6.16	6.08	6.13
Kenya	1979	2013	34	7.35	7.51	7.36	7.07	6.94	6.90
Mali	1977	2012	35	7.88	7.86	7.42	7.63	7.68	7.62
Peru	1976	2011	35	7.04	7.18	6.97	6.91	6.90	6.86
Philippines	1983	2012	29	6.61		6.60	6.65	6.89	6.96
Senegal	1976	2013	37	7.53	7.56	7.56	7.21	7.36	7.47
Tanzania	1982	2009	27	7.65		7.79	7.45		7.22
Uganda	1979	2010	31	7.60	7.71	7.58	7.62	7.41	7.41
Zambia	1982	2013	31	7.65		7.54	7.59	7.35	7.30
Zimbabwe	1979	2010	31	7.61	7.59	7.32	7.16	6.96	6.96

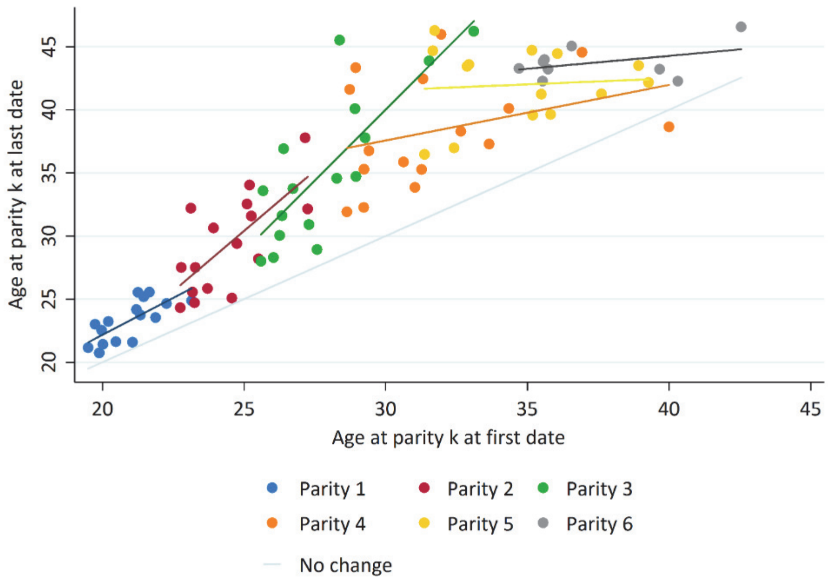
Table 3.8. Changes in the smoothed values of the standard deviation of the age at childbearing in the 16 countries

Country	First year	Last year	Interval	Change 12 annual	Change 23 annual	Change 34 annual	Change 14	Change 14 annual
Bangladesh	1984	2013	29	−0.0242	−0.0284	−0.0360	−0.8966	−0.0309
Colombia	1976	2009	33	−0.0147	−0.0066	0.0094	−0.1872	−0.0057
Dominican Republic	1976	2012	36	−0.0373	−0.0261	0.0166	−0.5857	−0.0163
Egypt	1979	2013	34	−0.0218	−0.0420	−0.0065	−0.7438	−0.0219
Ghana	1978	2013	35	−0.0523	0.0064	−0.0296	−0.9479	−0.0271
Indonesia	1977	2011	34	0.0068	−0.0209	0.0126	0.0187	0.0006
Jordan	1980	2011	31	−0.0437	−0.0303	−0.0035	−0.7786	−0.0251
Kenya	1979	2013	34	0.0003	−0.0281	−0.0132	−0.4507	−0.0133
Mali	1977	2012	35	−0.0350	0.0203	−0.0009	−0.2627	−0.0075
Peru	1976	2011	35	−0.0054	−0.0059	−0.0049	−0.1893	−0.0054
Philippines	1983	2012	29	−0.0019	0.0056	0.0258	0.3525	0.0122
Senegal	1976	2013	37	0.0026	−0.0349	0.0197	−0.0562	−0.0015
Tanzania	1982	2009	27	0.0174	−0.0345	−0.0256	−0.4358	−0.0161
Uganda	1979	2010	31	−0.0024	0.0041	−0.0208	−0.1935	−0.0062
Zambia	1982	2013	31	−0.0132	0.0044	−0.0225	−0.3528	−0.0114
Zimbabwe	1979	2010	31	−0.0264	−0.0163	−0.0203	−0.6564	−0.0212

Note: “Change 14” is the change from the first smoothed value to the last smoothed value. “Change 14 annual” is “Change 14” divided by the number of years in the full interval, which ranges between 27 and 37 years. “Change 12 annual” is the annualized change from the first smoothed value to 1990; “Change 23 annual” is the annualized change from 1990 to 2000; “Change 34 annual” is the annualized change from 2000 to the last smoothed value.

Age at reaching successive parities

Figure 3.21. Scatterplot of mean age of women when achieving specified parities, at the date of the first estimate, about 1980, and the date of the last estimate, about 2010. Each parity is indicated with a different color. Line segments show the trend in age for each parity. The estimates use the first and the most recent DHS surveys for each of the 16 countries.



The pattern of change in the ages at reaching successive parities is summarized in Figure 3.21, a scatterplot with a dot for each parity in each country that is observed at both the initial and final years. The dot color indicates the parity. The vertical axis gives the age at reaching the parity in the initial year, and the horizontal axis gives the corresponding age in the final year. The 45-degree line indicates no change between the initial and final years. With only one exception, the age at reaching a specific parity is higher in the final year than in the initial year, a shift that corresponds with delays in childbearing.

A straight line for each parity, with the same color as the dots for that parity, describes the results of a regression of the age in the final year on the age in the initial year. If the line is approximately parallel to the line of no change, then then the tendency is toward a fixed delay that is approximately the same for all initial ages at that parity. This pattern particularly characterizes parity 1. That is, all countries had a net delay in the age at the first birth, and the amount of the delay was about the same for all countries, regardless of what was the initial age at first birth.

Moving to parity 2, and then to parity 3, the regression lines become steeper, a pattern that suggests progressively greater delays or postponements in countries that had a higher initial age. For parity 3, the line is particularly steep. That is, the postponement of the third birth, in the final year, compared with the first year, was especially strong if the third birth was already relatively late in the initial year. For parities 4 and 5, the regression lines are *less* steep than the line of no change. That is, although these births strongly tend to occur later in the final year than in the first year, the postponement tends to be less for countries in which that birth was relatively late in the initial year. The combined effect is greater compression of the age distribution of childbearing, a pattern that is consistent with a reduction in the standard deviation.

A final caveat for the interpretation of these fertility trajectories is a reminder that the data have been structured by age and calendar year. An alternative approach would construct birth cohorts, and then express the rates as a function of age and cohort, or even as a function of age, period, and cohort together, as was done by Pullum in an analysis of long-term changes in U.S. fertility (Pullum 1980). In that analysis, age and period were found with a statistical model to be the primary determinants of the rates, and birth cohort added little. It is possible that in some countries in this analysis, cohort would be relatively more important, perhaps because successive cohorts may be sharply differentiated by their completed years of schooling, typically an important determinant of fertility.

Cohort identification was not included here because even with about 30 years of data we do not encompass the full span of childbearing—35 years, and the modelling required would have greatly expanded the scope of this report. Recently, Li and Tsui (2016) proposed an innovative approach to describing cohorts with a long series of DHS surveys from the same country. A future analysis may be able to re-analyze the data in this report with a cohort perspective. Certainly, actual family formation proceeds during the lifetime of individual women, moving from one parity to the next as they get older, and the period approach is artificially removed from that process.

Part 1 of this report describes the fertility trajectories of 16 countries from about 1980 to about 2010, using a minimum of five DHS surveys for each country. In general, the most important proximate determinant behind changes in fertility is known to be contraceptive use (Garenne 2014; Cleland et al. 2016). The second most important proximate determinant is generally changes in marital status, which is indicated in most countries by postponement of the first birth. Part 2 of the report uses a reduced set of four countries—Ghana, Indonesia, Kenya, and Senegal—to describe the use of modern contraception and how it is related to a standard set of covariates in those four countries.

Part 2: Contraceptive Trajectories

Part 1 of this report describes the fertility trajectories of 16 countries from about 1980 to about 2010, using a minimum of five DHS surveys for each country. Part 2 of the report uses a reduced set of four countries—Ghana, Indonesia, Kenya, and Senegal—to describe the use of modern contraception and how it is related to a standard set of covariates. The selected countries have at least six DHS surveys that span more than 20 years. The interest is partly in trends in modern contraceptive use and primarily in whether the use of contraceptives is becoming more equitable across subgroups over time. This analysis includes six background variables to examine these trends: parity, education, work status, ideal number of children, place of residence, and region. The results show whether the subgroups identified by these variables are becoming more similar in their contraceptive use. The analysis was performed by fitting logit models to allow the odds ratio to vary with time, where time is the date of the survey. The results are shown as odds ratio plots over time to clearly demonstrate their trends.

4. Data and Methods

4.1. DHS Data

Selection of the countries for the analysis was determined primarily by having completed at least six DHS surveys in the time interval from the 1980s to the 2010s. Ten countries met this criterion, and four were selected for this in-depth analysis: Ghana, Indonesia, Kenya, and Senegal (see Table 4.1). The three African countries selected are also USAID family-planning priority countries.[15]

The data collection for Indonesia, up to the survey in 1997, included East Timor. A few years later, East Timor gained independence, and it was no longer included in the Indonesia DHS; therefore, observations from interviews conducted in East Timor were dropped from the survey data for 1987–1997. Table 4.1 shows that of the four countries selected for the in-depth analysis, Indonesia has by far the largest sample sizes. Senegal and Indonesia completed seven DHS surveys; Ghana and Kenya completed six DHS surveys.

Table 4.1. The survey year and number of women age 15-49 in each survey (N) for Ghana, Indonesia, Kenya, and Senegal

	year (N)	year (N)	year (N)	year (N)	year (N)	year (N)	year (N)	Total N
Ghana	1988 (4488)	1993–94 (4562)	1998–99 (4843)	2003 (5691)	2008 (4916)	2014 (9396)		**33896**
Indonesia*	1987 (9451)	1991 (22813)	1994 (28044)	1997 (28690)	2002–03 (29483)	2007 (32895)	2012 (45607)	**196983**
Kenya	1988–89 (7150)	1993 (7540)	1998 (7881)	2003 (8195)	2008–09 (8444)	2014 (31079)		**70289**
Senegal	1986 (4415)	1992–1993 (6310)	1997 (8593)	2005 (14602)	2010–11 (15688)	2012–13 (8636)	2014 (8488)	**66732**

Note: * East Timor was removed from the Indonesia data of the earlier surveys.

4.2. Measures

The outcome of interest is the use of modern contraception by women age 15-49 who are currently in a union. This is a binary variable categorized as non-users and users of a traditional contraceptive method versus users of a modern method such as pills, IUD, injections, implants, diaphragm, female and male condoms, female and male sterilizations, foam or jelly, and the lactational amenorrhea method (LAM).

The analysis included six independent variables: parity (0 or 1, 2, 3, 4 or more), education (none, primary, secondary or more), work status (currently working, not working), ideal number of children (0-2, 3 or 4, 5 or 6, 7 or more), place of residence (urban, rural), and region. The earlier surveys in Indonesia had no question on work status and, therefore, this variable was removed from the analysis of Indonesia. Both women's age and parity are relevant to contraceptive use, but they are highly correlated, and it would be redundant to include both of them. Parity was chosen over age because it is more directly related to fertility preferences.

Variations across regions within a country are important, but of course the regions are defined differently in every country. The four countries covered by this in-depth analysis have the following regions:

> **Ghana,** five main regions: (1) Greater Accra, (2) West and Central, (3) East and Volta, (4) Brong-Ahafo and Ashanti, and (5) North, including Upper West and Upper East

[15] https://www.usaid.gov/what-we-do/global-health/family-planning/countries

Senegal, four main regions: (1) West, (2) Central, (3) South, and (4) Northeast

Kenya, categorized four main regions: (1) Nairobi and Central, (2) Coast and East and Northeast, (3) West and Nyanza, and (4) Rift Valley

Indonesia, several regions and provinces, with some changes over time, but grouped by provinces into two major regions: (1) Java Bali and (2) Outer Java Bali

There is great interest in variation by the wealth index, but the wealth index was not included as a covariate because it is a relative measure that is specific to the country and time of the survey. It is, therefore, difficult to interpret differences between countries or changes over time. Moreover, the earliest surveys for each country preceded the development of the wealth index, and it is not included in the full series.

