A RE-ASSESSMENT OF FERTILITY TRENDS IN 17 SUB-SAHARAN AFRICAN COUNTRIES

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Declaration

I, Kazuyo Machiyama, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

Some recent studies have suggested that fertility decline has slowed down in several sub-Saharan Africa countries, but have reached contradictory conclusions. This thesis re-assessed fertility trends in 17 sub-Saharan African countries over two decades. The first part of this study examined the data quality of 63 Demographic and Health Surveys. Date and age misreporting, particularly age displacement of children, was prevalent and the degrees varied across the surveys within the countries, which have affected fertility trends. Using a Loess regression and adjusting for common errors, trend estimation methods were introduced. The new methods produced both robust trend estimates and uncertainty intervals. The results pointed out the limitations of DHS data for trend estimation and the weakness of the earlier studies. In six countries the pace of decline has more than halved since the 1980s, but no country has it ceased entirely.

The second part of the thesis proposed modifications in Bongaarts' proximate determinants framework and applied them in order to explore the extent to which changes in proximate determinants support the Loess fertility trends. The results suggested that the changes in each proximate determinant varied greatly across the countries, and other proximate determinants, apart from contraception, have played important roles in inhibiting fertility in the region. Changes in sexual activity among married and unmarried were found. Overall, the trends of the TFR estimates from the proximate determinants framework were consistent with those of the Loess estimations. Specifically, the projected TFRs in the five countries (Benin, Kenya, Malawi, Nigeria and Zambia) where the Loess estimates depicted deceleration also failed to decline in the same periods.

The study recommends careful assessments of fertility trends using the rigorous methods, balancing the quality and quantity of questions in the DHS Questionnaire, and further research on marriage and family systems in sub-Saharan Africa.

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List of abbreviations

AIDS	Acquired Immunodeficiency Syndrome
ART	Antiretroviral Therapy
DHS	Demographic and Health Surveys
GDP	Gross Domestic Product
HDI	Human Development Index
HIV	Human Immunodeficiency Virus
ICPD	International Conference on Population and Development (Cairo, 1994)
IMR	Infant mortality rate
IRD	Institute for Resource Development
IUD	Intra-uterine device
Loess	Locally weighted scatterplot smoothing
LSHTM	London School of Hygiene and Tropical Medicine
MDG	Millennium Development Goals
PA	Periodic abstinence
PCA	Principle Component Analysis
PF	Potential Fertility
PMTCT	Prevention of Mother-to-Child Transmission of HIV
STI	Sexually Transmitted Infection
TFR	Total Fertility Rate
UN	United Nations
UNAIDS	Joint United Nations Programme on HIV and AIDS
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFPA	United National Fund for Population Activities
UN-HABITAT	United Nations Human Settlements Programme
USAID	United States Agency for International Development
WFS	World Fertility Surveys
WHO	World Health Organization

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Chapter 1 :INTROCUTION

1.1. Introduction

Sub-Saharan Africa is the only major region where rapid population growth is still under way. In the 1950s, the region consisted of only 7.3 per cent of the world's population. However, the population has increased by over 2.5 per cent per annum in the last four decades and is set to exceed 967 million by 2015 (United Nations 2011b). By 2050, it is projected that 21 per cent of the world's population will live in sub-Saharan Africa. Nevertheless, in this region, 51 per cent of the population is under the poverty line and millions of people are dying from preventable diseases (United Nations 2011a). The implication of the enormous growth in population means that the region faces immense challenges to both human and economic development, as well as sustainability of natural resources.

The region's growth is bolstered by persistent high fertility and a sustained decline in mortality. With the spread of decline in mortality rates, pace of fertility decline is a key determinant of population growth (United Nations 2009b). While Asia and Latin America began fertility transition in the 1950 or 1960s, most of the sub-Saharan African countries did not see this decline until the 1980s. By the end of the 1980s, in Botswana, Kenya, Namibia, South Africa and Zimbabwe, fertility had declined by more than one child per woman (Cohen 1993; Moultrie and Timæus 2003). Fertility in Southern Africa has fallen at almost the average rate of less developed countries since the 1960s. In the 1990s fertility started to fall in most countries in Eastern, Western and Middle Africa, but at different rates. The average total fertility rate (TFR) for the whole of sub-Saharan Africa was estimated to be 5.10 in 2005-10 (United Nations 2011b).

It is widely assumed that fertility decline, once initiated, will continue steadily to around the replacement level. Assessment of the pace of fertility decline in the later stages of transition has been neglected (Aminzade 1992; Bongaarts 2002a; Casterline 2001b). Recent studies, however, have challenged this widespread assumption. Bongaarts suggested that the pace of decline decelerated around 2000 in sub-Saharan Africa (Bongaarts 2006, 2008). Moreover, he concluded that fertility decline stalled in twelve sub-Saharan African countries in the midst of transition (Bongaarts 2008).

The issue now is how fast fertility will decline in the high-fertility sub-Saharan African countries; it is no longer a question of 'whether' or 'when' the transition starts (Lee 2003). The latest United Nations' World Population Prospect: The 2010 Revision has stressed yet again that the pace of decline in the high-fertility countries is the primary determinant of the projection of the world's future population. Sub-Saharan Africa has 39 of the 55 high-fertility countries in the world (United Nations 2011b). There is clearly an increasing need for careful assessment of the fertility trends in sub-Saharan Africa.

Before embarking on investigation of the recent fertility changes in Africa, it is important to provide background on sub-Saharan African fertility. The following sections discuss the evolution of our knowledge of African fertility in 1960-90, the socioeconomic environment, demography, economy and education, as well as the population policies and family planning programmes.

1.2. Evolution of knowledge on African fertility in 1960-90

There was little understanding of the demography of sub-Saharan Africa until the late 1960s. Prior to this, the first systematic description of African demography was attempted by Kuczynski in 1948 and 1949, and subsequently Brass et al. assembled estimates of the available demographic data (Brass et al. 1968; Kuczynski 1948, 1949). However, the data were extremely of poor quality and limited.

Following 29 of the sub-Saharan African countries gaining their independence, the first African Population Conference was held in Ibadan University, Nigeria, in 1966. Coale revealed that there were significant variations in rates of fertility and mortality within and between countries (Caldwell 1968). For instance, the TFR estimates ranged from 3.5 to more than 8.0 children per woman, drawing approximate conclusions about the levels of mortality and fertility (Caldwell 1968). He argued that, "there is widespread conviction that mortality is falling", and reported signs of population growth by more than three per cent. However, the fertility trends over time were speculative and it had been difficult to identify the onset of fertility decline. Page suggested that African fertility seemed stable because of scarcity of reliable demographic data (Page 1988).

World Fertility Surveys (WFS) were conducted between 1974 and 1982. These were the first nationally-representative and internationally-comparable data on fertility in developing countries, and for the first time made adequate demographic data available to some African countries, for use in making demographic profiles and creating concrete population policies. The results revealed that while most of the countries in Asia (except South Asia), the Pacific, Latin America, the Caribbean and North Africa had shown fertility decline since the late 1950s or early 1960s, there was no sign of decline in sub-Saharan Africa (International Statistical Institute and World Fertility Survey 1984). The average TFR in the nine sub-Saharan African countries studied was about 7 children per woman, ranging from 5.8 in Lesotho to 8.3 in Kenya. The TFR in Cameroon, Ghana and Nigeria was about 6.5 children on average, while the estimates in Benin, Côte d'Ivoire and Senegal were slightly higher, at about 7.0.

While there was no sign of decline in sub-Saharan Africa, South Africa was a singular exception. After the close examination and adjustment of the 1996 Census and the 1998 Demographic and Health Survey (DHS), it was found that fertility had declined somewhat since the 1960s. Between 1960 and 1996, the TFR fell by 3.2 nationally and by 3.5 among African South African women (Moultrie and Timæus 2003). The pace of decline accelerated significantly after introduction of the national family planning programme in 1974.

Following WFS, the United States Agency for International Development (USAID) succeeded the international project and renamed it the Demographic and Health Surveys (DHS) project in 1984. Demographic data in Africa have proliferated as the DHS project has expanded. The number of sub-Saharan African countries with at least one DHS survey increased from 12 countries in 1990 to 17 countries in 1995. As at 2011, 43 sub-Saharan African countries have conducted at least one survey. Ghana and Kenya had undertaken five surveys by 2010. This project has made significant contributions in increasing our knowledge of fertility in Africa.

In the early 1980s, the data from WFS, DHS-I and the censuses provided strong evidence of fertility decline in Kenya, Botswana and Zimbabwe since the 1980s (Arnold and Blanc 1990; Cohen 1993). After the second round of DHS, it became clear that at least Ghana, Kenya, Senegal and Zimbabwe showed obvious signs of the onset of fertility decline between the late 1980s and the 1990s (Mboup and Saha 1998). The remaining countries have followed since the 1990s or 2000s, but the pace of decline appears slower than in other developing countries. Moreover, the pace appears to have slowed even further in around 2000 (Askew et al. 2009; Bongaarts 2002a, 2006, 2008; Ezeh, Mberu and Emina 2009; Garenne 2008; Machiyama 2010; Schoumaker 2009).

1.3. Backgrounds

1.3.1. Demography

Sub-Saharan Africa is a diverse continent and has faced various challenges. The region is located south of the Sahel and has 856 million people in 24 million square kilometres (United Nations 2011b)[1]. It is thought that thousands of ethnic groups inhabit the continent and over 1,000 languages are spoken. Christianity is the most popular religion, particularly in Eastern and Southern Africa. In the Sahel and the coastal area of Eastern Africa, Islam is widely practised. Islam is in the majority in Mali and Niger, and comparable in Nigeria and Burkina Faso. Traditional religions are also practised in the continent.

After Ghana achieved independence in 1957, other countries followed, becoming independent from the colonial governments, the United Kingdom, France, Belgium, Portugal or Spain. Several countries have suffered conflict since the 1980s.

[1] In the United Nations, the classification of sub-Saharan Africa is commonly used to indicate all Africa except North Africa, with Sudan and South Sudan included. Sub-Saharan Africa consists of 52 UN member states, including St Helena (British overseas territory) and Réunion (French overseas territory). On the other hands, World Bank Group currently holds 48 member countries in sub-Saharan Africa, excluding Djibouti, Réunion and St. Helena, and South Sudan is a part of Sudan, as of 20 July 2011.

Figure 1.1: Map of Africa

**□ indicates the countries included in the later analysis.*
** South Sudan became independent in July 2011, but it has not indicated in this map.*

Table 1.1: Selected demographic and socioeconomic indicators by region, 1960-2009

Indicator / Region[2]	1960	1970	1980	1990	2000	2009
Total fertility rates						
Sub-Saharan Africa	6.66	6.72	6.70	6.29	5.59	5.05
South Asia	6.04	5.74	5.06	4.29	3.45	2.82
East Asia & Pacific	5.21	5.17	3.01	2.51	1.96	1.89
Latin America & Caribbean	5.97	5.29	4.20	3.22	2.65	2.19
Middle East & North Africa	6.92	6.69	6.27	4.90	3.25	2.72
Infant mortality rate (per 1,000 live births)						
Sub-Saharan Africa	-	133	116	109	98	81
South Asia	162	132	110	89	71	55
East Asia & Pacific	-	80	51	39	31	20
Latin America & Caribbean	103	86	63	42	28	19
Middle East & North Africa	160	130	90	54	37	26
Life expectancy at birth (years)						
Sub-Saharan Africa	40.9	44.5	48.1	49.9	50.1	52.5
South Asia	42.8	48.7	54.5	57.8	61.4	64.4
East Asia & Pacific	49.1	60.6	65.0	68.0	71.2	73.4
Latin America & Caribbean	56.2	60.2	64.5	68.3	71.6	73.6
Middle East & North Africa	47.4	52.9	59.0	65.1	69.4	71.4
Urban population (% of total)						
Sub-Saharan Africa	14.8	19.4	23.8	28.1	32.7	36.9
South Asia	16.6	18.6	22.3	24.9	27.3	29.8
East Asia & Pacific	20.5	23.3	26.4	33.3	40.7	48.0
Latin America & Caribbean	48.8	57.0	64.9	70.6	75.3	78.9
Middle East & North Africa	35.0	42.9	49.6	54.8	58.4	60.8
GDP per capita, PPP (constant 2000 international $)						
Sub-Saharan Africa	429	540	588	531	511	622
South Asia	158	225	238	325	446	713
East Asia & Pacific	913	1,729	2,293	3,255	3,926	4,928
Latin America & Caribbean	2,135	2,775	3,790	3,522	4,117	4,830
Middle East & North Africa	-	1,646	2,745	2,376	2,847	3,559

[2] Each region include all income levels of the countries in the respective geographical region

Indicator / Region	1960	1970	1980	1990	2000	2009
Human Development Indicator (1)						
Sub-Saharan Africa	-	-	0.29	0.35	0.32	0.38
South Asia	-	-	0.32	0.39	0.44	0.51
East Asia & Pacific	-	-	0.39	0.47	0.57	0.64
Latin America & Caribbean	-	-	0.58	0.62	0.66	0.70
Arab States	-	-	0.40	0.48	0.53	0.59
Literacy rate among young adults (15-24 years) (%) (2)						
Sub-Saharan Africa	-	-	-	65.3	68.7	72.0
Southern Asia	-	-	-	60.3	73.3	79.7
Eastern Asia	-	-	-	94.6	98.9	99.4
Latin America & Caribbean	-	-	-	91.7	96.1	97.0
Northern Africa	-	-	-	67.5	79.3	86.6
Population (million)						
Sub-Saharan Africa	229	293	387	515	672	841
South Asia	564	714	906	1129	1362	1568
East Asia & Pacific	1049	1291	1557	1817	2038	2182
Latin America & Caribbean	218	284	361	441	519	578
Middle East & North Africa	105	138	186	255	317	377

Source: World Development Indicators (2010), Human Development Indicators (2010) for HDI, United Nations (2011) for literacy rates
(1). The regions are based on the UNDP definition. The figure ranges from 0 to 1.
(2). The regions are based on the United Nations' classification

Table 1.1 shows selected demographic and socioeconomic indicators by region in 1960, 1970, 1980, 1990, 2000 and 2009. By 2010, over 80 million people live in this continent. As noted earlier, the population growth rate remains the highest in sub-Saharan Africa. The growth rate was at its highest in the early 1980s, but remains projected at 2.45 per cent for 2005-2010 (United Nations 2011b). This indicates that the population would double within 40 years. On the other hand, the East Asia and Pacific regions hold the largest population of 2.2 billion people in 2009. However, the population in Asian countries is projected to pass the peak in the 2060s, while that of the high fertility countries in the region is projected to continue to increase until the end of the 21st century (United Nations 2011b).

TFR has been high in sub-Saharan Africa, as described earlier. However, in the 1960s there were small differences between the regions (see Table 1.1). The TFR in South Asia, North Africa and the Middle East were over six children per woman in the 1960s, similar to Africa, and those in other regions were not less than five children. But TFRs have declined rapidly to under 2.9 by 2009 in all regions, with the exception of sub-Saharan Africa. The TFR in sub-Saharan Africa remains at 5.05 children per woman.

Mortality

The level of mortality is higher in sub-Saharan Africa than other regions, resulting from prevalent infectious and communicable diseases, poor living conditions and health services, and food insecurity (United Nations Economic Commission for Africa 2001). Nevertheless, infant mortality rates in South Asia, the Middle East and North Africa were the same as in sub-Saharan Africa in 1970, exceeding 130 deaths per 1,000 live births (see Table 1.1). Only in Africa did the rate remain as high as 81 deaths per 1,000 live births in 2009, whereas it has declined by 50-80 per cent in the other regions in the past 30 years. The under-five mortality rate in sub-Saharan Africa has declined from 184 in 1990 to 144 deaths per 1000 live births in 2008, but the region still has the highest rate in the world (United Nations 2011a). The maternal mortality ratio (MMR) is considerably high in sub-Saharan Africa. While the average of maternal deaths in South Asia, which has the highest MMR after sub-Saharan Africa, in 2008 were 323 deaths per 100,000 live births, it exceeded 500 deaths in Eastern and Middle Africa, with the highest rate being 629 deaths in Western Africa (Hogan et al. 2010).

In Sub-Saharan Africa, very little information has been available on cause-specific mortality. According to Rao et al.(Rao, Lopez and Hemed 2006), HIV/AIDS was the leading cause of deaths in 2000, followed by lower respiratory infection, malaria, and diarrhoeal diseases. AIDS cases started to be reported in the 1970s, although it was not known as AIDS until the 1980s. HIV has spread rapidly, mainly among heterosexual adults of reproductive age. HIV prevalence is highest in sub-Saharan Africa. In the whole region, prevalence reached 5.5 per cent in 2001, then declined to 4.7 per cent in 2009 (United Nations 2011a). However, the prevalence were still 40 per cent in many very high prevalence areas or heavily affected groups. Antiretroviral treatment (ART) has become dramatically available in the past ten years. Currently, more than one third of people living with advanced HIV are receiving antiretroviral therapy in sub-Saharan Africa (United Nations 2011a). While some southern countries have over 30 per cent HIV prevalence at national levels, the peak seems to have been reached in the early 2000s. The continuous provision of services and adherence to ART is challenging.

In 2009, life expectancy at birth was 53 years. Over the past 50 years, it has risen by only 12 years, whereas in other regions it has increased by over 20 years during the same period, reaching the same level as in Europe in 1950-55, which was 65 years (see Table1.1). The HIV/AIDS epidemic has been foremost in eroding the decades of progress in extending longevity. For example, life expectancy declined from 62 years in 1988 to 41 years in 2002 in Zimbabwe, and from 52 years in 1989 to 42 years in 2000 in Zambia (World Bank 2010). Due to the stabilisation of the epidemic, the expectancy increased to 45 years in both countries in 2009. The high fertility and short life expectancy keeps the African population young. The median age of populations is 18.6 year old (United Nations 2011b).

Migration

Compared with other regions, urbanisation in sub-Saharan Africa is low. In 1960, only 15 per cent of people lived in urban areas (see Table 1.1). Thirty-seven per cent currently live in urban areas, while 80 per cent live in urban areas in Latin America and the Caribbean region. Nonetheless, the rate of urbanisation is faster than other regions. There has been a 50 per cent increase over the past 30 years and it is projected that 50 per cent of the population will live in urban areas by around 2030 (UN-HABITAT 2010). It is important to note that about 72 per cent of the urban population in Africa live in slums (UN-HABITAT 2003). Furthermore, African urban population is projected to rise by 0.8 billion, to reach 1.2 billion in 2050, which will make the population the second largest, followed by Asia, due to the rapid natural population growth and rural-urban migration (UN-HABITAT 2010).

1.3.2. Economy

Despite possessing rich natural resources, the depth of poverty is greatest in sub-Saharan Africa. After independence, only a few countries enjoyed short-term prosperity and many countries faced economical and political challenges in the 1980s and 1990s. As shown in Table 1.1, the differences in GDP growth between regions are considerable. The GDP per capita increased by only 40 per cent in sub-Saharan Africa in the past half century, while in East Asia and the Pacific it increased by over five times in the same period. The contrast with South Asia is significant. The GDP per capita in South Asia was only 158 dollars, a third of that of sub-Saharan Africa in 1960, and subsequently it has increased rapidly by 4.5 times, exceeding sub-Saharan Africa. Furthermore, it declined in the 1990s, though economic growth has been observed in recent years. While the GDP per capita growth between 1990 and 1999 was 15 per cent; it was 54 per cent in between 2000 and 2008 (World Bank 2010). However, the gap within the region is large. The total GDP per capita of the richest 10 African countries is 25 times that of the poorest 10. Furthermore, it is worth noting that 65 per cent of the labour force is in agriculture (World Bank 2008).

The Human Development Index (HDI) is a comparable measure of socioeconomic status calculated from life expectancy, education and income indicator and ranging from 0 to 1. The index has been low in sub-Saharan Africa, and even declined in 2000. But it increased up to 0.38 in 2009. Other regions have experienced substantial increases in the past three decades and have typical values of 0.5-0.7.

1.3.3. Education

As shown in Table 1.1, the young adult literacy rate has increased by seven per cent between 1990 and 2009. Universal Primary Education (UPE) has been strongly implemented in the past two decades as one of the eight goals of the Millennium Development Goals (MDGs) (United Nations 2011a). Many African governments have made large increases in resources for primary education and the net enrolment to primary school sharply increased from 54 per cent in 1991 to 73 per cent in 2009 (United Nations 2011a). The gender gap is not traditionally strong, compared with South Asia. The literacy rate among women aged 15-24 increased faster than men, from 58 per cent in 1991 to 73 per cent in 2009 in sub-Saharan Africa (United Nations 2011a). However, drop-out from schools remains higher among girls. Only 79 girls to 100 boys enrol at secondary schools (United Nations 2011a). The gap has remained the same since 1990. But if focusing on children who have ever attended school, female children make great progress in recent years. Among children aged 13-15 who have attended school, more female enrolled secondary school than males in sub-Saharan Africa in 2000-2006 (Grant and Behrman 2010).

1.4. Population policies and family planning programmes

Population and high fertility has increasingly become an important item of the agenda in African nations in the past 20 years. Prior to the 1974 United Nations (UN) Population Conference held in Bucharest, population programmes suffered from weak governmental support and inadequate budgets, because Africa traditionally embraces a very strong pronatalist culture and there was clear resistance to family planning programmes (African Development Bank (AfDB) and African Development Fund 2000; United Nations Economic Commission for Africa 2001). There was also a view that economic development itself would reduce fertility. 'Development is the best contraceptive', the former minister of population in India stated at this conference.

WFS were conducted between the late 1970s and the early 1980s and produced reasonable demographic data for the first time, helping to form concrete population policies for African governments. Subsequently, DHS showed how family planning could improve women's health status. The information helped to convince many African governments to adopt a more positive attitude to family planning.

South Africa and Zimbabwe have a different history of family planning policy. The introduction of modern family planning services was much earlier than in other parts of Africa. Modern family planning was introduced for European settlers in 1953 in Zimbabwe, but it was not until 1965 that the Family Planning Association of Rhodesia was established under the Smith regime (Maggwa et al. 2001). However, the African population was not in favour of family planning, until independence in 1984 because they perceived family planning services as a strategy to control the size and movement of African population, compared with the white population. This perception was also shared in South Africa. Indeed, the family planning programme was explicitly designed in that way under Apartheid in South Africa (Chimere-Dan 1993). Nevertheless, contraceptive prevalence rates had reached 44 per cent among the African population in South Africa by the late 1980s under Apartheid (Kaufman 1998).

Kenya was the first sub-Saharan African country which established a national family planning programme in 1967. But the programme was not fully implemented and at the beginning there were no field workers or similar out-reach services. In 1974, still only one third of the government's facilities were offering family planning services (Freedman and Berelson 1976). In 1984 the government issued the National Population for Sustainable Development to implement the national population programmes, and the implementation was successful (Magadi et al. 2001). Similarly, most African governments established official policies to reduce fertility and population growth. By 1986 most sub-Saharan African countries had polices on contraceptive access by governmental direct support (United Nations 1998). But they did not receive international encouragement to implement them with conviction until the 1980s.

A more comprehensive concept of reproductive and sexual health and rights, and the empowerment of women were introduced. While these policies increasingly focused on the roles of women, youth and NGOs, and promoted family planning within a broader scope of sexual and reproductive health, concerns were raised concerning 'population control', practised in China and India during the period. At the 1994 International Conference on Population and Development (ICPD) in Cairo, an attempt was made to dismiss the notion of coercive family planning by promoting broader approaches to sexual and reproductive health and rights (Stephenson, Newman and Mayphew 2010). Nevertheless, family planning and population have become sensitive issues. Accompanied by the increased attention to and urgency of the HIV epidemic and MDGs, external funding for family planning decreased between the early 1990s and the early 2000s (Cleland et al. 2006b; Speidel et al. 2009; UNFPA, UNAIDS and NIDI 2005). The share that family planning received of funds for population health declined dramatically from 43 per cent in 1998 to 6 per cent in 2008. In contrast, the proportion of sexually transmitted diseases and HIV/AIDS activities reached 74 per cent in 2008 (UNFPA et al. 2005). Although the total expenditure from donors to population assistance has generally increased, it is still volatile and the amount has not returned to the level of 1998.

After a decade of neglect, population issues and family planning have once more gained attention. In 2007 universal access to reproductive health was added as Target 5b into the MDGs and contraceptive prevalence was adopted as an official MDG indicator to measure the progress. At the annual meeting of the UN Commission on Population and Development held in early April 2009, the UN and the international community pledged to increase efforts to address population and reproductive health in the developing countries (Guttmacher Institute 2009). African governments have increased resources for family planning (UNFPA et al. 2005) and increases in contraceptive prevalence have been observed in several countries in the past five years. For instance, Rwanda strengthened implementation of the family planning programme to reduce the rapid population growth. The 2010 Rwanda DHS preliminary report showed dramatic changes: the TFR declined from 6.1 in 2005 to 4.6 in 2010, and the modern contraceptive prevalence increased from 10 to 45 per cent in the same period (National Institute of Statistics of Rwanda (NISR), Ministry of Health and ICF Macro 2011).

1.5. Rationale

The rationales behind this study is that despite the growing concern about the slowing pace of fertility decline in sub-Saharan Africa, the methods used for assessing recent fertility trends in previous studies were overly simplistic and used without careful consideration of the nature and potential errors in the data. As discussed in detail in the next Chapter, the lack of data assessment and overly simple estimation methods may have produced misleading estimates of recent fertility levels and trends. There is a clear need for more robust methods.

After a decade of neglect, only in recent years has the population issue started to receive more attention due to the apparent stalling fertility declines, growing concerns about maternal health and climate changes. Therefore, it is a crucial moment for demographers to provide sufficient and accurate information on recent fertility trends to policy makers to help supply appropriate family planning services to the people most in need.

To fill the gap in research and meet the needs stated above, this PhD thesis re-assesses fertility trends in 17 sub-Saharan African countries over two decades. The use of a large volume of data permits the capture of similarities and differences in the population experiencing different rates of fertility decline. Few studies have attempted to validate the trend estimation with changes in proximate determinants of fertility with such a large volume of data.

1.6. Aims and objectives

The main aims of this PhD are to re-assess fertility trends in 17 sub-Saharan African countries over two decades; and investigate the extent to which changes in proximate determinants of fertility support the trend estimation. The specific objectives are:

(1) To assess age and date misreporting in DHS data (Chapter 4)

(2) To re-examine Kenya's fertility trends (Chapter 5)

(3) To re-examine fertility trends in 17 sub-Saharan African countries (Chapter 6)

(4) To review applicability of Bonggarts' framework to Africa (Chapter 7)

(5) To apply the formulation to explore the extent to which changes in proximate determinants support smoothed trends (Chapter 8)

This research will essentially provide not only a substantive contribution to the demographic literature in sub-Saharan Africa, but more specifically to the debate on the recent fertility changes in the region. It will also make a methodological contribution to trend estimation methods for fertility by introducing an innovative smoothing method. The results will be useful for policy makers, giving them access to more rigorous trend estimates, which may help in assessing the current levels and monitoring the progress of fertility decline.

1.7. Structure of thesis

This thesis aims to re-assesses fertility trends in 17 sub-Saharan African countries over two decades. Following this introduction, Chapter 2 reviews relevant literature regarding the explanations for persistently high African fertility, the recent studies on deceleration of fertility decline, and the aims and objectives of this PhD. Chapter 3 describes the data and an overview of the methodologies used for the analysis. Chapter 4 assesses the date and age misreporting in 63 DHS surveys from the 17 sub-Saharan African countries. Chapter 5 takes a closer look at fertility changes in Kenya, where stalling fertility decline is frequently reported, and examines several methods of estimating fertility trends. Chapter 6 applies the innovative trend estimation methods to the 17 countries and re-assesses fertility trends. Chapter 7 reviews Bonggarts' proximate determinants framework and discusses its applicability to the African context. In Chapter 8 the modified framework is applied to 17 countries, to assess whether the estimated fertility trends are supported by changes in the proximate determinants of fertility. The last chapter provides discussion and conclusions.

Chapter 2 :LITERATURE REVIEW

This chapter reviews the existing knowledge on persistent high fertility and the subsequent slow decline in Africa. The first section contrasts African fertility decline with declines in other developing countries, by reviewing the decades of debate over fertility theories. Subsequently, the distinct family organisation in Africa, with particular attention to kinship, is discussed extensively. Then, studies on recent deceleration of fertility declines are reviewed to identify research gaps.

2.1. Fertility changes in Africa and other developing countries

As described in Chapter 1, fertility transition in sub-Saharan Africa started later and has been of much slower pace than other less developed regions. It was not until the 1980s that the majority of sub-Saharan African countries initiated fertility decline. In contrast, Asia and Latin America began fertility transition in the 1950s or 1960s. As shown in Figure 2.1, fertility in these two regions has declined rapidly. The TFRs have declined by over three children for three or four decades. North African fertility was as high as seven in the 1960s, and the TFR has declined sharply to three by late in the first decade of the twenty-first century. Southern Africa depicted trends similar to Asia and Latin America. The TFR has declined since around 1965, having now reached 2.5 children per woman. Eastern, Western and Middle Africa, on the other hand, have shown different trajectories. Eastern and Western Africa exhibited the onset of decline in the 1980s, and Middle Africa has followed since the 1990s. The increases in TFR in Western and Middle Africa in the 1970s and 1980s respectively, resulted from reduction of secondary infertility caused by sexually transmitted diseases. In 2005-10, the average TFR in these regions remained at over 5 children per woman, while the rates were under three children in other regions.

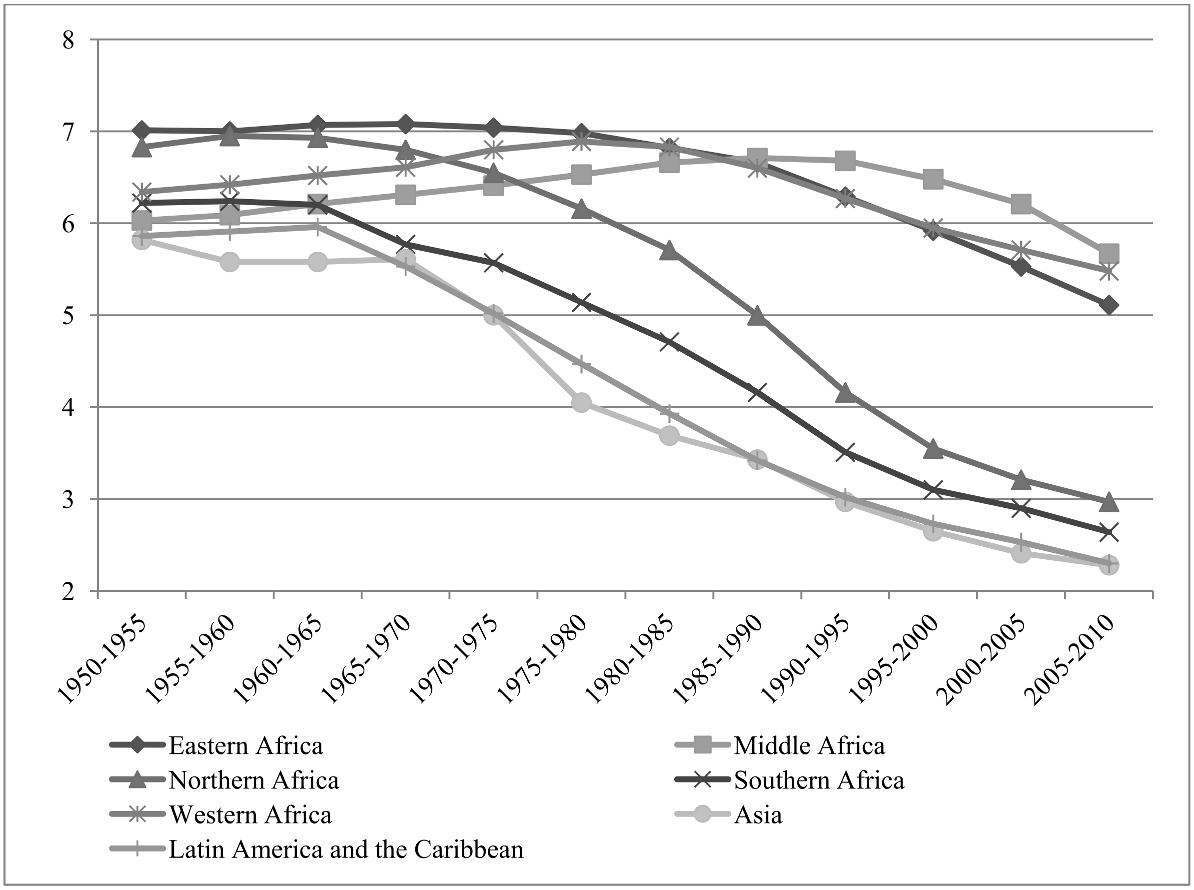

Figure 2.1: Total fertility rates in less developed regions, 1950-2010

Source: United Nations (2011)

One of the long-standing debates in the discipline of population studies is: why is fertility decline in sub-Saharan Africa later and slower? A vast body of literature has attempted to understand the extremely persistent high fertility in Africa. The first signs of fertility decline in Kenya, Botswana and Zimbabwe were found between the late1970s and the 1980s, but considerable scepticism was expressed due to doubts about data quality (Cleland 2001a). Debate had centred over the years on the difference in timing of the onset of decline and the factors which might trigger the onset. Regardless of decades of debate using historical data from Europe and contemporary data from developing countries, the explanation for fertility decline is still inconclusive. Although demographers have failed to explain differences in the timing of onset and pace of decline, we have observed onset of fertility transitions in most of the sub-Saharan African countries since the 1980s.

2.1.1. Economic approach

One of the explanations of Africa's late and slow transition is that socioeconomic development has been slow in sub-Saharan Africa. Several authors have demonstrated that socioeconomic development has an effect on fertility decline (Bongaarts and Watkins 1996; Bulatao and Lee 1983; Caldwell 2001; Coale 1973; Easterlin 1975; World Bank 1986). Compared with Asia and Latin America, African people, on average, have lower incomes, education and urbanisation. Most developing countries have enjoyed substantial economic growth and improvement in social development since the 1950s or 1960s. For instance, as shown in Table 1.1 in Chapter 1, South Asia, and the Middle East and North Africa have experienced more rapid development compared with sub-Saharan Africa. South Asia and sub-Saharan African regions had a TFR of over six children per woman in the 1960s with similar levels of infant mortality, life expectancy, urbanisation, literacy and gross domestic product (GDP) per capita. Life expectancy and infant mortality has improved dramatically in South Asia over the past three decades. On the other hand, the changes are much slower in Africa and the GDP declined during the 1990s (World Bank 2005). Within Africa, Botswana, Kenya and Zimbabwe had lower infant mortality rates, high levels of education and higher income. These are the countries which initiated fertility transition earlier than other countries. This fact may support the importance of socioeconomic development. Some claimed that structural adjustment triggered onset of fertility decline in several countries because couples were more aware of the cost of childrearing (Caldwell, Orubuloye and Caldwell 1992). These three countries were also less affected by the structural adjustment programmes (van de Walle and Foster 1990).

This economic view was at the core of the classical fertility transition theories. Notestein (1945) found that fertility decline in most European countries started in the late nineteenth century, followed by the industrial revolution occurring between the late nineteenth and early twentieth century. He has postulated that industrialisation, urbanisation and growth in income are the driving factors of demographic transitions (Notestein 1945; Notestein 1953).

Demand theories established by the behavioural economist Becker and others focused more on individual behaviour (Becker 1981; Pritchett 1994; Schultz 1961). Based on the principle of economics, households and families are considered to make rational decisions to maximise individual utility. As modernisation proceeds, income rises, more commodities become available, individual utility becomes more diverse, and the cost of childrearing, particularly the cost of education, increases. Couples assess the emotional gain and potential future return from childbearing and the opportunity costs – time and monetary costs for childbearing in the cost of potential income and consumption– and make rational decisions on whether and when they have a child. Moreover, Pritchett pointed out that contraceptive prevalence rates were not always correlated with TFR and asserted desired fertility as the most important factor (Pritchett 1994). He claimed that the effects of family planning policy were quantitatively small.