Time is obviously a central component of the analysis. It is measured with the mean century month code, or CMC, of the dates of the interviews in each survey. The CMC is the ordinal number of each month beginning with the start of the 20th century: January 1900 has CMC=1. If M is the ordinal number of the months within a year (1 through 12) and Y is year, with four digits, then CMC=M+12*(Y−1900). The following formulae can be used to convert a CMC to year and month, where the function "int" gives the integer part of a number:

$$Y = 1900 + \text{int}\,(CMC/12)$$
$$M = CMC - 12*(Y-1900)$$

For example, CMC=1350 is June 2012 and CMC=1375 is July 2014. If a continuous version of year is desired, the formula is y = 1900 + (CMC/12) − (1/24). Thus CMC=1375, or July 2014, on a continuous scale would be converted to 2014.542, which is the middle of July. Unless the correction of −1/24 is made, on a continuous scale y would be half a month too far into the calendar year.

4.3. Methods

Logit regressions and varying coefficient models (VCM) are applied to the combined data described earlier to model trends in the mCPR. Varying coefficient models are essentially models that allow the regression coefficients themselves to vary as flexible functions of other variables (Hastie and Tibshirani 1993). In this analysis, the coefficients are allowed to vary with time though flexible spline functions. Therefore, instead of the usual logit regression model,

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \sum_{i=1}^{n} \beta_i X_i,$$

where p is the fitted probability of modern contraceptive use, β_0 is the intercept, β_i represents the usual fixed coefficients, and X_i represents the independent variables, we have the varying coefficient model:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \alpha_0(t) + \sum_{j=1}^{m} \alpha_j(t) X_j.$$

This equation includes the fixed coefficients β that are in the usual logit regression model, but it also includes $\alpha_0(t)$, a time-varying intercept, and time-varying coefficients $\alpha(t)$ for the X_j variables, where t represents time. A VCM variable, therefore, such as education, may have both a fixed coefficient β and a time-varying coefficient $\alpha(t)$. A null hypothesis to be tested is whether the time-varying coefficient is equal to zero. If that hypothesis is retained, then the time-varying coefficient can be removed from the model. The VCM can be fitted with spline functions having a specified number of knots (Eilers and Marx 2002; Hastie and Tibshirani 1993; Marx 2010).

VCM are discussed extensively in the statistics literature (Cai, Fan, and Li 1999, 2000; Chiang, Rice, and Wu 2001; Fan and Zhang 2008; Hastie and Tibshirani 1993; Hoover et al. 1998; Huang, Wu, and Zhou 2002, 2004; Marx 2010). These models have been applied to the study of trends in health-related outcomes using longitudinal data (Cai, Fan, and Li 1999; Chiang, Rice, and Wu 2001; Hoover et al. 1998; Huang, Wu, and Zhou 2002; Lynch et al. 2011), as well as using cross-sectional health surveillance data (Assaf and Campostrini 2015; Assaf et al. 2016; Young et al. 2008).

Part 2 of this report uses models fitted with R software, using the *mgcv* and *survey* packages (Lumley 2014; Wood 2012), with additional detail in Appendix 1. Other analyses were performed with Stata version 14.

Beginning with a model that included time-varying coefficients for all the independent variables, a backward model selection compared the values of the Akaike Information Criterion (AIC). A comparison between two models led to the selection of the more complex model with more time-varying coefficients only if it produced a large drop in the AIC (a cutoff of more than 20 was chosen). No correction for the sample size was needed because the datasets for all the countries in the analysis are large (Anderson 2002).

In addition to fitting the VCM, logit regressions of the first and most recent survey for each country were also fitted for comparison. The analysis accounts for sample weights and the survey stratification.

The results are shown as plots of coefficients compared to time for all time-varying coefficients in the final model for each country. For easier interpretability, the coefficient plots are transformed to odds ratio plots for each category other than the reference category. These odds ratios are produced by adding the constant coefficient β for the category and exponentiating. The plots include 95% confidence bands produced by the *mgcv* R package (Marra and Wood 2012; Wood 2012, 2006). The constant odds ratios for each category, produced with standard logit regressions, are superimposed on the VCM odds ratio plots to show how the VCM captures the odds ratio trend for the period of observation. The odds ratio plots are produced on different scales, across countries and covariates. It would have been difficult to find a common odds ratio scale for the different models.

The next chapter lists the results of our analyses for the four countries covered in Part 2 of this report, organized alphabetically. The figures show the current modern contraceptive use for women age 15-49 and in a union. The tables show logit regressions for the first and last surveys, as well as the varying coefficient model for the surveys combined.

5. Results

5.1. Ghana

Figure 5.1 shows that current modern contraceptive use for women age 15-49 and in a union in Ghana increased from 5% in 1988 to 22% in 2014 (also see Appendix 2). Although the increase was fairly steady, the average annual increase was only about two-thirds of one percentage point. The TFR in 2013 was estimated in Part 1 to be 4.0. The goal of the analysis is to show the changing relationship of contraceptive prevalence to the covariates, including the use of the VCM approach to show trajectories of these relationships across the full time interval.

Table 5.1 summarizes the results of the logit regressions for the first and last surveys, as well as the VCM for all six Ghana surveys combined. In the logit regressions, and for both the first and last survey, the odds ratios are significant for women at parity 4 or more, for women with primary or secondary or higher levels of education, for working women, and for women who said their ideal number of children was seven or more. Between the first and last survey, these odds ratios all move toward a value of 1.

Urban and rural women are not significantly different in the first survey, but the difference becomes significant and reverses direction in the last survey; an odds ratio of 1.4 in the first survey changes to an odds ratio of 0.7 in the last survey. Without observing the odds ratio plots produced from the VCM, it would be difficult to understand how this change occurred or whether it was significant.

Figure 5.1. Modern contraceptive use by women 15-49 in a union in Ghana from 1988 to 2014.

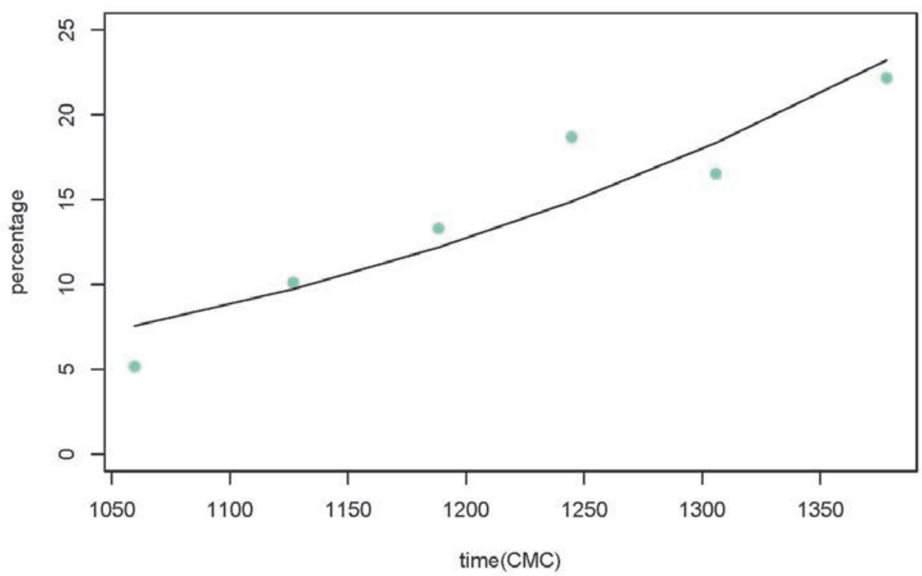


Table 5.1. Odds ratios for the Ghana logit regressions of modern contraceptive use for first and last survey and the varying coefficient model for the combined surveys

	1st survey	last survey	VCM
Parity (ref.= 0 or 1)			
2	0.95	1.42	1.34**
3	1.52	1.67**	1.66***
4+	3.17***	1.77**	2.18***
Education (ref.=none)			
primary	1.73**	1.58***	1.79***
secondary+	2.45*	1.44***	2.2***
s(time):edu none			.
s(time):edu primary			.
s(time):edu secondary+			**
Work status (ref.=not working)			
working	1.78**	1.36*	1.41***
Ideal number of children (ref.=0-2)			
3 or 4	0.35**	0.83	0.92
5 or 6	0.26**	0.70	0.77**
7+	0.30**	0.58**	0.53***
Place of residence (ref.=rural)			
urban	1.41	0.72**	1.2**
s(time):rural			**
s(time):urban			***
Ghana regions (ref.=Accra)			
West/Central	0.55	1.23	0.85
East/Volta	0.68	1.32	1.01
Brong-Ahafo/Ashanti	0.84	1.09	0.97
North/Upper West/Upper East	0.13**	0.87	0.76*
Observations	3,154	5,452	21651

s(time): coefficient spline function of time; ref.: reference category

. not significant, * p<0.05, ** p<0.001, *** p<0.001

The VCM selected for Ghana, using backward selection based on AIC values, contains time-varying coefficients for the categories of education and place of residence, shown in the following model:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 parity + \beta_2 edu + \beta_3 work + \beta_4 ideal + \beta_5 residence + \beta_6 region + \alpha_0(t) + \alpha_1(t) edu + \alpha_2(t) residence,$$

where p is the fitted probability of modern contraceptive use, the β*s* are the constant or fixed coefficients, and $\alpha_1(t)$ and $\alpha_2(t)$ are time-varying coefficients for education and place of residence, respectively.

As shown in Table 5.1, the spline functions used to model the time-varying coefficients of these categories are significant for the secondary or more education category and for the rural and urban residence category. The lack of significance for the primary education category is also apparent in the odds ratio plot (see Figure 5.2a). Despite a relatively higher odds ratio in the second survey, compared to the remaining surveys, as shown by the second odds ratio point, the plot shows a relatively steady trend over time in the odds of modern contraceptive use for women with primary education, compared to women with no education. The odds ratio plot for women with secondary or more education shows an initial increase in the odds ratio, after the first survey, before decreasing again toward an odds ratio of 1 (see Figure 5.2a). As stated in the methods, the odds ratio scales in the plots for the two education categories are different. The trend for the urban category in Figure 5.2b shows a clearly decreasing linear odds ratio trend. The trends for the secondary or more education category and the urban category also indicate a closing of the gap between these categories and their reference categories in women’s modern contraceptive use; in both odds ratio plots, the trend is toward an odds ratio of 1.

Figure 5.2a. Odds ratio plots for Ghana comparing primary education and secondary or higher, with no education. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).

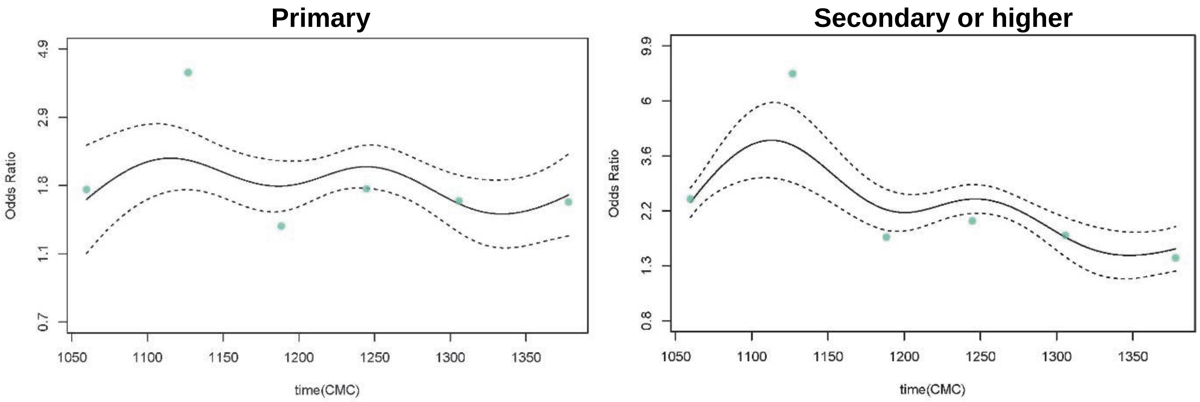
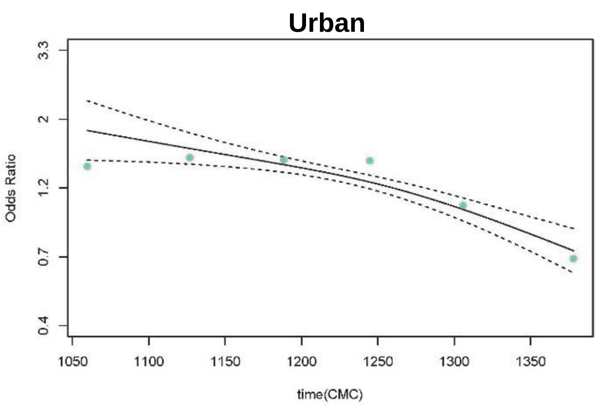


Figure 5.2b. Odds ratio plot for Ghana comparing urban areas with rural. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).



5.2. Indonesia

Modern contraceptive use in Indonesia was already relatively high at the time of the first survey, with 43% of women age 15-49 in a union currently using a modern contraceptive method in 1987. This increased to 58% in 2012, as shown in Figure 5.3 (see also Appendix 3). The average net increase in contraceptive use over the 25-year span is about three-fifths of one percentage point. This is a small annual increase, but because of the high initial value, the final value is consistent with the low estimated TFR of 2.7 in 2011 seen in Part 1.

Table 5.2 summarizes the regressions, which show changes between the first and last survey. Almost all of the variables are significant and follow the expected relationship with modern contraceptive use. In the first survey, however, the women with urban and rural residence were not significantly different, and in the last survey urban women had significantly lower odds of using modern contraception than rural women.

Figure 5.3. Modern contraceptive use for women 15-49 in a union in Indonesia from 1987 to 2012.

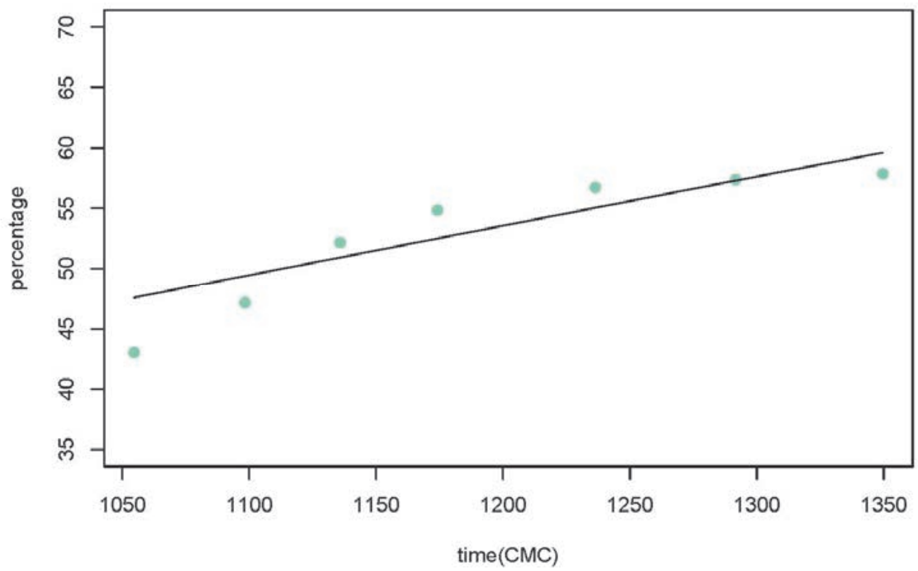


Table 5.2. Odds ratios for the Indonesia logit regressions of modern contraceptive use for first and last survey and the varying coefficient model for the combined surveys

	1st survey	last survey	VCM
Parity (ref.= 0 or 1)			
2	3.20***	2.81***	2.74***
3	4.07***	2.96***	3.03***
4+	3.57***	2.33***	2.36***
s(time):parity 0 or 1			*
s(time):parity 2			.
s(time):parity 3			***
s(time):parity 4 or more			***
Education (ref.=none)			
primary	1.75***	2.04***	1.84***
secondary+	2.82***	2.21***	2.2***
s(time):edu none			.
s(time):edu primary			.
s(time):edu secondary+			*
Ideal number of children (ref.=0-2)			
3 or 4	0.73***	0.61***	0.68***
5 or 6	0.46***	0.46***	0.44***
7+	0.35***	0.51***	0.43***
s(time):ideal 0-2			.
s(time):ideal 3 or 4			**
s(time):ideal 5 or 6			.
s(time):ideal7 or more			*
Place of residence (ref.=rural)			
urban	0.98	0.79***	0.87***
s(time):rural			***
s(time):urban			**
Region (ref.= Outer Java Bali)			
Java Bali	1.58***	1.37***	1.44***
s(time):Outer Java Bali			.
s(time):Java Bali			*
Observations	9,495	32,689	172805

s(time): coefficient spline function of time; ref.: reference category

. not significant, * p<0.05, ** p<0.001, *** p<0.001

The following VCM for modern contraceptive use selected for Indonesia includes time-varying coefficients for all the independent variables:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 parity + \beta_2 edu + \beta_3 ideal + \beta_4 residence + \beta_5 region + \alpha_0(t) + \alpha_1(t) parity + \alpha_2(t) edu + \alpha_3(t) ideal + \alpha_4(t) residence + \alpha_5(t) region\,.$$

Work status was not available in the earlier Indonesian surveys and, therefore, it is omitted from the model. The results of the VCM shown in Table 5.2 indicate that many of the coefficients changed significantly over time. Parities 3 and 4 or more show a significant and decreasing trend toward an odds ratio of 1. As Figure 5.4a shows, these categories are becoming more similar to the reference category of one child or none, in terms of modern contraceptive use. Parity 2 does not show a significant change, which is also apparent in the odds ratio plot in Figure 5.4a.[16]

[16] This plot also shows a confidence interval with a width that reaches zero at one point. When the trend is estimated with a straight line, Bayesian confidence intervals can reach a width of zero (Marra and Wood 2012; Wood 2006).

No significant trend is apparent for the primary education category, as indicated in Table 5.2 and Figure 5.4b. The odds ratio for the secondary or higher education category decreases initially toward 1, but then appears to plateau in the recent surveys (see Figure 5.4b).

As shown in Figure 5.4c, women reporting three or four as the ideal number of children slightly decreases their odds of contraceptive use, compared to women reporting zero to two children as the ideal number. Table 5.2 indicates that this trend is significant. The decrease, however, moves away from an odds ratio of 1 and, therefore, increases the gap between the two groups. On the other hand, the odds for women reporting seven or more children as the ideal number increases toward an odds ratio of 1 and, therefore, the gap between these women and those who reported zero to two as the ideal number of children declines.

Although Table 5.2 indicates that the time-varying coefficient for the urban category is significant, the odds ratio trend in Figure 5.4d appears to be more or less constant after the first two surveys. The Java Bali odds ratio plot in Figure 5.4e indicates a slightly decreasing but significant trend toward an odds ratio of 1.

Figure 5.4a. Odds ratio plots for Indonesia comparing parities 2, 3, and 4 or more with parities 0 and 1. The plots extend from June 1987 (CMC 1050) to June 2012 (CMC 1350).

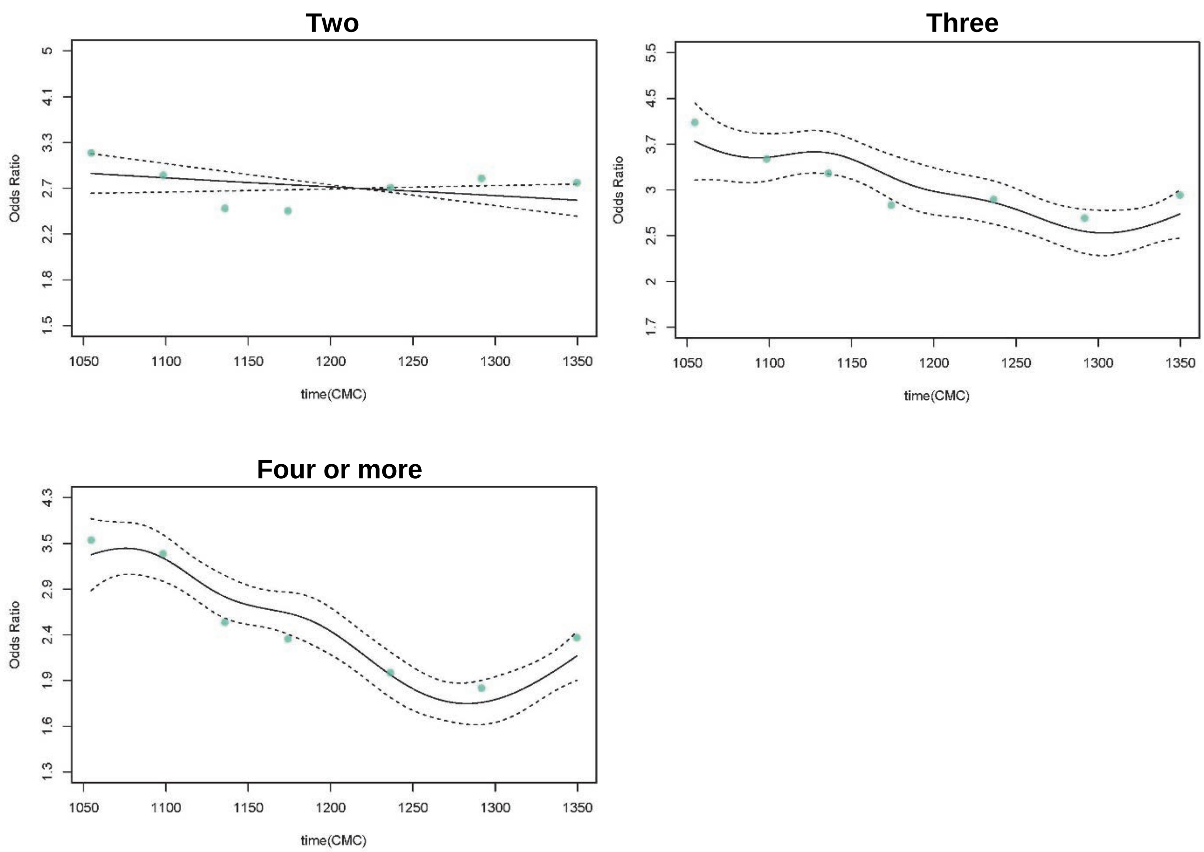


Figure 5.4b. Odds ratio plots for Indonesia comparing primary education and secondary or higher, with no education. The plots extend from June 1987 (CMC 1050) to June 2012 (CMC 1350).

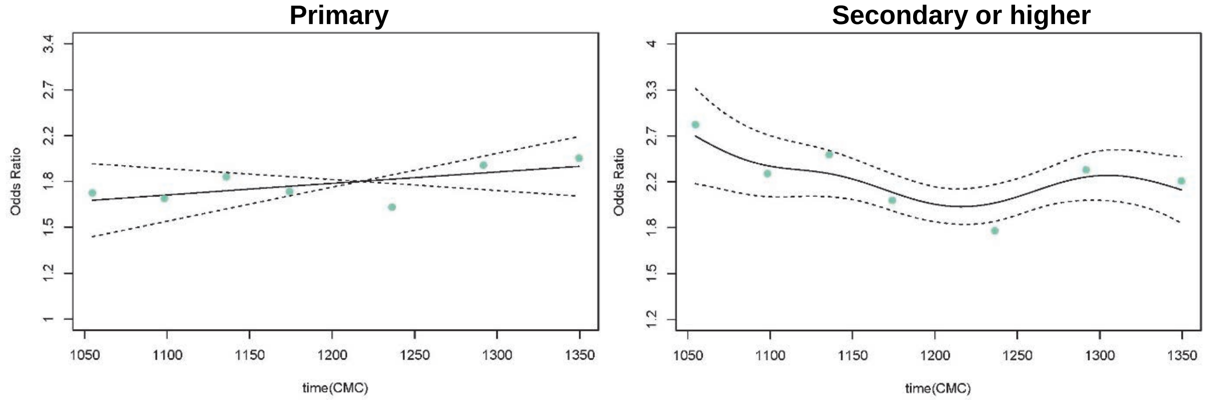


Figure 5.4c. Odds ratio plots for Indonesia comparing the ideal number of children categories of three and above with ideal number of children of zero to two. The plots extend from June 1987 (CMC 1050) to June 2012 (CMC 1350).