Caldwell has argued that the emergence of the concept of the smaller family and more investment in children, which he calls 'Westernisation', leads to a reversal of the net wealth flow from older to younger generations. In traditional societies, parents desire more children and make a rational decision to have more children to secure their future. The introduction of mass schooling and the labour market is linked with this social change. Parents invest more on children emotionally and materially, resulting in a reduction in the economic contribution from children. The direction of the net wealth flow is reversed: from parents to children. The diffusion of this realisation of cost of childrearing would start to erode traditional customs, leading to onset of fertility transition. Fertility transition is essentially a shift from traditional societies to modern societies (Caldwell 1982). The earlier paper postulated that there are only these two societies from the demographic point of view, and the transition occurs fairly quickly and analysis during the transition is of little importance since the destabilisation does not last long (Caldwell 1982).

However, his notion of dichotomy in societies may be too simplistic. As we have observed, fertility decline is slower than previously expected and now there is increasing concern that fertility may not converge at replacement level (Dorius 2008). Davis said that "'tradition' is merely a name for absence of change"(Davis 1963). The transitions are likely to have multi-phases. The observed fertility trends suggest that the transitions are slow and the notion of the dichotomy in societies does not help in understanding the slow fertility transition in Africa.

In fact, desired fertility in Africa has always been high. A recent study shows considerably high desired fertility in sub-Saharan Africa (Westoff 2010). In particular, desired fertility was the highest among married women in Chad, the Democratic Republic of Congo, Niger and Nigeria, at over 6.5 children. About 70 per cent of women in West and Eastern Africa who have four children still want to have more children. As discussed later in this chapter, this may be related to the dominance of lineage in reproductive decision-making. In contrast, women in Southern and Eastern Africa want an average of 4.5 children and an average of 42 per cent of women with four children want more. The desired fertility is much lower in countries in North Africa, Asia, Latin America and the Caribbean, ranging from two to four.

The demand theory corresponds with only one of three criteria of marital fertility decline suggested by Coale (1973). He claimed that marital fertility has to be "within the calculus of conscious choice" to start transition. In addition, two more conditions should be met for fertility decline. Effective techniques of family regulation must be known and available, and couples must perceive that a smaller family is advantageous. The demand theory focuses only on the third criterion and assumes that family regulation is available for couples with strong motives for smaller families. Furthermore, the theory also assumes that fertility falls only as a result of wide social and economic transformation.

2.1.2. Ideational /Diffusion models

Another widely credited explanation of high fertility in Africa is that its societies and cultures are diverse and not conducive to fertility decline across social groups compared with other regions. While the above economic approach had been widely accepted, the European Fertility Project led by Coale and others in Princeton University arrived at different conclusions. The verdict was that the sweeping socioeconomic approach is inclusive and insufficient. (Coale and Treadway 1986; Knodel and van de Walle 1979). The results concluded that socioeconomic factors were weak predictors of the onset of decline. Another important finding was that once a region had started into decline, the neighbouring regions with the same language or culture followed after short delays, regardless of the provincial level of development. The innovation – family limitation –

spread among regions, social groups or individuals. The onset of fertility decline in Europe occurred only between the late eighteenth and the early nineteenth century, while the levels of infant mortality rates, urbanisation and education were very diverse. The differences in timing of the onset of decline coincided with cultural settings, such as languages, receptivity towards family planning and women's status. The timing of transition was strongly linked with cultural boundaries and rapid decline was observed in culturally homogenous populations. The most notable example was found in the difference in the timing of the onset of decline between Walloon and Flemish populations in Belgium (Lesthaeghe 1978).

The economic approach does not provide a sufficient explanation of fertility decline in developing countries. Cleland and Wilson (1987) have argued further that family limitation is not a conscious decision in pre-transitional societies. Social customs, such as marriage and breastfeeding, regulate pre-transitional fertility. The populations where fertility decline is underway do not necessarily have a lower demand for children. Rather, their knowledge and motives have been translated to appropriate behaviour. Therefore, fertility decline requires drastic changes in both moral attitudes to, and knowledge of contraception. The rapid decline in Bangladesh is a good example. The TFR declined sharply from about seven children in the early 1970s to 3.4 children in 1993/4 in the absence of dramatic socioeconomic changes. The mean age at first marriage was still 16 years in the early 2000s (Macro International Inc. 2011), but the strong family planning policy and programmes resulted in high contraceptive prevalence compared to countries with the same level of socioeconomic development (Cleland et al. 1994).

Bongaarts and Watkins used TFR and HDI data from 68 developing countries and assessed causes of the onset and pace of fertility decline (Bongaarts and Watkins 1996). They suggested that socioeconomic development was an important factor, but it is insufficient to explain the variations in the timing of the onset of transitions or their speed. The findings identified the regional effects regardless of the level of HDI, and indicated the importance of social interaction or diffusion (Montgomery and Casterline 1996). Once a few advanced populations in a region have started fertility transition, fertility decline in the neighboring countries gradually begins, reducing the amount of socioeconomic change needed to trigger a transition. In other words, the threshold of socioeconomic indicators for the onset of fertility decline is reduced as the new idea diffuses. Later, Bongaarts suggested that fertility might be more responsive to socioeconomic changes in the middle stages of the transition than in the early stages (Bongaarts 2002b).

However, only limited data on the onset of decline in sub-Saharan Africa were available when Bongaarts and Watkins compared the timing of the onset in 1996. The level of life expectancy and gross primary school enrolment at the timing of the onset of decline seem to prove the shifting threshold model in sub-Saharan Africa (Bryant 2007). However, when TFR was modelled with a handful of socioeconomic indicators, sub-Saharan Africa was the only region where the actual fertility decline was slower than the predicted decline (Bryant 2007). The observed decline was faster than that predicted in Asia, Latin America and North and West Asia. The shifting threshold model across space, which Bongaarts et al. demonstrated, does not seem to be true with GDP per capita and other indicators.

Furthermore, Bulatao pointed out the weakness of the ideational approach. He argued that diffusion theory is not independent and appears to address only the process of fertility changes. The ideas which diffuse have to come from other explanations (Bulatao 2001). Diffusion is a process or pace of change, but it may neither determine the timing nor the direction of change (McNicoll 1980).

2.1.3. Combined approaches

As reviewed, neither the socioeconomic, the mortality, nor diffusion approach provide sufficient explanation of the slow fertility decline independently. More recently, Casterline and Cleland have reviewed the diffusion process of fertility and suggested that monocausal explanations should perhaps be abandoned and the 'blended theory' provide a plausible explanation (Casterline 2001a; Cleland 2001b).

An increasing number of demographers support the classic view that fertility decline is essentially a lagged response to mortality decline but that many other factors mediate this basic relationship (Cleland 2001a). Davis argued that demographic transition has a multiphasic feature. Regardless of level of development, a society will response to natural increase by one or more of three responses; migration, lower marriage rates or increased marital control of fertility (Davis 1963).

Mortality decline may be a driver of fertility transition and diffusion of innovation and new ideas accelerate the speed (Cleland 2001b). This blended notion revisits Coale's three conditions of fertility transition: (1) fertility must be within calculus of conscious choice; (2) effective techniques of fertility regulation must be known and available; and (3) lower fertility must be perceived to be advantageous (Coale 1973). Lesthaegue and Vanderhoeft (2001) have proposed a mathematical model to put this theory into operation. A similar approach was employed to assess the difference in contraceptive use in the early 1990s and early 2000s between Western and Eastern Africa (Cleland, Ndugwa and Zulu 2011). The findings showed that familiarity, readiness, willingness and ability to use contraceptives were still fairly low in the early 2000s in Western Africa. This indicates that knowledge, motive and ability to use contraceptives has not been translated to appropriate behaviour in Western Africa. The important conclusion is that all three conditions may need to change.

This notion of diffusion could be expanded to other reproductive behavioural changes, such as initiation of sexual activity, marriage, postpartum abstinence, breastfeeding and abortion. Socioeconomic factors exert effects on fertility only through changing the proximate determinants (Bongaarts 1978, 1982). As discussed further in Chapter 7, the effect of contraception on fertility in sub-Saharan Africa has been very small. This may be only because the prevalence has been too low to make an impact, although fertility is also regulated by other proximate determinants. There is abundant evidence that the effect of infertility and postpartum infecundability inhibit the fertility level to a greater extent in the region.

Although innovation often refers to contraceptive use in the debates, it is indeed the idea of 'family limitation' that was considered as innovation at the outset (Knodel and van de Walle 1979). Changes in reproductive behaviour apart from use of modern contraception may be not be 'unthinkable', but the change affects fertility. For instance, the practice of prolonged postpartum abstinence was at one time strictly practised by couples and observed by relatives. However, the practice has substantially eroded in the past decade. As the uptake and methods of contraception are likely to influence the pace of decline, changes in the other inhibiting factors of fertility may also have an effect. Few studies made a comprehensive assessment of the change in proximate determinants over decades (Anyara and Hinde 2006; Guengant and May 2001, 2009; Rutstein 2002).

2.2. Is African fertility different?

2.2.1. Family organisation in Africa and Eurasia

Apart from the lower level of socioeconomic development and higher desired fertility, one distinct characteristic of African societies compared with other regions is the dominance of lineage over the nuclear family. Prosperity and continuation of lineage is the core of African societies. Strong kinship bolsters high fertility through polygyny, fostering of children and an extensive production system (Caldwell et al. 1992; Goody 1977; Lesthaeghe 1989). A large family brings security with a labour force, current and future support, the safety of a community and wider networks through inter-marriage in Africa, where mortality and food availability is sometimes capricious. Children and land are often the only means of investment in the traditional societies.

As discussed earlier, Caldwell and others claimed that having a large family was a rational choice in pre-transitional societies (Becker 1981; Caldwell 1982). He argued that having many children was regarded as advantageous because net wealth flows from children to parents in pre-transitional agrarian societies (Caldwell 1982). A large family would be more likely to ensure food security, protection from outsiders and future support for parents than would a smaller family.

However, this widely believed notion is incorrect. A large household was not actually the norm in pre-transitional societies. It is shown that England and most parts of Northwest Europe had relatively small families in the pre-industrial period. The average size of a household was about five persons in English families before the early nineteenth century, in rural Denmark in 1787, and in Norway in 1801 (Hajnal 1982). It is often widely believed that the Asian regions used to have large families before the fertility transition.

However, the average size of household[3] was about five persons in Taiwan in 1915 and India in 1951 (Hajnal 1982). The first census in 1920 in Japan showed 54 per cent of households were nuclear families (Toda 1937).

While Hajnal assessed the similarity in size of household in pre-transitional Europe and Asia, he identified differences in family structure in the West and East: Northwest European families formed 'stem households' while Asian families created 'joint households'. In a stem family society, most of the people worked as servants in their adolescence, married later and acquired headship on marrying. On the other hand, in a joint household society, people married early, young married couples co-resided with the older persons (often with the husband's parent(s)), but the joint family would be split into two to three households (Hajnal 1982). Therefore, joint families were nuclear for some part of their life cycle. But this may have been less so in African systems (McNicoll and Cain 1989).

While Africa adopts joint family systems and practises ancestor veneration as in Asia, the mode of inheritance is at variance with the systems in Eurasian societies. Goody has argued that the mode of inheritance influences kinship, affinity, and interpersonal relationship in a household (Goody 1977). In Africa, inheritance is unilineal. Property is transferred between individuals of the same sex, from father to sons, and from a mother to daughters. Even in a matrilineal society, for example in Ghana, the eldest son is the heir of the maternal uncle. The children by any of the father's wives are also likely to be treated equally with regard to succession of property from the father. A male's property is transferred only to younger males in the same clan or lineage.

Africa used to have plenty of land and farming in Africa is extensive with the need for a greater labour force, unlike Europe and Asia where the land has to be farmed intensively and the ownership needs to be clear. Under the systems of communal property rights, land does not fall under the control of domestic groups in Africa. The corporate lineage group helps farmers help each other, shares the cost of childrearing, and sustains high fertility (McNicoll and Cain 1989). Until recently, there were no landlord-tenant

[3] As the majority of modern censuses use adopted, Hajnal defined household as 'a housekeeping or consumption unit'. They eat meals together or share means from a common stock of food. Servants in northwest Europe shared meals, thereby they are considered to be a member of a household.

relationships and self-employed agriculture is still common in Africa. Therefore, there was no way to materialise the property as an annuity, resulting in no formal hand-over , with the elderly remaining as heads of households for a long time. High mortality and shorter life expectancy has enabled to keep this system (Davis 1963).

In Europe and Asia, inheritance is bilateral and property is inherited by children of both sexes. In some societies, for example in Japan, only the first son used to have right of succession of property, therefore the property was not indivisible. A woman leaves her original family and enters her husband's family when she marries. There is little in the way of a relationship between a father and a mother's brother in this system. Furthermore, land is limited and intensively cultivated in Eurasia, restriction of entitlement as heir is of greater consequence.

It is important to note that fostering is common but adoption does not exist in Africa (Goody 1977). As mentioned earlier, children and cousins are fostered under lineage. But assistance is reciprocal, and fostering may work as a servant system. When a family want help, they need to marry and have children. In a traditional society, they do not hire a domestic servant from outside the lineage and there is no wage labour within the same lineage. Although polygyny is prevalent, any of the children can be an heir to the property of the older generation. On the other hand, adoption is commonly practised in Europe and Asia, in the event that a couple do not have a child. The couple adopt a child from a related or unrelated family, in order to secure an heir and restrict the inheritance of their property.

This different mode of inheritance influences marriage. Firstly, polygyny is prevalent in Africa and a 'co-wife' is often treated relatively equally. In Asia and Europe, polygyny is not as common as in Africa. The second wife is more likely to be regarded as a 'concubine', and her children are likely to be treated differently (Goody 1977). Secondly, conjugal couples are not common in Africa. A larger kin or lineage group maintains strong control over the demographic and economic behaviour of the individual members.

This form of reproductive decision-making system may be related to the exceptionally persistent and high desired fertility in sub-Saharan Africa. Some researchers have suggested that woman's empowerment is a key factor through which education influences fertility (Jejeebhoy 1995; Mason 1987). In Asia, it is suggested that the woman's greater power of household decision-making is associated with contraceptive use and birth intervals. However, greater power of household decision-making has not been as consistently associated with reproductive outcomes (Upadhyay and Karasek 2010). An African woman often has a separate budget from her husband to cater for children. However, reproductive decision-making may be largely influenced by the husband and his lineage. Although the measurement of empowerment needs careful assessment and this study looked at only four countries (Guinea, Mali, Namibia and Zambia), this might reflect differences in domains of a woman's empowerment between Asia and sub-Saharan Africa. This suggests that African women may not have autonomy over reproductive decision-making, though they have the power to make decisions over other household matters.

It is noteworthy that one study on women's empowerment has shown that only a minority of women in 12 sub-Saharan African countries (except Malawi) disagreed with any justification for their husbands' violence (Kishor and Subaiya 2008). Thirty five per cent of married women agreed that it was justifiable for a man to beat his wife when she refuses to have sex. In Mali, 76 per cent of women agreed with this reason.

This section has described the mode of inheritance and the dominance of lineage in African traditional society, which is different from those in Europe and Asia. While Africa and Asia both have a culture of joint family and ancestor veneration, the African family system is based on lineage. Inheritance of property would be left to any children in the same lineage. This system influences reproductive decision-making. Polygyny is common and conjugal ties are weak within couples. This dominance of lineage is not seen in Eurasia, and may well be a reason for the exceptional resistance to rapid fertility decline.

The arguments presented here are largely based on Goody's argument. However, caution is needed when engaging in broader generalisation, since his argument was mainly derived from his experiences in rural Western Africa (McNicoll and Cain 1989). In fact, he noted that household size is generally large in Western Africa and smaller in Eastern Africa, and polygyny in Eastern Africa is not as prevalent as Western Africa (Goody 1989). Furthermore, African societies have changed dramatically in the past decades, resulting in making them more diverse. The rapid urbanisation has made a great impact on the family system. Nevertheless, this review on the characteristics of African traditional family system, particularly the dominance of lineage over nuclear family, helps to understand the exceptionally high and slow fertility decline in sub-Saharan Africa.

2.2.2. Process of African fertility decline

I have argued that African fertility is resistant to decline. However, we have observed modest fertility decline in most parts of sub-Saharan Africa. This section reviews the process of African fertility decline.

Urbanisation may be a most important factor for African fertility, in addition to other social transformations (Goody 1989; Tabutin and Schoumaker 2004). Africa is the least urbanised region, but the pace of urbanisation is the fastest in the world. The gap between capital cities and rural areas within countries is large. There is substantially better access to education, health services and contraceptives in towns. It is evident that TFRs in capital cities are significantly lower than other parts of the countries. For instance, the TFR is 1.9 in Addis Ababa, 2.5 in Accra, Lomé, and Abidjan, and 2.8 in Nairobi according to the latest DHS surveys (Macro International Inc. 2011). Davis also suggested that rural-urban migration is one way to respond to high natural increase, apart from lower marriage rate and increased control of marital fertility (Davis 1963).

Caldwell pointed out changes in reproductive behaviour in Africa. He has posited that the contraceptive revolution does not necessarily occur at the same time as the demographic one. A high demand for contraception is observed among unmarried women and contraceptive use among married women is lower than among those who are unmarried (Caldwell 1982). Caldwell argued that the process of change in sub-Saharan Africa may be different from other countries (Caldwell et al. 1992). Strong resistance to limiting the numbers of children allowed birth spacing to become very widely used. He argues birth intervals would be extended and fertility declines in all age groups at the same time. Timæus and Moultrie have suggested that African women may postpone childbearng for indefinate periods, rather than either limitting or spacing (Timæus and Moultrie 2008). Therefore, the patterns of decline would differ from those in Europe and Asian countries that chose limiting behaviour and sharp decline in age-specific fertility rates at later ages (Knodel 1977).

However, fertility indeed declined among the younger age group in many Asian countries by postponement of marriage. The effects of late marriage were more significant in Asia than in Africa because premarital childbearing is rare. Along with the diffusion of parity-specific behaviour, fertility declined in young and older age groups in the region. Fertility transitions in Bangladesh and India appear to differ from other Asian transitions. Age at first marriage has not changed much and parity-specific behaviour of family limitation is significant, so that fertility drops sharply after first or second births.

Nevertheless, changes in reproductive behaviour in Africa seem at variance. In addition to higher contraceptive use among unmarried sexually active women than married women – however, the prevalence is still extremely low-, postpartum behaviour may be an important factor on fertility decline in Africa. As discussed extensively in Chapter 7, postpartum infecundability has largely regulated birth intervals in the region. Therefore, it is important to assess changes in this strong inhibiting factor as well as other proximate determinants of fertility to understand patterns and processes of African fertility decline.

2.3. Recent fertility decline between the late 1990s and 2000s

Regardless of the inconclusive explanations of persistent high fertility, most of the sub-Saharan African countries have initiated fertility transitions since the 1980s. It has been assumed that fertility decline would continue steadily up until replacement level, once transition is underway. The pace of decline was thought to be fairly quick (Bongaarts and Watkins 1996; Caldwell 1982) so the pace of fertility decline in the later stage of transition has not been much explored (Aminzade 1992; Bongaarts 2002a; Casterline 2001b).

However, Casterline (2001) found that the pace of decline observed between 1950 and 1990 in developing countries has varied greatly. The pace of decline in the first 10 years since the onset was fastest in the East Asian countries. The TFR fell by more than two-thirds during the first 25 years in East Asia and Singapore. In contrast, Guatemala and Papua New Guinea showed slower decline in early transition and had declined by less than 20 per cent in the first 25 years from onset.

It is commonly noted that decline increases its speed over time (Bongaarts and Watkins 1996; Kirk 1971, 1996). This appears to be confirmed by the fact that the speed of decline in developing countries is faster than that in historical Europe. However, it seems not to be the case in the later-starting transitions (Casterline 2001b). In the countries where transition commenced after 1970, fertility declined at a slower pace both in the first 10 and 25 years from onset. More noticeably, there was high variability in the pace across these late-starting countries. Sub-Saharan African countries are unmistakeably among the latter and the pace is markedly slower than elsewhere. Even the decline in Kenya in the 1980s and 1990s was not as rapid as in other regions. It is indeed no surprise to see a time-dependent process. The more receptive societies start transition and subsequently influence neighbouring areas. It may be noted that the later the onset, the slower the decline. The onset and pace of decline may have a negative association (Lesthaeghe and Wilson 1986).

These observations of slower decline in the region led to a concern over the shortcomings of the UN projection until the 2008 Revision (Bongaarts and Bulatao 2000; Casterline 2001b; Cleland et al. 2011). Although the UN provides three scenarios, the so-called high, medium and low variants, it does not provide data as to what extent each variant is more likely to occur (Raftery et al. 2009). Also the UN has neglected to illustrate the uncertainty surrounding the projections (Bongaarts and Bulatao 2000). A drawback of the projection methodology in the UN projection lies in the assumption that there would be constant rate of decline until TFR reached the replacement level. But on average, the pace of decline slowed down after mid-transition since 1970s. The method may not be sensitive enough to incorporate the slower decline or stalls (Bongaarts and Bulatao 2000; Casterline 2001b). Casterline asserted that the projected pace of decline in Africa should be regarded as 'for now as an open question' (Casterline 2001b).

The trend estimation and projection is not straightforward. The UN Population Division has published population estimation and projections in the past 50 years and data have been used as a primary source of demographic data in the world. However, the Population Division has faced challenges in the projection of future fertility due to the unexpected pace of fertility decline in the past (United Nations 2002). Several revisions have been made based on observed fertility trends. In the 1998 Revision, the projection was revised based on more rapid decline in developing countries and the increasing number of countries with lower fertility than previously expected. This revision projected that the world's population by 2050 would be 8.9 billion, 0.5 billion fewer than that in The 1996 Revision. This downward change was widely reported as indicating population growth was not as big an issue as expected (Bongaarts and Bulatao 2000). But the projection had to be upwardly revisited for The 2000 Revision because fertility decline in the countries in pre-transition or early transition were not as fast as previously projected.

In response to growing concerns over the accuracy of the estimation and projection and lack of confidence intervals, The World Population Prospects: The 2010 Revision has adopted a new method, resulting in revising not only the future projection but also some of the past estimates. The report placed emphasis on the premise that the world's population is contingent on the pace of fertility decline in high-fertility countries. Sub-Saharan Africa comprises two thirds of the high-fertility countries in the world. The TFR in sub-Saharan Africa is now projected to reach only 3.83 in 2025-30, instead of 3.40, which was expected in The 2008 Revision. For instance, Zambia's future projection has been largely revised. It is projected to see an increase in TFR from 6.10 to 6.30 between 2010-2020 in Zambia, based on the medium variant (United Nations 2011b).

The markedly slow pace of decline in sub-Saharan Africa has been increasingly studied over the past 10 years. Bongaarts suggested that the pace of decline decelerated in around the year 2000 in sub-Saharan Africa (Bongaarts 2006, 2008). Moreover, Bongaarts concluded that decline in fertility stalled in 12 sub-Saharan African countries in the midst of their transitions (Bongaarts 2008)[4]. Despite using the same data, i.e. DHS, other studies have arrived at different conclusions about the extent of the apparent stalls in fertility decline in Africa. Garenne found that fertility decline had stalled in six countries, while Schoumaker identified fertility stalls only in Kenya and possibly Rwanda (Garenne 2008; Schoumaker 2009). Westoff and Cross (2006) also provided evidence of stalling fertility decline in Kenya. Sneeringer (2009) assessed cohort fertility trends and reported that fertility transitions had slowed only in the Republic of the Congo (Brazzaville) and Madagascar. Table 2.1 summarises their results in the countries where national TFR published in the DHS STATcompiler did not show decline in recent inter-survey periods.

[4] Bongaarts defined a stall as no statistically significant decline in TFR between the two most recent surveys, using the TFR for the three years prior to each (Bongaarts 2008).

Although there is accumulating evidence of a slower pace of decline, the results are puzzling. It is clear that there is an urgent need for a robust accurate method of fertility trend estimation.

Table 2.1: Comparison of literature on stalling fertility

Country/Period	Bongaarts[2]	Garenne 2008	Schoumaker 2009	Sneeringer 2009[3]
Benin				
2001-06	Stall	Decline	Early transition	Decline
Cameroon				
1998-04	Stall	Decline	Decline	Decline
Ghana				
1998-03	Stall	Stall	Decline	Decline
2003-08	Decline	na[1]	na	na
Kenya				
1998-03	Stall	Stall	Stall	Decline
Nigeria				
1999-03	Stall	Stall	Early transition	Decline
2003-08		na	na	na
Rwanda				
2000-05	Stall	Stall	Stall[4]	Decline
2005-07/8	Decline	na	na	na
Tanzania				
1999-04	Stall	Stall	Decline	na
Uganda				
1995-00/1	Stall	Decline	Pre-transition	Decline
2000/1-06		na		
Zambia				
1996-01/2	Stall	Decline	Decline	Decline
2001/2-08		na	na	na

Note:
[1] na indicates that the latest DHS survey was not included when the study was conducted.
[2] The trends are determined using Bongaarts' method (Bongaarts 2008).
[3] Cohort fertility was used.
[4] Stall in Rwanda was less certain.

2.4. Explanations for pace of fertility decline

This unexpected trend led demographers to understand the mechanism of the deceleration of speed of decline in the middle of transitions. Bonggarts noted that 'conventional theories have little to say about the pace of fertility decline or the level at which fertility will stabilize at the end of the transition' (Bongaarts 2002a). But the explanations for pace of decline are essentially explanations of fertility decline. Each determinant and explanation of the onset of decline or variation in levels of fertility in general also affects the pace of decline. Although the findings on the mechanisms of the inconclusive trends are unlikely to provide plausible explanations, the following section reviews the findings.

Firstly, socioeconomic development is one of the primary determinants of fertility decline according to the conventional theories reviewed earlier (Bongaarts and Watkins 1996; Bulatao and Lee 1983; Caldwell 1982, 2001; Coale 1973; Easterlin 1975; Notestein 1953; World Bank 1986). As noted in Chapter 1, sub-Saharan Africa has experienced flagging economy while much of the world saw substantial economic growth in the past decades. In contrast, the GDP per capita in sub-Saharan Africa reduced in the 1990s (World Bank 2005). Furthermore, HIV/AIDS eroded the decades of progress in life expectancy and under-five mortality rates increased in East and Southern Africa (Hill et al. 2004). Poor economic performance and increased mortality may be behind the stalling of fertility. (Westoff and Cross 2006)

Secondly, the slow decline may be attributable in part to the lower priority assigned to family planning programmes in recent years (Blanc and Tsui 2005; Bongaarts 2008; Cleland et al. 2006b; Speidel et al. 2009; UNFPA et al. 2005). For instance, the USAID population funds rose sharply from US$250 million in 1993 to 550 million in 1995, and dropped sharply the next year. The budget remained at US$400 million until 2005 (Gillespie et al. 2009; Speidel et al. 2009). This change appears to have a greater effect in Kenya (Cleland et al. 2006b) and as a result, the proportion of women who received contraceptives from public health facilities reduced (National Coordinating Agency for Population and Development (Kenya) et al. 2004).

Bos and Bulatao examined the pace of fertility changes in five-year periods from 1950-55 to 1990-1995 (Bos and Bulatao 1990). Although various socioeconomic and reproductive indicators were examined, the factor strongly related to the pace of decline was the pace of change in the previous five-year period. This factor was more strongly associated with the current pace of decline than infant mortality, gross female secondary school enrolment, or urbanisation. These results are perhaps no surprise. But this reminds us that fertility changes are not likely to be abrupt and the pace of decline is a good predictor of projections for the future. This suggests that the past fertility estimation should be carefully examined if more accurate future projections are to be assured.

Fourth, some societies may be more conducive to rapid social changes due to differences in the distribution of paths of social interaction (Bongaarts and Watkins 1996). Fertility decline might proceed more rapidly in one region, due to a range of paths of social interaction between and within societies, regardless of levels of socioeconomic status. Retherford (1985) noted that ‘socially integrated’ societies are more likely to diffuse a new idea, so fertility decline would occur more rapidly. Good examples of rapid decline are the Asian countries, such as China, South Korea and Thailand. The governments strongly implemented the population policies and also the countries are relatively homogeneous (Bongaarts and Bulatao 2000). In contrast, weak ties may accelerate the decline. Granovetter (1973) suggests that weak ties provide a bridge between social groups, leading to the diffusion of decline. Sub-Saharan Africa contains social groups with strong ties, but there is large heterogeneity within the region. The diversity might make the diffusion difficult in the region.

2.5. Quality of demographic data in sub-Saharan Africa

One reason for the above contradictory results is failure of the analyses to take fully into account the quality of DHS data. While the MEASURE DHS project is acknowledged to exercise high standards in data collection, no survey is immune to error, and abundant evidence exists that such errors tend to be more pervasive in sub-Saharan Africa than elsewhere (Arnold 1990; Johnson et al. 2009; Rutstein and Bicego 1990). One of the most serious problems in using retrospective birth histories from cross-sectional household survey data to examine demographic trends is age displacement of children. In the DHS Woman’s Questionnaire, women are asked a range of questions on health related to each child born during a predetermined number of years prior to the survey (generally between

January of the fifth full calendar year and the month of interview). These questions are not asked about children born before the predetermined boundary date. As a result, interviewers could be motivated to transfer birth dates of children backwards across the boundary date in order to reduce their workloads by avoiding the extra questions. Whether or not interviewer-motivated bias is the cause, dates of births occurring 0-5 years preceding a survey do tend to be displaced backwards, leading to a deficit of births during this period and a surplus for six and more years prior to the survey. This pattern of age transfer will overstate the pace of recent fertility decline (Goldman, Rutstein and Singh 1985; Potter 1977). It is also of concern in studies of child mortality (Murray et al. 2007; Sullivan 2008). A related problem of lesser importance is downward age displacement of teenage women so that they become ineligible for interview. If one survey has more severe data errors and affect a TFR estimate than successive surveys, it may distort the direction of fertility trends, causing an erroneous impression of a fertility decline or stall. Thus it is important to assess data quality before estimating fertility trends.

A few studies developed methods to adjust for data errors and produced more reasonable trends, but the results appear rather sensitive to recent data and the methods involve an element of subjective judgement (Machiyama 2010; Schoumaker 2009). More robust methods are needed.

2.6. Methods of estimating fertility trends

There are many methods to examine the pace of fertility changes. Recent studies have extended more careful examinations. Garenne examined the trends in some detail and explored fertility change for over 60 years (Garenne 2008). Although using a more robust method by reconstructing birth histories, he did not acknowledge the data quality and discrepancies in the estimates from two successive surveys. Moreover, he pooled the data together and masked the differences (Garenne 2008). The results showed in the report appear to largely overlook the fertility changes.

On the other hand, Schoumaker recently undertook extensive assessments of data quality and this work greatly enhances our understanding of stalls in fertility (Schoumaker 2009, 2010, 2011). He identifies two types of data quality problems which affect fertility trends; omission and displacement of births, and different sampling implementation between surveys. Adjusted fertility estimates controlling for these errors were then obtained. He concluded that the claimed stalls in fertility were all spurious, except in Kenya and possibly Rwanda, which is a considerably different verdict from the results of prior studies[5]. Although his methods are very innovative and more rigorous than other studies, the errors and procedure to adjust for them seem to be based on an assumption that the estimate before the boundary year is accurate and subsequent low fertility is due mainly to omission of births (Schoumaker 2011). Thereby, he concluded that omission, rather than age displacement of children, was a main cause of underestimation, although he acknowledged that it was difficult to quantify. However, without more detailed analysis, it is not plausible to conclude that observed low fertility in 0-4 years prior to a survey is due only to omission and the trends before the boundary year is correct. When comparing the TFR for the same reference period from two successive surveys, the estimate from the more recent survey is usually higher than that from earlier surveys (Arnold 1990, Schoumaker 2011, Pullum 2006). It is not possible to determine which estimate is more accurate, or if both estimates have problems (Pullum 2006). In particular, when fertility in a period after a boundary year in the last survey is lower than the level during the period before the boundary year, it is difficult to determine whether the lower fertility is due to either omission, displacement of birth, a real fertility decline, or combination of these errors. There is no more recent survey for the last survey to assess the observed trends retrospectively. Therefore, the adjusted estimates after the boundary year in Schoumaker's analysis (2009, 2010) might be overestimated.

Furthermore, age displacement of children is essentially considered to occur only between the boundary year and a year before the boundary year, and omission of births after the boundary year is constant in his study. However, births are often inflated not only a year before the boundary but also distributed throughout 5-15 years preceding the survey (Blacker 2002; Potter 1977). Nevertheless, it is difficult to quantify age displacement for over 2 years and differentiate it from omission.

Given the inconsistent findings and the unclear mechanism of fertility stall, I hypothesize that the number of observed stalls may be overstated, due to lack of careful

[5] The paper presented at PAA 2010 shows more stalls. (Schoumaker 2010)

consideration of the quality and nature of DHS data. Most of the previous studies on recent fertility changes in Africa used rather simplistic approaches to estimating the pace of fertility decline and provided unconvincing results. These early studies often relied solely on selected average TFRs derived from DHS country reports or DHS STATcompiler (Bongaarts 2008; Shapiro and Gebreselassie 2008; Westoff and Cross 2006). These two average estimates of TFRs, approximately five years apart, were used to determine the pace of decline. This is an overly simplistic approach for examining fertility trends and can produce misleading trends. The use of the simple method of estimating fertility without consideration of data quality is likely to account for the different views on the countries which have stalled fertility decline. Although it is important to acknowledge stalls, it is crucial to make use of the available DHS micro-datasets and provide fertility estimates after careful consideration of DHS data quality, as well as a robust approach.

Chapter 3 : METHODS

This chapter presents the data and the methods that were used for undertaking the study presented in this thesis. The first section describes the data, Demographic and Health Surveys, from 17 sub-Saharan African countries. The second section provides analysis strategies. The methods used for the analyses in chapters 4 to 8 are provided in detail at the beginning of the relevant chapters.

3.1. Data

The data used for this study derives from 63 Demographic and Health Surveys (DHS) from 17 sub-Saharan African countries undertaken between 1986 and 2009 (see the list in Appendix 1). The countries were selected because they have conducted three and more DHS surveys, and allowed me to assess fertility trends for about two to three decades as well as to provide a greater opportunity to identify and adjust for errors than is possible when analysing data from only one or two surveys.

Overview

DHS are the most reliable and internationally-comparable nationally-representative data sources on population and health in sub-Saharan Africa. Followed by WFS and Contraceptive Prevalence Surveys, the DHS project started in 1984. The surveys obtain data on fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria and nutrition from developing countries. DHS data are the most widely used data related to population and health. The number of questions has significantly increased in recent years in response to the high demand for health-related data. Since 2001, population-level HIV testing has been added in most surveys in Africa. While worldwide, 84 countries have undertaken at least one survey, Africa is a majority. Surveys have been carried out in 43 African countries as of July 2011. In Africa, only seven per cent of the populations were living in the countries where 90 per cent of events (births or deaths) are registered in civil registrations and there has been no improvement since 1965 (Mahapatra et al. 2007). Therefore, the large coverage and extensive information at national level have made the data an essential source on population and health for the countries studied and major international organisations for policy making, monitoring and evaluation.

To examine the fertility trends over long periods, this study selected 63 DHS surveys in 17 sub-Saharan African countries with three or more DHS surveys by December 2010. These are Benin, Burkina Faso, Cameroon, Ghana, Kenya[6], Madagascar, Malawi, Mali[7], Namibia, Niger, Nigeria, Rwanda, Senegal Tanzania, Uganda[8], Zambia and Zimbabwe (see the map in Chapter 1). This represents about a third of the sub-Saharan African countries. The survey years range from 1987 (the first Senegal DHS) to 2008/9 (the fifth Kenya DHS). Focusing on countries with three and more surveys allowed me to assess fertility trends for about three decades as well as to provide a greater opportunity to identify and adjust for errors than is possible when analysing data from only one or two surveys. Uganda DHS 1988 is excluded from this analysis due to the limited geographical coverage. A full list of 63 surveys used for this analysis is presented in Appendix 1, with year and phase of survey, numbers of women and births, and boundary year for child health questions.