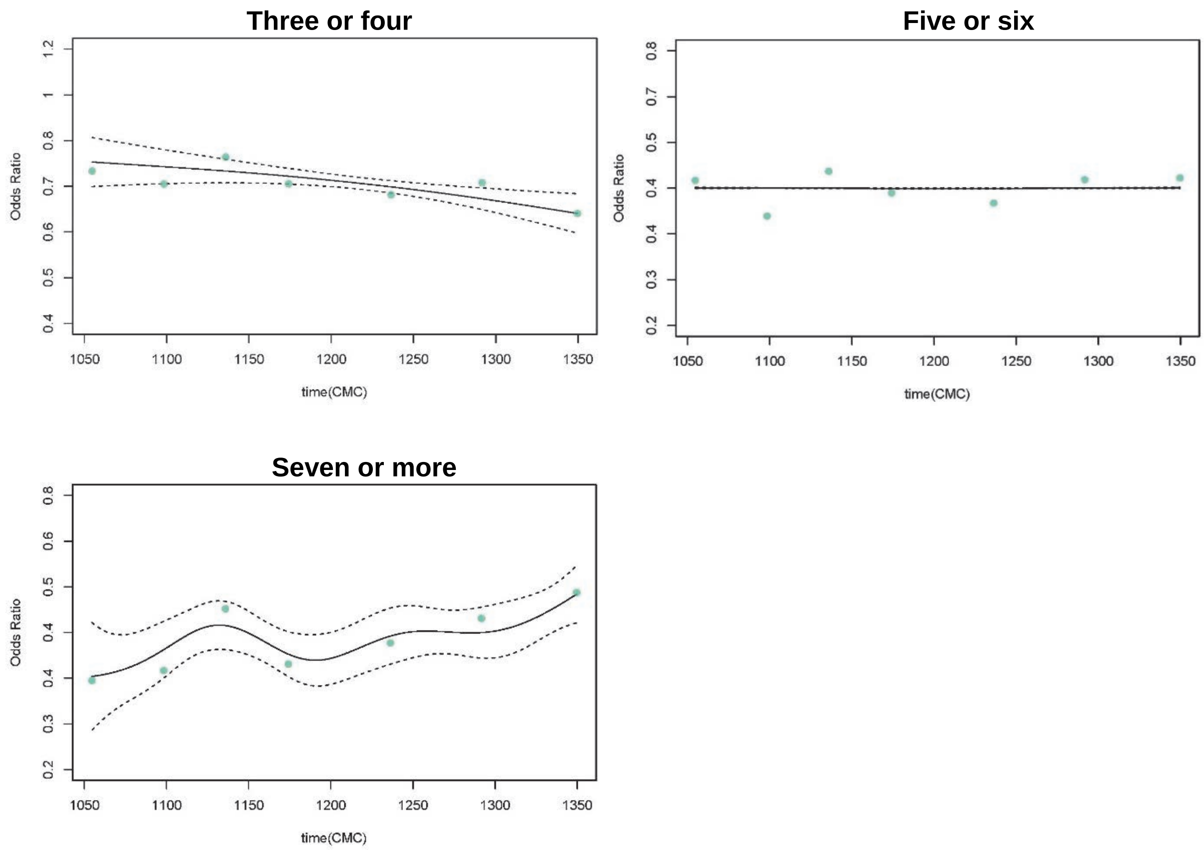


Figure 5.4d. Odds ratio plot for Indonesia comparing urban areas with rural. The plots extend from June 1987 (CMC 1050) to June 2012 (CMC 1350).

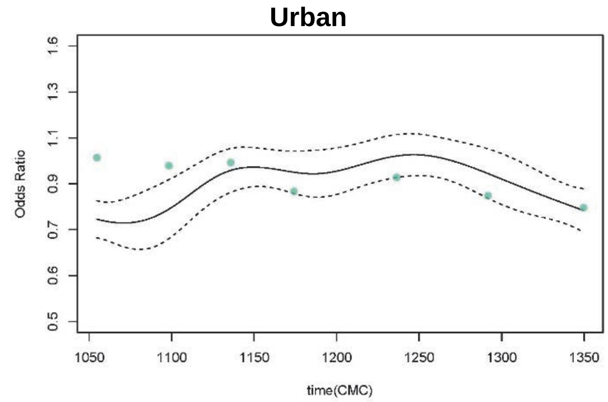
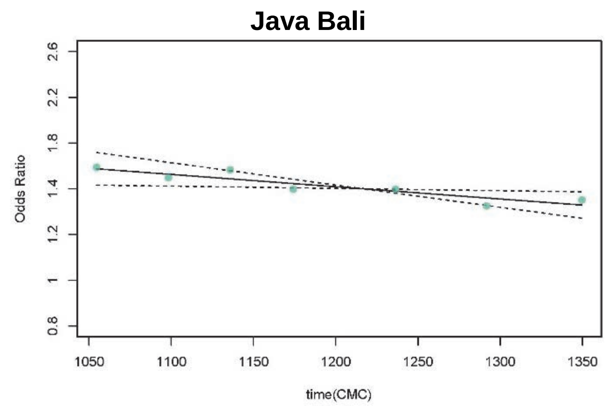


Figure 5.4e. Odds ratio plot for Java Bali region category, compared to the outer Java Bali reference category. The plots extend from June 1987 (CMC 1050) to June 2012 (CMC 1350).



5.3. Kenya

As shown in Figure 4.4, modern contraceptive use for Kenyan women age 15-49 in a union increased steadily from 18% in 1988–89 to 53% in 2014 (see also Appendix 4). This is the largest increase of all four countries in Part 2, and the final value is the highest of the three SSA countries in Part 2. The net annual increase is one and one-third of a percentage point. In Part 1, the TFR in 2013 is estimated to be 4.0.

Table 5.3 indicates that almost all the variables are significantly related to modern contraceptive use in both the first and last surveys. There were some changes in the odds ratios between the two surveys, including a large drop in the odds ratio for parity 4 or more, from 7.8 in the first survey to 2.7 in the last survey, compared to the reference parity of 0 or 1.

Figure 5.5. Modern contraceptive use for women 15-49 in a union in Kenya from 1988 to 2014

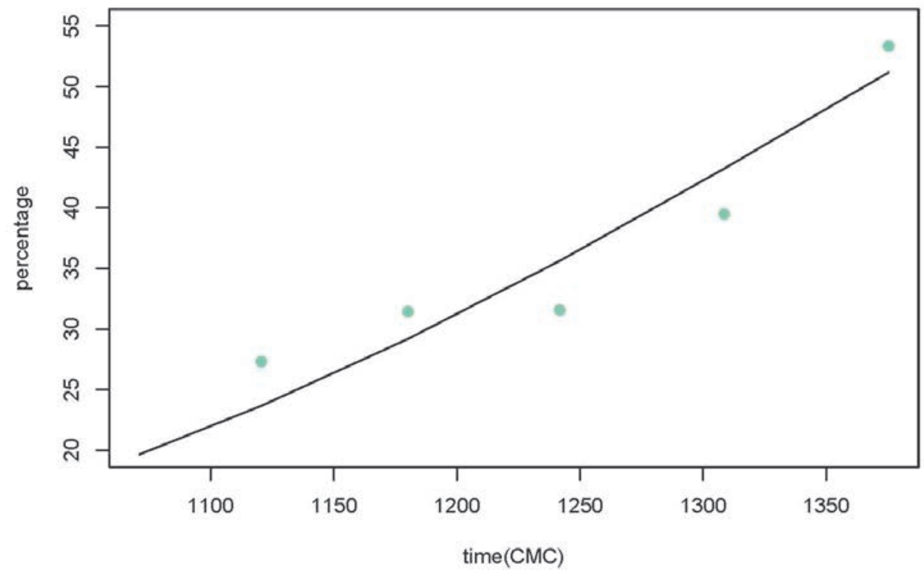


Table 5.3. Odds ratios for the Kenya logit regressions of modern contraceptive use for first and last survey and the varying coefficient model for the combined surveys

	1st survey	last survey	VCM
Parity (ref.= 0 or 1)			
2	2.94***	2.48***	2.53***
3	4.67***	2.69***	3.07***
4+	7.80***	2.65***	3.9***
s(time):parity 0 or 1			.
s(time):parity 2			.
s(time):parity 3			.
s(time):parity 4 or more			***
Education (ref.=none)			
primary	2.35***	3.25***	2.61***
secondary+	3.92***	3.80***	4.41***
s(time):edu none			.
s(time):edu primary			.
s(time):edu secondary+			**
Work status (ref.=not working)			
working	1.58***	1.24**	1.35***
Ideal number of children (ref.=0-2)			
3 or 4	0.68*	0.60***	0.62***
5 or 6	0.44***	0.40***	0.39***
7+	0.43**	0.20***	0.25***
Place of residence (ref.=rural)			
urban	1.38*	1.16*	1.14**
Region (ref.=Nairobi/Central)			
Coast/East/Northwest	0.74	0.77*	0.62***
West/Nyanza	0.36***	0.73**	0.43***
Rift Valley	0.79	0.58***	0.50***
s(time):Nairobi/Central			.
s(time):Coast/East/Northeast			**
s(time): West/Nyanza			***
s(time):Rift Valley			**
Observations	4,746	9,001	33049

s(time): coefficient spline function of time; ref.: reference category
. not significant, * p<0.05, ** p<0.001, *** p<0.001

The following VCM for modern contraceptive use selected for Kenya includes time-varying coefficients for parity, education, and region:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 parity + \beta_2 edu + \beta_3 work + \beta_4 ideal + \beta_5 residence + \beta_6 region + \alpha_0(t) + \alpha_1(t) parity + \alpha_2(t) edu + \alpha_3(t) region$$

As shown in Table 5.3, only one category of the parity and education variables has a significant time-varying coefficient. As Figure 5.6a shows, the odds ratio plots for parities 2 and 3 show a relatively constant trend, and women with parity 4 or more show a significantly reduced odds ratio of using modern contraceptive use, compared to women with parities 0 or 1. The trend for parity 4 or more also decreases toward an odds ratio of 1, a trend that indicates a closing of the gap between this category and the reference category.

This decreasing gap between categories is also found in the odds ratio plot of the secondary or higher education category, but only for the last three surveys (see Figure 5.6b). While the primary education category appears to have a slightly increasing odds ratio trend, this was not statistically significant, as indicated in Table 5.3.

All the coefficients for regions are significantly time-varying, relative to the reference region. As seen in Figure 5.6c, after the second survey all the odds ratio plots for region have a trend that is increasing and moving toward 1. The regions are becoming similar in their modern contraceptive use.

Figure 5.6a. Odds ratio plots for Kenya comparing parities 2, 3, and 4 or more with parities 0 and 1. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).

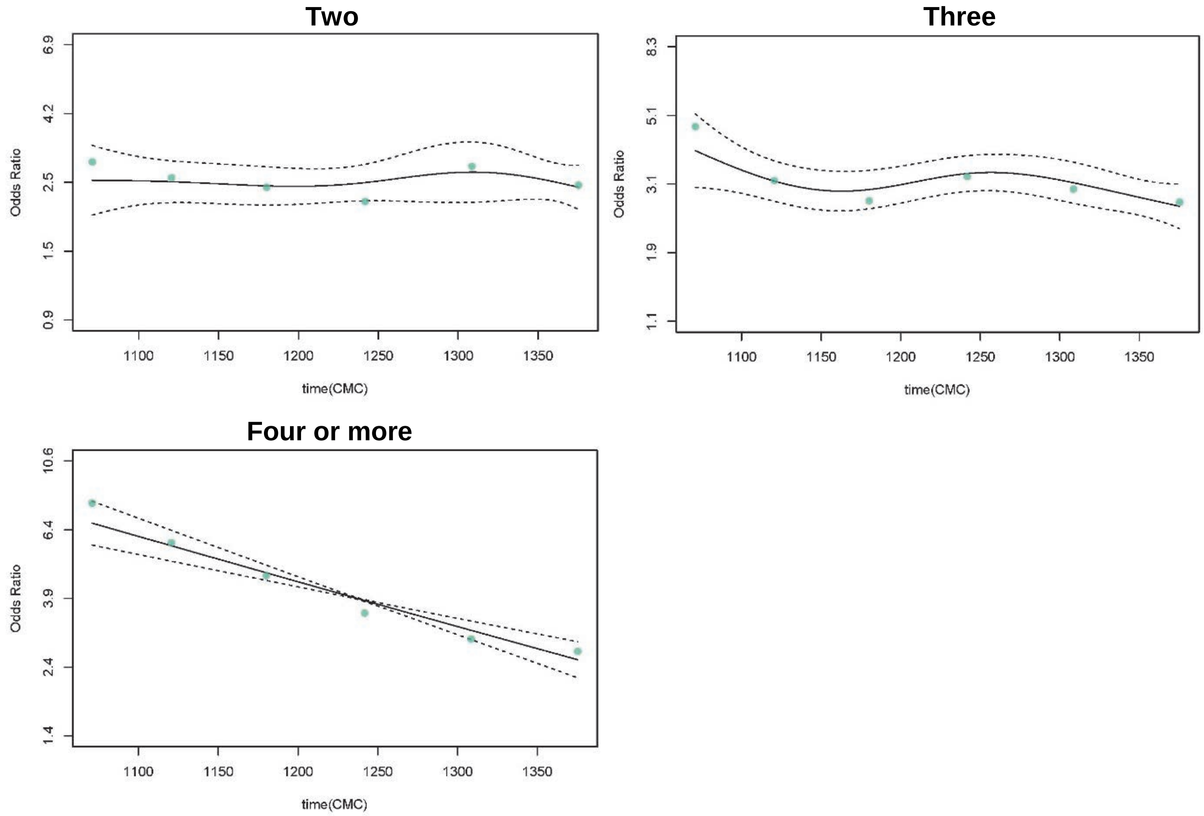


Figure 5.6b. Odds ratio plots for Kenya comparing primary education and secondary or higher, with no education. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).