Survey Design and Data Collection

The data collection methods used in each of the surveys are standardised, though they are not exactly the same. The surveys are implemented by the respective governments with external technical and financial supports. The cross-sectional household-based surveys are designed to provide population and health data at national levels, using two-stage

[6] North-East province and 4 other northern districts were not covered in the first three surveys. To ensure comparability in the data for the entire period, they were excluded from the 2003 Kenya DHS dataset. As the district ID was not included in the 2008/09 Kenya DHS, only North-East province was excluded from this analysis.

[7] Mali DHS 1987 did not cover nomadic population in region of Gao, resulting in the coverage in rural areas was 90 per cent. But no adjustment was made for this analysis.

[8] To ensure the comparability, the current two western and four northern districts were excluded from the Uganda datasets.

sampling[9] (Macro International Inc. 1996). A national census is typically used as a sampling frame and provides enumeration areas which help to create primary sampling units (PSU). Based on probability proportional to size (PPS), PSUs are selected from the list of the enumeration areas. In the second stage, households are randomly selected with equal probability from each PSU. In several surveys, fewer households and clusters are sampled in areas with sparse populations. On the other hand, urban areas are oversampled to obtain enough cases for analysis. As a result, all samples except the ones from the 1988 and 1993 Ghana DHS and the 1986 and 1992/93 Senegal DHS were not self-weighting.

In a standard survey, data are collected by trained fieldworkers using Household and Woman's Questionnaires. The Household Questionnaire asks the background information on all household members to the heads of the selected households. The Woman's Questionnaire approached all women aged 15-49 in the households. All surveys sampled women aged 15-49 years old, with the exception of Nigeria 1991 which interviewed women aged 10-49 years. The numbers of women interviewed vary across surveys and time, generally between 4,000 and 8,000 women (see Appendix 1). In recent years, the sample sizes have increased to obtain representative data at regional levels. For instance, the latest Nigeria DHS contains over 33,000 women, four times as large as the first survey. Each dataset generally includes from 10,000 to 15,000 births depending on the number of women interviewed and the level of their fertility. Appendix 1 also presents the number of women interviewed and a total number of births. The quality of data used in this study will be discussed in detail in Chapter 4.

3.2 Methods

The main analytical methods used in this research include descriptive methods, (e.g. frequency, mean, median, percentage and cross-tabulations), various indices to measure date and age misreporting, principal component analysis (PCA), locally weighted scatterplot smoothing (Loess), multilevel Loess regression and Bongaarts' framework for the proximate determinants of fertility. STATA SE/10 and 11 were used for the entire analysis, except Loess regression which was analysed with R version 2.11.

[9] Only Mali DHS 1987 survey used three-stage stratified sampling.

Analysis Strategy

This research set out with the intention of extending Pullum's assessment of age and date misreporting in DHS data (2006) by focusing on sub-Saharan Africa. Age displacement of children and women, incompleteness of birth date reporting and digit preference in the 63 DHS surveys were assessed. The correlations between the misreporting were also explored and a Data Quality Index was developed using PCA to measure the level of overall data quality for each survey.

The main analysis is a re-estimation of fertility trends after allowing for the age and date misreporting and using a more robust estimation approach. Partial TFRs (15-39) by single calendar year for 10 years preceding each survey were obtained to depict the detailed fertility trends, and to identify age displacement of children as well as discrepancies in the estimates derived from successive surveys. Furthermore, this age displacement was adjusted using the method developed by Pullum.

Subsequently, the trends were modelled using the adjusted data points and Loess regression. I applied the method developed by Murray et al.(Murray et al. 2007) for child mortality estimation to fit Loess regression curves to the adjusted partial TFR data points. Loess is a widely used smoothing method, which produces a new smoothed value for each required time point by running a linear regression with the highest weight on data points close to the time point of interest and smaller weights for other data points according to their distance from the time point of interest. This procedure was repeated to obtain smoothed values for every year.

The second part of the analysis aims to explore the extent to which changes in proximate determinants support the Loess fertility trends obtained in the first part of the thesis. A range of cross-tabulations was performed to assess the recent reproductive behaviours in the countries studied. A modified Bongaarts framework of the proximate determinants of fertility was then applied. This is a multiplicative index, using a proportion of sexually active women, median duration of postpartum insusceptibility, contraceptive prevalence and infertility. The details of the respective methods are discussed in each chapter.

Chapter 4 : ASSESSMENT OF AGE AND DATE MISREPORTING

4.1. Introduction

At the end of the literature review in Chapter 2, I pointed out that data quality was not carefully assessed in earlier studies on recent fertility changes in Africa. Given the inconsistent findings and the unclear mechanism of fertility stall, I hypothesized that the number of observed stalls may be overstated, due to lack of careful consideration of the quality and nature of DHS data.

This chapter firstly assesses the level of age and date misreporting in 63 DHS surveys from 17 sub-Saharan African countries. The incompleteness and misreporting of women's and children's ages and dates of birth are observed using nine indicators. Furthermore, a data quality index is developed to attempt to summarise these indicators and give overall data quality. A part of the results will be used in Chapter 5, which further discusses the drawbacks in the current approach to estimating fertility trends.

Data quality of other variables, such as those used for the proximate determinants analysis, was not assessed in this thesis. As discussed in Chapter 7 and 8, there may be more errors and biases in these variables. However, the main aim of this thesis is to provide more accurate trend estimation of TFRs over two decades than previous studies. Because age and date misreporting directly affects TFR estimates, the assessment of the misreporting is essential for fertility trend estimation.

4.2. Literature Review

4.2.1. DHS data quality

Until the late 1960s, understanding of fertility trends in sub-Saharan Africa has been extremely limited due to paucity of the data. A few countries conducted censuses, but the collected data were often unreliable and inconsistent. The greatest challenge was that most adults were not able to report their age with accuracy. WFS provided reasonably accurate data for fertility estimation for Africa (Cohen 1993). DHS started in the early 1980s and the close assessment of the data reported that errors were the most severe in sub-Saharan Africa, among other regions, mainly due to misreporting of ages and omission or systematic transfer of vital events (IRD 1990a). Based on these findings, Cohen suggested that "a single point estimate of fertility from Africa should be interpreted with some caution" (Cohen 1993).

DHS has provided the most reliable information on national fertility in developing countries in the past 25 years. However, no survey is immune to errors. In the 1980s-1990s the quality of WFS and Phase I DHS surveys was carefully scrutinised and the errors occurring in this type of household survey were identified (Arnold 1990; Cleland and Scott 1987). Since then, every DHS survey report routinely has presented response rates, age distributions of household populations and eligible respondents, and numbers of live births by single calendar year in appendices to enable the readers to assess the quality of the data. Furthermore, DHS Methodological Reports carefully assessed the level of errors occurring in a number of DHS surveys. The potential errors were: misreporting of age and birthdates of women and children; displacement of birthdates and age of women and children; omission of births; incompleteness of reporting; and sampling errors (Arnold 1990). The response rates have been as high as over 95 per cent for the Household and Woman's Questionnaire (Macro International Inc. 2011). Most of the errors were more pervasive in sub-Saharan Africa than other parts of the developing world (Arnold 1990). More recent studies also noted that the data from sub-Saharan Africa still contained more evidence of age transfers (Johnson et al. 2009; Pullum 2006).

The quality of fertility measurement depends largely on age and date of birth reporting. In the DHS Household and Woman's Questionnaire, the respondent is asked to provide her birthdate (both year and month) and age in the current completed year. When she is not clear about the information, the interviewer is instructed to 'prove to try to estimate' it by relating the ages of other household members, or age at the birth of her first child or her marriage (ORC Macro 2006). Particular emphasis is placed on finding out the respondent's age. While there is a choice, 'don't know', for the question on month and year of the respondent's birth, the interviewer must complete the section on age in the questionnaire. Similarly, a respondent is asked to provide both year and month of all her live births, the current age of her live children and age at death of deceased children. When a respondent does not possess this information, the interviewer is directed to make a best estimate of the birth year by comparing with that of other children, as well as the birth month, by relating an important event, such as Christmas, Easter or the weather at the time of year. The interviewer is reminded to ensure that date is entered for the birth year of all live births, ages of living children and age at death of deceased children in the questionnaires. This is emphasised in every phase of DHS surveys. The phrases of the questions on age and date reporting and the instructions in the interviewer's manual have not changed since DHS-I (IRD 1987, 1990b; Macro International Inc. 1997; ORC Macro 2002, 2006). Given that an appreciable number of women do not have a clear idea about their age and date of birth and there is little improvement in civil and vital registrations, which could be used to verify the collected data, the interviewers and respondents may often be forced to hazard a guess in reporting ages and birthdates in sub-Saharan Africa. These estimates are likely to be biased (Arnold 1990). It is more evident in the countries where the level of women's education is low (Arnold 1990; Pullum 2006). Given the relatively small proportion of educated women, sub-Saharan Africa is more prone to age and date misreporting, resulting in effects on fertility measures.

Among the several types of errors, age displacement of children remains a most serious problem when examining demographic trends (Pullum 2006; Sullivan 2008). If a woman has a child born during a predetermined number of years prior to the survey, she will be asked a range of questions on child health, such as antenatal care during pregnancy, breastfeeding practice, children's immunisation and nutritional status. It is reasonable to consider that interviewers could be motivated to transfer dates of childbirths backwards in order to avoid the additional questions and reduce their workloads. This displacement is likely to occur when a respondent is not able to provide the exact year of a child's birth, and either the respondent or the interviewer has to estimate dates of birth (Arnold 1990). While a mother may have a tendency to round up the ages of children who are approximately 0-4 years to 5 years, it is more likely that age displacement of children would occur on the part of an interviewer, who has learned that the transfer would reduce his or her workload. The boundary point for eligibility generally falls in January of the fifth or sixth full calendar year prior to the year the interview started. In other words, births occurring 0-5 years before a survey tend to be pushed backwards, resulting in an underestimation of births during the period and overestimation in the six and more years before the survey.

This transfer has long been known to affect demographic measures and has sometimes exaggerated the speed of fertility decline (Goldman et al. 1985; Potter 1977). DHS reports usually provide an average of TFRs during the three years before a survey to avoid this underestimation in the boundary year (Rutstein and Rojas 2006). However, there may be an underestimation in the number of children throughout the 5-year period after the boundary year and transference to earlier dates. Moreover, if one survey has a more severe underestimation of TFR, it may distort the direction of fertility trends, causing an erroneous impression of a fertility decline or stall. Concern about the length of the questionnaire, which may have adverse effects on data quality, has been increasing in recent years (Murray et al. 2007). While the effects of this error on the estimation of fertility trends in sub-Saharan Africa has not been widely assessed, the methods for child mortality estimation have been more advanced and the concern about displacement is growing in this area. Several recent studies have revealed that omissions and severe displacement of births, especially among deceased children, have adversely affected child mortality estimation (Johnson, Rutstein and Govindasamy 2005; Sullivan 2008). Because child mortality rates are often averaged for the five-year period preceding a survey, the rates are more likely to be affected by the error than TFR estimates. For instance, child mortality in Ghana was considered to have stalled between two DHS surveys in 1998 and 2003. Further investigation concluded that it was a spurious stall due to omission and age displacement of deceased children in the 1998 survey (Johnson et al. 2005).

With the same motivation, age displacement also occurs among household members. Women's age displacement may be caused by interviewers' systematic misreporting of women's ages as outside the eligible range of 15-49, in order to reduce their workloads. In most countries, upward transfer of women's age is more prevalent. The possible reasons for this upward transfer are: (1) lower educational level among older women; (2) relative difficulty in estimating the age of older women than younger women; and (3) motivation for interviewers to reduce their workloads by avoiding older women, who have long birth histories (Pullum 2006). There is also the possibility that women consciously round their ages up or down. For example, rounding up the age 45-49 to 50-54 is common. Unusually, rounding up the age 10-14 to 15 years among the girls who were interviewed by male interviewer were found in the 2005 Senegal DHS (Johnson et al. 2009). The study has explored risk factors of age displacement of women and has reported differentials in the levels of upward and downward age displacement of women by sex of interviewers and when the language of the questionnaire differed from the language of interviewers, but the directions of the errors were varied (Johnson et al. 2009).

Another error, if extensive, will affect fertility trends is omission of live births (Arnold 1990, Pullum 2006, Schoumaker 2009, 2010, 2010). Omission is more likely to occur to older women with high parity. Omission may be more widespread in Africa partly because women are less educated. Deceased children are likely to be omitted (Sullivan 2008). Due to high child mortality, there may be more omission in sub-Saharan Africa. While respondents may not report deceased children, especially neonatal death, the interviewers may be reluctant to ask number of questions about deceased children to the women (Sullivan 2008). Omission may occur with the same reasons for age displacement of births by interviewers. Furthermore, the design of the Questionnaire (length of the reference period) and length of Questionnaire may be associated with omission (Schoumaker 2011). The 1999 Nigeria DHS is considered to have severe omission. However, the severe underestimation found in the Nigeria Survey is not common. It is usually difficult to differentiate omission from age displacement of births (Pullum 2006; Schoumaker 2011).

As reviewed so far, it is clear that assessment of DHS data quality is crucial for re-examination of recent fertility trends in sub-Saharan Africa.

4.3. Methods

4.3.1. Data

This assessment used the Individual (women), Birth and Household Member datasets from 63 DHS surveys in the 17 sub-Saharan African countries. The list of the surveys used can be found in Appendix 1.

4.3.2. Analysis

This chapter extends the work published as DHS Methodological Report 5 on assessment of age and date misreporting (Pullum 2006), by adding more recent datasets published by December 2010 and presenting all the indicators of age and date misreporting by country by survey. The indicators measure: incompleteness of birthdates of women and children; women's digit preference in age; and age displacement of women and children. Furthermore, correlations between indicators were also explored and thereafter a data quality index was developed using principal component analysis (PCA) to measure overall data quality for each survey. Some parts of the results have been published as a DHS Working Paper, which focused on nine sub-Saharan Africa countries (Machiyama 2010).

4.3.2.1. Incompleteness of birthdates

Proportions of women and children who possess the essential information on date and age were obtained. These helped to give an idea of the amount of imputation needed at data processing. In a DHS survey, women are asked to provide three pieces of information regarding ages and birthdates of themselves and all their live births: current age in completed year; the year; and the month of birthdate. In cases where the information is not provided or inconsistent, the data would be imputed at the stage of data processing. Individual and Birth datasets include a variable to indicate whether a respondent provides the three pieces of information, or whether imputation is needed. Proportions of those without all the information among women aged 15-49 and births aged 0-15 years were obtained, because births which occurred for 10 years prior to each survey were used for the analysis, which estimates TFRs by single calendar year.

4.3.2.2. Digit preference

While the previous indicator measures completeness of the data, digit preference in women's ages is indicative of inaccurate reporting. Incorrect age reporting may affect age-specific fertility rates. There is often a tendency to round down or up to another age ending in 0 or 5. Myers' Index is a commonly used method to measure digit preference in age reporting. This index produces deviation of the proportion of the total population reporting ages with a given terminal digit, from 10 per cent, and the index is half the sum of the deviations from 10 per cent. For this analysis, Myers' blended Index, which adjusts for the fact that there are more people age at x than $x+1$ due to births and deaths, was used (Myers 1940; Siegel and Swanson 2004). Based on the formulae, a STATA command 'myers' developed by Pullum and Rodríguez was used to compute values of the Index for each survey (Rodríguez 2006) . The higher the value, the greater the dissimilarity. This analysis focused on digit preference in the age interval 15-44, to have all end digits (0-9) equally represented.

4.3.2.3. Age displacement of women

Age displacement refers to the systematic transfer of respondents and children across an age boundary for eligibility for specific survey questions. The eligibility for the Woman's Questionnaire is to be aged between 15 and 49. Therefore, age transfer of women occurs by misreporting the age of eligible women as either under 15 years or over 49 years. *De facto* female residents, i.e. women who stayed last night in the selected households are eligible for interview. To measure the systematic age transfer of women across the boundary for eligibility (age 15-49) for the Woman's Questionnaire, an age ratio is widely used (Arnold and Blanc 1990; Rutstein and Bicego 1990). This method takes three age intervals to obtain two ratios of the reported number of women in that age interval to the number of women in the preceding intervals. When examining downward displacement of women, a ratio of the number of women aged 5-9 to the frequency of women aged 10-14, and a ratio of age 10-14 to age 15-19 are obtained, and relative levels of the displacement are compared.

Based on this conventional method, Pullum reformulated the age ratio, to make it interpretable, and to estimate the number and proportions of women transferred, using individual-level data (Pullum 2006). Pullum has displayed the following table for illustration of his method.

Age interval	Observed frequency	Fitted frequency
5-9	*a*	*a*

10-14	b	$\hat{b}$
15-19	c	$\hat{c}$
20-24	d	d

For downward displacement, using frequencies of women aged 5-9 (a), 10-14 (b), 15-19 (c), and 20-24 (d), he models the expected numbers of women aged 10-14 ($\hat{b}$) and 15-19 ($\hat{c}$). This model requires two assumptions. Firstly, this method assumes that the displacement occurs only between the two 5-year age group intervals across the boundary and the sum of the second (b) and third (c) frequencies is correct ($\hat{b} + \hat{c} = b + c$). Another requirement is that fitted age ratios, $d/\hat{c}$, $\hat{c}/\hat{b}$, $\hat{b}/a$ are linear on a log scale. Considering changes in both cohort size and mortality, the second assumption seems plausible and was validated (Pullum 2006). Under these assumptions, Pullum made the following equation to estimate the number of women transferred.

$$\ln(\hat{b}/\hat{a}) = \alpha,\ \ln(\hat{c}/\hat{b}) = \alpha + \beta,\ \ln(\hat{d}/\hat{c}) = \alpha + 2\beta$$

The sum of the above equation gives

$$\ln(\hat{b}/\hat{a}) + \ln(\hat{c}/\hat{b}) + \ln(\hat{d}/\hat{c})\ \ln = 3(\alpha + \beta),\text{ or } \ln(\hat{d}/\hat{a}) = 3\ln(\hat{c}/\hat{b}),\text{ or } \hat{c}/\hat{b} = (\hat{d}/\hat{a})^{1/3}$$

This leads to

$$\hat{c} = (\hat{b}+\hat{c})\frac{(\hat{d}/\hat{a})^{\frac{1}{3}}}{1+(\hat{d}/\hat{a})^{\frac{1}{3}}}$$

After computing the expected frequencies, the proportion of women transferred can be estimated by an equation $(\hat{c} - c)/\hat{c} = 1 - c/\hat{c}$. It is also applied to estimation of $\hat{b}$. This is an extremely useful method and is also used to adjust for the displacement to re-examine fertility trends.

4.3.2.4. Age displacement of children

The same method as for age displacement of women was applied for age displacement of children. Instead of using a five-year age group, two single calendar years before and the boundary, that is four years in total, were used to estimate the expected number of children in a year prior to the boundary year and in the boundary year. For instance, in the survey in 1993 in Ghana, the boundary month was January 1990. That is, the women were asked various questions on health related to each child born between January 1990 and the interview date. The numbers of births in 1988, 1989, 1990 and 1991 were used to estimate the expected proportion of children born in 1989 and 1990 when there was no displacement. The two assumptions seem plausible for age transfer of children, because numbers of children in a calendar year should be generally constant, i.e. the ratio should be 1, or change linearly on log scale. The limitation of this method is that displacement across more than two years was not able to be assessed.

4.3.2.5. Omission of live births

There are several ways to assess omission. Two indicators were obtained in this chapter: ratio of neonatal deaths (NN) to infant deaths (INF) and sex ratio at birth. These measures were used to assess omission in DHS data (Johnson et al. 2005; Sullivan, Bicego and Rustein 1990).

The first 28 days of life is at highest risk of dying. As overall mortality improves, the ratio of neonatal deaths to infant deaths will increase. If a ratio for a given survey is substantially deviated from the other ratios in successive surveys, this may indicate omission of deceased children in the survey. If a ratio is lower than the others, there may be omission of neonatal deaths. On the other hand, if a ratio is higher than the other ratios in successive surveys in the same country, there may be omission of postnatal deaths or simply due to improvement of postnatal mortality.

Sex ratio at birth is an indicator of omission of births in one gender. Normally this kind of omission is observed in societies that devalue one gender or the other. The ratio is usually between 105 and 106 boys to 100 girls, ranging from 103 to 107 (Johansson and

Nygren 1991, James 1987). Ratios significantly above or below this range are suggestive of omissions in the absence of sex-specific abortion, which is thought to be low in Africa.

However, omission is difficult to measure. The first ratio assesses only relative deficit of live birth only among deceased children across surveys in a country. If the extent of omission of dead children is constant across surveys, the ratios will not capture omission. Moreover, as these are relative indicators, they will not be able to be included into calculation of the data quality index.

4.3.2.6. Correlations of the errors and data quality index

Eight indicators were obtained to measure age and date misreporting for each survey. Due to the number of the indicators, it is not easy to capture the overall levels of data quality by survey or by country, or to compare the overall level of data quality of one survey with another.

First of all, correlations of the indicators were obtained to assess whether one indicator might be indicative to the overall data quality and how the data errors correlated with each other. Subsequently, PCA was performed to summarise the indicators of age and date misreporting. PCA is a widely used variable reduction procedure, used especially when some variables are correlated with one another, or when the distribution of variables varies across cases (Jolliffe 2005). This multivariate analysis produces factor coefficient scores (factor loadings or weights). Let X_1- X_8 be the observed six indices, the model is described as below.

$$\text{PC}m = a_{m1}X_1 + a_{m2}X_2 + a_{m2}X_2 + a_{m3}X_3 + a_{m4}X_4 + a_{m5}X_5 + a_{m6}X_6 + a_{m7}X_7 + a_{m8}X_8$$

where a_m indicates the weight (factor score) for the mth principal component.

Absolute values of the indicators were used for the PCA models since the negative values of the measures merely indicate the opposite direction of the errors, rather than improving data quality. Furthermore, omission indicators were not able to be included into PCA. Although omission is an important error, the two indicators were relative measures and do not directly quantify the extent of omission. There may be a way to use a model life table, but conventional model life tables do not usually have information of neonatal mortality. A ratio of infant deaths to under-five child deaths may be an alternative. However, under-five mortality is often affected by another error, age displacement of children. Therefore, use of under-five mortality for measurement of omission is not appropriate.

Sex ratio at birth is about 105 girls to 100 boys, between 103 and 107, in most populations. However, some suggested that there is heterogeneity across populations (James 1987, Garenne 2009). Thus, it is perhaps not reasonable to determine a threshold as a normal range of sex ratios and construct an index.

The first principal component (PC1) is an index of those indicators with the largest amount of information common to all variables and explains the largest variation of the indicators. The second component (PC2) is independent from the first component, and explains additional but smaller amounts of variation than the PC1. Subsequently, orthogonal and oblique rations of the factors were performed to help interpretation of the components. When components scores are correlated, oblique rotation should be explored as orthogonal rotation relies on the assumption that components are completely independent, which is often considered somewhat artificial. After the errors were standardised, the indicator values were multiplied by the scores (*a*) and totalled to produce a data quality index value for each survey.

A positive data quality index score is associated with a higher level of errors, and the smaller the values (including negative values) the higher the level of data quality. Since five surveys in DHS-I do not have household member datasets and age displacement of women cannot be obtained, the surveys were excluded from this analysis. The 1999 Nigeria DHS was also excluded, because the eligibility of women for the Woman's Questionnaire was age 10-49 years, which created significantly high level of data errors.

STATA SE/10 and 11 were used for the analysis in this Chapter.

4.4. Results

4.4.1. Age and date misreporting

The results shown in Table 4.1 suggest that the levels of errors varied markedly by survey and by country. The minus sign of the indicators merely refer to the opposite direction of the errors, rather than the level of the data quality. A negative value of downward age displacement of women suggests that the number of women aged 15-19 is higher than the frequency of women aged 10-14, whereas the expected displacement occurs from age group 15-19 to outside of the eligible age group, i.e. 10-14 age group. If age displacement of children is less than zero, the measure indicates that there are more children in the year of boundary than one year before the boundary.

The proportion of women who did not provide the set of information on their birthdates (age in completed year, year and month of birth) varies substantially by sub-region. While in Western Africa, the level of data incompleteness was high, Namibia, Zambia and Zimbabwe had less than 10 per cent in the latest surveys. It ranged from 0.5 per cent in the 2006/7 Namibia DHS to 94 per cent in the 1987 Mali DHS. In general, this error has decreased significantly over the years in all the countries. Since incomplete information is associated with the level of a woman's educational attainment, the observed improvement is more likely due to the recent advancement in women's education (Arnold and Blanc 1990; Pullum 2006). Nonetheless, the proportions of incomplete data in Benin, Burkina Faso, Mali and Niger still exceeded 60 per cent in the most recent surveys.

Children's birthdates were substantially better reported than women's birthdates. Although in the past, over 40 per cent of birthdates were incomplete in Benin, Burkina Faso, Mali, Niger and Senegal, the quality has dramatically improved in all countries. In the latest surveys, most of the countries were less than 10 per cent incomplete.

One might expect that digit preference in women's age reporting would have also improved as more women provided complete information on their ages and birthdates. However, noticeable increases were found in eight countries: Benin, Ghana, Malawi, Mali, Niger, Nigeria, Senegal, Tanzania and Zimbabwe. The 2006 Benin DHS shows strong digit preference ending in 0 or 5, resulting from a serious deficit of women aged 15-24 (INSAE and Macro International Inc. 2007). The Myers' Index exceeded 10 in the latest surveys in Benin, Mali, Niger, Nigeria, The results indicate that the improvement in completeness of age and birthdate reporting does not necessarily imply enhancement of accurate reporting.

Age displacement of women was shown to be more severe in the highest age group than the youngest group, as suggested by earlier studies (Arnold and Blanc 1990; Pullum 2006). The error has generally decreased in recent surveys, while Benin, Malawi, Niger and Rwanda have worsened in both upward and downward age displacement. The latest surveys in Ghana, Kenya, Nigeria, Tanzania, Uganda and Zambia suffered from more downward displacement of women than the preceding surveys. This might be because more girls aged 15-19 were in school when the interviewers visited selected households than in the past. Upward displacement was generally more severe than downward displacement. While this error has improved in most of the countries, Benin, Cameroon, Niger and Rwanda have more upward displacement than the previous surveys, which would affect TFRs by excluding some women aged 45-49 who had higher parity. However, only downward displacement was adjusted for partial TFRs and is presented in the next chapter, because partial TFRs (15-39) were computed to ensure comparability over time.

An unusual upward transfer from 10-14 age group to 15-19 was observed in the 1999 Nigeria survey. This shift is likely to be false, because there was actually a large transfer of girls aged 10-14 to those aged 5-9, resulting from the fact that the eligibility for this survey was women aged 10-49 (Pullum 2006).

The level of age displacement of all children has not shown steady improvement over the years. In the survey of Niger 2006, Mali 2006, Ghana 1993, Madagascar 2008/09, Malawi 2000, Madagascar 2004 and Burkina Faso 1993, approximately 20 per cent of all children born in the predetermined time frame of the survey were misreported to be born a year before the boundary year. For instance, the 2006 Niger DHS, for instance, had the largest age displacement across the boundary year. It is estimated that figures for 26 per cent of the children were pushed back, indicating that they were born a year before the boundary year. This is not a negligible level and it is crucially important to take it into account when estimating fertility trends.

A number of surveys contained more than 30 per cent displacement of deceased children (Benin 2006, Ghana 2003, Kenya 1989 and 2008/9, Malawi 2000, Mali 2006, Namibia 2007, Niger 2006, Nigeria 1990, Rwanda 2000, and Tanzania 1991 and 2004). This confirms the findings that displacement of deceased children was considerably higher than that of live or all children (Sullivan 2008). Consequently, it may have led to a large overestimation of the decline in child mortality in recent years.

The latest surveys in Rwanda and Zambia presented a noticeable shift of births in different directions and with negative values. The boundary month for both surveys was January 2002 and the numbers of live births showed spikes in 2000, probably because of a preference for the year before the new century. Consequently, the number of births in 2001 was much lower than in 2000 and 2002, which is likely to be a reason for the unusual direction of age displacement of children in these countries. Surges in the number of births in 2000 were also found in Kenya, Madagascar and Nigeria, as depicted in Chapter 6.

It is noteworthy that large displacement was found in several surveys in phase 5, conducted between 2003 and 2009. In the questionnaire for this phase of the DHS surveys, the number of questions on pregnancy, postnatal care and breastfeeding increased from 53 to 71, and 37 new questions were added in the section on immunisation, health and nutrition (Macro International Inc. 2008; ORC Macro 2001). As suggested by Sullivan, interviewers might be reluctant to ask the long list of the health questions, particularly about deceased children (Sullivan 2008).

Omission was assessed by the two indicators shown in Table 4.1. The ratios of neonatal deaths to total infant deaths (NN: INF) have generally increased over years in most of the countries, as expected if mortality is falling. However, the ratio of neonatal deaths to infant deaths plunged in 1998 in Ghana, in 2003 in Cameroon, in 1996 in Zambia. As extensively assessed (Johnson et al. 2005), the lower ratios in the 1998 Ghana DHS survey suggest that there were fewer neonatal deaths, implying omission of neonatal deaths. The similar results were found in other surveys (Cameroon DHS 2004, Kenya DHS 1998, Mali DHS 2006, Rwanda DHS 2000, Tanzania DHS 1996 and Zambia DHS 1996).

The 2008/9 Kenya DHS showed the ratio of neonatal deaths to infant deaths substantially increased from 0.47 to 0.61. While this may indicate an increase of overall neonatal deaths, this might suggest that there may be omission of postnatal deaths. The 2004/5 Tanzania DHS and the 2007 Zambia surveys appear to have similar trends. Furthermore, the ratios of neonatal deaths to infant deaths were generally low in Burkina Faso, Niger, Uganda and Zambia.

As mentioned earlier, the limitation of the ratio is that the indicator does not capture omission when live children are equally omitted. For instance, it is considered that there was severe omission of live births in the 1999 Nigeria DHS surveys. But the ratio presented in Table 4.1 did not capture the omissions.

The sex ratio at birth ranged from 94.7 in the 1992 Senegal DHS to 108.5 in the 1992 Niger DHS. In seven surveys (Cameroon 1998, Ghana 1998, Madagascar 2004, Namibia 1992, Senegal 1992/3, Uganda 1995 and Zambia 1996), the sex ratios were under 98.0. This might reflect omission of dead boys.

Table 4.1: Age and date misreporting in 17 sub-Saharan African countries

			Incompleteness of birthdates		Digit preference in women's age	Age displacement					Ratio of neonatal (NN) deaths to infant deaths (INF)	Sex ratio	Data Quality Index	
						Estimated % of women displaced		Estimated % of births in boundary year misreported in preceding year						
Country	Year of Survey	Phase	Women's birth dates(%)	Children's birth dates(%)	Myers' blended Index	Women 15-19	Women 45-49	Alive children	Dead children	All children			Scores constructed from PC1	Scores constructed from PC2
Benin	1996	3	78.3	41.5	5.9	11.2	6.6	1.7	11.3	3.4	0.44	101.0	2.05	-1.10
Benin	2001	4	73.2	39	14.2	7.7	12.6	6.7	21.7	9.3	0.46	101.2	2.83	-0.21
Benin	2006	5	62.6	13.5	17.8	13.7	15.6	17.3	30.2	19.1	0.50	101.6	1.58	2.06
Burkina Faso	1993	2	80.3	27.1	7.2	12.1	32	18.9	29.2	21.3	0.48	102.9	2.55	1.94
Burkina Faso	1998/9	3	86.9	42.7	5.7	10.1	18.2	11.3	16.7	12.7	0.41	104.1	2.85	0.08
Burkina Faso	2003	4	81.3	5.2	5.8	4.5	6.7	9.5	27.5	13.2	0.40	104.6	0.40	-0.67
Cameroon	1991	2	50.9	30.7	8.5	4.7	27.3	7.8	18.7	9.3	0.56	102.2	2.04	-0.27
Cameroon	1998	3	36.6	5.8	7.1	5.8	8.8	8.5	19.3	9.8	0.51	97.3	-0.49	-0.67
Cameroon	2004	4	30.7	6.3	5.8	1.4	11.6	5.7	17	7.5	0.41	99.5	-0.52	-1.42
Ghana	1988	1	51.3	20.6	13.1	N/A	N/A	-1.3	-9.1	-2.2	0.60	103.4	N/A	NA
Ghana	1993	3	45.9	17.8	10.2	17.8	20.6	24	16.8	23.4	0.64	104.1	0.93	2.67
Ghana	1998	3	36.7	13.3	9.5	14.1	6	7.2	19.2	8.7	0.53	97.0	-0.19	0.23
Ghana	2003	4	30.8	2.3	5.2	9.5	11.5	11.2	38.4	14.1	0.69	102.3	-0.91	0.22
Ghana	2008/9	5	21.2	4	7.4	4.8	9.3	17.3	19.5	17.5	0.62	107.9	-0.82	-0.01

			Incompleteness of birthdates		Digit preference in women's age	Age displacement: Estimated % of women displaced		Age displacement: Estimated % of births in boundary year misreported in preceding year			Ratio of neonatal (NN) deaths to infant deaths (INF)	Sex ratio	Data Quality Index	
Country	Year of Survey	Phase	Women's birth dates(%)	Children's birth dates(%)	Myers' blended Index	Women 15-19	Women 45-49	Alive children	Dead children	All children			Scores constructed from PC1	Scores constructe from PC
Kenya	1989	1	37	2.8	6.7	N/A	N/A	17.8	30.2	18.9	0.47	98.1	N/A	N/A
Kenya	1993	3	34.3	8.3	7.6	16.1	28.5	7.7	19.2	8.7	0.44	99.6	0.17	1.32
Kenya	1998	3	27.6	2.1	5.3	13.3	15.9	5.4	17.9	6.5	0.40	103.9	-0.96	0.17
Kenya	2003	4	26.7	3.3	4.7	6.9	14	2.5	8.5	3.2	0.47	104.0	-0.83	-0.99
Kenya	2008/9	5	22.9	1.3	6.7	11.2	3.7	12.7	33.8	14.3	0.61	107.2	-1.36	0.25
Madagascar	1992	2	32.8	19.3	5.6	10.7	21.8	7.1	19.2	9.5	0.45	103.7	0.42	0.22
Madagascar	1997	3	35.8	21.5	4.3	1	10.7	7.1	19.1	9	0.45	102.0	0.28	-1.60
Madagascar	2004	4	24.9	11.3	4.7	15.3	20.1	22.3	13.2	21.6	0.56	95.8	-0.34	1.89
Madagascar	2008/9	5	19	1.6	5.2	4.1	13.1	15.8	31.2	17.1	0.53	103.9	-1.02	-0.10
Malawi	1992	2	29.6	3.8	7.2	14.8	16.8	4.4	24.8	9.4	0.33	101.8	-0.64	0.77
Malawi	2000	4	28.3	1.5	5.3	11.7	12.2	20.7	32.8	23	0.43	99.3	-0.95	1.39
Malawi	2004	4	23.4	1.1	7.1	21.7	18.4	15.2	26.2	17.1	0.38	99.8	0.96	2.45
Mali	1987	1	93.9	61.6	4.7	N/A	N/A	1.9	18.8	6.7	0.53	105.4	N/A	N/A
Mali	1995/6	3	84.7	3.3	11.9	11.6	11.3	7	14.4	8.7	0.53	99.7	0.87	0.37
Mali	2001	4	80.7	5.1	12.3	15.4	16.2	3.2	26.4	9.1	0.54	103.4	1.01	1.09
Mali	2006	5	68.6	7.1	13.1	8.6	8.8	22.8	32.5	25.1	0.50	103.0	0.89	1.48