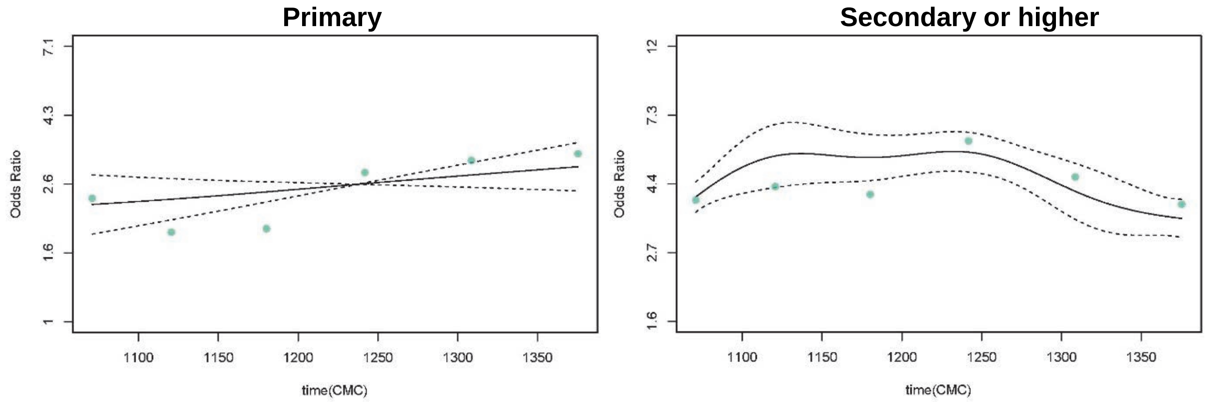
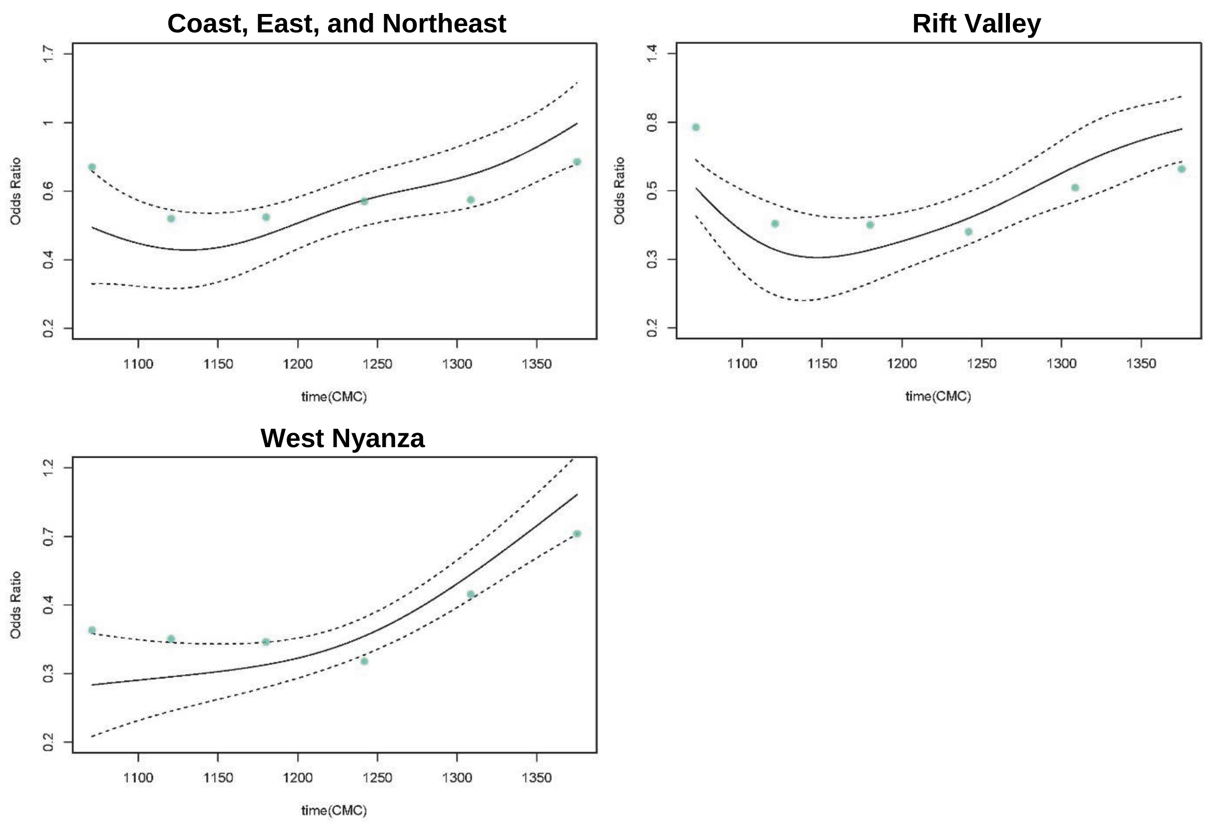


Figure 5.6c. Odds ratio plots for Kenya comparing regions of Kenya with Nairobi/Central. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).



5.4. Senegal

In Senegal, modern contraceptive use for women age 15-49 in a union increased from only 2% in 1986 to 20% in 2014 (see Figure 5.7 and Appendix 5). The net annual increase in prevalence was about two-thirds of one percentage point, close to the net annual increases in Ghana and Indonesia over approximately the same time interval. The final prevalence is close to the final prevalence in Ghana, 20%, but in Part 1, the TFR for Senegal in 2013 is estimated to be 4.9, almost a full child greater than the final TFR in Ghana, 4.0.

Table 5.4 shows that all the parity and education categories, except for parity 2 in the first survey, as well as the category for urban women, have significant odds ratios for modern contraceptive use, compared to their reference categories. Several regions and categories of the ideal number of children, however, have non-significant odds ratios. These odds ratios decrease between the first and last survey for the categories of secondary and more education, urban, and the northeast region.

Figure 5.7. Modern contraceptive use for women 15-49 in a union in Senegal from 1986 to 2014.

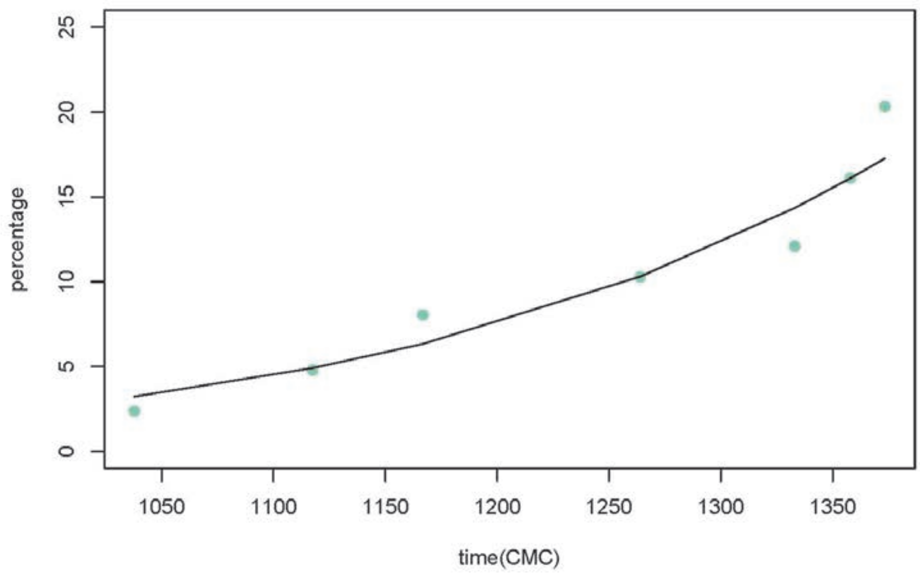


Table 5.4. Odds ratios for the Senegal logit regressions of modern contraceptive use for first and last survey and the varying coefficient model for the combined surveys

	1st survey	last survey	VCM
Parity (ref.= 0 or 1)			
2	2.75	3.38***	2.03***
3	3.83**	2.86***	2.91***
4+	3.55**	4.85***	3.75***
s(time):parity 0 or 1			.
s(time):parity 2			**
s(time):parity 3			.
s(time):parity 4 or more			.
Education (ref.=none)			
primary	2.61*	2.07***	2.5***
secondary+	7.27***	2.70***	3.98***
s(time):edu none			.
s(time):edu primary			*
s(time):edu secondary+			***
Work status (ref.=not working)			
working	1.84*	0.96	1.1
Ideal number of children (ref.=0-2)			
3 or 4	1.03	0.81	1.05
5 or 6	0.45	0.78	0.8
7+	0.31*	0.38*	0.5***
Place of residence (ref.=rural)			
urban	6.34**	1.48**	2.6***
s(time):rural			*
s(time):urban			**
Senegal regions (ref.=West)			
Central	2.57	1.51	0.62***
South	1.13	0.78	0.73***
Northeast	3.56*	1.00	0.77**
s(time):region west			*
s(time):region central			.
s(time):region south			***
s(time):region northeast			.
Observations	3,358	5,820	46383

s(time): coefficient spline function of time; ref.: reference category

. not significant, * p<0.05, ** p<0.001, *** p<0.001

The following Senegal VCM for modern contraceptive use includes time-varying coefficients for parity, education, place of residence and region:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 parity + \beta_2 edu + \beta_3 work + \beta_4 ideal + \beta_5 residence + \beta_6 region + \alpha_0(t) + \alpha_1(t) parity + \alpha_2(t) edu + \alpha_3(t) residence + \alpha_4(t) region$$

Table 5.4 shows that, of the parities, only parity 2 has significant time-varying coefficients. This pattern is also indicated in the odds ratio plots in Figure 5.8a. Parities 3 and 4 show a constant odds ratio trend over time, but the odds ratio for parity 2 appears to be increasing for the last three surveys, away from a value of 1.

As shown in Figure 5.8b, the odds ratios for the education categories, compared to the no education reference category, have been decreasing significantly. The trends imply that gaps between the education categories are decreasing, in terms of modern contraceptive use.

Figure 5.8c shows that urban women have a significantly decreasing odds ratio, compared to rural women, moving toward 1 since the third survey. Table 5.4 indicates that only the south region has significant time-varying coefficients, with an odds ratio trend that increases toward an odds ratio of 1, but then decreases again after the fourth survey (see Figure 5.8d).

Figure 5.8a. Odds ratio plots for Senegal comparing parities 2, 3, and 4 or more with parities 0 and 1. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).