			Incompleteness of birthdates		Digit preference in women's age	Age displacement					Ratio of neonatal (NN) deaths to infant deaths (INF)	Sex ratio	Data Quality Index	
						Estimated % of women displaced		Estimated % of births in boundary year misreported in preceding year						
Country	Year of Survey	Phase	Women's birth dates(%)	Children's birth dates(%)	Myers' blended Index	Women 15-19	Women 45-49	Alive children	Dead children	All children			Scores constructed from PC1	Scores constructe from PC2
Namibia	1992	2	5.9	5.9	3.7	1.2	14.4	6.7	-4.1	5.9	0.57	95.7	-1.20	-1.60
Namibia	2000	4	1.7	2	4.3	8	22.5	9.9	26.2	11	0.53	102.4	-1.24	0.13
Namibia	2006/7	5	0.5	0.7	3.8	3.1	7.2	8.4	33.6	10.4	0.53	105.5	-1.89	-1.17
Niger	1992	2	92.3	40.6	18.3	5.8	27.6	5.6	21.3	11.1	0.36	108.5	4.34	0.56
Niger	1998	3	89.6	3.9	14	0.3	9.6	8.4	10.1	9.1	0.39	101.9	1.37	-0.96
Niger	2006	5	66.4	15.2	19.3	17.1	19.4	22.9	38.1	26.4	0.45	105.1	2.01	3.40
Nigeria	1990	2	44.7	16.6	26.1	19.7	28.8	15.9	32.5	19.3	0.52	98.8	2.38	3.84
Nigeria	1999	4	36.2	16.1	19.2	-17.4	17.9	8.4	16.8	9.5	0.51	105.0	N/A	N/A
Nigeria	2003	4	23.9	8.4	15.7	1.2	14.1	-2.2	6.8	-0.1	0.52	105.0	0.28	-1.45
Nigeria	2008	5	24.8	2.7	16.8	4.7	9	9.8	28.6	13	0.56	103.5	-1.36	0.25
Rwanda	1992	2	61.6	6.6	5.7	5.3	14.7	0	11.7	1.9	0.48	101.1	0.21	-1.34
Rwanda	2000	4	46.9	4.4	6.3	10	2.7	11.5	31.6	15.7	0.42	101.4	-0.67	0.13
Rwanda	2005	4	54	2.5	5.3	3.6	6.1	1.1	2.8	1.3	0.46	103.3	-0.53	-1.94
Rwanda	2007/8	5	11.7	1.3	3.8	16.3	8.4	-10.8	6.4	-8.4	0.48	102.3	-1.84	0.34
Senegal	1986	1	65.9	18.4	3.3	N/A	N/A	10.9	16.5	11.9	0.55	103.6	N/A	N/A
Senegal	1992/3	2	49.9	40.6	9	3.4	21.5	7.6	19.6	9.5	0.53	94.7	2.38	-0.71
Senegal	1997	2	43.9	17.2	2.9	7.3	19.8	4.5	5.8	4.6	0.58	102.0	0.31	-0.90
Senegal	2005	4	32.1	9.7	6.4	-0.4	13.9	6.3	13.2	7.2	0.61	106.1	-0.15	-1.47

			Incompleteness of birthdates		Digit preference in women's age	Age displacement					Ratio of neonatal (NN) deaths to infant deaths (INF)	Sex ratio	Data Quality Index	
						Estimated % of women displaced		Estimated % of births in boundary year misreported in preceding year						
Country	Year of Survey	Phase	Women's birth dates(%)	Children's birth dates(%)	Myers' blended Index	Women 15-19	Women 45-49	Alive children	Dead children	All children			Scores constructed from PC1	Scores constructed from PC2
Tanzania	1991/2	2	57.4	16.7	5.1	5.1	10.8	3.8	30	8.1	0.44	102.6	0.50	-1.07
Tanzania	1996	3	40.4	6.7	5.9	9.9	6.2	9.4	25.8	11.8	0.39	105.6	-0.62	-0.16
Tanzania	1999	4	35.7	2.9	4.1	3.7	3.1	2.4	3.8	2.6	0.44	104.1	-1.14	-2.00
Tanzania	2004/5	4	26.6	1.6	5.5	6.9	2.4	-0.2	33.6	4.1	0.50	100.7	-1.40	-1.39
Uganda	1995	3	44.1	6.1	7.7	10.3	31.3	15.8	25.3	17.3	0.36	95.9	0.59	1.54
Uganda	2000/1	4	41.6	5.4	7.5	12	15.5	13	21	14.1	0.39	98.8	-0.20	0.81
Uganda	2006	5	36.8	2.7	5.5	14.3	7.5	11.7	22	13.5	0.40	98.5	-0.99	0.63
Zambia	1992	2	11.8	1.8	4.8	-1.3	17.3	4.1	7.2	4.7	0.42	100.3	-1.08	-1.48
Zambia	1996	3	18.7	1	5.2	6.7	7.4	10.2	24.9	13.1	0.35	97.9	-1.37	-0.37
Zambia	2001/2	4	16.4	1.5	3.2	5.2	5.8	8.8	13.1	9.5	0.42	101.0	-1.62	-1.10
Zambia	2007	5	8.6	0.8	2.1	11.7	2	-1.6	-0.6	-1.6	0.52	99.2	-2.28	-1.24
Zimbabwe	1988	1	10.1	0.4	5.2	N/A	N/A	5.3	-6.1	4.5	0.57	101.1	N/A	N/A
Zimbabwe	1994	3	4	0.3	5.9	9.5	6.9	-0.4	16.5	0.9	0.48	98.5	-1.87	-1.15
Zimbabwe	1999	4	3.1	0.5	2.3	9.9	21.3	1.4	16.3	2.9	0.46	105.5	-1.61	-0.55
Zimbabwe	2005/6	5	1.1	0.4	4.4	7.8	12.8	4	-2	3.5	0.41	104.2	-1.77	0.97

Table 4.2: Correlations of age and date misreporting errors

	Incompleteness of birthdates		Digit preference for women's age	Age displacement of women		Age displacement of all children	NN:INF	Sex ratio
	women	children		downward	upward			
Incompleteness of birthdates of women	1.00							
Incompleteness of birthdates of children	0.59***	1.00						
Digit preference	0.48***	0.32*	1.00					
Downward age displacement of women	0.08	-0.01	0.23	1.00				
Upward age displacement of women	0.19	0.41*	0.31*	0.26*	1.00			
Age displacement of children	0.24	0.09	0.39**	0.45***	0.29*	1.00		
NN: INF	-0.17	-0.003	0.05	-0.06	-0.02	0.09	1.00	
Sex ratio	0.12	0.02	0.09	-0.16	-0.07	-0.001	0.11	1.00
Mean	39.5	10.1	7.8	8.8	13.8	10.8	0.48	101.8
Standard deviation	25.16	11.81	4.83	5.26	7.61	6.49	0.08	3.12

*<0.05 **<0.01 ***<0.001

*Five surveys in DHS-I and the 1999 Nigeria DHS were excluded. N=57

4.4.2. Correlations between indicators on age and date misreporting

Table 4.2 presents correlations between the indicators. Generally, the correlations were not strong. Nevertheless, incomplete birthdates of women were strongly correlated with incomplete birthdates of children (r=0.59) and the digit preference (r=0.48) with < 0.001 level of significance. It is reasonable that surveys with a higher proportion of women who did not possess complete information on their birthdates are likely to have a higher proportion of incomplete reporting of children's birthdates and digit preference.

Age displacement of children were strongly correlated with downward age displacement of women (r=0.45) and Myers' Index (r=0.39). This may indicate that these indicators resulted from the same error.

Two omission indicators, ratio of neonatal deaths to infant deaths and sex ratio at birth, were not correlated the other indicators.

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4.4.3. Data quality index

A data quality index was constructed to summarise the values of the six age and date misreporting indicators presented in Table 4.1. As stated above, the indicators of omission were not included into the PCA models.

Table 4.3: Percentages of total variations explained by principal components

Component	Eigenvalue	% of total variation explained	Cumulative %
PC 1	2.47	0.41	0.41
PC 2	1.33	0.22	0.63
PC 3	0.83	0.14	0.77
PC 4	0.57	0.09	0.87
PC 5	0.50	0.08	0.95
PC 6	0.30	0.05	1.00

As shown in Table 4.3, the first principal component accounted for 41 per cent of variations in all the data and the first two components explained 63 per cent of the variations. Moreover the eigenvalues exceeded over 1.00 in PC1 and PC2. Thus, the first two components are retained for further analysis.

The loadings of each variable by components are shown in Table 4.4. While most of the variables are loaded in PC1, downward age displacement of women and age displacement of children were assigned relatively large weights in PC2.

Table 4.4: Factor scores for variables entering the computation of the first and second principal components

Variable	PC1	PC2
Incompleteness of women's birthdates	0.46	-0.38
Incompleteness of children's birthdates	0.42	-0.50
Myers' Index	0.47	-0.01
Downward age displacement of women	0.29	0.62
Upward age displacement of women	0.40	0.06
Age displacement of children	0.39	0.47

Table 4.5: Factor scores for variables entering the computation of the first and second principal components, after orthogonal rotation

Variable	PC1	PC2
Incompleteness of women's birthdates	0.59	-0.03
Incompleteness of children's birthdates	0.63	-0.14
Myers' Index	0.38	0.28
Downward age displacement of women	-0.14	0.67
Upward age displacement of women	0.28	0.29
Age displacement of children	0.03	0.61

In order to understand what variables seem to be measured by each component, orthogonal and oblique rotations were performed. Table 4.5 shows the results of orthogonal rotation. Compared with the results in Table 4.4, PC1 assigned more weights on incompleteness of women's and children's birthdates and Myers' Index, while PC2 gave more loadings to downward age displacement of women and age displacement of children.

PC1 and PC2 contained most of the highly weighted variables (the cumulative proportion of variance was 0.57). When component scores were calculated, these were correlated each other (r =0.21) and, therefore, oblique rotation was explored. Table 4.6 shows the results of oblique rotation.

The results were similar for both forms of rotations and were considered more informative than the unrotated components. The findings suggest that PC 1 represents mainly respondents' bias, because incompleteness of birthdates and digit preference is associated with respondents' misreporting. On the other hand, PC2 explains interviewers' bias as downward age displacement of women and age displacement of children may result from interviewers' misreporting.

Table 4.6: Factor scores for variables entering the computation of the first and second principal components, after oblique rotation

Variable	PC1	PC2
Incompleteness of women's birthdates	0.59	-0.001
Incompleteness of children's birthdates	0.63	-0.11
Myers' Index	0.40	0.31
Downward age displacement of women	-0.12	0.66
Upward age displacement of women	0.30	0.31
Age displacement of children	0.05	0.61

Index scores were produced from the oblique rotations as these were marginally more advantageous. Based on the results from the oblique rotation, two data quality indices scores were constructed for each survey based on PC1 and PC2. The values were presented in the right columns in Table 4.1. The data quality index score constructed from on PC1 was highest in the 1992 Niger DHS, the 1998/9 Burkina Faso DHS, and the 2001 Benin DHS. As shown in Table 4.7, generally West African countries had higher scores, indicating their data quality is poorer. The index score derived from PC2 was highest in the 1990 Nigeria DHS, the 2006 Niger DHS and the 1993 Ghana DHS. Malawi and Niger had higher mean of data quality index derived from PC2.

Table 4.7: Mean data quality index by country

	Mean Data Quality Index (PC1)	Mean Data Quality Index (PC2)
Benin	2.15	0.25
Burkina Faso	1.93	0.45
Cameroon	0.34	-0.78
Ghana	-0.25	0.78
Kenya	-0.75	0.19
Madagascar	-0.17	0.10
Malawi	-0.85	1.53
Mali	0.92	0.98
Namibia	-1.44	-0.88
Niger	2.57	1.00
Nigeria	0.96	0.82
Rwanda	-0.71	-0.70
Senegal	0.85	-1.03
Tanzania	-0.67	-1.15
Uganda	-0.20	0.99
Zambia	-1.59	-1.05
Zimbabwe	-1.75	-0.89

4.5. Discussion

There are limitations in this analysis. It is important to note that almost all of the indicators may confound misreporting. It is also possible that apparent age transfers may in fact not exist and could be the result of genuine irregularities. For instance, there was an irregular large slump in the number of births in 1966 in Japan, because it had been believed that girls born in that year would become fierce based on the Chinese Sexagenary cycle. On the other hand, some errors might have been unrecognised because they effectively disappeared (Pullum 2006). As described earlier, the unusual upward age transfer of children in the latest surveys in Rwanda and Zambia might be because the irregular spikes of births in 2000 cancelled out downward age transfer of children. Furthermore, the indicators of age displacement assessed age transfer of children for only two years across the boundary month. As discussed in Chapter 2, there is some evidence that births occurring for 0-5 years prior to a survey have been transferred to the earlier 5-year periods (Potter 1977). However, it is difficult to determine a period when transference is made without verification by another source of data. The omission indicators are relative measures and were not able to quantify the extent of omission of live births.

Regardless of the limitations, this chapter provides extensive information on age and date misreporting and presents large variations in the level of data quality by country and by survey. Incompleteness of birthdates and age digit preference has improved over the years. However, a high prevalence of age displacement of children was observed. A key finding is that this error did not show a clear downward trend in more than half of the countries and their latest surveys contained more age displacement than the previous surveys. Although the indicator measured transfers between only two years, it is likely that they were shifting over few years across the boundary year, as shown in Chapter 5. Consequently, the aggregated TFR for three years prior to the survey used in the earlier studies on recent fertility changes in sub-Saharan Africa may be underestimated, resulting in misleading fertility trends. Furthermore, there were some signs of omission of deceased children in six surveys.

It is clear that the levels of quality of data were not constant across surveys within the countries. For instance, the quality of data in the 1999 Nigeria DHS was obviously substantially poorer than the successive surveys, resulting in distortion of the fertility trends over years. Although there was no survey with such a high level of data errors, fertility trends in some countries are likely to be affected by the difference in the level of data quality across surveys.

The results of the data quality index showed that the six errors were not strongly correlated with each other. Incompleteness of birthdates and the Myers' Index were fairly correlated. This might suggest that these errors resulted mainly from a bias, respondent's bias. Similarly, the second principal component explained the variations of downward age displacement and age displacement of children, indicating that these were associated with the same biases. These may be interviewers' misreporting, or a combination of the mother's spontaneous bias and interviewers' bias.

Regardless of the limitations of data quality index, this chapter made it clear that there are important errors in DHS and large variations in misreporting. In particular, age displacement of children has been prevalent in sub-Saharan Africa, indicating that fertility trends may be distorted by this error. Furthermore, this error seems more significant in some of the latest surveys. There was also some evidence of omission of deceased postnatal deaths in the latest surveys in Kenya, Tanzania and Zambia. There is clear need for consideration of data errors when estimating fertility trends.

Chapter 5 : RE-EXAMINATION OF KENYA'S FERTILITY TRENDS

5.1. Introduction

The previous chapters have shown that there is a clear need for a rigorous method of estimating fertility trends. Chapter 2 discussed the nature and quality of DHS and the weakness of the fertility methods used in the earlier studies on recent fertility decline in sub-Saharan Africa. Chapter 4 provided the results of an extensive assessment of age and date misreporting in 63 surveys from 17 sub-Saharan African countries. While completion of the reporting has been improved, age displacement of children has been prevalent and did not show improvement over the years in the region. It is likely that this error has affected fertility trends in the previous studies.

Given the evidence of the error and the hypothesis, cChapters 5 and 6 present a core part of this thesis by introducing an innovative method of estimating fertility trends taking into account the errors and its application. This chapter examines fertility changes in Kenya in the past three decades to demonstrate the methods and results in detail. Kenya's fertility stall is the most commonly reported in previous studies (Askew et al. 2009; Bongaarts 2006, 2008; Ezeh et al. 2009; Garenne 2008; Shapiro and Gebreselassie 2008; Westoff and Cross 2006). The Kenya DHS (KDHS) of 1998 and 2003 revealed that average TFR for three years prior to each survey increased from 4.7 in 1998 to 4.9 in 2003. This was a surprise because Kenya was the vanguard which established a national family planning programme in 1967, as the first country in sub-Saharan Africa. The strong implementation of the programme since 1984 made Kenya change from one of the countries with highest fertility to a country which successfully reduced fertility rapidly. It might reflect the large reduction of external funding to family planning and an increase in child mortality due to HIV/AIDS epidemic during the same period (Cleland et al. 2006b; Westoff and Cross 2006). Yet this apparent fertility trend is not consistent with information on the proximate determinants; the proportion of women sexually active in the past four weeks prior to the interview decreased and contraception increased among the sexually active women (Westoff and Cross 2006). Furthermore, the KDHS 2008/9 shows a resumed decline in the average TFR to 4.6. In fact, the TFR has not changed significantly changed since 1998. Although it was significantly higher in 1993 (5.4 [5.143-5.662]), there was no significant changes: 4.7 [4.479-4.919] in 1998; 4.9 [4.614-5.155] in 2003; 4.6 [4.218-4.899] in 2008/9 (Central Bureau of Statistics (CBS), Ministry of Health [Kenya] and ORC Macro 2004; Kenya National Bureau of Statistics and ICF Macro 2010; National Council for Population and Development (NCPD), Central Bureau of Statistics (CBS) and Macro International Inc. 1994; NCPD, CBS and Macro International Inc. 1999). Although there is more evidence of stagnation around 2000 in Kenya than other sub-Saharan countries, the extent of this and the mechanisms involved are still unclear. Thus, new robust methods were applied to reassess fertility changes in Kenya.

This chapter proposes an innovative method of estimating fertility trends using DHS survey datasets. This method was applied to obtain better estimates of the course of fertility changes in sub-Saharan Africa. This analysis incorporates five important developments since an earlier study on the assessment of effects of data quality on estimating fertility decline in sub-Saharan Africa (Machiyama 2010). First, the number of countries studied was increased to 17. Second, a smoothing method developed by Murray et al. (2007) for child mortality estimation to the series of estimates was employed with some modifications. The use of a range of weights made the estimates more robust for short- and long-term estimation. Third, uncertainty intervals were obtained to indicate the precision of the estimates. Fourth, a method of adjusting for clustering by multilevel analysis that allows for the fact that the obtained adjusted TFR (15-39) estimates derived from a particular survey are highly correlated with each other is presented. Furthermore, two more data assessments were conducted to assess discrepancies between surveys within the countries. The inter-survey comparison in composition and parity shows the imprecision in more detail at the end this result section.

Definitions of fertility stall

Although this research aims to re-assesses the fertility trends for decades it may be useful to review literatures on definitions of a fertility stall. The term has been used and studied more widely in the past ten years, but there is no consistent definition yet (Moultrie et al.

2008). Few prior studies discuss the criteria and most have been urged to focus on investigating potential causes of stalls (Aghajanian 1991; Bongaarts 2006; Eltigani 2003; Shapiro and Gebreselassie 2008; Westoff and Cross 2006). The term has usually been considered to refer a fertility pattern where TFR fails to decline between two surveys in a mid-transitional country.

Gendell is the first person who identified a fertility stall and also has established four criteria of stall (Gendell 1985, 1989). Firstly, the fertility transition must have been initiated by the fertility falling from more than five children in TFR by at least 20 per cent. The twenty per cent is twice the ten per cent decline which has historically been used as a sign of onset of fertility transition (Casterline 2001b). Secondly, the decline should have averaged at least 0.15 TFR units annually for the five years preceding the supposed stall. Thirdly, there should be no decline during the stalled period or the rate of decline should be the half the rate at most in the preceding time period of stall. The duration is defined as at least five years, acceptably four years in the case the decline resumes. Fourth, the stall should occur at well above the replacement level.

Moultrie et al. develop Gendell's definition more rigorously (Moultrie et al. 2008). They have proposed to define a period of stall as duration when the rate of fertility decline in a time period is significantly smaller than that in the previous period. This definition requires a significant change in *pace* between two time periods, which Bongaarts considered as unnecessary (Bongaarts 2008). It has further suggested that there should be no significant difference from zero in the slope of the line between the two data points.

Bongaarts and Garenne employed more simple criteria. Bongaarts defined a stall as no statistically significant decline in the TFR between two successive observations, using the TFR from data aggregated over three years preceding each of the two most recent surveys (Bongaarts 2008). Furthermore, the countries with limited decline of less than 0.25 births per women were regarded to have stalled (Bongaarts 2008). Similarly, Garenne defined a stall 'as periods during which the slope changed from negative to nil or positive, the change in slope being significant at the $P<0.05$ level' (Garenne 2007).

While identifying a short-term stall is important, it is important to have a *long view.* In fact, it is not straightforward to determine the beginning and the end of a stall. Change in TFR is often too slow to detect a significant change for a few years. Moreover, African fertility decline is generally very slow and would not achieve a decline of 0.15 or double pace in TFR as Gendell suggested. Therefore, it is difficult to determine the duration of stall. The issue we are now facing is how fast fertility declines and what the implications are over a long term. Excessive concentration on examining short-term changes may mislead the understanding of fertility and miss the bigger picture. Because of this reason, this research does not aim to identify a short-term stall. Rather, the focus lies on re-assessment of pace and trajectories of fertility changes in the past decades.

5.2. Methods

STATA SE/11 and R version 2.11.1 were used for the entire analysis.

5.2.1. Adjusted partial total fertility rates (15-39) by single calendar year

Partial TFR estimates for ages 15-39 were generated for each of the 10 calendar years prior to the year of fieldwork of each survey. Partial TFRs are preferred to full TFRs to circumvent the problem of truncation of ages 40-49. Fertility rates of women 40-49 usually contribute only 10 per cent of a full TFR (Garenne 2008). Extending the analysis beyond this 10-year period would bring increasing problems of truncation and data quality. In other words, women aged 40-49 at 10 years prior to the time of a survey are 50-59 year at the survey, so that their data is not available in the individual dataset. This aims to depict the detailed levels and trends of fertility and identify age displacement of children across the boundary year as well as to explore whether there is a discrepancy between consecutive surveys during which the retrospective estimates from two consecutive surveys overlap.

Data in the year that data collection ended covers a small fraction of births and exposure that would have occurred in the whole year. Consequently, the estimated rate would not be representative of the fertility rate of the full calendar year and the reference period is likely to be distorted because numbers of women interviewed by month are not equally distributed during the fieldwork (Becker and Pullum 2007). Therefore, the data for the year of each survey were excluded from the analysis for surveys in which data collection started before the middle of the year.

The TFR (15-39) estimates were adjusted for downward age displacement of women and backward age displacement of children using Pullum's method presented and used to estimate the levels of the error in Chapter 4 (Machiyama 2010; Pullum 2006). The numbers of births and the exposure were collapsed by calendar year and mother's 5-year age group in the process of computing the partial TFRs. Then, the estimated proportions of women aged 15-19 misreported as aged 10-14 were transferred back to the 15-19 age group, by adjusting number of women aged 15-19 for each year. Since there is no information about births to the misreported women, the adjustment was made under an assumption that such women were nulliparous. One would think that women aged 15-19 who have ever had live births may be more likely to be transferred than the teenagers who had not given a birth. The transfer may also be related to the way of field-work, such as use of translators and number of visits to households (Johnson et al. 2009)

Similarly, age displacement of children was adjusted by estimating proportions of children transferred across the boundary year. The numbers of births to all mother's age groups were uniformly adjusted for the proportion of misreported children between the two years. This makes an assumption that age displacement occurs equally in all age groups, though the distributions of age displacement among women are unknown. Furthermore, this correction assumed that age transfer was restricted to the two years across the boundary year (Pullum 2006). This is a limitation because there is evidence that age displacement was occurred beyond the two years (Potter 1977). Thus the recent estimates might be underestimated and the estimates before the boundary might be overestimated. However, the Loess estimation methods introduced in the next section uses various degrees of smoothing, which will not be unduly affected by recent estimates. Subsequently, partial TFRs were re-estimated using the above adjusted number of births and women-years.

5.2.2. Loess-based approach

The method developed by Murray et al. (2007) for child mortality estimation was applied to fit Loess (locally weighted scatterplot smoothing) regression curves to the adjusted partial TFR data points. Loess is a widely used smoothing method, which produces a new smoothed value for each required time point by running a linear regression with the highest weight on data points close to the time point of interest and smaller weights for other data points according to their distance from the time point of interest. This procedure was repeated to obtain smoothed values for every year. The basic Loess function used is:

$$\log(y) = \beta_0 + \beta_1 x + \varepsilon$$

where y is the partial TFR (15-39), x is calendar year and ε is an error term.

This function was fitted using weighted least squares regression. The weights for each data point were tuned by a parameter α which controls the proportion of the data points used in the regression and hence the degree of smoothing. For α <1, the weight function is calculated using the 100α% of the data points of the partial TFR closest to the time of interest x_0, using the function.

$$w = (1-(\frac{\psi}{\Psi})^3)^3$$

where w is the weight corresponding to the time point x, $\psi = \| x - x_0 \|$ is the distance between time point x and the time of interest x_0, and Ψ is the maximum value of ψ among the 100α% of data points under consideration. For instance, when α is 0.5, the 50 per cent of adjusted partial TFR data points closest to the time of interest x_0 are used to fit the weighted least squares regression line. To fit the above function the highest weight is given on the partial TFR estimate at x_0, smaller weights are given to the rest of the 50 per cent of the data points that are used according to their distance from x_0, and zero weight is given to the other 50 per cent. For instance, when α is 0.5 and x_0 is 1995 using the Kenya datasets, the 50 per cent of adjusted partial TFR data points, i.e. 25 data points, closest to 1995 are used to fit the weighted least squares regression line. As there are two estimates for each year around 1995 except 1998, the 25 data points between 1989 and 2001 are used and the maximum value of ψ, Ψ is six years. The weights are calculated using the above formulae according to distance from year 1995. The full list of the weights is shown in Table 5.1.

Table 5.1: Weight allocation, Kenya, 1989-2001 (α = 0.5, x0 = 1995)

KDHS 1993	KDHS 1998	KDHS 2003	KDHS 2008/9	Weights
1989	1989			0.0000
1990	1990			0.0748
1991	1991			0.3485
1992	1992			0.6699
	1993	1993		0.8930
	1994	1994		0.9862
	1995	***1995***		***1.0000***
	1996	1996		0.9862
	1997	1997		0.8930
		1998		0.6699
		1999	1999	0.3485
		2000	2000	0.0748
		2001	2001	0.0000

For α ≥ 1, all data are included and the weighting function becomes*

$$w = (1\text{-}(\frac{\psi}{\Psi\, \alpha^{1/2}})^3)^3$$

For instance, when α is 1.0 and x_0 is 1995 using the Kenya datasets, all the partial TFR estimates are used to fit the weighted least squares regression line. The maximum value of ψ, Ψ, is 16 years. The full list of the weights is shown in Table 5.2.

When predicting the partial TFR (15-39) for time points later than the most recent observed TFR the weights corresponding to the last observed data point were used.

Table 5.2: Weight allocation, Kenya, 1989-2001 (α = 1.0 or 2.0, x0 = 1995)

KDHS 1989	KDHS 1993	KDHS 1998	KDHS 2003	KDHS 2008/9	Weights (α = 1.0)	Weights (α = 2.0)
1979					0.000	0.27
1980					0.005	0.36
1981					0.036	0.44
1982					0.100	0.53
1983	1983				0.193	0.62
1984	1984				0.308	0.69
1985	1985				0.432	0.76
1986	1986				0.555	0.82
1987	1987				0.670	0.87
1988	1988				0.769	0.91
	1989	1989			0.850	0.95
	1990	1990			0.911	0.97
	1991	1991			0.954	0.98
	1992	1992			0.980	0.99
		1993	1993		0.994	***1.00***
		1994	1994		0.999	***1.00***
		1995	***1995***		***1.000***	***1.00***
		1996	1996		0.999	***1.00***
		1997	1997		0.994	***1.00***
		1998	1998		0.980	0.99
			1999	1999	0.954	0.98
			2000	2000	0.911	0.97
			2001	2001	0.850	0.95
			2002	2002	0.769	0.91
				2003	0.670	0.87
				2004	0.555	0.82
				2005	0.432	0.76
				2006	0.308	0.69
				2007	0.193	0.62
				2008	0.100	0.53

To estimate the degree of certainty for each Loess estimate, statistical simulation was performed. Since a partial TFR for each year is a non-sampled aggregated multiplicative data point it is not possible to compute confidence intervals. Instead, statistical simulation draws random numbers and provides probability distributions of TFR. The degree of certainty was expressed as uncertainty intervals, which are different from confidence intervals, because the computation was made from random draws, instead of observations in a survey samples. To simulate a parameter, point estimates and the variance-covariance matrix of the estimates are needed (King, Tomz and Wittenberg 2000). Most statistical packages provide the matrix. The parameters are drawn randomly from a multivariate normal distribution defined by the coefficient and the variance-covariance matrix derived from the Loess regression.

Similar to the work by Murray et al. (2007), to estimate uncertainty intervals for each country a range of α values between 0.1 and 1.0 were used, starting with the lowest value of α that could be used given the number of observed data points, and increasing the value of α by 0.05 until 1.0. For each value of α the Loess function was fitted using weighted least squares as explained in the above. In order to estimate how uncertain the smoothed trends were, 1000 random draws were simulated from the multivariate normal distribution defined by the estimated/predicted regression coefficients and their variance covariance matrix for each value of α, and the fitted TFR for the required time point was calculated for each set of random draws. The 1000 fitted TFRs per α value were then pooled across the set of α values. Since the distributions of the simulated random draws are often skewed (Silverwood et al. 2008), the simple percentile method was used to obtain uncertainty intervals. The percentile method was applied to estimate uncertainty ranges for non-sampled data in stastical simulation (Alkema et al. 2008, Baltussen et al. 2002, Brigges et al.1997). The median value provides the final fitted TFR and the 2.5th and 97.5th centiles give an uncertainty interval. In other words, 95 per cent of the simulated Loess estimates at a given year fall into the intervals.

The previous study used a built-in Loess command in STATA (Machiyama 2010). Only a single α was rather arbitrarily selected, and the value was small (approximately 40 per cent of data points were included in each regression), meaning the results were perhaps overly sensitive to recent (potentially spurious) estimates which deviated from the overall trend. In contrast, the current method uses a range of α values, so that both short- and long-term trends are incorporated (Silverwood and Cousens 2008).

Murray et al. (2007) used a range of α values between 0.1 and 2.0. The maximum value of α was selected because even when the maximum α was 1.5 the result was close to that from ordinary least-squares regression (Murray et al. 2007). More recently, however, the same group concluded that this approach might be too conservative (Rajaratnam et al.

2010). In other words, there is a possibility of over-smoothing of recent changes. In order to be sufficiently sensitive to recent changes, 1.0 was used as potential maximum values of α and the trajectory was compared with the case of using 2.0 to assess how this change influences the trajectories. When the maximum value of α is 2.0, the weights were calculated using the second formulae for $\alpha \geq 1$. The weight allocation was presented in Table 5.2.

Variability in the sample sizes of surveys is not taken into account in the Loess method. The unit of analysis for the Loess regression is the adjusted partial TFRs. The number of data points ranged from 30 to 50. As long as linear regression can be performed to fit a Loess curve for each year, there is no minimum number of data points for this approach.

5.2.3. Multilevel analysis

Within each country, estimates of the TFR (15-39) derived from the same DHS survey are likely to be more correlated with each other than estimates from different surveys. The current Loess approach, however, assumes that the estimates are independent. In order to assess how this dependency may have affected the overall Loess trends, a simple random slope and intercept multilevel model were incorporated into the Loess approach in place of the linear model given above. The model then becomes:

$$\log(y_{ij}) = (\beta_0 + u_{0i}) + (\beta_1 + u_{1i})\, x_{ij} + \varepsilon_{ij}$$

where

$$\begin{pmatrix} u_{0i} \\ u_{1i} \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{u0}^2 & \sigma_{u01} \\ \sigma_{u01} & \sigma_{u1}^2 \end{pmatrix}\right)$$

and $\varepsilon_{ij} \sim N(0, \sigma_\varepsilon)$, with y_{ij} and x_{ij} now the *j*th values within the *i*th survey. u_{0i} is the random intercept and u_{1i} the random slope for survey *i*. The multilevel model was fitted using the same weight function as for the standard Loess approach and the fitted TFR values were calculated as before.

When deciding on the set of α values to use two additional criteria were introduced: 1) data from at least three surveys (i.e. non-zero weights) were required in each year for which estimates were sought; 2) at least two surveys were required to contribute at least two data points in each year for which estimates were sought. Values of α which did not meet these criteria were excluded from the analysis. Based on these criteria, a set of α values ranging from 0.40 to 1.0 were used for the Kenya datasets. The weight allocation is shown below.

Table 5.3: Weight allocation, Kenya, 1990-2000 (α = 0.4, x0 = 1995)

KDHS 1993	KDHS 1998	KDHS 2003	KDHS 2008/9	Weights
1990	1990			0.000
1991	1991			0.116
1992	1992			0.482
	1993	1993		0.820
	1994	1994		0.976
	1995	***1995***		***1.000***
	1996	1996		0.976
	1997	1997		0.820
		1998		0.482
		1999	1999	0.116
		2000	2000	0.000

An alternative set of criteria for the selection of alpha values were also considered: (1) data from at least two surveys were required in each year; (2) at least one survey was required to contribute at least two data points in each year. This is a minimal set of criteria to ensure having both between-survey and within-survey information. However, the uncertainty areas provided were fairly volatile. Therefore, the first criteria described above were selected.

There are various thoughts on the minimum number of level 2 units required for multilevel analysis, but there is no agreement and it often depends on the study. In this analysis, multilevel models were used to assess the effect of clustering, because the assumption of independence among the partial TFR estimates is clearly invalid. The number of data points of the partial TFRs for the first level of the analysis ranged from 30 to 50, while there are only three to five surveys for the level 2 of the analysis. The number of a level 2 variable, i.e. number of surveys, is few. The number of surveys available within each country is at the very lower limit for multilevel modelling, though there is no agreement on minimum number of group. However, as the number of surveys increases, the reliability of the multilevel approach will improve. Presently, it would perhaps be best to consider the multilevel approach more as a useful diagnostic tool to identify countries in which the within- and between-survey trends differ substantially, indicating that closer scrutiny of the results may be required.

5.2.4. Inter-survey comparison: composition of respondents

With few exceptions, DHS surveys select nationally representative samples. Therefore, the demographic and socioeconomic characteristics of respondents, such as women's levels of highest educational attainment, in the same birth cohorts are expected to remain constant or show a gradual change across surveys. If one survey over-represents a group of women with lower fertility due to different sampling implementation, the fertility rates may be underestimated compared to in the successive surveys. The difference in composition of women may occur, particularly when the sampling frame is changed. For instance, women's levels of highest educational attainment is an important determinant of fertility decline and the proportions of women do not change dramatically by birth cohort between two surveys at national level unless a large number of women go on to the higher institutions in the inter-survey period. These changes are mostly expected to be seen in the two youngest birth cohorts aged 15-24 at the time of survey. If, for instance, a second-to-last survey samples a higher proportion of women with secondary education in the same birth cohorts compared to the last survey, this leads to over-representation of educated women in the survey and may result in lower fertility than expected. These different compositions of women across surveys may also lead to a false fertility stall when the second-to-last survey would produce relatively lower fertility due to higher proportion of educated women compared to in the last survey, if other conditions are constant. To assess the differences in the composition, this analysis compares proportions of women who have attended secondary or higher schools by 10-year birth cohort for each survey. Kenya DHS in 1993, 1998 and 2003 were assessed given that the 1998 survey appears to have discrepancies with successive surveys according to the results from partial TFR by single calendar year.

5.2.5. Inter-survey comparison: average parity

Reconstruction of average parity by birth cohort was often used to compare fertility estimates collected in WFS with censuses data in the 1980s to detect omissions or age displacement of children (Goldman et al. 1985). In this analysis, births after the first month of field work of an earlier survey are subtracted from birth histories of the later survey, and the maternal history was reconstructed to compute average parity by birth cohorts. The two estimates of average parity should match as the reference time is the same. However, if recent births are pushed backward in the later survey, the later survey may show higher average parity than the earlier survey. Also omissions of births can be detected. When there is omission or age displacement of children at the same extent across successive surveys, this approach which assesses levels of parity relatively will not able to detect the errors. Since several studies have suggested that pace of fertility decline in Kenya changed between the late 1990s and the early 2000, the DHS surveys conducted in 1993, 1998 and 2003 were presented for this analysis.

5.3. Results

Figure 5.1 shows unadjusted and adjusted partial TFR estimates for single calendar years between 1979 and 2008 in Kenya. The hollow points indicate unadjusted estimates and the filled points represent those adjusted for age displacement of children and downward age displacement of women. Overall, Figure 5.1 illustrates rapid decline between the 1980s and early 1990s, and markedly slower decline since the mid-1990s.

The adjusted and unadjusted estimates were almost identical apart from the fact that correction for downward age displacement of women slightly reduced the levels of the unadjusted estimates throughout the years. However, large differences were observed in the boundary years and the year before each boundary year. These are clear signs of age displacement of children. The differences were most pronounced between the estimates in 1982 and 1983 derived from the KDHS 1989, and between those in 2002 and 2003 from the KDHS 2008/9. The unadjusted TFR plunged by almost 1.0 child between 2002 and 2003. A spike in fertility apparently occurred in 2000 according to the most recent survey.

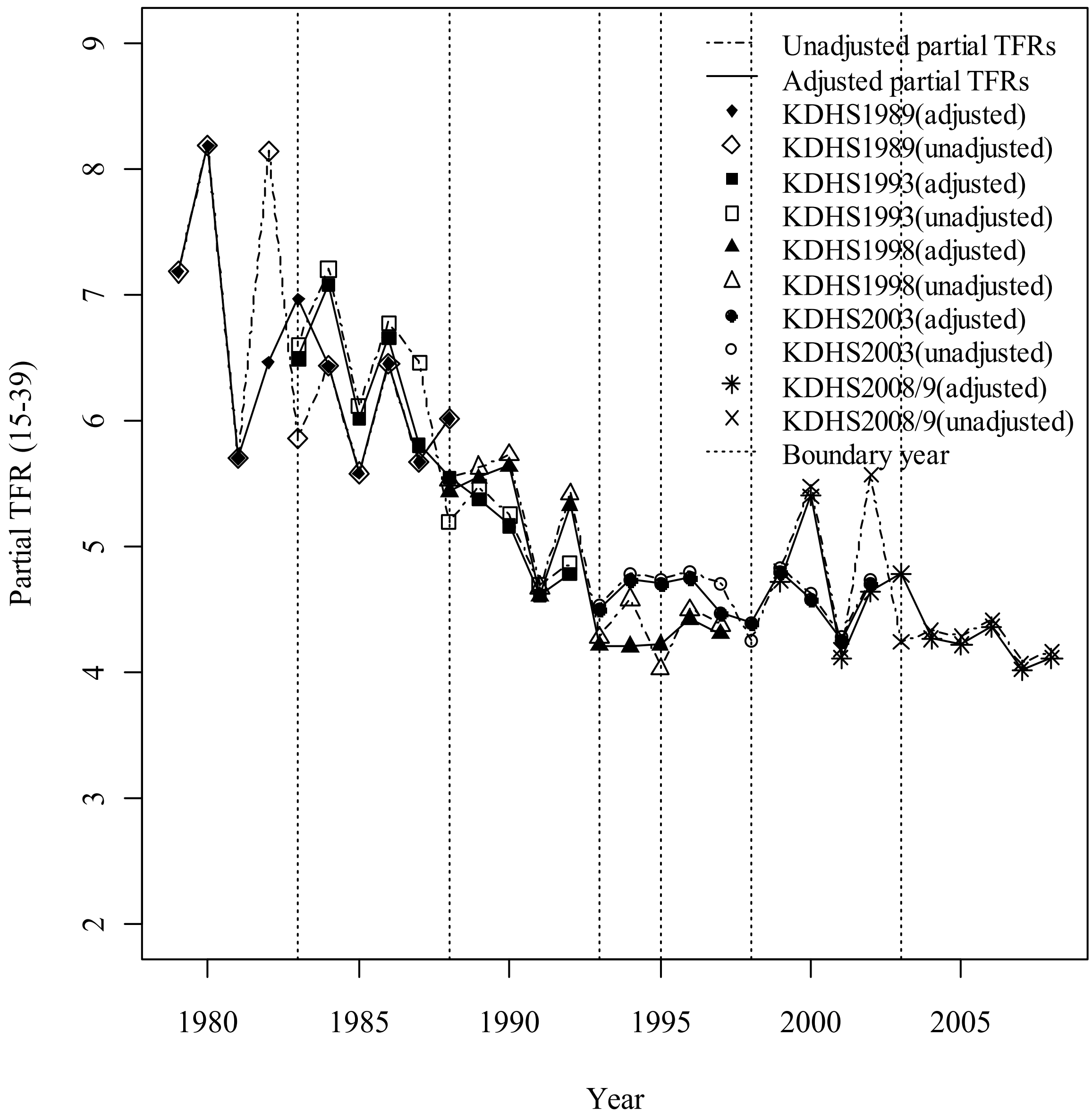


Figure 5.1: Unadjusted and adjusted partial total fertility rates (15-39) by single calendar year, Kenya, 1979-2008

Source: DHS surveys.

This may result from digit preference for this year of birth as similar spikes were also found in the latest surveys in Madagascar, Nigeria, Rwanda and Zambia (see Figure 6.1 in Chapter 6).

The adjustment effectively smoothes out the large fluctuations caused by age displacement of children. The extent of the correction of downward displacement of women was consistent throughout the years. Moreover, the estimates derived from successive surveys were generally similar during the overlapping periods. This consistency is indicative of the relatively good quality of data in Kenya's DHS surveys.

It is perhaps worth noting that the adjusted and unadjusted estimates derived from the KDHS 1989 are identical except for those in the boundary year and the year before. This is because only age displacement of children was adjusted; adjustment for age displacement of young women was not possible due to the unavailability of data on the single-year age distribution of women aged less than 15 years old. The KDHS 1998 had two boundary years: 1993 for anthropometry and 1995 for child health questions. I experimented with estimates adjusted for age displacement of children across 1993, but they made little difference to the fit of the Loess regressions. Thus, the estimates adjusted for age displacement across 1995 were used for the rest of analysis.

Figure 5.2 compares Loess smoothing trends using maximum α values of 1.0 and 2.0. The bold solid line and dashed lines indicate the median and uncertainty limits of the fitted partial TFR using a maximum α value of 1.0, while the other lines represent the Loess curve from the model using 2.0 for the maximum value of α. The point estimates were very similar except between 1989 and 1998, and the uncertainty areas were slightly narrower for the model with the maximum α of 1.0. This model shows more abrupt deceleration in the 1990s and slightly slower decline after 2000 than the other. The fitted partial TFR and the uncertainty areas with a maximum α value of 1.0 appear to more closely depict the fertility changes in Kenya as the model with an α value of up to 2.0 appears to have smoothed out the short-term plateau in the decline. Both models were applied to other countries, but the results were in all cases very similar. The Kenyan example suggests that use of 2.0 as the maximum value of α may be too insensitive when there are recent or abrupt changes. Therefore, 1.0 for the maximum value of α was used for the rest of the analysis.

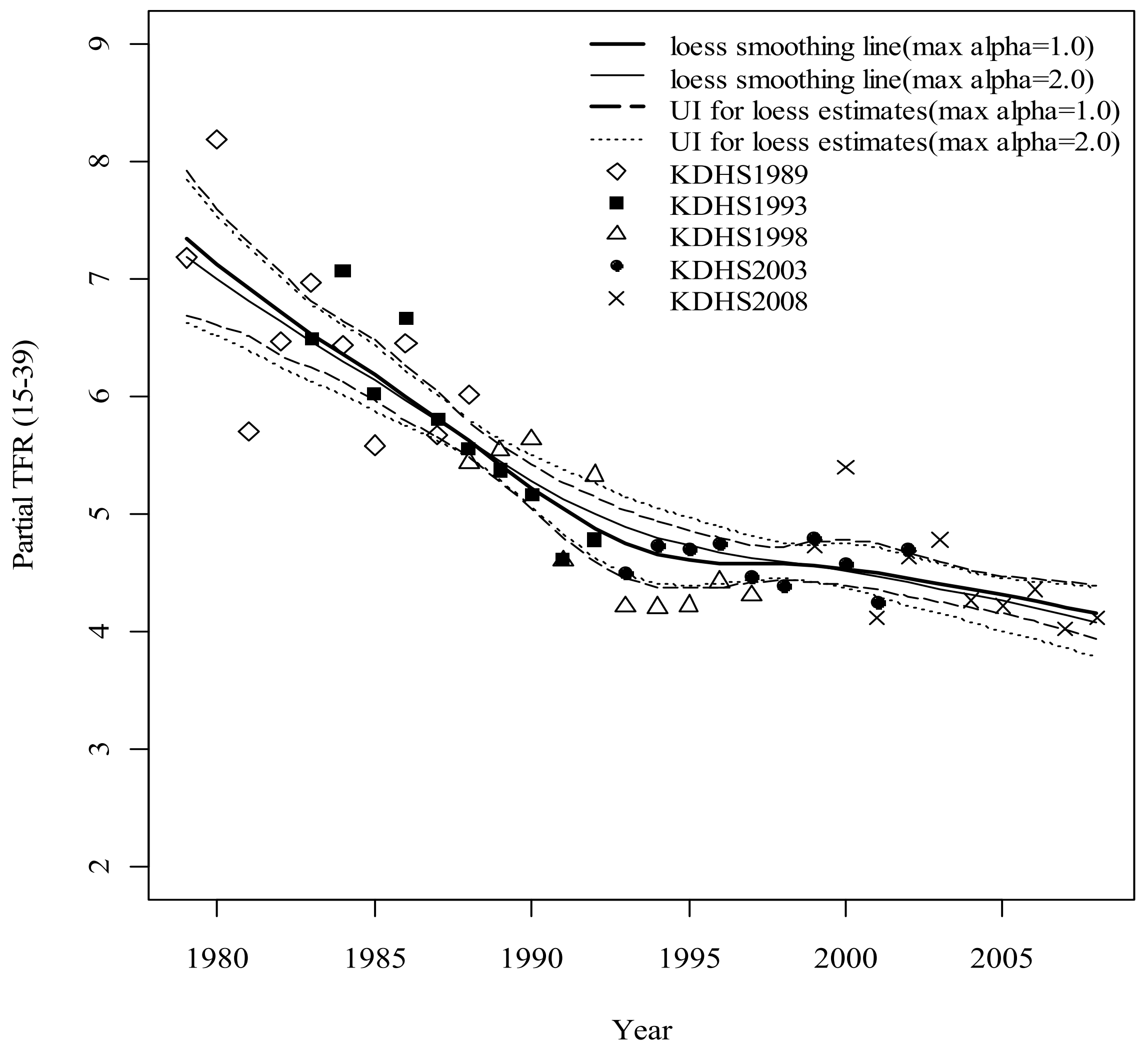
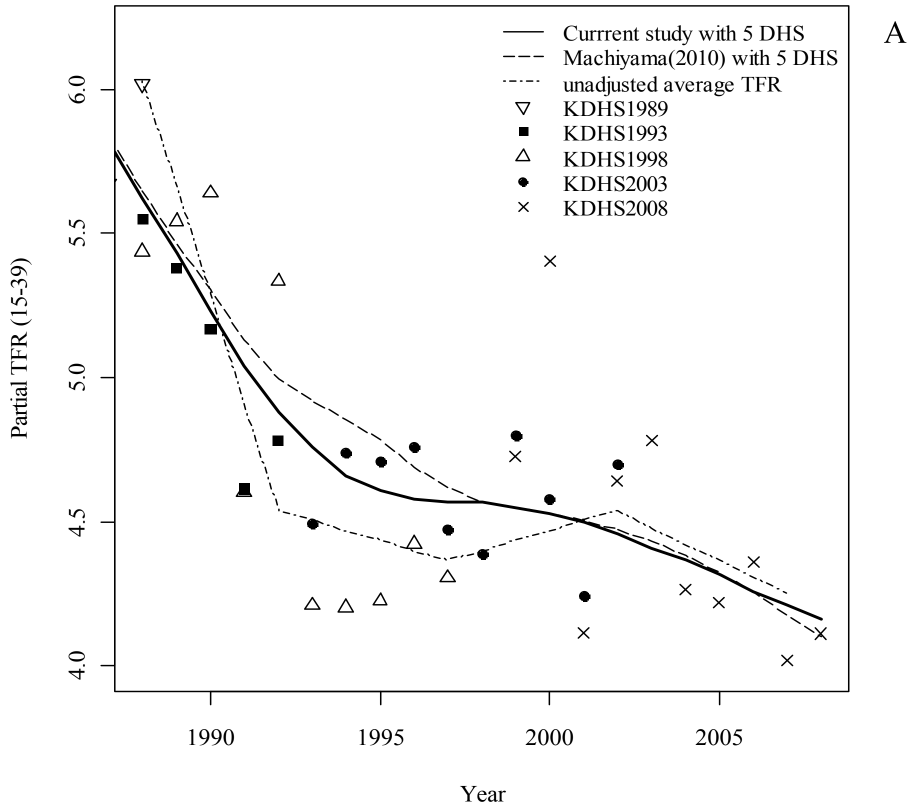


Figure 5.2: Partial total fertility rates (15-39) by single calendar year, Kenya, 1979-2008: comparison of use of two alternative maximum α values

Source: DHS surveys.

Next, the effects of different analytic approaches to estimating fertility trends were explored. Figure 5.3 shows trends in the TFR (15-39) between 1988 and 2008 in Kenya using five different approaches. Figure 5.3.A presents trends from three approaches using the data derived from five surveys: (a) the current approach; (b) the previous approach (Machiyama 2010); (c) using unadjusted average partial TFR (15-39) for three years prior to each survey. The trends derived from unadjusted TFRs have been used by most previous studies and depict a reversal of fertility decline between 1998 and 2003, followed by a small decline between 2003 and 2008.



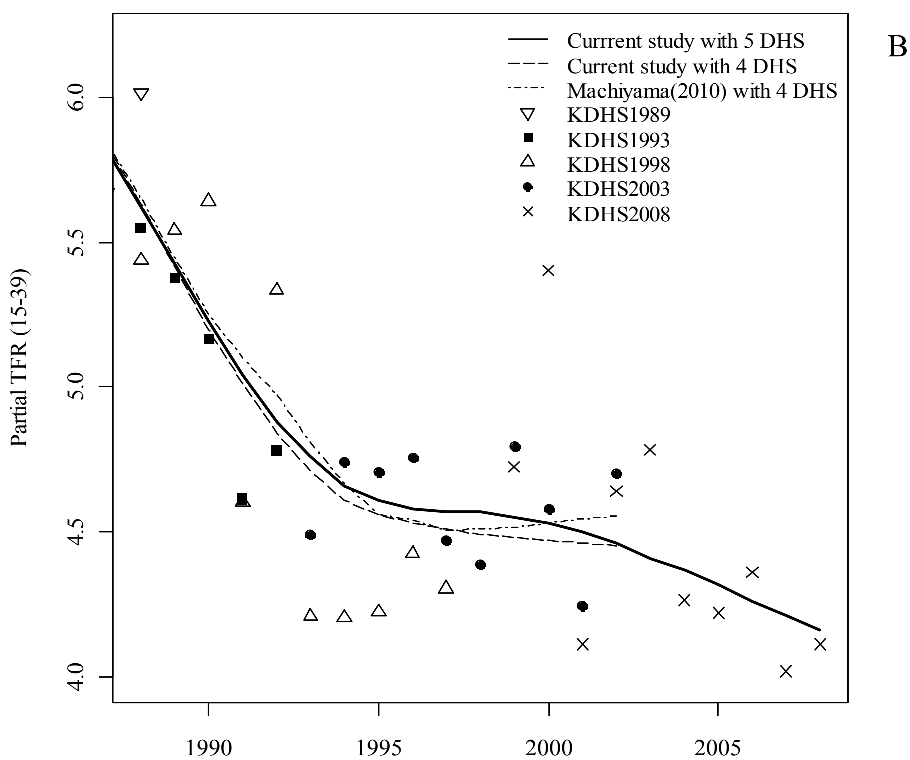


Figure 5.3: Partial total fertility rates (15-39), 1988-2008, Kenya: (A) comparison of the methods using 5 DHS; (B) comparison of the methods using 4 DHS

Source: DHS surveys.

On the other hand, the current study and previous study both suggest a similar deceleration in the pace of fertility decline throughout the entire period since 1995. The gap between the point estimates derived from the current approach and the previous method widened until 1995 and converged to no difference in 1998. The previous approach may not be sensitive enough to capture anomalous data points around 1995.

Figure 5.3.B. shows trends from (a) the current approach using the data from the first four DHS surveys (1989, 1993, 1998 and 2003); (b) the previous approach with the four DHS surveys, and (c) the current approach with five DHS surveys. The previous approach with four surveys (b) suggested that the fertility decline ceased around 1995 and was followed by a slight upward trend. The current approach also suggests that a deceleration occurred, but that decline continued after a short-term plateau in the late 1990s. Using the current approach, the slopes obtained with data from four and five surveys are quite similar, though the trend estimates without the data from the most recent survey are a little steeper. These findings suggest that the current approach is more robust way of estimating short- and long-term trends than the previous method because the latter gave a different trajectory when a new dataset is added to the analysis.

A multilevel analysis was performed to assess how clustering of partial TFR estimates derived from the same survey affects the overall Loess trend. Figure 5.4 shows the fitted standard and multilevel Loess trends for Kenya. The point estimates were generally very similar, though the multilevel approach estimated slightly smaller partial TFRs than the standard approach between 1992 and 2003. The multilevel uncertainty intervals are again similar to the standard ones near the centre of the plot, but much wider towards the extremes, particularly after 1995. These differences are likely due to within-trends of the last three surveys being distinct from those of earlier surveys.

The last sections explored possible explanations for the discrepancies in estimates derived from the data for two successive survey periods, mentioned earlier. Table 5.1 presents the proportions of women with secondary or higher education, by birth cohort and by survey. The difference in the proportions of educated women in the youngest cohort in Kenya is presumably due to the increase in the number of women going on to higher levels of schooling between the survey periods.

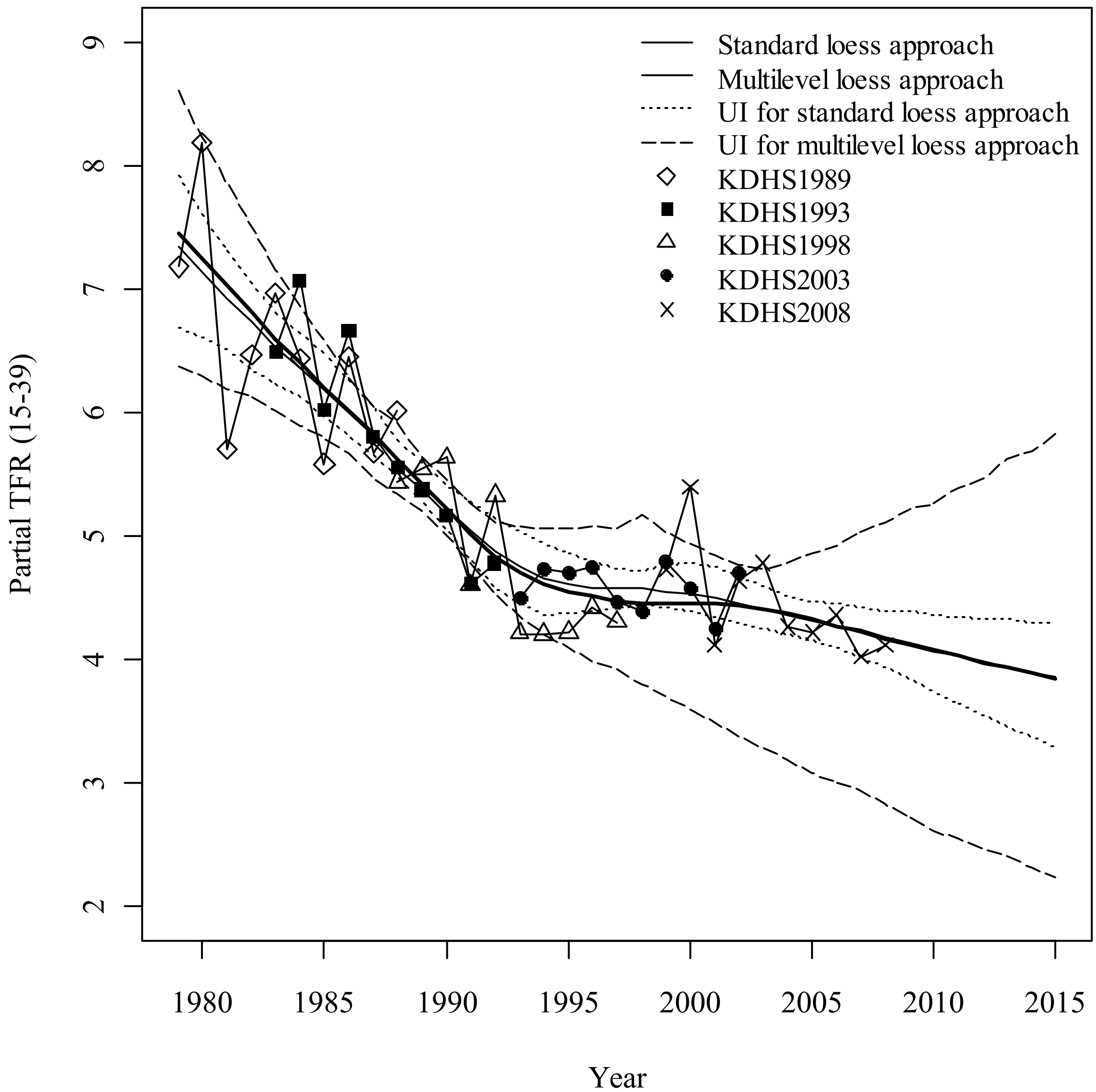


Figure 5.4: Comparison of standard loess and multilevel loess approaches for estimating TFR (15-39) trends, Kenya, 1979-2015

Source: DHS surveys.

This inter-survey comparison was performed in eight other countries (Machiyama 2010). Generally, the proportions were fairly similar across surveys, which implies that the composition of women by educational levels was quite similar and comparable across the surveys. It is unlikely that these slight differences have greatly affected trends of the fertility declines. Only in Ghana and Nigeria, the discrepancies were clearer. Ghana DHS 2003 had lower proportions of women with secondary or higher education in the 1960-89, though the differences were insignificant. This might have resulted from use of a new census as a sampling frame in the 2003 survey. In contrast, Nigeria showed a clearer difference across the surveys. The 1999 survey contained higher proportions of women with secondary or higher education among all birth cohorts except the 1980-89 cohort compared to in the 1990 and 2003 surveys. Birth cohort 1960-69 in the 1999 survey included about 31 percent of educated women, while the 1990 and 2003 surveys encompassed about 23 percent, though the difference was not significantly different. This may have led to lower estimation of fertility in the 1999 survey.

Table 5.2 shows average parity by birth cohort and by survey. Parities were similar across the successive surveys. For instance, in Kenya parity in 1998 and the estimates from the 2003 DHS survey have 0.1 or less differences among all birth cohorts. The composition of women in terms of average parity was fairly similar as well, and the small differences were unlikely to substantially affect estimation of fertility trends. The result suggests that there was no substantial omission or age displacement of children to earlier period. Yet, the previous study using this method showed that in the 1999 Nigeria DHS all birth cohorts had lower parity than the estimates from two successive surveys, probably resulting from substantial omissions of live births in the survey (Machiyama 2010).

This analysis was also repeated in eight countries (Machiyama 2010). In Nigeria DHS 1999, all birth cohorts had lower parity than the estimates from 2 other surveys. It is more plausible to say that there were substantial omissions of births in the 1999 survey. Other countries exhibited good agreement in parity. The results indicate that there was no substantial displacement of average number of births from the recent periods to the earlier periods across the first month of the field work of the earlier survey.

5.4. Conclusions

This chapter scrutinised Kenya's fertility changes using various estimates: unadjusted and adjusted TFRs by single year, the Loess estimates using a maximum α value of 1.0 or 2.0, and the multilevel Loess estimates. These lead to a clear conclusion that there is steep deceleration in pace of fertility decline since 1995 in Kenya. However, the application of the new innovative method suggested that the pace of decline appears to increase again in recent years and it is likely to continue to decline. Demonstration of use of different maximum values of α and use of different number of the datasets suggested that the Loess method with maximum α value of 1.0 is a robust method to depict fertility trends over a few decades. The next chapter applies this method for the other 16 countries and discuss the patterns of declines more extensively.

Table 5.4: Percentage of women with secondary or higher education by birth cohort and survey, Kenya

Survey / Birth Cohort	Percentage of women with secondary or higher education [95% CI]			
	1989	1993	1998	2003
1940-49	4.1 (2.92 - 5.70)	5.7 (3.91 - 8.36)	*	na
1950-59	15.4 (13.08 - 17.96)	16.0 (13.48 - 18.77)	19.7 (16.96 - 22.80)	21.93 (18.46 - 25.84)
1960-69	31.3 (28.79 - 33.82)	32.3 (29.36 - 35.35)	33.0 (30.14 - 35.98)	32.09 (28.73 - 35.65)
1970-79	20.5 (15.83 - 26.05)	26.2 (23.97 - 28.63)	36.2 (33.56 - 38.91)	32.01 (29.27 - 34.89)
1980-89	na	na	18.2 (15.13 - 21.71)	27.16 (24.91 - 29.53)

Table 5.5: Average parity by birth cohort and survey, Kenya

Survey / Birth Cohort	Average parity [95% CI]			
	1993	1998 reconstructed for 1993	1998	2003 reconstructed for 1998
1940-49	7.7 (7.37 - 7.96)	6.9 (6.43 - 7.40)	7.0 (6.53 - 7.49)	na
1950-59	6.1 (5.96 - 6.30)	5.9 (5.78 - 6.12)	6.3 (6.14 - 6.50)	6.2 (5.91 - 6.39)
1960-69	3.3 (3.17 - 3.38)	3.3 (3.14 - 3.36)	4.2 (4.09 - 4.35)	4.3 (4.12 - 4.43)
1970-79	0.5 (0.49 - 0.57)	0.5 (0.48 - 0.56)	1.4 (1.37 - 1.51)	1.5 (1.43 - 1.59)
1980-89	na	na	0.1 (0.07 - 0.12)	0.0 (0.04 - 0.06)

*an asterisk indicates a figure is based on fewer than 25 unweighted cases and has been suppressed.

Chapter 6 : RE-EXAMINATION OF FERTILITY TRENDS IN 17 SUB-SAHARAN AFRICAN COUNTRIES

6.1. Introduction

Chapter 5 proposed the innovative method adjusting for the common data errors and clustering of the data points by surveys. Using the data from Kenya, where fertility stall is more often reported, it presented compelling evidence of the validity of the method. It also pointed out the weakness of the methods widely used in the previous studies. Subsequently, this chapter presents its application to 16 sub-Saharan African countries. Furthermore, the pace of decline is compared with the estimates from the latest UN's World Population Prospect: the 2010 Revision.

Furthermore, the extent to which national fertility changes are attributable to changes in the educational and residential composition of the population of adult women was examined. Few studies have assessed fertility changes at sub-national level (Garenne 2008; Shapiro and Gebreselassie 2008). Residence and education are two of the most important structural factors associated with fertility decline. Women living in urban areas and educated women are in general more likely to postpone marriage, and to have access to education, health services and formal jobs as well as to adopt new behaviours such as the use of modern contraception. Urbanisation has accelerated in sub-Saharan Africa. The urban population in sub-Saharan Africa increased from only 26 per cent in 1975 to 40 per cent in 2009 (UN-HABITAT 2010). Women's educational attainment has also dramatically improved in recent decades. These social changes are part of the engine of fertility decline. Assessing the extent to which changes in the composition of the population of women have contributed to national fertility trends will aid understanding of the dynamics of fertility decline within countries.

6.2. Methods

6.2.1. Data

As discussed in Chapter 3, this study used individual, birth and household member datasets from 63 DHS surveys in 17 sub-Saharan African countries that have conducted three or more DHS surveys (see the list in Appendix 1).

6.2.2. Methods

The Loess methods were used in the way described in Chapter 5.

6.2.2.1. Standardisation by education and residence

Trends in the TFR (15-39) by means of Loess regression were estimated for six population strata defined by type of residence (urban/rural) and three levels of highest educational attainment (no education/primary education/secondary or higher education) for each country. The estimates were then standardised by the educational and residential composition of women in the first survey for each country. The difference between the observed Loess partial TFR (15-39) and the standardised Loess TFR (15-39) in the latest year divided by the observed change in partial TFR since 1980 or 1985, provides the percentage of change in national fertility decline attributable to the compositional changes during the period.

6.3. Results

Using the improved method, fertility trends in 16 other countries were re-assessed in addition to Kenya. Figure 6.1 displays trends of partial TFR (15-39) in the past 15-20 years in the 17 countries. The unbroken line represents the median values of the fitted TFRs and the dashed lines indicate the uncertainty limits. The degree of variability in the data points varies between countries. The data points were widely scattered in Mali, Niger, Nigeria, and Rwanda and their uncertainty areas were consequently wider, suggesting poorer data quality. In contrast, in Kenya, Tanzania and Zimbabwe the data points were more consistent and less scattered, indicating better quality.

On the whole, all the countries show at least some fertility decline. In Kenya and Zimbabwe, the annual declines were over 2.0 per cent in the 1980s, then the pace decelerated to 1.35 per cent or lower in the 2000s. Kenya's deceleration since 1995 is particularly striking. Benin, Malawi, Zambia and Zimbabwe have experienced a halving of the pace of fertility decline since the 1980s, but their declines did not cease (see Table 6.1). Nigeria appears to have experienced deceleration, though, due to the very poor quality of the data, cautious interpretation is required (National Population Commission [Nigeria] 2000). In Ghana and Rwanda the pace of decline was rapid in the 1980s, slowed down in the 1990s, and then remained similar or reduced even more since 2000. In contrast, in Cameroon and Senegal fertility has continued to drop at almost the same pace throughout the past 20 years. The slopes of the trends were linearly downward throughout the period. In Mali, Tanzania, and Uganda, annual declines have consistently remained one per cent or below, suggesting that they remain in the very early stage of their transitions. While Mali and Uganda appear to have experienced some acceleration, Tanzania may have seen a further reduction in the pace at a high level in 2000-05. In Niger, the evidence suggests that the onset of fertility decline occurred in the 2000s.

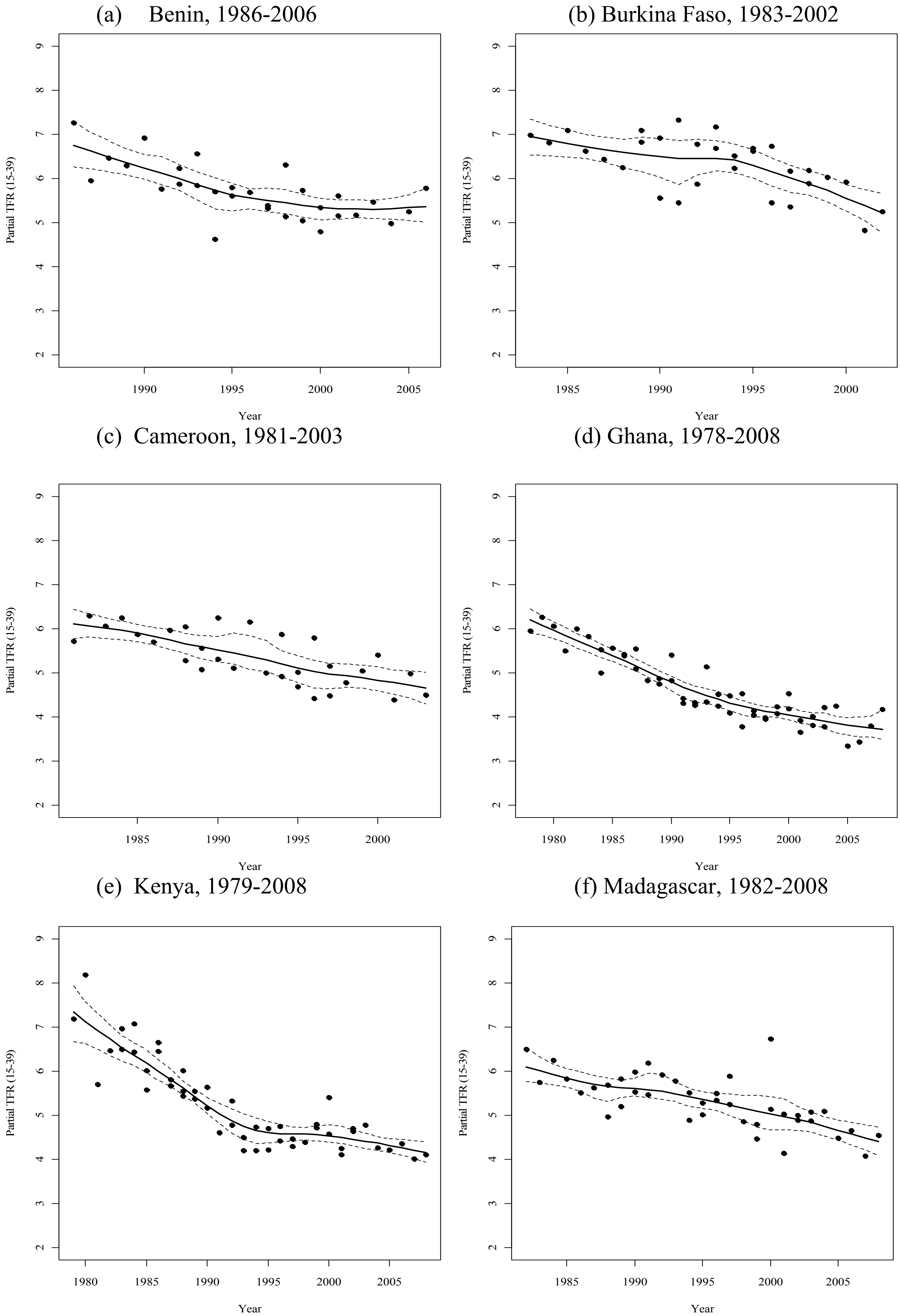
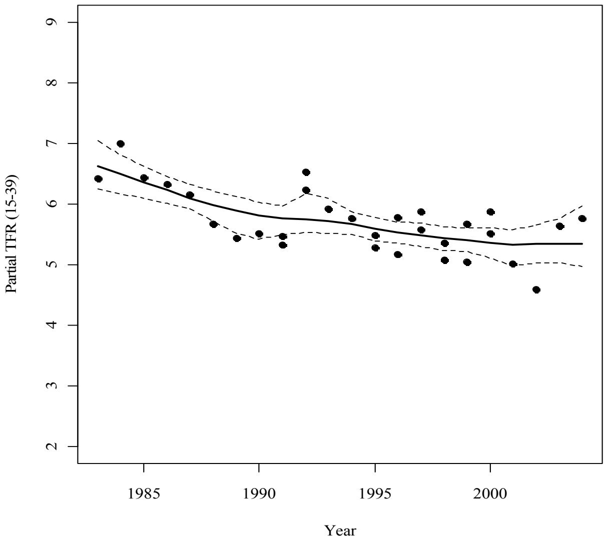
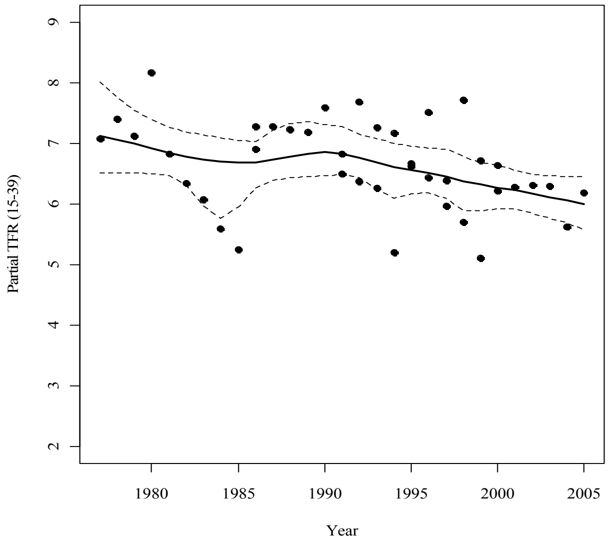