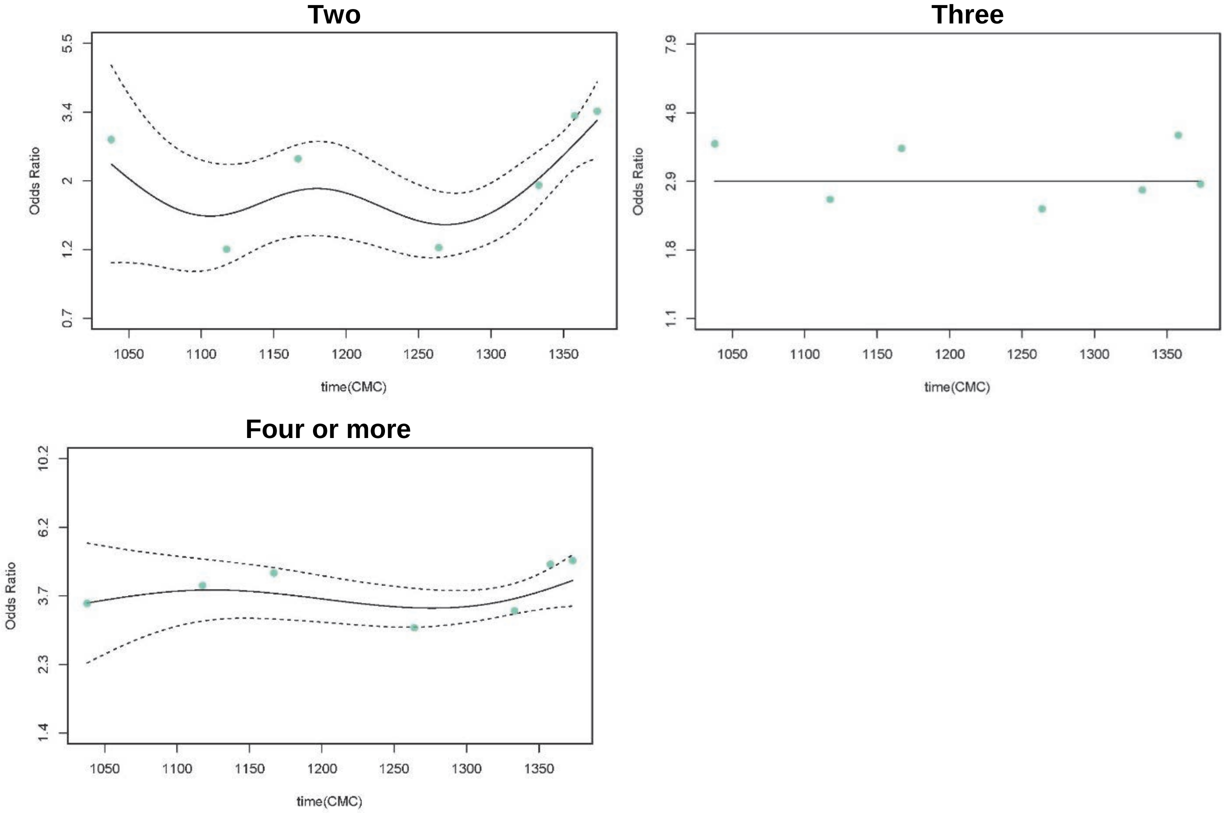


Figure 5.8b. Odds ratio plots for Senegal comparing primary education and secondary or higher, with no education. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).

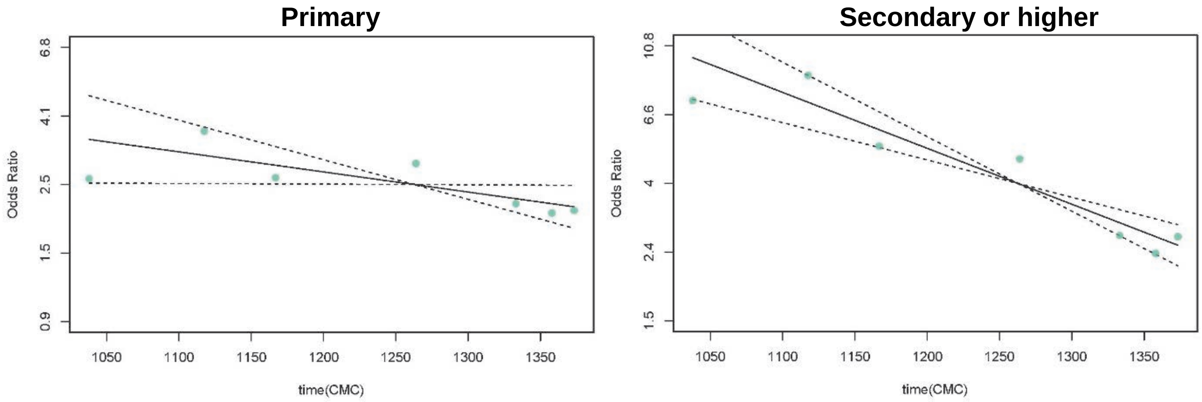


Figure 5.8c. Odds ratio plot for Senegal comparing urban areas with rural. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).

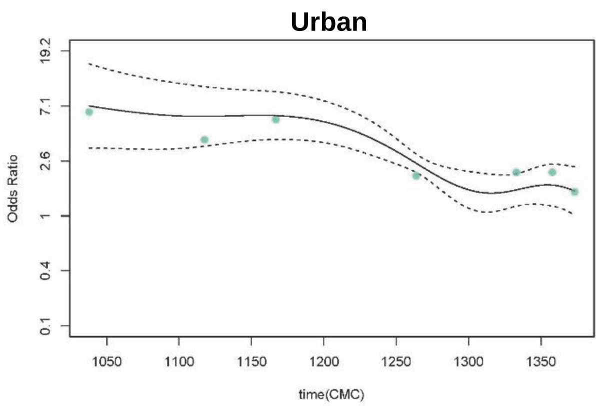
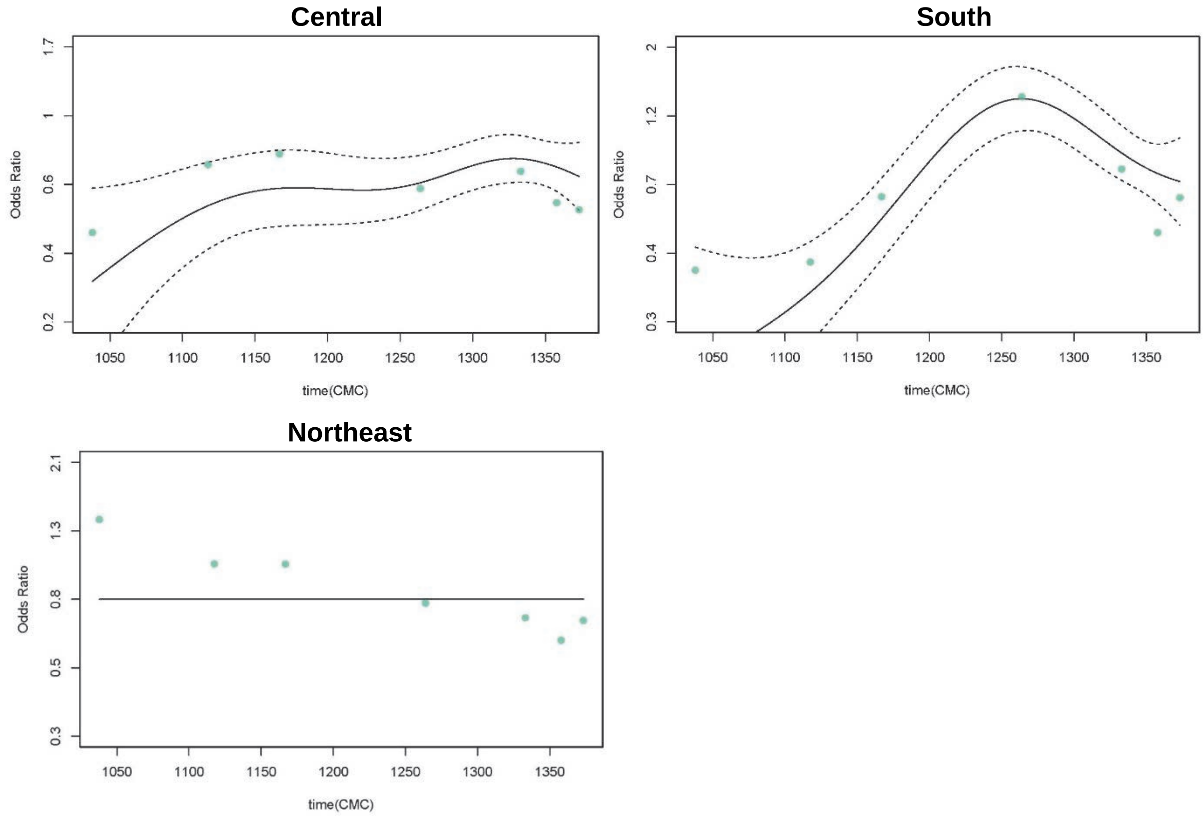


Figure 5.8d. Odds ratio plots for Senegal showing the three Senegal regions, compared to the west region reference category. The plots extend from June 1987 (CMC 1050) to July 2014 (CMC 1375).



5.5. Summary

The application of varying coefficient models to a long series of DHS surveys from Ghana, Indonesia, Kenya, and Senegal has shown that the odds ratios of most of the covariates included in the model have been significantly changing over time. For all four countries, education has significantly varying coefficients for one or more of its categories, usually for the secondary or more education category. Varying coefficients are also found for parity (except for Ghana), ideal number of children (except for Ghana and Kenya), place of residence (except for Kenya), and region (except for Ghana). The work status variable does not have significant time-varying coefficients in any of the countries. The odds ratio plots for almost all the significant varying coefficients show a clear trend moving toward an odds ratio of 1. Inequalities in modern contraceptive use for women age 15-49 and in a union appear to be decreasing for these subgroups.

Some patterns that appear in the fertility trends in Part I may be explained by findings in the VCMs. In Indonesia, although the VCMs were significant—most likely due to the large sample size, compared to the other countries in the analysis—the odds ratio trends do not appear to be pronounced. Weak trends were found for the categories of secondary or more education, seven or more ideal number of children, urban women, and the Java Bali region. This plateauing of the odds ratio trends may be related to the plateau in the TFR, as shown in Figure 3.6. Indonesia has the highest mCPR, compared to the remaining countries in the analysis, which could also be a reason for less prominent trends than the other countries in the analysis.

The analysis includes only three African countries and one Asian country, so generalizations to other countries are limited; however, extension to other countries with six or more surveys, or perhaps even with five surveys, which would include all the countries in Part 1, would be possible.

Some limitations of VCMs can be noted. First, these models were fitted with relatively few time points. In this analysis, two countries had six surveys and two countries had seven surveys, providing only six or seven distinct time points per country. More time points would improve the ability to capture trends in the coefficients/odds ratios. The VCM fit for all the countries use third degree splines and two knots. Using a different degree for the splines or more knots may produce slightly different results, but it was beyond the scope of this report to review the possible different combinations. In general, the odds ratio plots do appear to track the data points well for most of the subgroups examined.

A second limitation is that fitting VCMs requires long computation times, especially with adjustments for the complex survey design (sampling weights, clusters, and strata). Computation time would increase further with larger samples or more surveys or the addition of more covariates. Only six covariates were included here, but future studies could include other covariates, such as partner's education or indicators of women's empowerment. Future analysis using this method with more surveys or variables could select models with a subsample of the data before using the complete data to fit the final selected model.

Another limitation is the inability of the method to project trends, mainly because the method is non-parametric and uses spline functions. The method can be used to describe trends in the range of the available data and to test whether the trajectory is statistically significant from a constant line, but we cannot project the trend seen in the odds ratio plots. Many statistical procedures do allow for extrapolation or projection, but VCM does not.

Despite these limitations, the method can show how the odds ratios for the selected covariates and countries are, in fact, changing significantly over time, for the most part moving toward a reduction in disparities. The analysis can inform policy makers of the timing when past interventions appear to have been successful and for which groups.

6. Discussion and Conclusions

Part 1 of this report (Chapters 2 and 3) describes trajectories of fertility in 16 countries that have had at least five DHS surveys. Using a total of 98 surveys, and the birth history data for the 10 calendar years before the surveys, we describe levels and trends over approximately the 30-year time interval from 1980 to 2010, with some variation from one country to another in the first year, last year, and interval. The analysis blends the surveys together by aggregating births and exposure into arrays for single years of age and time—35 years of age and about 30 years of time.

Five trajectories were constructed from these arrays. The quantum or volume of fertility is measured by the Total Fertility Rate and the General Fertility Rate. The tempo or timing of fertility is measured by the mean age at childbearing, the standard deviation of the age at childbearing, and, derived from the Cumulative Fertility Rate, the ages at which women reached parities 1, 2, 3, and so on. The estimates are adjusted for sampling weights. The numbers were smoothed with a simple procedure (four-year splines with knots at calendar years divisible by four) and with no adjustments for possible displacement or omission of births. All of the specific numbers given in the report are smoothed.

The surveys from Egypt and Jordan were limited to ever-married women, and were also adjusted with all-women factors to provide unbiased estimates for the national population of all women age 15-49 living in households, regardless of marital status. When factors from the 1990 survey of Jordan were extended backward through the 1980s, a period in which age at marriage was increasing, the result was a spuriously high estimate of 8.0 for the TFR. Based on information in the DHS report on the 1990 survey, a more plausible estimate of 7.5 is suggested for 1980. Otherwise, the estimates for Egypt and Jordan are plausible and consistent with other sources.