Figure 6.1: Partial Total Fertility Rates (15-39) by single calendar year, 17 sub-Saharan African countries

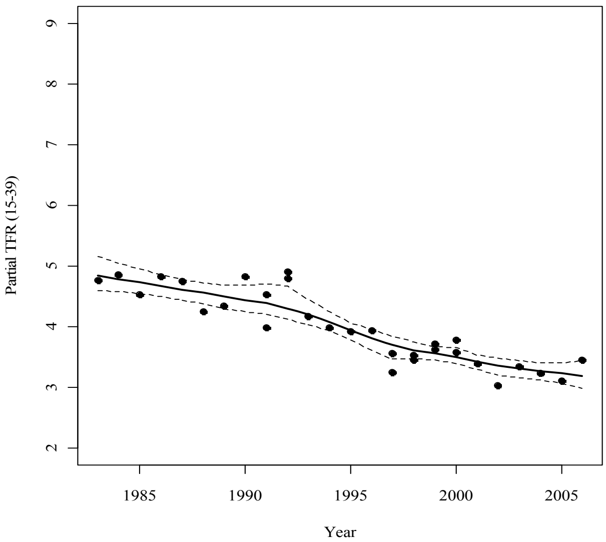
(g) Malawi, 1984-2004



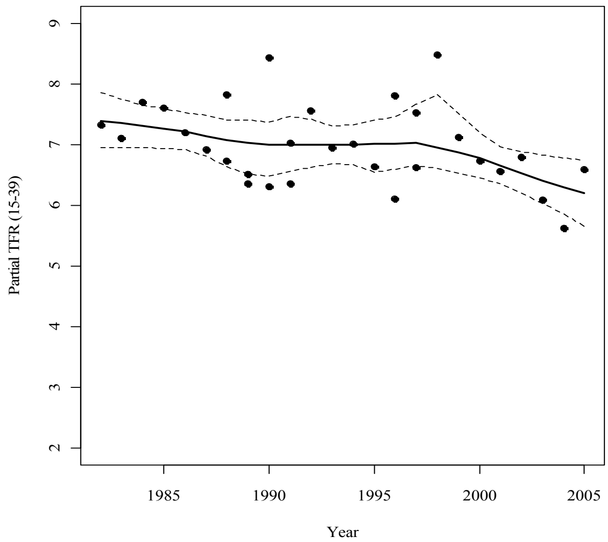
(h) Mali, 1982-2008



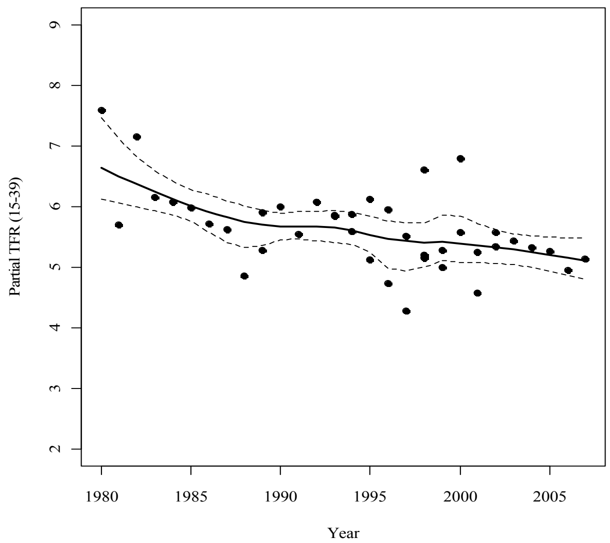
(i) Namibia, 1983-2006



(j) Niger, 1982-2005



(k) Nigeria, 1979-2008



(l) Rwanda, 1982-2008

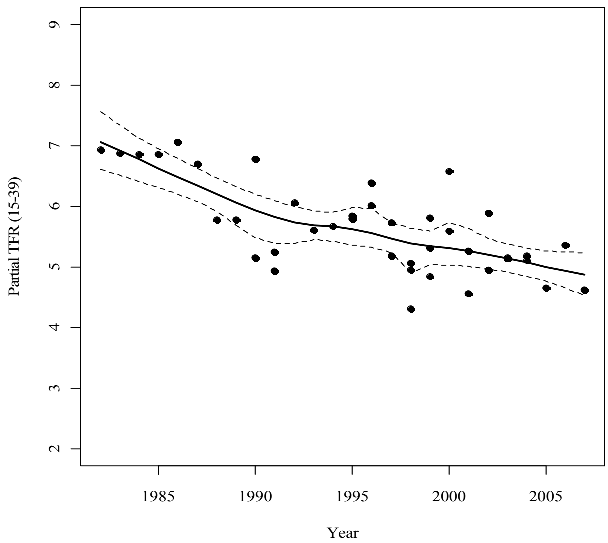
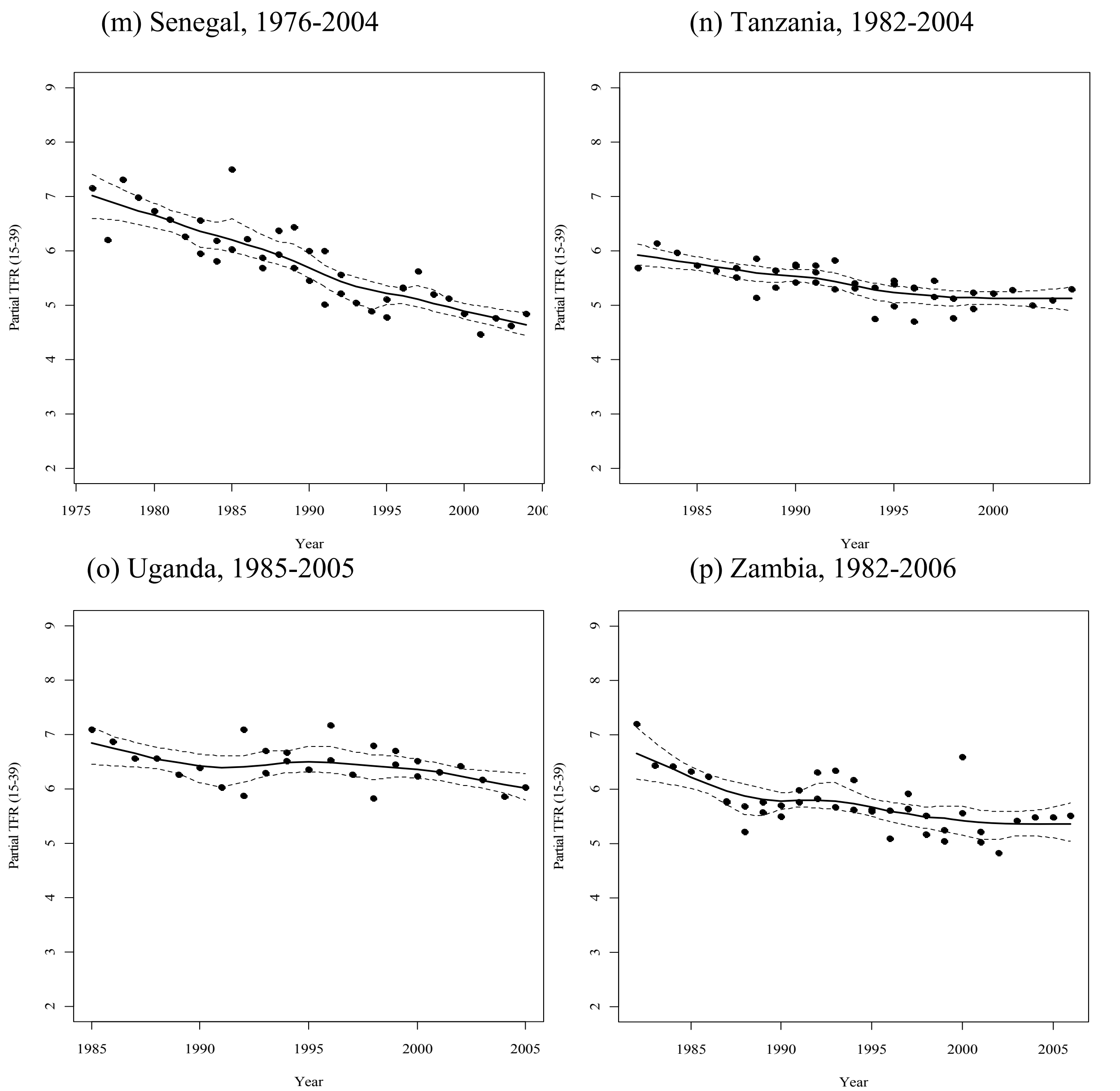


Figure 6.1: Partial Total Fertility Rates (15-39) by single calendar year in 17 sub-Saharan Africa countries (continued)



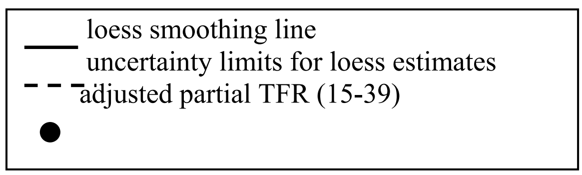


Figure 6.1: Partial Total Fertility Rates (15-39) by single calendar year in 17 sub-Saharan African countries (continued)

Figure 6.2 presents the average annual per cent of decline in partial TFR in 2000-05 compared with 1990-95 for the 17 sub-Saharan African countries. The countries below the 45º equivalence line saw a deceleration in the rate of decline and countries above 45º equivalence line an acceleration. The pace in 1990-95 was used as a comparator instead of that in the 1980s since the estimates in the 1980s may be overestimated, as discussed later. Therefore, rapid decline of fertility in the countries which were in early transition in the 1980s is not covered in Figure 6.2. More than half of the countries experienced a reduction in the pace in fertility decline in this period. The pace in Benin, Ghana, Kenya, Malawi, Tanzania, Namibia, and Zimbabwe slowed down, whereas Burkina Faso, Niger and Uganda saw acceleration during this period. The latter show acceleration because these countries initiated the transition very recently. The widespread deceleration in pace of fertility decline coincides with the smaller increase in contraceptive prevalence in the early 2000s compared with the 1990s (Cleland et al. 2011). It is alarming that more than a half of the mid-transitional

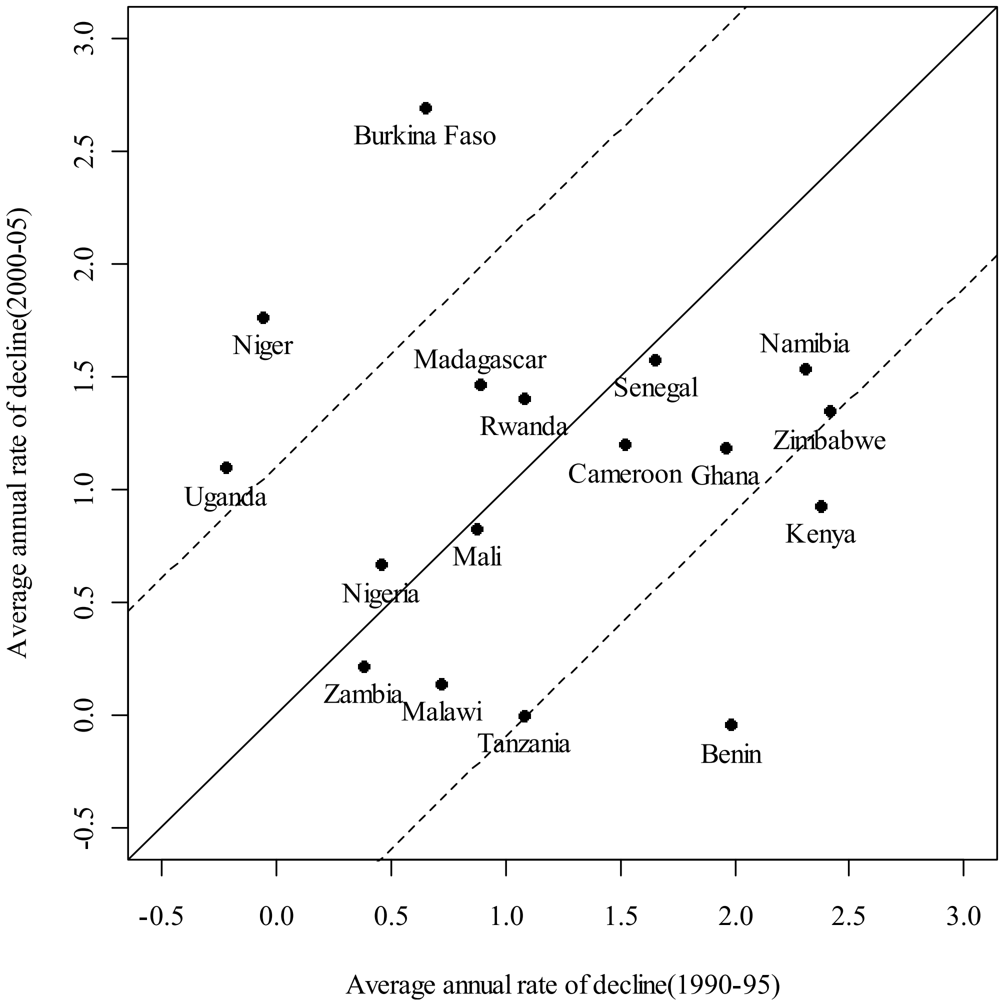


Figure 6.2: Average annual rates of decline in partial TFR in 2000-05 compared with 1990-95, by country

countries have seen fertility decline slow down at a high level of total fertility.

Previously the results in this study were compared with the UN's World Population Prospect: the 2008 Revision (Machiyama et al. 2010). The results suggest that the UN overestimated the speed of fertility decline by more than 0.1 per cent in average annual rate of change in 10 out of the 17 countries in the 1990s, and in 9 countries in the 2000s compared with our results. The 2010 Revision adopted a new method and projects a substantially slower pace of decline than the 2008 Revision (Alkema et al. 2011). The estimates and projections in 2000-05 or and/or 2005-10 have been upwardly revised in all the 17 sub-Saharan African countries except Namibia, Uganda and Zimbabwe. The TFRs in Malawi, Mali, Niger Nigeria were entirely changed and the new estimates show much slower pace of decline. In addition, the new method makes an assumption that TFRs would converge at 1.85 in 2098, instead of 2048.

Table 6.1 compares annual rates of fertility change by decade between the UN estimates and the Loess estimates in this research. The pace of the UN estimates was obtained by interpolating TFR estimates using the data between 1975-2015 derived from The 2010 Revision of UN's World Population Prospect (United Nations 2009b). The differences between the two estimates have narrowed compared with the ones with the 2008 Revision. The pace of decline from this study was slower in 13 countries in the 1990s and 7 countries in the 2000s than the UN estimates.

However, it is important to highlight that the estimates from this thesis might estimate a faster pace of decline in the 1980s than the UN in most countries. Most of the countries conducted their first DHS surveys in the early 1990s and age shifting of children across the five-year boundary was more substantial in the first than in subsequent surveys , thereby perhaps exaggerating the fertility decline (for example in Nigeria and Rwanda). Also, there is evidence that census estimates, taken into account by the UN but not by us, were lower than DHS estimates in some countries (Alkema et al. 2008). This diagnosis suggests that use of only one DHS survey is insufficient for trend estimation, even after applying Pullum's correction for backward age displacement of children.

Table 6.1: Comparison of TFR (15-49) between Loess and UN estimates of the pace of fertility decline in 17 sub-Saharan African countries

		Average annual rate of change (%)		
		1980s	1990s	2000s
Benin	Loess[1]	-1.85	-1.46	0.04
	UN[2]	-0.41	-1.11	-1.16
Burkina Faso	Loess	-0.94	-1.46	-2.70
	UN	-0.31	-0.81	-0.67
Cameroon	Loess	-1.07	-1.27	-1.20
	UN	-0.79	-1.50	-1.00
Ghana	Loess	-1.98	-1.54	-1.19
	UN	-1.40	-1.61	-1.10
Kenya	Loess	-2.66	-1.34	-0.93
	UN	-1.87	-1.66	-0.65
Madagascar	Loess	-1.00	-1.03	-1.47
	UN	-0.48	-1.10	-1.58
Malawi	Loess	-1.55	-0.76	-0.11
	UN	-0.88	-0.94	-0.21
Mali	Loess	-0.10	-0.86	-0.83
	UN	0.01	-0.36	-0.75
Namibia	Loess	-1.21	-2.12	-1.54
	UN	-1.84	-2.26	-2.02
Niger	Loess	-0.68	-0.30	-1.77
	UN	0.13	-0.38	-0.59
Nigeria	Loess	-1.45	-0.49	-0.67
	UN	-0.54	-0.79	-0.63
Rwanda	Loess	-2.00	-1.06	-1.13
	UN	-1.50	-1.73	-0.76
Senegal	Loess	-1.46	-1.41	-1.27
	UN	-1.03	-1.61	-1.34
Tanzania	Loess	-0.82	-0.72	0.00
	UN	-0.66	-0.80	-0.29
Uganda	Loess	-1.23	-0.11	-1.10
	UN	-0.03	-0.33	-1.04
Zambia	Loess	-1.64	-0.61	-0.22
	UN	-0.96	-0.51	0.16
Zimbabwe	Loess	-2.70	-1.76	-1.35
	UN	-2.59	-2.51	-1.56

Source: World Population Prospect: The 2010 Revision and DHS surveys.

Note. 1. These were obtained by dividing the Loess partial TFR (15-39) estimates by 0.9, assuming women 40-49 would contribute 10 per cent of full TFR (15-49).

2. These were obtained by interpolation using TFR (15-49) estimates in 1975-80 and 2010-15 derived from the UN's World Population Prospects: The 2010 Revision, assuming that fertility declines exponentially between the periods

Table 6.2: Partial TFR trends between 1980s and 2000s: observed and standardised by the educational and residential composition of the reproductive age women

Country	1980/1985/1990		2005		
	Year	Observed Loess partial TFR	Observed Loess partial TFR	Standardised Loess partial TFR	% decline attributable to changes in composition
Benin	1990	6.25	5.35	5.56	23.3%
Burkina Faso	1985	6.80	4.8	4.88	4.0%
Cameroon	1985	5.90	4.54	5.01	34.6%
Ghana	1980	5.97	3.81	4.21	18.5%
Kenya	1980	7.13	4.32	4.89	20.3%
Madagascar	1985	5.85	4.66	4.69	2.5%
Malawi	1985	6.37	5.34	5.94	58.3%
Namibia	1985	4.73	3.23	3.62	26.0%
Nigeria	1980	6.63	5.21	5.91	49.3%
Rwanda	1985	6.63	5.01	5.20	11.7%
Senegal	1980	6.66	4.58	5.04	22.1%
Zambia	1985	6.22	5.37	5.39	2.4%
Zimbabwe	1980	6.15	3.45	3.76	11.5%

Source: DHS surveys.

Table 6.2 presents observed Loess partial TFRs in either 1980, 1985 or 1990 from the earliest survey, and observed and standardised Loess partial TFRs in the latest year after excluding the four early transition countries. The results show that a considerable proportion of fertility decline in the last 15-30 years was attributable to compositional changes. In Cameroon, Malawi, and Nigeria, over 30 per cent of decline has been due to compositional changes, whereas they contributed least in Burkina Faso, Madagascar, and Zambia. In fact, there are very limited changes in the composition of women in Burkina Faso: the proportion of women living in rural areas remains at 80 per cent, and 80 per cent of women has never been to school. This is an interesting case, because fertility seems to have been falling with limited social change.

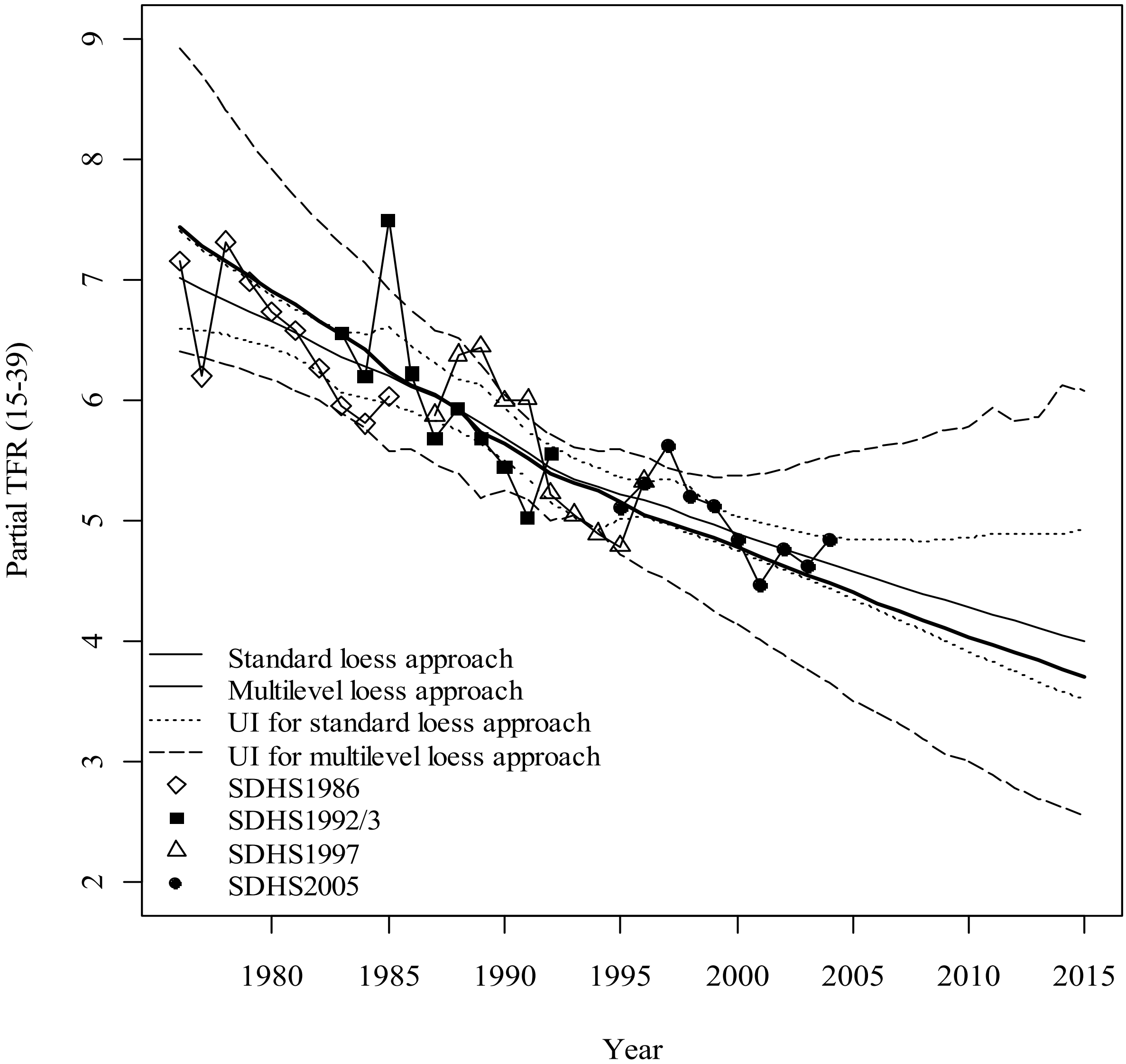


Figure 6.3: Comparison of standard loess and multilevel loess approaches for estimating TFR (15-39) trends, Senegal, 1976-2015.

Source: DHS surveys

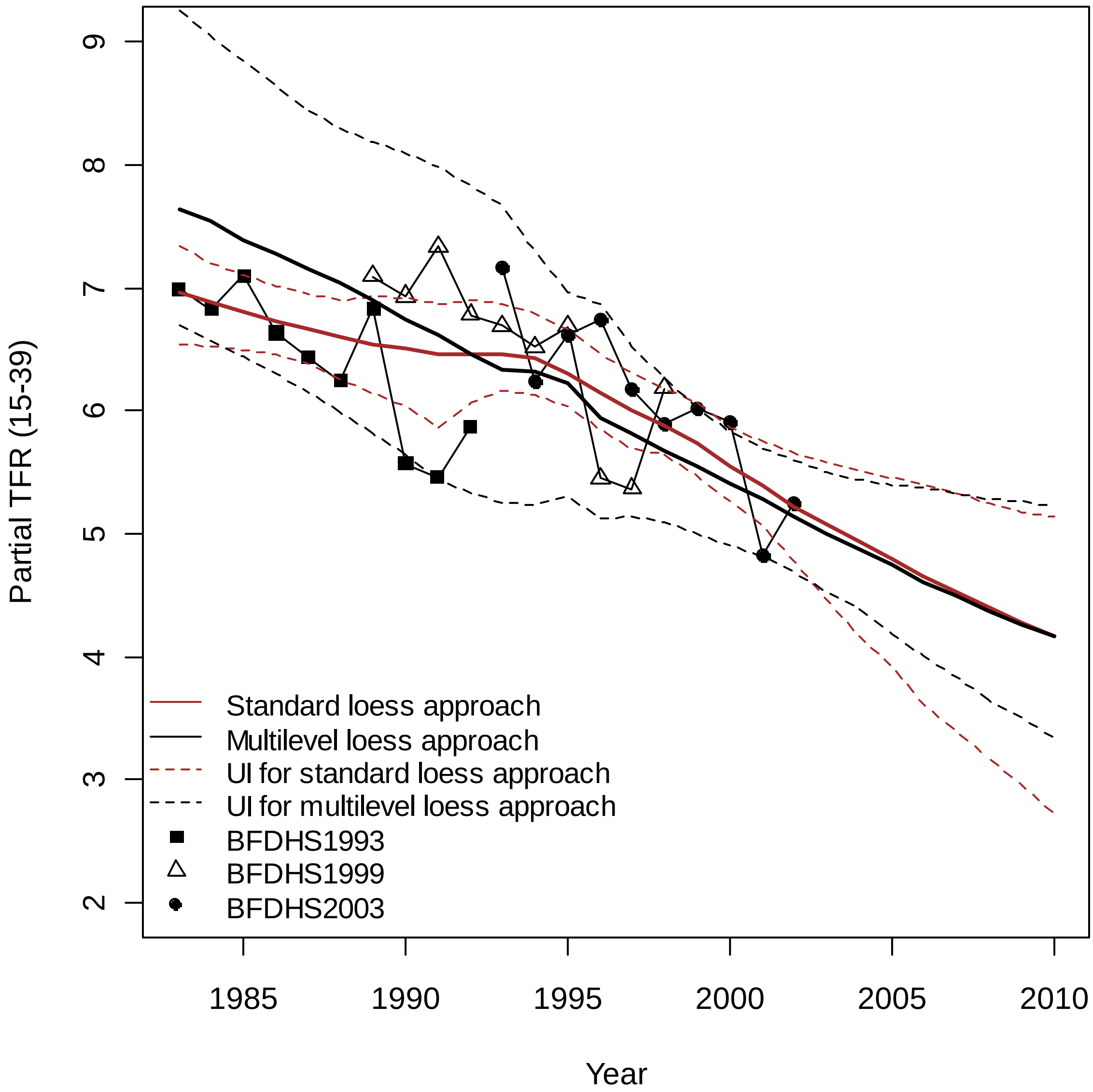


Figure 6.4: Comparison of standard Loess and multilevel Loess approaches for estimating TFR (15-39) trends, Burkina Faso, 1983-2010

A multilevel analysis was performed to assess how clustering of partial TFR estimates derived from the same survey affects the overall Loess trend. Figure 6.3 displays the trends from the standard and the multilevel analysis in Senegal. The multilevel approach resulted in a slightly steeper trend throughout the period, though the estimates between about 1985 and 1995 were very similar under the two approaches. The uncertainty intervals were a similar width according to the two approaches between about 1985 and 1995, but much wider under the multilevel approach outside this range. Given that there are only four independent sources of data, as the standard approach incorrectly assumes the 40 data points are independet, the multilevel approach and these wider uncertainty areas are possibly more appropriate.

Figure 6.4 shows the fitted standard and multilevel Loess trends for Burkina Faso. There are discrepancies in point estimates, particularly during the earlier period, due to clear differences between the within- and between-survey trends. All three surveys have similar within-survey slopes which are reflected in the multilevel trend, but there are between-survey differences in level. As the second and third surveys are more similar, with first survey being somewhat anomalous, the multilevel trend is fitted closer to the level of estimates from these surveys. The differences between the fitted trends under two approaches highlight issues with the data which should be considered.

6.4. Discussion

The analysis confirms that fertility declines have slowed down in recent years in some parts of sub-Saharan Africa. Among the 17 countries studied, six have seen the pace of decline more than halve since the 1980s. An acceleration was observed in only two countries. However, the extent of deceleration has been relatively limited compared with that suggested by previous studies. Compelling evidence exists that the pace of fertility decline has decelerated in Benin, Kenya, Malawi, Nigeria, Zambia and Zimbabwe during the past two decades, but the only complete cessation of decline in the countries studied was a short-term plateau in Kenya in the late 1990s. Constant rates of decline were observed in Cameroon and Senegal, and acceleration since the 1980s was found in Burkina Faso and Madagascar. The fact that this conclusion differs from those of previous analyses is attributable to the use of new methods, adjustment for certain errors in the data, and the addition of new datasets.

The pace of decline estimated in this study is substantially slower than that in the 2008 UN estimates for the 1990s and 2000s, but there were smaller differences with the 2010 UN estimates for the 2000s. This suggests that the UN's projection for sub-Saharan Africa in the 2008 Revision overestimated the pace of decline, and support the recent changes of the estimates in the 2010 Revision.

Another key finding is that compositional changes have contributed substantially to recent fertility changes. Over 30 per cent of the fertility decline in Cameroon, Malawi, and Nigeria since 1980 or 1985 can be attributed to educational and residential compositional changes. This finding is important since it stresses that total fertility trends tell us little about changes in reproductive behaviour within the countries.

There are several limitations to this study. First, I relied solely on data from DHS surveys. The major source of non-sampling error, age displacement of children was adjusted. However, other problems also exist in the data.

Omission of births is another potential error in DHS surveys. Omission could be serious, especially if the births of children who died in infancy are systematically underreported. However, DHS make every effort to avoid this error. The questionnaire contains questions on total number of sons and daughters, and total number of children ever born as well as full birth histories. Moreover, the training of interviewers emphasises the importance of obtaining accurate information on births. There is little evidence of omission except in the Nigeria 1999 survey, though it is difficult to differentiate between omission and age displacement of children (Goldman et al. 1985; Arnold 1990; National Population Commission [Nigeria] 2000). Omission is likely to occur mostly among women aged 40-49 with high parity (Arnold 1990). Furthermore, as presented in the previous study (Machiyama 2010) and discussed in Chapter 5, the examination of average parity by birth cohort between successive surveys shows evidence of substantial omission only in the 1999 Nigeria DHS. To the extent that this is true, our estimates of the partial TFR (15-39) will be unaffected by omissions of births.

With regard to Loess smoothing, selection of the minimum and maximum values of α is somewhat arbitrary, as is the density of α values between these limits (Silverwood and Cousens 2008). While this will not seriously affect the point estimates in most cases, the uncertainty areas could be affected. But this analysis represents a distinct improvement on relying entirely upon a single, arbitrarily chosen, value of α as in Machiyama (2010), and the results obtained in this approach appear to provide plausible uncertainty intervals.

In addition, the current Loess method may have smoothed out minor fluctuations, such as brief stalls. The use of small α values allows the capture of short-term changes in trend, but when they are pooled with the estimates/predictions corresponding to larger α values any such hiatuses in the downward trend may disappear. However, the results have shown that use of the maximum α value of 1.0 effectively picked up the short-term plateauing of fertility in Kenya. Moreover, if more substantial stalls occurred, the method should capture them. As most short-term stalls are likely to be spurious, caused by age displacement of children or other errors, this characteristic of the method is not necessarily a deficiency.

It is theoretically important to take into account the clustering of partial TFR estimates within surveys as the assumption of independence is clearly invalid. Currently the number of surveys available within each country is at the very lower limit of what is feasible for multilevel modelling. However, as the number of surveys increases, the reliability of the multilevel approach will improve. Presently, it is perhaps best to consider the multilevel approach more as a useful diagnostic tool to identify countries in which the within- and between-survey trends differ substantially, indicating that closer scrutiny of the results may be required.

This study has significantly improved the estimation of fertility decline from retrospective survey data by use of the new method which is more robust, not easily affected by anomalous estimates, and incorporates both short- and long-term trends. Secondly, estimating uncertainty intervals for the estimates helps significantly in the interpretation. Furthermore, the multilevel analysis helps to assess how the clustering of the estimates within each survey affects the overall Loess trends.

The analysis confirms fertility declines have decelerated in fewer countries than previously thought. However, the findings support the recent claim that UN's medium variant until 2008 had been optimistic. The population of countries with a partial TFR (15-39) of above 5, such as Benin, Malawi, Mali, Niger, Nigeria, Rwanda, Tanzania, Uganda, and Zambia, are projected to double or triple in size by 2050 (United Nations 2009b). The implications of the enormous population growth expected in these countries for social and economic development is immense. Therefore, detailed and robust monitoring of fertility trends is crucial.

Chapter 7 :REVIEW OF THE APPLICATION OF THE PROXIMATE DETERMINANTS FRAMEWORK TO SUB-SAHARAN AFRICA

7.1. Introduction

The previous chapters examined fertility changes in 17 sub-Saharan African countries during the past two decades and concluded that the pace of recent fertility declines decelerated in six countries (Benin, Kenya, Malawi, Nigeria, Zambia and Zimbabwe). The objective of this chapter is to review the applicability of Bongaarts' proximate determinants model to Africa. This leads to the next chapter which will assess the extent to which changes in proximate determinants support the estimated fertility trends, using a modified form of Bongaarts' framework.

7.2. Literature review and descriptive analysis

7.2.1 Bongaarts' proximate determinants framework

More than 30 years have passed since John Bongaarts developed the proximate determinants framework, following the work of Davis and Blake who identified eleven 'intermediate' determinants of fertility (Bongaarts 1978; Davis and Blake 1956). This framework made significant contributions to the interpretation of changes and differentials in fertility levels across populations. Seven proximate determinants were identified: (1) the proportion of married among women of reproductive age; (2) contraceptive use and effectiveness; (3) postpartum infecundability; (4) incidence of induced abortion; (5) fecundability (or frequency of intercourse); (6) prevalence of permanent sterility; and (7) spontaneous intrauterine mortality (Bongaarts 1978). Amongst these seven determinants, the first four explained 96 per cent of the variations in the observed TFR estimates in 41 developing, developed and historical populations (Bongaarts 1982).

This innovative development generated countless studies which applied this framework to a variety of countries in the 1980s and the early 1990s. Along with an increase of population data, notably from WFS and DHS, the accumulating evidence advanced our understanding of the mechanisms of fertility and fertility trends. One significant feature of this framework is that it distinguishes the effects of biological and behavioural factors on fertility from social, cultural, economic, institutional, psychological and environmental factors. The latter factors influence fertility only through modifying the proximate determinants (Bongaarts, Frank and Lesthaeghe 1984). This evidence has further stimulated the heated debate over explanations of fertility decline.

As individual data became available, several studies on birth intervals arrived at different results. They suggested that the effects of social and economic variables on the duration of birth intervals remained, after adjustment for proximate variables (Bumpass, Rindfuss and James 1986; Palloni 1984; Trussell et al. 1985). More recently, Baschieri and Hinde have introduced a novel method of using DHS month-by-month calendar data (Baschieri and Hinde 2007). The results have demonstrated that the variations in birth intervals between the first and second births among individual women in Egypt were sufficiently explained by the proximate determinants. Moreover, the individual effects of social, economic and cultural factors were insignificant.

The proximate determinants are in fact particularly important to sub-Saharan African fertility. While the primary cause of rapid fertility decline in Asia was the rapid diffusion of modern contraceptive use to limit the number of children, the correlation between TFR and contraceptive prevalence has been weaker in Africa (Blanc and Grey 2000; Westoff and Bankole 2001). There is also abundant evidence that long-term breastfeeding, postpartum abstinence and pathological sterility are crucial factors in inhibiting fertility in the region (Bongaarts et al. 1984; Lesthaeghe 1980). While the model was used extensively in the 1980s and 1990s, it seems rather underused in recent years. A few studies have applied the model, but they have often merely used the original Bongaarts' formulation without any assessment of its applicability to Africa (Guengant and May 2001, 2009; Sibanda et al. 2003). Some modifications have been suggested (Anyara and Hinde 2006; Jolly and Gribble 1993; Singh, Casterline and Cleland 1985). While Stover has suggested comprehensive revisions (1998), there is little review of its application, specifically to the African context (Anyara et al. 2006).

The time has come to assess whether Bongaarts' framework can be adequately applied to Africa using new evidence and data. This chapter reviews the evidence focusing on five problems when applying the framework to Africa (Bongaarts et al. 1984): (1) appreciable levels of premarital exposure to pregnancy; (2) low frequency of sex within marriage; (3) polygyny; (4) high level of pathological sterility; and (5) widespread use of traditional family planning methods. Not only published literature, but also the data from the DHS STATcompiler available at the ICF Macro website, and the results from descriptive analysis using the DHS data, are synthesised into this review. The comprehensive review will help to understand reproductive behaviour in contemporary Africa. At the end of this chapter, the necessary modifications to Bongaarts' model will be proposed.

Data quality of the variables used for the proximate determinants analysis in Chapter 7 and 8 was not assessed comprehensively in this thesis. There may be more errors and biases in these variables than age and date misreporting, though relatively reliable indicators were used. However, the main aim of this thesis is to provide accurate trend estimation of TFRs over two decades. The proximate determinants analysis does not aim to provide accurate estimates. Rather, this model was sued to assess the extent of which the projected TFRs constructed from the model support the Loess estimates.

7.2.2. Premarital exposure to conception

The proportion of married women is a principal proximate determinant in Bongaarts' framework. It is intended to quantify the degree of the inhibiting effect caused by time, when a woman does not engage in sexual intercourse regularly (Bongaarts 1978). Women who are cohabiting or in a union generally have more intensive exposure to the risk of pregnancy than those outside a union. Thus, marriage (including consensual union) is used as a proxy for sexual exposure in Bongaarts' framework.

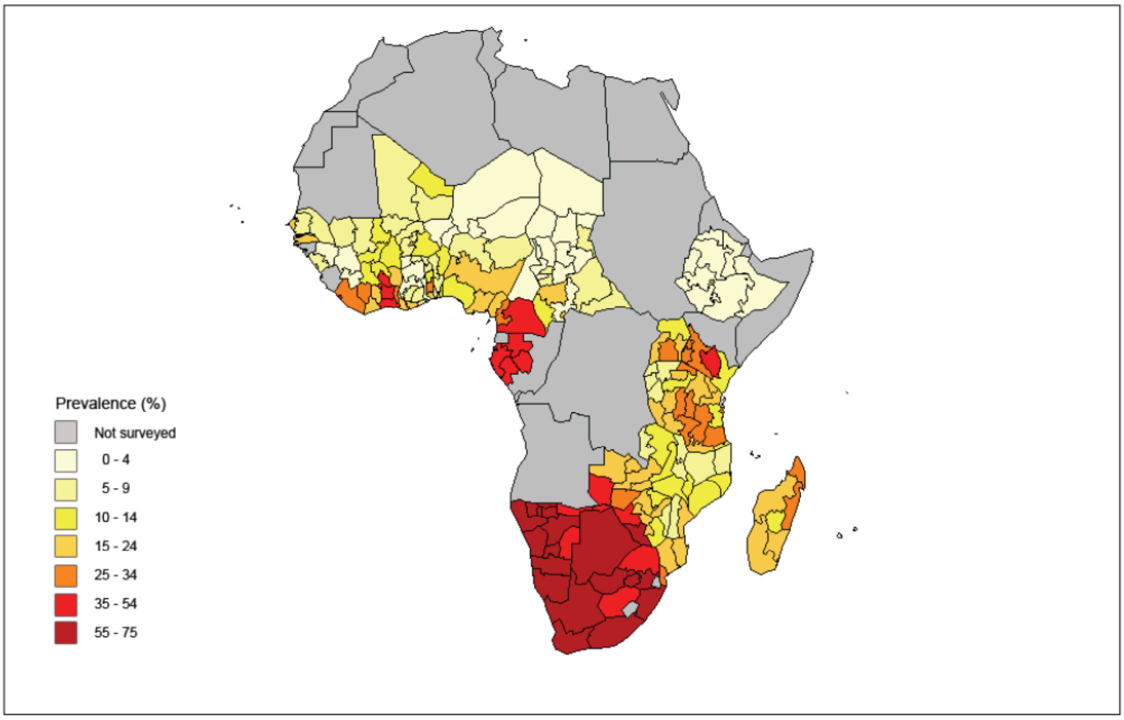


Figure 7.1: Prevalence of premarital fertility in Africa, by region

Source: Garenne and Zwang (2006a)

The exposure to conception, however, is not confined within marriage in sub-Saharan Africa. In addition to early marriage and sexual debut, premarital exposure is far from negligible. The earlier literature reported that premarital childbearing has been very common in Botswana and Namibia (Westoff, Blanc and Nyblande 1994). The median age of first birth and first marriage were 19.6 and 23.9 in Botswana, and 21.0 and 24.8 in Namibia, indicating widespread premarital childbearing in the two countries (Westoff et al. 1994). In contrast, based on the DHS data between 1986 and 1989, premarital childbearing was very rare in Burundi (Gage-Brandon and Meekers 1993). Premarital childbearing is also uncommon in Ethiopia. Despite the rapid rise of age at first marriage, over 90 per cent of never-married women remained childless in 2000 in Addis Ababa (Sibanda et al. 2003).

Figure 7.1 from the paper by Garenne et al. clearly presents the variability in prevalence of premarital childbearing, i.e. the proportion of women who gave birth before first marriage (Garenne and Zwang 2006a). The prevalence was high (over 35 per cent) in Southern Africa (Botswana, Lesotho, Namibia, Swaziland and South Africa), Congo, Gabon, and some parts of Cameroon, Côte d'Ivoire, Kenya, Zimbabwe and Zambia. However, it was not common in Western Africa and the Sahel regions. This considerable regional variation in premarital fertility needs to be taken into account when applying the proximate determinants model.

Age at first sex

Duration of premarital exposure to conception is determined by age at first sex, marriage and childbearing. Early sexual debut often leads to premarital childbearing and longer durations of exposure to sexual intercourse. This results in high fertility in low contraceptive-prevalence countries. Sexual initiation occurs at an early age and often precedes marriage in Africa (Blanc and Rutenberg 1991; Caldwell et al. 1992). Among women who had ever married, over 50 per cent had premarital sex in Ghana, Kenya, Liberia and Togo while only 13 per cent had done so in Mali and 20 per cent in Burundi, based on the DHS data in the period 1986-1989 (Meekers 1994). Among single women aged 18-19, over 45 per cent had sexual intercourse in the past four weeks prior to the DHS survey in Ghana, Kenya Uganda and Zimbabwe, while the levels were much lower in Burundi and the Latin American countries in the period 1984-1993 (Blanc and Rutenberg 1991).

Table 7.1: Median ages at first sexual intercourse, marriage and birth among women aged 25-29 in 17 sub-Saharan African countries

	Age at first sexual intercourse		Age at first marriage		Age at first birth	
	1990-96	2003-8	1990-96	2003-8	1990-96	2003-8
Western/Middle Africa						
Benin	17.2	17.7	18.7	18.7	19.8	20.0
Burkina Faso	17.2	17.4	17.5	17.7	19.0	19.3
Cameroon	16.0	16.5	16.9	18.1	19.3	19.4
Ghana	17.0	18.6	18.9	21.0	20.3	21.8
Mali	15.8	16.2	16.1	16.7	18.6	18.6
Niger	15.0	15.8	15.1	15.7	17.8	18.0
Nigeria	16.4	18.1	17.2	19.3	19.6	20.9
Senegal	16.5	19.3	16.8	19.2	19.3	21.2
Median	*16.5*	*17.6*	*17.1*	*18.4*	*19.3*	*19.7*
Eastern Africa						
Kenya	17.0	18.3	19.5	20.2	19.3	19.8
Madagascar	17.0	17.2	18.9	18.4	19.6	19.5
Malawi	-	17.5	17.7	18.2	18.7	19.0
Rwanda	20.2	20.0	20.9	20.6	22.0	21.7
Tanzania	17.2	17.3	19.0	19.0	19.5	19.6
Uganda	16.0	16.7	17.8	18.0	18.9	18.8
Zambia	16.4	17.4	18.0	18.7	18.8	19.2
Zimbabwe	18.4	18.9	19.3	19.6	19.7	20.1
Median	*17.0*	*17.5*	*19.0*	*18.9*	*19.4*	*19.6*
Southern Africa						
Namibia	19.0	18.7	24.9*	29.2*	21.2	21.4
North Africa/Southeast Asia						
Egypt	na	na	19.9	21.2	21.7	22.9
Bangladesh	na	na	14.8	15.6	17.9	18.1
Indonesia	18.6	20.5	18.6	20.2	20.4	21.9
Latin America						
Bolivia	19.0	18.8	20.6	21.1	21.1	21.2
Colombia	20.2	17.9	21.5	21.8	22.6	21.8
Dominican	19.9	17.8	19.8	18.5	21.7	20.3

Source: Macro International Inc, 2011. MEASURE DHS STATcompiler. http://www.measuredhs.com
*Note: * The medians are among women aged 30-34 as there were few married women in the 25-29 age group.*

Table 7.1 shows median ages at first sex, first marriage and first childbearing among women aged 25-29 in 17 sub-Saharan African countries and 6 countries from other regions. This shows early initiation of sexual activity in Eastern (17.5 years) and

Western Africa (17.6 years) compared with Southern Africa and Latin America. In recent years, women initiated sexual activities slightly later. In Senegal, in particular, the median has increased by 2.8 years in the past 10 years. Ghana and Nigeria experienced relatively greater increases by about 1.6 years. In contrast, the three Latin American countries experienced small declines to around 18 years old, but the medians were still higher than in Western and Eastern Africa.

Age at first marriage

Traditional African marriage is characterised by early marriage, widespread polygyny and frequent remarriage. Lesthaeghe et al. have described sub-regional patterns of marriage in Africa. In the Sahel region and Western and Middle Africa, early marriage and polygyny is widespread, and the age difference between spouses is large. In Eastern Africa, polygyny is less common and marriage occurs at around 20 years among women. In Southern Africa, there is little polygyny, late age at marriage, and higher proportions of never-married women (Lesthaeghe 1989). Early entry to marriage in Western Africa precludes premarital pregnancies (Lesthaeghe 1989). Polygyny also permits large age differences between spouses, which supports early marriage (Pebley and Mbugua 1989).

As observed in the late 1990s (Tabutin and Schoumaker 2004), Table 7.1 shows similar sub-regional patterns. The median age at first marriage was 18.4 years in Western Africa and 18.9 years in Eastern Africa. Change in age at first marriage is most significant in Namibia. Although the median was among women aged 30-34, it substantially increased from 24.9 to 29.2 years old. This significant postponement of marriage has also been reported in other Southern African countries (Bongaarts 2007). According to the combined data from the 1992 and 2000 DHS surveys, premarital births accounted for 60 per cent of the first birth and 43 per cent of all births in Namibia (Garenne and Zwang 2006b). Age at first sex and childbearing did not increase appreciably indicating that a growing number of women had premarital childbearing in the country. Moreover, a significant proportion (14 per cent) of never-married women at age 40-49 emerged in Southern Africa (Tabutin and Schoumaker 2004). Marriage does not seem to be a universal norm any longer in Southern Africa.

Postponement of marriage is appreciable in Western Africa. The medians increased by over 2.1 years in Ghana, Senegal and Nigeria, resulting in an increase by 1.3 years in the sub-region. In contrast, there is virtually no change in Eastern Africa. The countries from other regions listed in Table 7.1 did not show much change, either. However, compared with many Arab and Magreb countries, where the medians increased by between four and six years over 20-25 years, limited changes were observed, particularly in Eastern Africa (Tabutin and Schoumaker 2005).

Age at first birth

As shown in Table 7.1, age at first childbearing has not changed significantly in all the sub-regions. The medians were 19.7 in Western Africa and 19.6 in Eastern Africa. The changes were limited. Only in Ghana, Nigeria and Senegal did the medians increased by more than one year. Although the changes were small, the median age at first birth in Benin, Ghana, Nigeria, Senegal, Rwanda, Zimbabwe and Namibia exceeded 20 years in 2003-8.

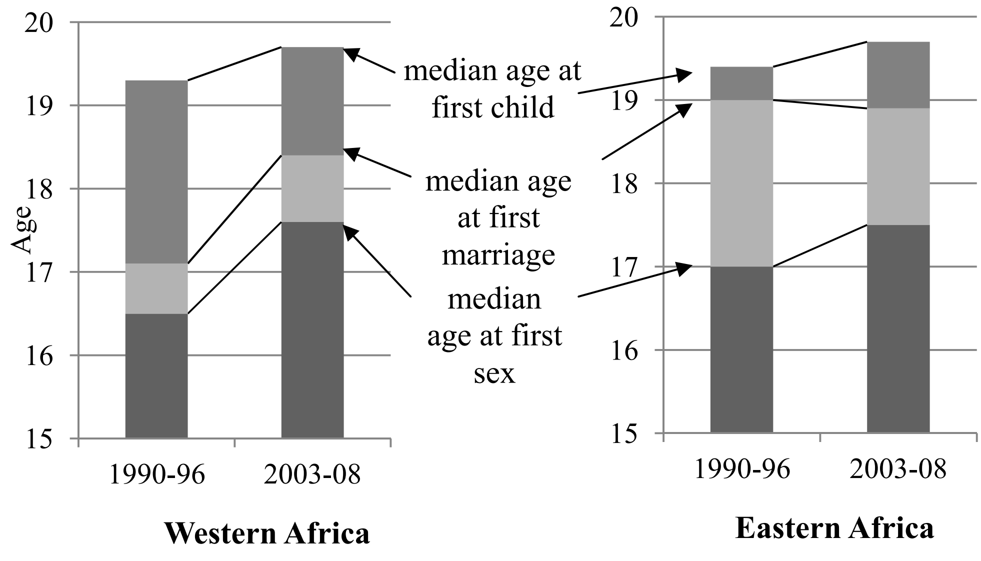


Figure 7.2: Changes in median ages at first sex, first marriage and first child among women 25-29 in Western and Eastern Africa

Figure 7.2 compares changes in median age at first sex, first marriage and first childbearing between eight Eastern and eight Western African countries. It is interesting to note that the two sub-regions had different patterns of changes. In Western Africa, all the median ages increased over the years. The increase in age at first marriage, however, is faster. This result is a small increase in duration of premarital exposure from 0.6 years to 0.8 years. The duration between first marriage and first childbearing was reduced from 2.3 to 1.3 years in Western Africa. The earlier marital conception in Western Africa might be due to smaller age differences and the reduction of arranged marriages such that the couple tends to have less coital frequencies (Rindfuss and Morgan 1983).

On the other hand, the changes in Eastern Africa are different. The duration of premarital sex declined due to later sexual debut and slightly earlier marriage. The earlier marital conception appears to have decreased. In Namibia, the duration of premarital exposure increased significantly from 5.9 years to 10.5 years and premarital childbearing is very common, which is similar to other Southern African countries (Bongaarts 2007). This phenomenon, where the postponement of marriage is greater than the postponement of sexual debut, has been observed in other developing countries (Blanc and Way 1998; Welllings et al. 2006). Therefore, premarital exposure to conception remains important in sub-Saharan Africa.

7.2.3. Exposure to conception within marriage

It is often assumed that exposure to pregnancy within marriage is more or less similar across populations. Bongaarts initially claimed that "*coital frequency is not a very important determinant of fertility differences among populations*" (Bongaarts 1978). But he acknowledged later that there are significant variations in the patterns of sexual union and sexual activities in sub-Saharan Africa (Bongaarts et al. 1984).

Patterns of exposure to pregnancy within union are very different in sub-Saharan Africa from other regions. While sexual activity often occurs outside marriage, married couples have lower coital frequencies than in other parts of the world. The WHO surveys on HIV/AIDS and sexual behaviour reported that proportions of currently married women aged 15-49 who had sex in the last month ranged from 42 per cent in Togo to 64 per cent in Tanzania (Caraël 1995). In other regions, such as Singapore, Thailand and Rio de Janeiro, the figure was more than 80 per cent. The mean coital frequencies in the last month prior to the survey were surprisingly as low as two or less in Togo, Côte d'Ivoire and Lesotho; whereas the mean in Rio de Janeiro was more than seven. In the same study in Europe, the means were between 6.8 and 8.4 episodes per month (Sandfort et al. 1998). Brown also assessed coital frequency in nine sub-Saharan African countries using DHS data collected during 1989-1994 (Brown 2000). This analysis revealed that mean monthly coital frequencies were extremely low, from 1.5 episodes in Burkina Faso and 1.6 in Ghana to 2.8 in Nigeria among all married women. In East and Southern Africa the frequencies were slightly higher: 3.0 episodes in Kenya and Namibia to over 7.3 episodes in Rwanda. Furthermore, the episodes among sexually active women were fewer in Western Africa, compared with Rwanda, Uganda and Zimbabwe.

As Bongaarts and Potter have described, fecundability (the monthly probability of conception) is determined not only by the frequency of sexual intercourse during the fertile period, but also by physiological factors, i.e. fecundity (Bongaarts and Potter 1983; Udry 1993). Age and physiological factors are closely associated with fecundability (Weinstein, Wood and Ming-Cheng 1993). Coital frequency may have countervailing effects on fecundability due to inter-individual as well as intra-individual variability in both behavioural and physiological factors (Grime 2009; Steiner et al. 1996). While the relationship between coital frequency and fertility is not straightforward, there is nevertheless a positive link between coital frequency and fecundability (Bongaarts and Potter 1983). It is also generally acknowledged that the relationship is not linear and that the variances are larger if the frequency is under ten episodes per month (Bongaarts and Potter 1983). For example, while an increase of coital frequency from two episodes to six episodes would reduce approximate waiting time to conception by 15 months, an increase from six episodes to ten episodes would reduce only a few months. Brown and Weinstein et al. have argued that difference in coital frequency may have a substantial impact on fertility between populations (Brown 2000; Weinstein et al. 1993). This may be the case, especially in areas where coital frequency is low.

Why do African couples have sex less frequently? According to Caraël, the possible reasons are : (1) lactational taboos; (2) polygyny; (3) non-cohabitation among married couples; (4) sex outside regular partner (1995). Blanc and Rutenberg have stated that temporary separation, men's and women's expectations about marriage and the extent of prevalence in arranged versus romantic marriages may explain the low frequencies (Blanc and Rutenberg 1991). These characteristics will be discussed in detail in the next sections.

7.2.3.1. Prolonged breastfeeding and postpartum abstinence

Prolonged breastfeeding

Sub-Saharan Africa is known for its prolonged breastfeeding practice. The duration, frequency and intensity of breastfeeding affect the duration of postpartum infecundability. A woman remains infecundable after pregnancy until the regular pattern of ovulation and menstruation is resumed. When breastfeeding lasts for one to two years and more, the duration of amenorrhea lasts for about 60 to 70 per cent of the duration of breastfeeding (Bongaarts and Potter 1983). According to DHS surveys in 1990-96, the median duration of breastfeeding in 18 countries was 21 months, from 17.9 months in Namibia to 28 month in Rwanda (Haggerty and Rutstein 1999). Similarly, the medians durations of amenorrhea were much longer in sub-Saharan Africa than other parts of developing countries. The longest median was 17 months in Rwanda while Namibia had the shortest length of 8.5 months. Out of the 18 countries, 14 countries had medians of more than one year (Haggerty and Rutstein 1999). Thus, women in Africa are infecundable for a longer period after birth than other regions.

Postpartum abstinence

In addition to the prolonged breastfeeding period, postpartum abstinence is a cultural taboo to have sex with a breastfeeding mother. The classical reason is to avoid ill-health and malnutrition of the mother and child. In several cultures it is believed that a breastfed child would be affected by semen poisoning breast milk, or the foetus conceived during this period would not have enough nutrition because of concurrent breastfeeding (Caldwell and Caldwell 1977; Schoenmaeckers et al. 1981). The intention of postpartum abstinence was not to control the number of children. It was purely intended to sustain maternal and child health, not to limit the number of children (Page and Lesthaeghe 1981). Furthermore, the prolonged abstinence may serve to prevent a close conjugal relationship by maintaining psychological and physical distance and thereby reinforcing the dominance of the lineage (Caldwell and Caldwell 1977; Lesthaeghe 1978). Consequently, long-term postpartum abstinence and amenorrhea, i.e. postpartum insusceptibility, protects women from the risk of a subsequent pregnancy for 2 - 3 years after the conception of a child. This practice is considered to be further facilitated within polygyny by the existence of co-wives and by widespread male extramarital sex (Bongaarts et al. 1984).

The patterns of postpartum abstinence vary widely by culture, ethnic group and religion. Schoenmaeckers et al. (1981) have mapped patterns of the duration of postpartum abstinence. The long postpartum abstinence area starts from southern Senegal extends to Lake Chad and curves southward to the Democratic Republic of Congo. On the other hand, the regions around Lake Victoria, such as Rwanda and Burundi, and northern Sahel, have the shortest (less than 40 days) postpartum abstinence periods. In Rwanda and Burundi couples do not practise abstinence, probably because of the contradictions between Christianity and the separation of spouses, as well as the custom of drinking cow's milk (Page and Lesthaeghe 1981; Schoenmaeckers et al. 1981). According to DHS surveys in 1990-96, the duration varied: from one month in Rwanda to 13 months in Cameroon and 19 months in Burkina Faso (Haggerty and Rutstein 1999).

Table 7.2: Median durations of postpartum amenorrhea and abstinence among women aged 15-39, by survey and by country (months)

		DHS 1	DHS 2	DHS 3	DHS 4	DHS 5
Benin	amenorrhea	12.6	11.0	10.3		
	abstinence	15.0	8.0	7.3		
Burkina Faso	amenorrhea	14.2	15.6	14.3		
	abstinence	17.9	18.8	11.6		
Cameroon	amenorrhea	10.3	10.0	8.9		
	abstinence	12.7	11.2	6.0		
Ghana	amenorrhea	13.9	12.3	10.5	10.5	8.5
	abstinence	8.2	8.3	7.9	8.6	7.3
Kenya	amenorrhea	10.3	10.3	8.0	9.4	8.9
	abstinence	2.6	2.8	3.1	2.8	3.0
Madagascar	amenorrhea	12.1	10.8	9.5	9.7	
	abstinence	3.6	3.5	3.3	3.0	
Malawi	amenorrhea	11.5	12.4	11.2		
	abstinence	na	5.6	5.4		
Mali	amenorrhea	12.9	13.4	11.4	10.4	
	abstinence	2.9	2.7	2.5	2.5	
Namibia	amenorrhea	8.2	9.4	5.4		
	abstinence	6.2	7.8	6.6		
Niger	amenorrhea	14.8	15.3	15.2		
	abstinence	2.5	2.4	2.2		
Nigeria	amenorrhea	14.1	12.1	12.9	11.1	
	abstinence	10.5	5.9	3.0	3.5	
Rwanda	amenorrhea	16.2	14.0	13.9		
	abstinence	0.6	0.6	0.6		
Senegal	amenorrhea	15.2	14.0	12.7	11.1	
	abstinence	3.1	3.5	2.8	3.1	
Tanzania	amenorrhea	13.0	11.7	11.7	11.2	
	abstinence	6.1	5.3	4.6	3.9	
Uganda	amenorrhea	11.9	11.2	10.6		
	abstinence	2.3	2.2	2.7		
Zambia	amenorrhea	11.5	11.3	12.9	10.8	
	abstinence	4.3	4.5	4.7	3.9	
Zimbabwe	amenorrhea	12.1	12.6	12.3	13.8	
	abstinence	2.9	3.4	3.0	2.5	

Source: DHS

Table 7.2 shows median durations of postpartum abstinence and amenorrhea among women aged 15-39 in the 17 sub-Saharan African countries. There are significant variations in median duration of postpartum abstinence, ranging from 0.6 months in Rwanda to 19 months in Burkina Faso. Postpartum abstinence is practised for longer periods in Western Africa than Eastern Africa as described the above. In the earliest surveys, in the 1990s the medians exceeded 10 months in Benin, Burkina Faso, Cameroon and Nigeria, and over 5 months in Ghana, Malawi, Namibia and Tanzania. The changes in these countries, where the abstinence has been a traditional practice, were substantial. Benin, Burkina Faso, Cameroon and Nigeria reduced the medians from 35 per cent to 67 per cent. Tanzania also saw decline by over 30 per cent in the past decades. In Mali, Niger and Senegal the durations have been very short (about 2-3 months). In Rwanda postpartum abstinence is not traditionally practised. According to a DHS report, only 10 per cent of women had not resumed sexual activity at four to five months after birth (Institut National de la Statistique du Rwanda (INSR) and ORC Macro 2006).

The earlier literature predicted the erosion of postpartum abstinence, positing that modernisation and the improvement of women's education and status would trigger the changes (Benefo 1995; Schoenmaeckers et al. 1981). The explanations, however, may be of a more practical nature. According to a qualitative study in Benin, both men and women reported that they faced difficulty in abstaining for long periods of time (Capo-Chichi and Juarez 2003). Postpartum abstinence is often enforced by mothers-in-law who encourage wives to share their rooms, i.e. sleep separately from their husbands after birth (Achana et al. 2010). However, separate rooms is impractical in urban areas (Capo-Chichi and Juarez 2003). In addition, women increasingly fear that husbands might seek extramarital partners (Cleland, Ali and Capo-Chichi 1999). Prolonged postpartum abstinence is associated with extramarital sex, resulting in husbands' greater exposure to the risk of HIV infection (Cleland et al. 1999). Thus in recent years wives increasingly resume sexual intercourse (Zulu 2001).

A study in rural Northern Ghana revealed the same trends (Achana et al. 2010). Women, men as well as mothers-in-law, the supposed 'gate-keepers' of postpartum abstinence, were aware of the risk of husbands' seeking extramarital sex and contracting HIV infection, during postpartum abstinence. Coupled with easier access to modern contraception, the practice of postpartum abstinence has eroded in these districts. Women in Abidjan and Malawi also expressed the similar increasing fear that their husbands may seek extramarital sex (Desgrées-du-Loûa and Broub 2005; Zulu 2001).

Another type of abstinence, permanent abstinence, has also been widely practised in sub-Saharan Africa (Bongaarts et al. 1984). Women practise abstinence, permanently, when they become grandmothers. This occurs increasingly after the age of 35 years. It is considered to be inappropriate for grandmothers to 'compete' with their daughters or daughters-in-law over their roles within the lineage and the family (Page and Lesthaeghe 1981). Since this study focuses on women under 40 years old, the effect of permanent abstinence is perhaps likely to be small.

Postpartum amenorrhea

The median durations of postpartum amenorrhoea were over 10 months in the earliest surveys in all countries except Namibia. Overall, there was no substantial change in the length of amenorrhea. The decline was significant only in Ghana and Namibia (over 35 per cent). The medians were shorter than 10 months in the latest surveys in Cameroon, Ghana, Kenya, Madagascar and Namibia, indicating that women resume ovulation slightly earlier than in the past.

These little changes are supported by the constant length of breastfeeding in the region. In the late 1990s a slight decline in postpartum amenorrhea was also found, although there was not much change in the length of breastfeeding (Haggerty and Rutstein 1999; Tabutin and Schoumaker 2004). According to the DHS STATcompiler, the median duration of breastfeeding at the national level remained similar in the countries studied in the latest surveys (Macro International Inc. 2011).

Nevertheless, there are suggestions that some mothers were confused about the breastfeeding practice in high HIV-prevalence areas, although the link is not convincingly proven (Noel-Miller 2003). World Health Organisation (WHO) had recommended six-month exclusive breastfeeding to prevent vertical transmission. This was since 2006, after having recommended that HIV-positive women do not breastfeed at all (WHO et al. 2007). This seemed to create confusion among health workers (WHO 2010). Furthermore some mothers received mixed messages regarding the breastfeeding practice (Underwood et al. 2006). The abrupt large increase of postpartum amenorrhea in 2000 in Namibia might reflect the changes in breastfeeding practice. The median duration of any breastfeeding increased by two months between the 1992 and 2000 Namibia DHS surveys.

Yet, the trends in mean duration of postpartum amenorrhea do not always correspond with the changes of duration of breastfeeding (Magadi and Agwanda 2007). While the length of postpartum amenorrhea should be determined by lactational infecundability, it may also be affected by HIV infection. Women in the advanced stages of HIV infection may have menstrual disorders. However, it is important to note that if the child died in infancy, the mother will have shorter periods of breastfeeding, and postpartum amenorrhea will be shorter (Gregson, Zaba and Hunter 2002).

7.2.3.2. Non-co-residence of married couples

Long-term spousal separation can appreciably reduce women's exposure to pregnancy. Several studies pointed out that Bongaarts' framework did not take into account spousal separation, though it was re-evaluated later (Bongaarts and Potter 1979). Several studies have suggested the negative effects on fertility through the increase in contraceptive use among migrants; the higher incidence of marital breakdown; or the increase of secondary sterility (Hampshire and Randall 2001; Massey and Mullan 1981; Timæus and Graham 1989). Spousal separation often results from male labour migration. It is particularly widespread in Southern Africa. Furthermore, polygyny may cause temporal separation between wives and husbands. Labour outmigration is an increasingly common phenomenon in Western Africa. In recent years, more married women, particularly those who are more educated, migrate independently to cater for their children (Adepouju 2003).

Women can be grouped into five groups based on their virginity, marital and residential status. The five groups are: (1) never married women who had never had sex; (2) never married women who had had sex; (3) currently married or cohabiting women living with their husbands; (4) currently married or cohabiting women whose husbands were staying elsewhere; (5) formerly married.

Information on the co-residence of married couples is available in the DHS data. However, this is a crude measure of separation, since no information on duration or time is provided. The data is derived from the question: *Is your husband/partner living with you now or is he staying elsewhere?*. The answer is: *living with her* or *staying elsewhere*. Therefore, husband staying elsewhere may mean staying away for one night or for months. Nevertheless, this variable is an available proxy for co-residence.

Table 7.3 displays distributions of women by these five groups. The proportions of women who had never had sexual intercourse ranged from 11 per cent in Niger to 38 per cent in Rwanda. Premarital sexual activities varied considerably across the countries. Proportions of non-virgin single women were from 0.5 per cent in Niger to 46 per cent in Namibia. Married women living with their husbands was still the dominant category in most countries, particularly in Western Africa. However, marriage appears to be no longer a universal norm in Namibia. Only 25 per cent of women in Namibia were married and living with their husbands.

Table 7.3: Distributions of women (15-39) by virginity, marital and residential status in 17 sub-Saharan African countries, 2003-2009 (%)

country	Never married women who never had sexual intercourse	Never married women who had sexual intercourse	married women living with husband	married women staying apart from husband	formerly married women	Total
Benin	12.1	11.8	62.8	10.5	2.9	100.0
Burkina Faso	15.3	7.5	67.7	6.8	2.6	100.0
Cameroon	15.0	12.9	50.1	14.8	7.2	100.0
Ghana	19.3	20.2	39.9	14.3	6.4	100.0
Kenya	20.0	16.3	43.2	12.6	7.9	100.0
Madagascar	14.1	7.8	59.9	7.3	10.8	100.0
Malawi	13.0	6.6	62.8	7.2	10.4	100.0
Mali	12.5	1.8	68.6	14.4	2.8	100.0
Namibia	19.3	45.7	24.8	5.9	4.5	100.0
Niger	11.4	0.5	67.4	17.4	3.3	100.0
Nigeria	17.0	13.3	60.2	6.7	2.8	100.0
Rwanda	37.6	7.9	41.1	4.4	9.1	100.0
Senegal	30.0	1.8	40.8	23.0	4.4	100.0
Tanzania	15.4	11.4	60.1	5.0	8.1	100.0
Uganda	17.3	10.6	52.8	8.0	11.3	100.0
Zambia	15.5	14.7	54.2	5.4	10.3	100.0
Zimbabwe	24.2	7.2	40.9	15.1	12.6	100.0

Source: DHS. Own analysis

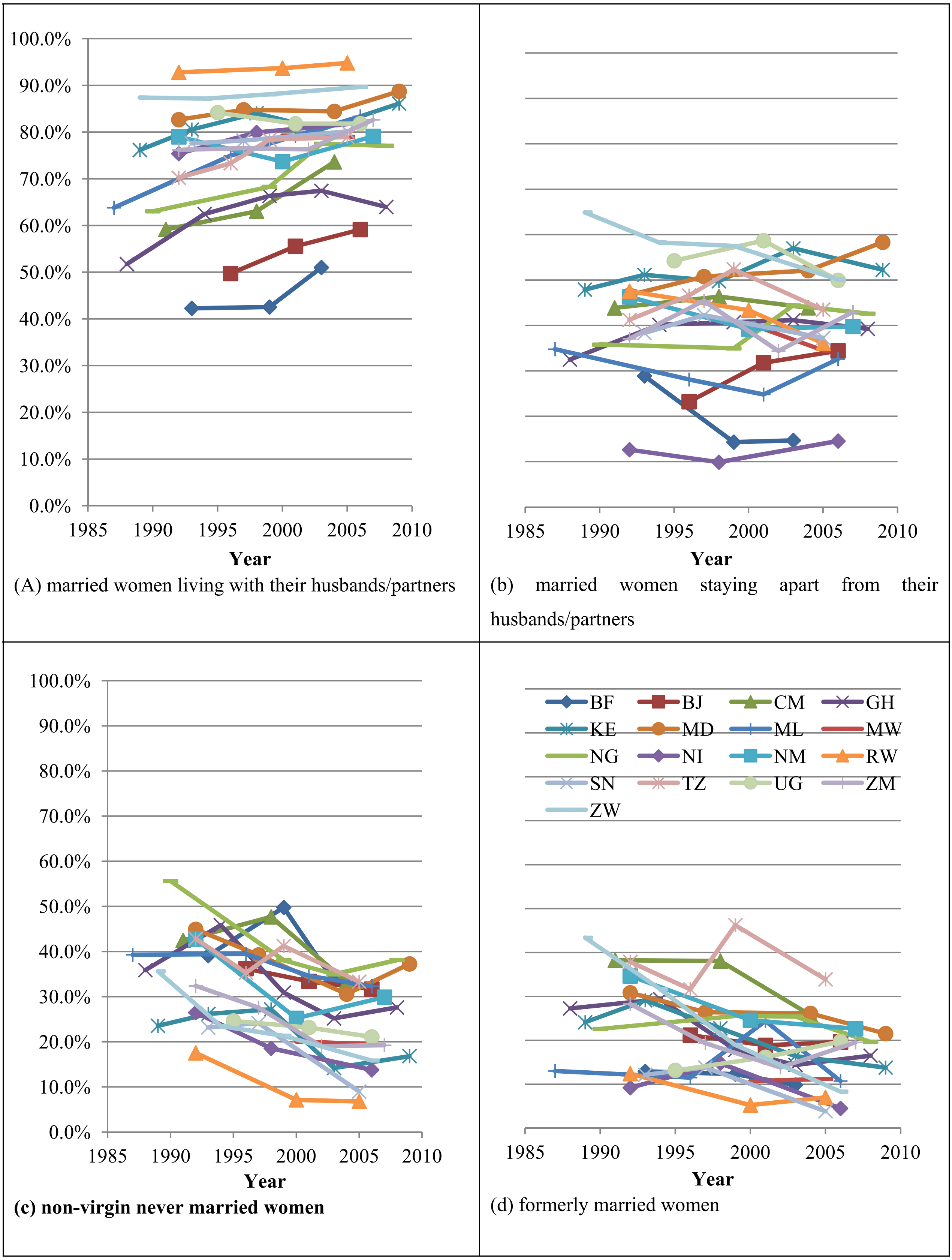


Figure 7.3: Proportions of women (15-39) who had sex in the last 28 days by marital and co-residential status, in 17 sub-Saharan African countries, 1986-2009

There were appreciable proportions of married women whose husbands stay elsewhere. Spousal separation has been historically common in Zimbabwe mainly due to male labour migration (15 per cent). Recently, this was found to have increased in Western Africa. In Senegal 23 per cent of women were married and staying apart from their husbands, and 18 per cent in Niger. These women comprised over 10 per cent in Benin, Cameroon, Ghana, Kenya and Mali. Formerly married women comprised more than 10 per cent in Madagascar, Malawi, Uganda, Zambia and Zimbabwe. Married couples may opt for divorce when there is a suspicion of infidelity or HIV infection (Reniers 2008).