The 16 countries included 8 from SSA and 8 from other regions. At the beginning of the series, all of the SSA countries other than Zimbabwe were above the median. The only non-SSA country above the median was Jordan. At the end of the series, all of the SSA countries were above the median, and all of the countries above the median were in SSA. The level of consistency is high between the initial and final levels of the TFR. Zimbabwe had a slow rate of decline and moved from an initial level that was below the median to a final level that was above the median. Jordan had a large rate of decline and moved from well above the median to slightly below the median. About half of the statistical variation in the TFR at the end of the series could be explained by the TFR at the beginning of the series.

The TFR and GFR declined in all countries. The median TFR declined by 42%, from 6.43 to 3.76. This is an average annual decline in the median of almost a tenth of a child per year. Briefly, the following paragraphs review the patterns by grouping the 16 countries into three groups based on the final TFR, as given in Table 3.1. The values, given to two decimal places, overstate the accuracy of the estimates but make it easier for readers to manipulate and confirm the estimates.

Five countries ended the series in a half-child range from 2.14 to 2.67 that is close to replacement: Colombia, Bangladesh, the Dominican Republic, Peru, and Indonesia (from lowest to highest). The trajectories for all five are characterized by a steep early decline, including an interval in which the TFR dropped by a full child in an interval of about five years, followed by a levelling off as the TFR approached replacement. In some cases, the most recent part of the trajectory is so flat that it cannot readily be described as still converging to replacement, but at least the levels are low.

The Philippines is the only other country with a TFR below 3.00, and just barely, at 2.97. Its trajectory has been steady, but much more gradual than the other five countries. Together, these six countries include all of the countries from Latin America and the Caribbean, South Asia, and Southeast Asia that are included in this report.

At their most recent estimate of the TFR, five countries have a level of 4.91 or more—say, between 5 and 6: Senegal, Zambia, Tanzania, Mali, and Uganda (from lowest to highest). Senegal, Mali, and Uganda appear to have fallen by about one child since about 2000, and their latest surveys suggest continuing decline. By contrast, Zambia has been flat since 2000 and Tanzania has had an *increase* of about one full child.

Five countries are intermediate to these two groups, with their final smoothed TFR in a range from 3.51 to 4.61: Jordan, Egypt, Kenya, Ghana, and Zimbabwe (from lowest to highest). It is fair to classify their trajectories as stalled from about 2000 to 2010. Kenya shows the most evidence of a net decline since 2000. Zimbabwe, by contrast, appears to have had a net *increase* since then.

In most countries, the mean age at childbearing has fluctuated somewhat, but with little net change across the span of about 30 years. Generally, it is in the range of 28 to 30 years of age. Countries with an initially younger childbearing age have remained younger, and countries with an initially older childbearing age have remained older. This pattern has three principal exceptions. Bangladesh, Colombia, and the Dominican Republic can be traced back to values of around age 28 in the late 1970s, and as they progressed to being the three countries with the lowest final TFR, their mean age at childbearing also fell substantially. The mean age in Bangladesh at the final date is estimated to be age 24.7, an extremely low level. It is clear that the main pathway to low fertility in these three countries was a reduction in higher-order births. With time this may be balanced with the delay of early births, pushing the mean age up again. This pattern is suggested by the Dominican Republic, in which the mean age dropped rapidly until 2000, and since then has been rising, returning to the same level as in 1990.

The standard deviation of age at childbearing was generally in the range of 6.5 to 8.0 years around 1980 and in the range from 6.0 to 7.5 years in 2010, a decline of about half a year, implying a greater concentration in the age of the mother at the births of her children as the number of children fell. Jordan and Egypt had the smallest standard deviations at the end, and were among the smallest standard deviations at the beginning of the series. Bangladesh and the Dominican Republic had the next lowest values at the end. The eight countries of SSA had the eight largest standard deviations at the beginning, ranging from 7.35 to 8.01. By the end, all had fallen, and Kenya—the country with the lowest TFR in SSA at that time—no longer had one of the eight most highly dispersed distributions of age at birth. The standard deviation for Kenya had fallen to 6.9, slightly less than the Philippines. The only evidence that the standard deviation may tend to return to earlier levels comes from the Dominican Republic. Its standard deviation, like its mean, as noted above, by the end had returned to approximately the 1990 level.

The calculation of the ages when the Cumulative Fertility Rate reaches successive integer values is somewhat innovative. The numbers must not be interpreted as mean ages, but they do convey information about the prevailing timing and spacing of births and how they have changed over time. The main generalization, implied in Figure 3.21, is that, with one exception, all parities were achieved later at the end of the series than at the beginning. For the first parity, the delay was about the same amount across countries, regardless of the initial level; for parities 2 and 3, but especially for parity 3, the delay was greater if the initial age was later; for parities 4 and 5, but especially for parity 5, the delay was less if the initial age was later. We summarize this pattern as another manifestation of a slightly greater concentration of childbearing around a relatively stable mean age.

Figure 6.1. Scatterplot showing the most recent TFR and current mCPR for each survey from Ghana, Kenya, Indonesia, and Senegal.

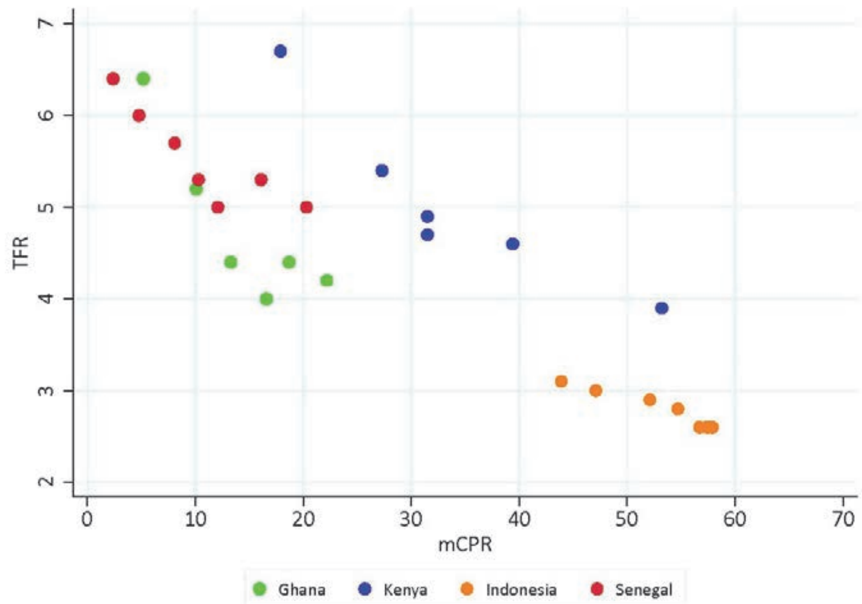


Figure 6.1 is, a scatterplot showing the most recent TFR and current mCPR for the 4 countries and 26 surveys included in both Parts 1 and 2 of this report. “Recent” and “current” apply to the dates of the surveys. The TFR values in this figure are extracted from Stat Compiler for the three years before each survey. That is, the TFR values in the figure are not the smoothed single-calendar year TFRs calculated and described in Part 1. The mCPR values are also drawn from Stat Compiler. The TFR and mCPR from Stat Compiler generally match with the numbers in the main survey report. Each country—Ghana, Kenya, Indonesia, and Senegal—is shown in a different color.

The figure illustrates the general negative relationship between fertility and contraceptive prevalence. The causal relationship between fertility and contraceptive prevalence is predominantly that higher prevalence is followed by lower fertility, the reverse of the sequence in the data from a single survey, so the timing is reversed in the figure, but there is enough continuity in each country to produce strong linear relationships between the two indicators. If a line were fitted through the points for each country, one line per country, all four lines would have negative slopes, although the slopes and intercepts would be different for each line. Each country follows a sequence from the upper left point to the lower right point, a kind of joint trajectory of fertility and contraception that follows the chronology of the surveys.

The analysis in Part 2 does not focus on trends in contraceptive prevalence, but on trends in the association between contraceptive prevalence and parity, ideal number of children, level of education, work status, urban-rural residence, and region of the country. The main interest is in the logit regression of modern contraceptive use on the covariates in the first survey, in the last survey, and in a smoothed trajectory going from the first survey to the last survey. The trajectory of odds ratios indicates whether there is a general movement toward odds ratios that are not significantly different from 1, a pattern that would imply a convergence of prevalence levels in the comparison and reference categories. The statistical method is VCM, or varying coefficient models. The use of VCM for a sequence of DHS surveys is innovative.

Not only is modern contraceptive use increasing steadily in Ghana, Indonesia, Kenya, and Senegal, but the disparities between specific groups in their use of modern contraceptive methods are also decreasing.

Family-planning programs and interventions appear to be successful in reaching major sub-populations. A number of review articles have found successful interventions in increasing contraceptive use that target both the demand and supply side (Cleland et al. 2006; Lopez et al. 2015; Mwaikambo et al. 2011; Phiri, King, and Newell 2015).

The analysis uses the six covariates to estimate the VCMs. Depending on the country, some covariates have significant time-varying coefficients, that is, the odds ratios were changing, and some did not. Education had time-varying coefficients in all four countries, all showing a decrease in disparity, especially for the comparison of secondary or higher education with no education. Disparities also decreased between certain regions and urban and rural residence. The wealth index was not included, but in an analysis of recent trends in inequalities in 11 outcomes, including use of modern contraception, Assaf and Pullum (2016) found that disparities significantly decreased between the last two surveys for the countries included here. In addition, two of the countries, Ghana and Indonesia, were found to have achieved equality in modern contraceptive use across wealth quintiles in the most recent survey, according to the concentration index (Assaf and Pullum 2016). The absence of significant time-varying coefficients for work status in any of the countries indicates that disparities between working and non-working women in their contraceptive use still remain.

The VCM and odds ratio plots highlight not only where interventions are successful in decreasing the gaps between the subgroups but also where interventions are needed due to increasing or unchanged disparities.

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Appendices

Appendix 1: R code used to fit the Varying Coefficient Models (VCMs)

The *mgcv* R package (Wood 2012, 2006) is used to fit the varying coefficient models, using the gam function. The gam function is used to fit generalized additive models and can also be used to fit varying coefficient models. Using Ghana as an example, we have the following VCM, as describe in section 5.1:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 parity + \beta_2 edu + \beta_3 work + \beta_4 ideal + \beta_5 residence + \beta_6 region + \alpha_0(t) + \alpha_1(t) edu + \alpha_2(t) residence$$

where p is the probability of modern contraceptive use, the βs are the constant coefficients, $\alpha_0(t)$ is the time-varying intercept, and $\alpha_1(t)$ and $\alpha_2(t)$ are the time-varying coefficients for the education and place of residence variables, respectively.

The following R code can be used to fit this VCM:

```
##############################################################################
Loading the mgcv package
library(mgcv)

# Attach the Ghana data (GHall) which appended data from six surveys
attach(GHall)

# The data contains the coded variables mcpr (modern contraceptive use), time (CMC of the survey), prty
# (parity), edu (education), work (work status), ideal (ideal number of children), locl (place of residence) #
and region.
# Fit the VCM model defined above and store it in an object with the name modelghana
modelghana <-  gam(mcpr ~ 1   + s(time, bs="ps", k=12, m=c(3,2)) + prty + edu
                              + s(time, bs="ps", k=12, m=c(3,2), by=edu) + work + ideal + locl
                              + s(time, bs="ps", k=12, m=c(3,2), by=locl) + region,
                               family=binomial("logit"))
##############################################################################
```

In the code above, *gam* is the function from the *mgcv* package, *s* is used to define the spline functions, and *ps* selects for P-splines, *k* are the number of knots, and *m=c(3,2)* indicates the use of a third-degree B-spline basis with a second-order difference penalty, as recommended by (Eilers and Marx 2002). The number of knots provided is 12, or two for each survey; for Indonesia and Senegal, we used 14 knots based on seven surveys. To indicate that we would like to have varying coefficients for the education and the place of residence categories, we use the *by* option as shown. The model also specifies that a binomial family with a logit link is to be used. Please see Assaf and Campostrini (2015) for a more detailed explanation of using VCMs for repeated surveys.

The odds ratio plots are produced by the *plot.gam* function of the *mgcv* package. We used the AIC of the models, using the AIC basic function in R.

The models fit for this analysis also uses the *survey* package (Lumley 2014) to account for the stratification design and the sampling weights. We combined the *mgcv* and *survey* packages to define the *svygam* function, which can be used as the *gam* function above.

Appendices 2–5: Description of Sample for Ghana, Indonesia, Kenya, and Senegal

Appendix 2. Description of the sample for each Ghana survey for total sample and for women 15-49 in a union using a modern contraceptive method (mCPR)

variable	category	1988 %	1988 % mCPR	1993–1994 %	1993–1994 % mCPR	1998–1999 %	1998–1999 % mCPR	2003 %	2003 % mCPR	2008 %	2008 % mCPR	2014 %	2014 % mCPR
			5.2		10.1		13.3		18.7		16.6		22.2
parity	0 or 1	37.3	3.1	38.0	7.1	43.4	10.9	45.4	12.9	47.4	12.3	45.4	16.7
	2	12.7	3.0	13.9	9.5	13.3	8.7	12.2	19.6	13.2	15.5	14.0	21.8
	3	11.0	4.1	11.9	12.0	10.9	14.5	11.3	18.5	11.0	17.4	12.0	24.6
	4+	39.0	7.0	36.2	11.2	32.3	16.1	31.1	21.5	28.3	19.1	28.6	24.1
education	none	39.7	3.2	35.0	3.6	29.1	8.9	28.2	11.0	21.2	10.8	19.1	17.4
	primary	52.8	6.5	54.7	13.4	18.0	12.9	20.0	20.7	20.1	18.0	17.8	26.8
	secondary or more	7.5	10.1	10.3	25.0	52.8	16.8	51.8	24.7	58.7	19.5	63.1	23.1
work status	not working	49.3	3.1	25.5	8.4	26.3	8.7	24.8	14.7	24.7	9.7	26.5	17.6
	working	50.7	6.7	74.5	10.5	73.7	14.1	75.2	19.2	75.3	17.3	73.5	23.0
ideal number of children	0-2	3.6	15.1	11.0	15.7	11.5	15.5	9.6	19.5	9.8	16.8	9 (8	25.0
	3 or 4	39.7	6.2	52.0	12.1	54.6	14.7	56.3	22.4	59.3	18.4	57.2	23.4
	5 or 6	30.8	4.7	21.0	8.0	19.4	13.2	22.5	17.7	21.5	17.3	23.8	21.9
	7 or more & don't know	25.9	3.5	16.0	5.5	14.5	7.9	11.5	7.5	9.4	7.6	10.0	17.0
place of residence	rural	66.1	3.9	62.3	7.4	64.1	11.4	51.6	14.9	51.5	15.1	46.2	24.6
	urban	33.9	8.1	37.7	15.8	35.9	17.4	48.4	24.2	48.5	18.6	53.8	19.8
region	Greater Accra	13.3	10.6	13.5	18.0	16.7	17.4	16.6	26.0	17.3	22.2	20.2	19.4
	West/Central	19.1	4.1	18.3	10.7	23.6	10.9	17.3	15.6	17.7	15.1	21.0	25.4
	East/Volta	26.8	5.0	22.1	10.3	24.0	16.3	19.2	20.5	18.6	18.9	17.0	27.3
	Brong-Ahafo/ Ashanti	29.5	6.0	26.7	10.1	22.4	14.3	30.1	22.4	29.2	17.6	27.3	22.5
	North/Upper West/ Upper East	11.3	0.7	19.3	5.7	13.3	7.1	16.9	10.0	17.1	10.2	14.5	16.0
Total observations		4488	3156	4562	3204	4843	3131	5691	3549	4916	2876	9396	5321

Appendix 3. Description of the sample for each Indonesia survey for total sample and for women 15-49 in a union using a modern contraceptive method (mCPR)

variable	category	1987 %	1987 % mCPR	1991 %	1991 % mCPR	1994 %	1994 % mCPR	1997 %	1997 % mCPR	2002–2003 %	2002–2003 % mCPR	2007 %	2007 % mCPR	2012 %	2012 % mCPR
			43.0		47.2		52.2		54.9		56.7		57.4		57.9
parity	0 or 1	24.5	27.6	28.3	34.1	28.1	40.7	30.6	45.1	30.9	46.0	32.5	46.6	48.6	45.2
	2	17.8	51.4	19.5	56.2	21.1	60.7	22.5	64.9	25.3	68.7	28.1	69.8	23.8	68.3
	3	15.1	54.1	15.8	55.6	17.3	63.5	17.1	63.5	18.0	65.8	18.0	65.1	14.2	65.6
	4+	42.6	44.1	36.4	48.4	33.5	50.3	29.8	52.1	25.7	51.0	21.4	50.8	13.4	56.1
education	none	21.5	30.9	19.0	35.9	15.7	38.6	13.0	43.1	7.9	44.8	6.9	40.1	3.3	41.8
	primary	61.2	43.9	61.0	48.3	60.2	53.3	58.8	56.1	53.9	57.5	47.6	57.7	33.2	59.6
	secondary or more	17.3	54.5	20.0	53.8	24.1	57.5	28.1	57.5	38.2	58.0	45.5	59.4	63.5	57.7
ideal number of children	0-2	30.2	48.3	36.2	52.8	38.1	57.5	39.1	61.7	42.2	63.3	48.8	63.1	57.6	62.7
	3 or 4	42.5	46.8	38.2	49.6	33.3	55.1	33.7	57.2	37.2	56.6	33.2	55.9	29.3	53.5
	5 or 6	11.3	35.4	8.3	36.6	5.9	41.5	5.7	44.9	5.4	42.8	5.7	43.8	3.9	47.3
	7 or more & don't know	16.0	27.9	17.3	34.5	22.6	41.1	21.4	40.8	15.2	43.4	12.3	44.6	9.2	49.9
place of residence	rural	71.4	40.8	70.7	45.6	70.8	50.7	72.0	54.7	54.2	56.5	58.2	57.5	47.8	58.7
	urban	28.6	48.7	29.3	51.1	29.2	55.8	28.0	55.2	45.8	57.0	41.8	57.1	52.2	57.0
region	outer Javi Bali	41.5	35.4	35.8	40.2	36.0	44.7	37.1	48.7	36.7	50.5	36.9	52.5	39.9	53.3
	Java Bali	58.5	48.5	64.2	51.1	64.0	56.4	62.9	58.5	63.3	60.3	63.1	60.2	60.1	60.8
Total observations		9451	8724	22813	21022	28044	26071	28690	26770	29483	27857	32895	30931	45607	33465

Appendix 4. Description of the sample for each Kenya survey for total sample and for women 15-49 in a union using a modern contraceptive method (mCPR)

		1988–1989		1993		1998		2003		2008–2009		2014	
		%	% mCPR	%	% mCPR	%	% mCPR	%	% mCPR	%	% mCPR	%	% mCPR
			17.9		27.3		31.5		31.5		39.4		53.2
parity	0 or 1	34.1	6.2	40.4	13.7	41.7	19.5	42.9	21.3	41.3	28.2	42.2	41.8
	2	10.1	14.7	11.4	26.8	13.1	35.2	12.7	35.9	14.5	49.0	16.3	60.4
	3	9.6	19.8	9.3	29.4	10.2	33.3	11.5	39.9	12.5	46.0	13.3	62.1
	4+	46.1	20.8	38.9	31.3	35.1	34.4	33.0	31.6	31.7	37.6	28.1	51.4
education	none	25.2	9.7	17.9	15.3	11.5	16.1	12.7	8 7	8.9	12.0	7 2	15.3
	primary	54.4	19.2	57.6	25.6	59.3	28.2	58.0	28.8	56.8	38.3	50.3	55.7
	secondary or more	20.4	29.3	24.5	44.9	29.2	46.3	29.3	51.7	34.3	52.1	42.7	59.0
work status	not working	88.4	16.1	51.0	23.0	48.1	28.3	41.5	23.3	43.2	31.2	38.5	44.7
	working	11.6	33.9	49.0	30.8	51.9	33.6	58.5	36.0	56.8	44.1	61.5	57.2
ideal number of children	0-2	11.7	27.9	25.0	40.9	22.9	44.7	23.7	46.9	24.5	53.4	27.4	67.1
	3 or 4	52.7	20.7	51.7	28.6	51.2	34.0	49.2	35.6	51.7	42.9	52.7	56.2
	5 or 6	23.9	14.0	13.0	17.1	16.2	21.4	14.4	23.8	14.3	27.8	12.1	43.8
	7 or more & don't know	11.7	11.3	10.3	11.9	9.7	16.7	12.7	9.7	9.4	16.4	7.8	21.0
place of residence	rural	82.7	16.4	82.2	25.4	76.8	29.0	74.9	29.2	74.6	37.2	59.2	50.9
	urban	17.3	25.5	17.8	37.9	23.2	41.0	25.1	39.9	25.4	46.6	40.8	56.9
region	Nairobi/Central	23.4	29.9	21.2	46.0	20.4	51.3	24.6	52.6	19.3	57.1	25.0	62.8
	Coast/East/ Northeast	24.7	18.0	28.2	25.8	25.3	31.0	26.3	28.7	26.5	35.8	26.1	48.9
	West/Nyanza	30.6	10.1	29.9	21.6	32.9	23.9	26.2	23.6	27.4	36.0	23.4	55.2
	Rift valley	21.2	18.1	20.7	21.0	21.5	26.4	22.8	24.5	26.8	34.7	25.6	46.8
Total observations		7150	4765	7540	4629	7881	4834	8195	4919	8444	4828	3107	18549

Appendix 5. Description of the sample for each Senegal survey for total sample and for women 15-49 in a union using a modern contraceptive method (mCPR)

		1986		1992–1993		1997		2005		2010–2011		2012–2013		2014	
variable	category	%	% mCPR	%	% mCPR	%	% mCPR	%	% mCPR	%	% mCPR	%	% mCPR	%	% mCPR
			2.4		4.8		8.1		10.3		12.1		16.1		20.3
parity	0 or 1	38.1	0.9	39.3	2.4	42.7	3.7	48.0	7.6	48.7	7.4	49.3	7.5	49.0	10.6
	2	11.3	3.4	10.8	3.3	10.6	8.9	10.7	8.5	11.2	12.8	11.0	19.6	11.3	26.8
	3	10.0	3.4	8.6	5.2	8.6	10.2	9 1	12.6	9.4	15.0	10.0	22.3	10.4	21.3
	4+	40.6	2.6	41.3	5.9	38.1	9.3	32.4	12.0	30.7	13.9	29.6	18.1	29.3	24.0
education	none	77.2	1 2	73.0	2.2	66.6	3.9	59.6	5.4	57.9	7.9	54.8	11.6	51.0	14.3
	primary	13.5	5.9	17.1	13.1	20.9	17.1	25.2	18.3	21.8	20.5	22.5	24.5	23.3	29.6
	secondary or more	9.2	22.1	9.9	29.4	12.5	34.5	15.2	29.7	20.4	25.6	22.8	29.2	25.7	33.4
work status	not working	73.5	1.8	55.3	4.8	43.9	8.9	62.0	8.5	60.4	10.1	56.0	13.4	54.3	18.3
	working	26.5	4 9	44.7	4.8	56.1	7.5	38.0	13.1	39.6	14.9	44.0	19.0	45.7	22.3
ideal number of children	0-2	3.4	8 8	4.3	12.0	4.5	20.4	5 7	18.5	4 6	15.6	3.3	25.6	2.9	27.8
	3 or 4	17.3	8.4	24.3	9.7	30.1	15.2	25.4	16.8	29.8	19.1	30.5	23.1	32.5	27.0
	5 or 6	26.3	2.5	28.7	5.2	29.2	7.3	30.2	11.2	30.5	12.3	35.6	17.6	32.8	23.9
	7 or more & don't know	53.0	0.7	42.7	2.3	36.3	3.8	39.3	5.9	35.8	7.7	30.7	9.7	31.8	12.2
place of residence	rural	59.0	0.3	58.2	1.4	55.8	2.1	51.3	5 5	50.7	6.5	54.2	9.2	46.3	13.0
	urban	41.0	6.7	41.8	11.9	44.2	19.3	48.7	18.0	49.3	20.2	45.8	27.3	53.7	28.8
region	West	37.9	5.5	36.9	10.1	38.1	16.4	40.0	17.7	38.9	19.5	38.0	26.9	41.1	31.6
	Central	34.6	0.5	36.1	2.2	34.1	3.9	33.0	4.9	34.7	7.4	33.8	10.2	30.2	12.3
	South	14.5	0.6	11.0	1.7	12.0	4.1	11.0	12.0	10.6	10.9	10.2	11.7	9.8	17.9
	Northeast	13.0	2.4	16.0	3.2	15.8	5.1	16.0	6.1	15.7	8.5	18.0	11.3	18.9	15.5
Total observations		4415	3364	6310	4450	8593	5851	14602	9866	15688	10347	8636	5554	8488	5500