Figure 7.3 presents recent sexual activity by the above four groups of women, by country and by survey. The results shed light on substantial variations in sexual activity by the group. First, over half of the married women living with their husbands or partners were sexually active while less than 60 per cent of married women whose partners were away had had sex in the past 28 days. The other two groups had a lower proportion of sexually active women. About 40 per cent of non-virgin, never-married women and 20 per cent of formerly married women had had sex in the past month before the survey.

This elucidates the interesting trends. The proportions of sexually active married women living with their husbands increased since the early 1990s. In the latest surveys, the proportions ranged from 51 per cent in Burkina Faso to 95 per cent in Rwanda. Married women whose husbands were away did not show clear trends, ranging from 9.9 per cent in Niger in 1998 to 65 per cent in Zimbabwe in 1989. Although this variable on residential status is rough, similar findings were reported by Brown (Brown 1997). Non-virgin unmarried women who had had sex in the last 28 days uniformly decreased in most countries over time. There were clear significant declines particularly between the early 1990s and the early 2000s. The proportions ranged from 7 per cent in Rwanda to 37 per cent in Nigeria. This is likely to be the result of behavioural changes due to HIV/AIDS prevention campaigns. Probably due to the same reasons, sexually active formerly married women declined to under 20 per cent. The decline was most significant in Zimbabwe, decreasing from 40 to 10 per cent. The findings suggest that sexual activity was gradually confined within marriage, compared with the past. Living arrangements seem to be a key factor which determines recent sexual activity.

7.2.3.3. Sex outside marriage

Extramarital sexual activity is high in Africa. The nationally representative surveys on AIDS reported that the proportions of men in marriage or in steady relationships who reported two or more sexual partners in the past year in sub-Saharan Africa showed that a high proportion (34 per cent) of all married men had extramarital sex. This was in Côte d'Ivoire and about 24 per cent in Tanzania and Lusaka, and a low proportion, 15.7 per cent, in Thailand (White, Cleland and Caraël 2000). In contrast, the proportions in Europe and the USA ranged from 5 to 10 per cent (Caraël 1995). Another study showed that multiple partnership was more common in developed countries than in developing countries (Welllings et al. 2006). There was wider variability in this measure among married women in the surveys in Africa, from less than 10 per cent in Togo and Burundi up to over 15 per cent in Tanzania (Caraël 1995). Postpartum abstinence is associated with extramarital sex. In Benin, 32 per cent of husbands whose wives were practising postpartum abstinence had extra marital contacts, while 20 per cent of the husbands with no abstinence had extramarital sex (Cleland et al. 1999).

Although a higher occurrence of childbearing outside marriage and low frequencies of sexual intercourse within marriage was observed, the review shows that co-residence is an important factor which determines the level of sexual activity. Thus, marriage is not the best indicator of regular sexual activity in sub-Saharan Africa. As recommended by Stover, the proportion of women sexually active in the past 28 days will be used in the analysis, rather than proportions of married women.

Stover defined 'sexually active' as women who had had sex within 0-28 days prior to the interview date as well as women who did not have sex in the last 28 days but who were either pregnant, in postpartum abstinence or in postpartum amenorrhea at the time of the survey. Evidently, the latter women have been exposed to the risk of pregnancy recently. Women in postpartum abstinence or in postpartum amenorrhea are taken into account in the index of postpartum infecundability, while pregnant women are considered to be at risk in the very recent past. Based on his definition, the mean proportions of sexual activity among currently married women who live with husbands was as high as 92.1 per cent while the counterparts, whose partners were staying elsewhere was 70.0 per cent in the 63 DHS surveys from the 17 sub-Saharan African countries. Interestingly, the former figure is similar to the levels found in Asia and Latin America (Caraël 1995). This suggests that married women living with their partners in Africa had a similar level of sexual activity, after defining women in postpartum insusceptibility and pregnancy as sexually active. This also indicates that there is no clear evidence of confusion over the periods of sexual abstinence with contraception, which was the concern of Anyara et al. (Anyara and Hinde 2006). Therefore, since the effects of postpartum insusceptibility will be measured by the index of infecundability, this index of the proportion of women sexually active proposed by Stover is an appropriate proxy for regular sexual activity.

7.2.4. Polygyny

Polygyny is an important feature of the family structure in sub-Saharan Africa. Polygyny has been most prevalent in Western Africa. According to the DHS data between 1986 and 1991, over 50 per cent of women aged 35 and over were in polygynous unions in Mali, Nigeria, Senegal and Togo (Westoff et al. 1994). On the other hand, Eastern African countries except Uganda had a lower level of polygyny, particularly in Madagascar (Westoff et al. 1994). Although it was once believed that this practice would be eroded through the processes of modernisation, polygyny still remains widespread. In circa 1999, 23 per cent of women aged 15 to 49 in Ghana were in polygynous marriages and 55 per cent in Burkina Faso (Tabutin and Schoumaker 2004; Westoff 2003). Polygyny was slightly less widespread in Central Africa: 33 per cent in Cameroon (Tabutin and Schoumaker 2004). It seems that coastal Western African countries, such as Ghana, Cameroon, Nigeria and Togo, experienced small declines in recent years (Locoh 2009). In East Africa, the proportions of polygyny were lower and more varied (ranging from 4 per cent in Madagascar to 39 per cent in Uganda). It was the least in Southern Africa (14 per cent) (Tabutin and Schoumaker 2004).

Table 7.4 shows proportions of married women aged 15-39 who reported that they had at least one co-wife. Polygyny was prevalent in most countries while fewer women were in polygynous unions in Madagascar. Over the years in all the countries the proportion of women in polygynous unions has declined. The reductions have been largest in Ghana, Kenya, Namibia and Zimbabwe.

It is assumed that polygyny reduces fertility through reducing the frequencies of sexual intercourse (Kattan and Burnett 2004; World Bank and UNICEF 2009). However, the findings on the effect on fertility are inconclusive. Several studies have suggested that significant reduction in the frequencies of sexual intercourse may slightly reduce fertility (Garenne and van de Walle 1989; Pison 1986).

Table 7.4: Percentages of married women (15-39) who had co-wives, in 17 sub-Saharan African countries

	% of married women who had co-wives	
	1990-96	2003-08
Benin	46.1	39.9
Burkina Faso	49.1	44.6
Cameroon	36.1	27.3
Ghana	25.0	16.3
Kenya	16.6	11.3
Madagascar	3.9	3.0
Mali	40.9	36.1
Malawi	15.9	14.2
Nigeria	39.0	30.2
Niger	33.4	33.0
Namibia	12.7	6.1
Rwanda	12.1	9.6
Senegal	43.1	33.2
Tanzania	24.9	20.8
Uganda	29.0	27.0
Zambia	16.1	13.2
Zimbabwe	16.8	10.8

Source: DHS. Own analysis.

Fertility is associated not only with coital frequency but also with individuals' physiological factors, postpartum insusceptibility and contraceptive use. Women in polygynous unions may have lower fertility on average because infertile women are likely to be in polygynous unions (Pebley and Mbugua 1989). Multivariate analysis has revealed that the effect of polygyny on fertility was small, once women's ages and marital duration were adjusted and childless women were excluded (Pebley and Mbugua 1989; Sichona 1993).

Furthermore, polygyny and monogamy are not necessarily clear-cut (Ezeh 1997). There are often discrepancies in reporting the type of marriage by husbands and wives. According to the DHS STATcompiler, more women tended to report that they had a co-wife than men: the difference is about 12 per cent (Macro International Inc. 2011). Monogamous women may enter into polygynous unions at any point (Sichona 1993). Ezeh found that women and men living in areas with a high prevalence of polygyny had a higher desired fertility. Ezeh argued that polygyny is not an individual-level variable. Since being in a polygynous union is not entirely the woman's choice, the effect on fertility and desired fertility may not be seen at the individual level. Furthermore, fertility may be maximised as polygyny ensures that women remain in the union continuously throughout their reproductive lives by early marriage and quick remarriage after marital dissolution (Ezeh 1997; Pebley and Mbugua 1989; Westoff et al. 1994).

Table 7.5: Percentages of women married and fecund women (15-39) who had sex in the last 0-28 days and the median duration of postpartum abstinence by type of marriage, 2003-2008

	% of fecund married women who had sex in the last month		Median duration of postpartum abstinence (months)	
	Monogamous	Polygynous	Monogamous	Polygynous
Benin	85.5	82.3	6.3	9.1
Burkina Faso	86.5	83.1	10.4	12.4
Cameroon	86.1	87.0	5.3	5.6
Ghana	79.5	80.2	6.3	7.9
Kenya	90.9	89.7	2.6	2.6
Madagascar	95.2	85.6	2.7	5.4
Malawi	94.2	89.2	4.9	5.5
Mali	88.7	91.3	2.5	2.4
Namibia	86.2	79.1	4.6	5.1
Niger	91.7	93.0	2.3	1.9
Nigeria	85.2	89.7	3.5	2.8
Rwanda	96.7	92.7	0.4	0.8
Senegal	85.8	85.1	2.8	2.7
Tanzania	94.7	89.5	3.5	3.4
Uganda	95.3	90.3	2.4	2.6
Zambia	94.6	90.8	3.4	3.1
Zimbabwe	89.0	87.9	2.2	2.1

Source: DHS. Own analysis.

Table 7.5 compares recent sexual activity and the median duration of postpartum abstinence, between women in monogamous and polygynous unions. Although it is often assumed that women in polygynous unions have sex less frequently, 79-93 per cent of women in polygynous unions had sex in the past four weeks. Women in pregnancy, postpartum amenorrhea and postpartum abstinence were excluded from these figures. The gaps between monogamous and polygynous unions were very small and there was a 10 per cent difference only in Madagascar at maximum.

Furthermore, polygyny is often constituted through an arranged marriage. Couples who have married in an arranged way are likely to have lower coital frequency (Rindfuss and Morgan 1983). On the other hand, one may hypothesise that family nuclearisation and stronger conjugal bonds in recent years have increased coital frequency. Westoff has suggested that recent increased proportions of sexually active women among the educated group is probably associated with the increasing uptake of contraceptives among this population (Westoff 2007).

Furthermore, it is thought that women in polygynous union observe postpartum abstinence for longer periods due to the sexual availability of co-wives. However, the practice has been eroded over the years as noted earlier. The differences in the duration between monogamous and polygynous unions were more than two months only in Benin and Burkina Faso. The differences in postpartum abstinence between the two types of marriage have become smaller over the years. These findings suggest that lower coital frequency, within marriage in Africa may now not be due to prevalent polygyny. It may be due, rather, to the practice of postpartum abstinence, though it has eroded, and non-co-residence. These may be the primary explanations as discussed earlier.

7.2.5. Sterility

7.2.5.1. Sexually transmitted diseases and sterility

There are small differences in the definitions in the disciplines of demography, epidemiology and medicine, but infecundity, sterility and infertility have been used interchangeably in this thesis (Rutstein and Shah 2004).While sterility was identified as one of the seven important proximate determinants, it was not included in the initial Bongaarts' model. Pathological sterility, however, was responsible for large differentials in levels of fertility in sub-Saharan Africa. Frank has estimated that pathological sterility inhibited about 15 per cent of fertility levels based on the national data between the 1960s and the early 1980s (Frank 1983). Bongaarts et al. reported that 60 per cent of the variability in total fertility in 18 sub-Saharan African countries, was explained by infertility (Bongaarts et al. 1984).

Pathological sterility is caused by sexually transmitted diseases through cervicitis, salpingitis and pelvic inflammation disease (PID). The high prevalence, particularly, of gonorrhoea has caused a high incidence of pathological infertility, both primary and secondary infertility, in sub-Saharan Africa. STIs, such as gonorrhoea, Chlamydia, syphilis and trichomoniasis were considerably prevalent in sub-Saharan Africa, 119 cases per 1000 persons; whereas the figures were 50 in South and Southeast Asia and 71 in Latin America and the Caribbean (WHO 2001).

7.2.5.2. Levels and trends of sterility in sub-Saharan Africa

The common way to measure levels of primary sterility is to measure the proportion of women childless at age 40-44 among women who have been married for at least five years. Based on the DHS data from 1995-2000, sub-Saharan Africa contained the countries with the highest proportion of childless women aged 40-44 (4.4 per cent in Niger, 4.7 per cent in Madagascar. 7.3 per cent in Cameroon, and, 10.5 per cent in the Central African Republic) (Rutstein and Shah 2004).

Women with either primary or secondary sterility are measured by the lack of a birth (or current pregnancy) after several years of sexual relations and the desire to conceive. In the DHS data, for low contraceptive use countries, women are regarded as infecund if they had not had a child for the past five years while they were neither in postpartum amenorrhea, pregnant nor menopausal, have never used contraception, and 5 years or more have passed since first marriage (Rutstein and Rojas 2006). Moreover, self-reported infertility is included in the measurement. The prevalence of secondary sterility increases with age, due to infecundity preceding menopause.

According to the DHS data from 1995-2000, Middle Africa and Eastern Africa had the highest proportion of women with secondary infertility, as shown in Table 7.6 (Rutstein and Shah 2004). This measurement focused on women who was first married five or more years ago and had never used any contraception. Age-standardised proportions of women aged 25-49 who were infecund were over 25 per cent in Cameroon, Mali, Nigeria and Uganda. The prevalence in Uganda may be too high because self-reported infertility was over 25 per cent even in the youngest age groups. This shows that, as Stover has suggested, it is essential to take into account pathological infertility when applying the proximate determinants model to sub-Saharan Africa.

While some infertility is often caused by pre-existing STIs, infertility is disproportionally prevalent among HIV-positive women (Favot et al. 1997). However, based on the study by Rutstein and Shah, there was no obvious pattern in changes in primary and secondary infertility in the countries with high HIV prevalence at population level (Rutstein and Shah 2004).

Table 7.6: Percentages of currently married women aged 25-49 with secondary infecundity, by region, DHS surveys 1994-2000

Country		Secondary infecundity (%)
Sub-Saharan Africa		
	Benin	22.0
	Burkina Faso	23.2
	Cameroon	26.4
	Ghana	24.3
	Kenya	24.0
	Madagascar	26.3
	Malawi	24.1
	Mali	27.9
	Niger	26.6
	Nigeria	30.7
	Senegal	20.3
	Tanzania	24.1
	Uganda	37.7
	Zambia	22.0
	Zimbabwe	19.5
South Asia		26
Southeast Asia		23
Caribbean/Central America		20
Latin America		14

Source: Rustein and Shah 2004
*age-adjusted.

7.2.6. Contraception

7.2.6.1. Contraceptive prevalence

While contraception is the strongest inhibiting factor on fertility worldwide, it has played a limited role in most parts of sub-Saharan Africa. In addition to the lower overall contraceptive prevalence, African women often prefer traditional methods of family planning to modern methods. This includes periodic abstinence and withdrawal, which have higher failure rates. While the prevalence of modern methods is negatively correlated with the abortion rate, the prevalence of traditional methods are positively associated with abortions (Marston and Cleland 2003). Traditional methods are widely practised particularly among women in Benin, Cameroon, Burkina Faso, Malawi, Madagascar and Nigeria (Curtis and Neitzel 1996; Sullivan et al. 2005). In sub-Saharan Africa as a whole, the use of traditional methods reduced the shares over the years. The prevalence of traditional methods decreased from 56 per cent in 1980-84 to 31 per cent in 2000-2005 (Seiber, Bertrand and Sullivan 2007).

Table 7.7 presents modern and traditional contraceptive prevalence in the 1990s and 2000s in the 17 countries. In Eastern African countries, modern contraception is popular and the prevalence has increased over the years, reaching 15-30 per cent. In Malawi, for instance, the prevalence has increased sixfold. Modern contraceptive prevalence was over 30 per cent in Namibia and Zimbabwe. Less than one per cent of women used traditional methods in these countries.

Table 7.7: Contraceptive prevalence among women (15-49), by type of methods in 17 sub-Saharan countries

	1990-96		2003-08	
	Any modern method	Any traditional method	Any modern method	Any traditional method
Benin	3.4	12.4	6.9	10.1
Burkina Faso	4.0	17.9	9.8	4.0
Cameroon	4.2	14.9	13.5	11.9
Ghana	9.3	9.2	13.5	5.3
Kenya	20.7	4.8	28.0	3.6
Madagascar	3.5	9.5	23.0	8.5
Malawi	6.3	2.8	22.4	1.9
Mali	5.0	2.3	6.2	0.8
Namibia	21.4	0.8	45.7	0.4
Niger	2.3	0.1	4.5	4.2
Nigeria	3.8	3.1	10.5	3.8
Rwanda	8.6	5.2	5.6	3.9
Senegal	4.5	2.5	7.6	0.5
Tanzania	5.9	3.1	17.6	3.9
Uganda	7.4	3.9	15.4	3.5
Zambia	7.0	2.7	24.6	4.4
Zimbabwe	31.1	2.8	39.1	0.8

Source: DHS. Own analysis.

In contrast, in Benin, Cameroon and Niger about half of the women using family planning relied on traditional methods. Modern contraceptive use (about 5-10 per cent) was extremely low. The shockingly low prevalence and slower progress in Western Africa was scrutinised by Cleland et al. (Cleland et al. 2011). Attitudinal resistance remained a barrier as well as access to contraceptives. The proportion of women who approved of contraception increased only from 32 per cent to 39 per cent. This represents strong resistance to contraceptive use. This is likely due to the low availability of contraception and lower female educational attainment compared with Eastern Africa.

7.2.6.2. Traditional methods

A popular non-modern family planning method is periodic abstinence (PA). PA is widely used in Middle and Western Africa (Che, Cleland and Ali 2004). According to the UN data in 2009, 2.3 per cent of all women in Western Africa and 8.9 per cent in Middle Africa were using PA (United Nations 2009a). An anthropological study in southern Cameroon reported that 10 per cent of women used PA (Johnson-Hanks 2002). Secondary schools in Cameroon teach periodic abstinence as a main method of family planning. In the latest surveys in these two countries, the prevalence of the current use of PA was 7 per cent in Benin and 10 per cent in Cameroon. This was 42 per cent and 38 per cent of the overall prevalence of current contraceptive prevalence (Macro International Inc. 2011).

The correct knowledge of the fertile period is essential for the effective use of PA. Based on 15 developing countries, the users with the correct knowledge varied considerably across the populations (Che et al. 2004). As shown in Table 7.8, the correct knowledge of the fertile period varies considerably across the 17 countries, ranging from 5.5 per cent of current users in Malawi (2004) and 35.5 per cent in Kenya to 82.5 per cent in Madagascar (Macro International Inc. 2011). It is suggested that the prevalence of PA increases with education (Curtis and Neitzel 1996). PA was significantly popular among unmarried sexually active women in Benin, Cameroon and Madagascar. In Benin and Cameroon, only about 60 per cent of all users had correct knowledge about the fertile period in the latest surveys (Macro International Inc. 2011). This variability of the knowledge suggests that use-effectiveness of PA varied considerably. Furthermore, there seems to be no increase in the proportions of users with the correct knowledge over time. The next chapter will provide information on the modification in the effectiveness of PA for each country.

Table 7.8: Percentages of women using periodic abstinence and users (15-49) with the correct knowledge of the fertile period

		proportions of women using PA		
	Users with correct knowledge	among currently married women	among unmarried sexually active women	Among all women
Benin 2006	59.4	6.9	23.9	7.2
Burkina Faso 2003	47.2	3.1	2.6	2.6
Cameroon 2004	55.7	10.2	20.1	10.0
Ghana 2008	69.6	4.7	11.7	4.0
Kenya 2008-09	35.5	4.7	4.2	3.2
Madagascar 2008-09	82.5	9.7	13.6	7.9
Malawi 2004	5.5	0.5	0.5	0.4
Mali 2006	47.7	0.8	3.7	0.7
Namibia 2006-07	18.7	0.4	0.2	0.3
Niger 2006	61.3	0.1	0	0.1
Nigeria 2008	39.3	2.1	7.2	2.1
Rwanda 2005	32.7	4.2	3.3	2.4
Senegal 2005	59.2	0.6	0	0.4
Tanzania 2004-05	48.1	2.0	3.9	1.8
Uganda 2006	30.8	2.8	4.2	2.0
Zambia 2007	36.1	1.2	1.4	0.9
Zimbabwe 2005-06	28.8	0.2	0	0.1

Source: Macro International Inc, 2011. MEASURE DHS STATcompiler. http://www.measuredhs.com

Bongaarts suggested 0.70 for average use-effectiveness of all the methods except sterilisation, the IUD and the pill in developing countries, based on the survey in the Philippines in 1977. It was, however, rather a rough estimate (Bongaarts 1982). Due to the high prevalence of traditional methods, small difference in their average use-effectiveness may make a large difference in estimates in Africa when using the proximate determinants model. While some studies have suggested modifications (Anyara and Hinde 2006; Jolly and Gribble 1993), no studies have carefully assessed the average effectiveness of the family planning methods, particularly traditional methods in Africa.

7.2.6.3. Modern contraceptive methods

With regard to modern methods, African women prefer reversible methods. While female sterilisation is the most widely used method in developing countries, followed by the IUD, the pill and injectables, the use is extremely limited in sub-Saharan Africa (Seiber et al. 2007). The method mix has been changing in the past decades. There is a clear shift from the pill to injectables. The pill was the most popular modern method followed by injectables, female sterilisation, the IUD and the condom in the period 1980-1984, in the region (Seiber et al. 2007). A significant increase was observed in the prevalence of injectables: it increased from 3.2 per cent, in the early 1980s, to 25.7 per cent, in the early 2000s. This is now the most widely used modern method. The prevalence of the pill declined slightly to 18.6 per cent, in 2000, after the peak of 23.7 per cent, in the early 1990s. Similarly, the use of the IUD peaked in the 1990-94 period to 7 per cent; the prevalence declined to 2.9 per cent in the period 2000-2005. This also shows that the prevalence of the IUD and the pill peaked in 1990-1994 and then declined, which is consistent with the findings in Cleland et al. (Cleland et al. 2011). Condom use has increased from 3.2 per cent to 8.3 per cent in the period 2000-2005. Because of the limited evidence of efficacy of traditional methods and changes in method mix in the region, adequate modifications are needed for an index of contraception.

7.2.7. Abortion

Abortion is one of the most difficult health issues to quantify. The estimation is particularly so in Africa because abortion is illegal in most countries, although few cases reach the point of prosecution. The only exceptions are the instances where it is done to save the mother's life. As a result, many clandestine abortions are performed. Nevertheless, data has become available and the estimation methods have been developed (Sedgh et al. 2007; Shah and Ahman 2010; Westoff 2008; WHO 2007). It is estimated that more than 5 million abortions, nearly all unsafe, are performed per year. Sub-Saharan Africa has the highest incidence rate in the world: 31 unsafe abortions take place per 1,000 women aged 15-44 years every year. 16 pregnancies among a 100 live births end in unsafe abortions (WHO 2007). Eastern Africa is the highest sub-region with 39 unsafe abortions per 1,000 women. This is, where the rate is approximately 27 in Middle and Western Africa and under 20 in Southern Africa (WHO 2007).

Abortions in Africa occur mostly on young women. A quarter of all unsafe abortions occur among adolescents aged 15 to 19 and about 40 per cent among women under 25 (Shah and Ahman, 2010). Young women in Africa are exposed to the highest risk of unsafe abortion compared with other regions.

Due to its relatively liberal abortion law, Ghana has collected more data on abortion than other African countries. The first nationally representative population survey, focusing on abortion and maternal health, was conducted in 2007. The report revealed that 7 per cent of all pregnancies for 5 years prior to the survey ended in abortion. 15 per cent of women aged 15-49 had had an abortion, of which 57 per cent were performed by a physician (Ghana Statistical Service (GSS), Ghana Health Service (GHS) and Macro International Inc 2009). The total abortion rate, the number of abortions an average woman would have if she had abortions at the current rate throughout her reproductive lifetime, was 0.4 abortions per woman. Given that the total abortion rate was 0.4, TFR was 4.6 and the overall CPR was 20.9 per cent based on the GMHS, index of abortion, Ca, would be estimated as 0.96.

However, the estimates are significantly lower than the ones from other studies. Sengh et al. reported 27 unsafe abortions, per 1000 women, and 10 abortions, per 100 pregnancies, in Western Africa. Ahiadeke's study in Southern Ghana, in 1997-98, estimated that 19 per cent of all pregnancies ended in abortion and that 17 per cent of them were performed by physicians (Ahiadeke 2001). Furthermore, Westoff estimated the total abortion rate as 1.6 (Westoff 2008). The estimates from the Ghana Maternal and Health Surveys are likely to be at the low end of the estimates.

Although abortion is not negligible and there may even be increases in West and Middle Africa, recently (Shah and Ahman 2010), it is still impossible to obtain reasonable incidence and data for Bongaarts' proximate determinants analysis. Therefore, most papers have assumed Ca is 1 (Rutstein 2003).

7.3. Conclusions

This chapter has reviewed literature and analysed the recent levels and trends of proximate determinants and reproductive behaviours, by highlighting five distinct characteristics of African fertility. The first feature is prevalent premarital exposure to pregnancy. It is not universal in the whole region, but appreciable, particularly in

Southern Africa. While the median age at first sex has risen in the past two decades, postponement of marriage was faster in speed in several Western African countries and the Southern African sub-region, suggesting longer durations of exposure to conception before marriage. Thus, for this region, the index of marriage is not suitable as a measure of the inhibiting effect of periods when women are not engaged in sexual activity regularly, on fertility.

Second, the framework assumes that coital frequency, within marriage, is invariant across populations. Figure 7.3 clearly demonstrated variations in recent sex by marital and co-residential status, in the 17 countries. It is important, however, to note that the proportions of women sexually active, among married women living with their husbands, were as high as (92 per cent) in other regions, when women in postpartum abstinence, postpartum amenorrhea and pregnancy are considered as sexually active. This suggests that the lower coital frequencies within marriage, in Africa, are likely associated with the practice of prolonged postpartum abstinence and amenorrhea, the avoidance of sex during pregnancy and non-co-residence. The findings confirm that being in a marriage does not equate with being, invariably, at a high risk of frequent sexual exposure. As Stover has suggested, the proportion of sexual activity seems more relevant in Africa than the original index of marriage. This modification will also be able to capture the observed changes in recent sex, within and outside marriage, over the decades.

Third, polygyny was still prevalent in most of the countries studied. While polygyny has been thought to reduce fertility, the earlier studies showed inconclusive results. Once infertile women, who are more likely to be in polygynous unions, were excluded, polygyny did not appear to, substantially, affect sexual activity or lengthen the duration of postpartum abstinence. The second and third distinct characteristics of African fertility suggest that sexual activity and marriage seems more complex than previously thought. Bongaarts and Bulatao have suggested more research on marriage, recently (Bongaarts and Bulatao 2000). This review on sexual activity and polygyny has broadened our understandings of marriage and sexual activity, and lends support to the importance of research on marriage.

Forth, Bongaarts did not initially include pathological sterility in the framework. The prevalence of STIs in sub-Saharan Africa has been higher than other regions. Despite the improvement in STI treatment, the prevalence of secondary infertility seems to be still high. HIV causes infertility in its advanced stages. However, there seems to be no clear evidence of a pattern of infertility in high HIV-prevalence countries (Gregson, Zaba and Hunter 2009; Rutstein and Shah 2004).

Fifth, the original Bongaarts' formulation used rough estimates of average use-effectiveness of contraception. Despite the popularity of periodic abstinence and withdrawal, worldwide, the effectiveness of traditional methods has not been carefully quantified. Table 7.8 showed that proportions of PA users, who understood the fertility period correctly, varied considerably across the countries. While 80 per cent of users in Madagascar had correct knowledge, less than 60 per cent of users in Benin and Cameroon understood the fertile period correctly. They were at a higher risk of unintended pregnancy, often leading to abortions. Although it is difficult to obtain reasonable estimates, the average use-effectiveness of the traditional methods need better estimates. Furthermore, they need to be used appropriately in the proximate determinants framework. The next chapter will address this problem.

While more data on fertility and reproductive behaviour has become, increasingly, available, plausible estimates on the incidence of abortion, at population level, are still extremely rare. The apparent underestimation of the abortion incidence in the first nationally-representative survey, in Ghana, demonstrated the difficulty in obtaining abortion data at the population level. As more women go to secondary school and abortion is likely to be used to postpone childbearing among young women, abortion might have played an important role in fertility, in recent years.

This review has provided comprehensive information and insights on fertility and reproductive behaviours in Africa. At the same time, this also revealed that there is a clear need for assessment and modification of the proximate determinants framework, when the framework is applied to sub-Saharan Africa. Yet, only a few studies have made appropriate modifications in their applications in this region. In order to understand the mechanism of recent fertility trends, the next chapter will introduce the modifications and apply them to the 17 sub-Saharan African countries.

Chapter 8 : APPLICATION OF THE PROXIMATE DETERMINANTS FRAMEWORK IN 17 SUB-SAHARAN AFRICAN COUNTRIES

8.1. Introduction

The previous chapters examined fertility changes in the 17 sub-Saharan African countries over the past two decades. Chapter 6 concluded that the pace of recent fertility declines decelerated in six countries in the early 2000s (Benin, Kenya, Malawi, Nigeria, Zambia and Zimbabwe). Subsequently, Chapter 7 reviewed the literature and performed a descriptive analysis to explore the applicability of Bongaarts' proximate determinants framework to the African context. The five distinct characteristics of African fertility (prevalent premarital exposure, lower coital frequencies within marriage, polygyny, high pathological infertility and reliance on traditional family planning methods) were found to be still prevalent, and changes were observed. The review suggested that most of the revisions proposed by Stover (1998) were relevant, but that several modifications, such as average-use effectiveness, were required for the application to Africa. This chapter refines the revisions based on the findings in the previous chapter, and applies them to the 17 countries. This is aimed to explore the extent to which changes in proximate determinants support the Loess fertility trends.

8.2. Methods

Once more data became available, Stover revised Bongaarts' proximate determinants framework to make it more appropriate for the application to developing countries, in the late 1990s (Stover 1998). His model consists of the following five variables: (1) proportions of women sexually active; (2) contraception use and effectiveness; (3) duration of postpartum infecundability; (4) induced abortion; and (5) pathological infecundity. His revision takes into account the three distinct characteristics of African fertility discussed in the previous chapter, i.e., premarital sex, lower coital frequencies within marriage and high pathological infertility. This thesis has employed his method and further suggests important modifications to the contraceptive index and the use-effectiveness of family planning methods.

The Stover's revised multiplicative proximate determinants equation is:

$$TFR = PF * Cx * Ci * Ca * Cu * Cf$$

where TFR=total fertility rates

PF = potential fertility

C*x* = index of proportion of women sexually active

C*u* = index of contraception

C*a* = index of abortion

C*i* = index of postpartum infecundability

C*f* = index of infecundity

A value of each index ranges only from 0 to 1. While a value of 0 indicates that the determinant completely inhibits fertility, a value of 1 denotes that it has no effect on fertility. When a value is closer to zero, it indicates that the determinant is more influential and associated in reducing the fertility rate. In order to make it comparable with the Loess estimates, proximate determinants among women 15-39 were assessed. Therefore, index of sterility, for instance, obtained in this analysis is likely be lower than those among women 15-49.

8.2.1. Index of sexual activity (C*x*)

The original index uses proportions of married women. As discussed earlier, sexual activity is appreciable outside marriage and varies within marriage depending on co-residence, and the practice of postpartum abstinence and breastfeeding in Africa. These features indicate that marriage is not an appropriate measure of the inhibiting effects of the duration of non-regular sexual activity on TFR. Proportions of sexually active women are a more suitable measure, as suggested by Stover.

In the DHS Woman's Questionnaire, there is a question about recent sexual activity, *"When was the last time you had sexual intercourse?*" and respondents are expected to answer in terms of the number of days, months or years (Measure DHS 2008). Becker (1995) has suggested that this question minimises bias compared with a question on coital frequencies for a month prior to a survey, because the latter is more likely to be influenced by the perception of normative or desired behaviour, and heaping (Becker 1995). Therefore, the question on recent sexual activity has been included in the Woman's Model Questionnaire since DHS-I. This variable gives information neither about monthly coital frequency, nor if a woman had had sex during her 48-hour fertile period in the past month. The primary aim of this question is to estimate fecundability by measuring the proportion of women who are at risk of conception in the last menstrual cycle, through exposure to sexual activity (Becker 1995; Blanc and Rutenberg 1991). Therefore, the data on whether women had had sex in the past four weeks is often used to determine if the women are sexually active. The four-week window matches the women's menstrual cycle.

This analysis used proportions of women who had had sex within 0-28 days prior to the interview date. Women who did not have sex in the last four weeks but who were either in pregnancy, postpartum abstinence or postpartum amenorrhea, at the time of survey, were also included. Evidently, the women in the latter category have been exposed to the risk of pregnancy recently. Women who had never had sex; and women who were sexually inactive in the past 28 days; and were neither in pregnancy, postpartum amenorrhea, nor abstinence were not considered to be sexually active.

As mentioned in Chapter 7, when using this definition, the mean proportion of those sexually active among currently married women who live with their husbands, was as high as 92.1 per cent in the 63 DHS surveys from the 17 sub-Saharan African countries. This suggests that recent sexual activity among married women -- those living with their husbands and women in pregnancy and postpartum insusceptibility are considered sexually active -- is at the same level as that of married women in Asia and Latin America (Caraël 1995). This evidence supports the fact that the index of those sexually active is an appropriate proxy for regular sexual activity in Africa. The measure takes into account premarital exposure and infrequent sexual activity among married women who do not live with their husbands. The question on recent sexual activity was included in all the surveys that were examined except the 1993/4 Senegal DHS, the 1992 Malawi DHS and the 2008 Rwanda interim DHS. Therefore, it was not possible to obtain the index from these three surveys.

8.2.2. Index of postpartum infecundability (C*i*)

This index is intended to measure the effects of the duration of postpartum infecundability on fertility. Stover has used the median duration of postpartum insusceptibility, instead of the period of breastfeeding, and calculated the index as below:

$$Ci = 20 / (18.5 + i)$$

where i = average duration of postpartum insusceptibility.

As resumption of ovulation, i.e. the end of postpartum infecundability, can be examined only by clinical methods, the duration of postpartum infecundability used to be computed from the median duration of breastfeeding, as a proxy in the original proximate determinants framework. However, the information on postpartum insusceptibility, a combined effect of postpartum abstinence and amenorrhea, has become available in all the DHS datasets. Based on Stover's revision, this analysis used the median duration of insusceptibility as a proxy of the duration of postpartum infecundability.

Furthermore, it is suggested that the extent of heaping in the duration of postpartum insusceptibility is smaller than that in the lengths of breastfeeding. It is known that the duration of breastfeeding is often substantially skewed to the right due to women who breastfeed a child for a long time (Stover 1998). Furthermore, it is often heaped at 3, 6, 12 and 24 months due to recall bias (Gebreselassie, Rutstein and Mishra 2008; Haggerty and Rutstein 1999; Sambisa and Curtis 1997). A study on postpartum behaviour in Kenya, Indonesia, the Dominican Republic and Peru has reported that the duration of postpartum amenorrhea heaped at 2, 6 and 12 months, and that there was limited heaping in the duration of abstinence. Nevertheless, the extent of the digit preference was not as significant as in the case of breastfeeding (Gebreselassie et al. 2008). Therefore, the use of the median duration of insusceptibility is preferable.

The median duration of postpartum insusceptibility was computed based on the mother's status in postpartum insusceptibility, at the time of survey, according to the Guide to DHS Statistics (Rutstein and Rojas 2006). The analyses were based on the number of births; thus, one mother might have contributed to more than one birth for the analysis. Haggerty and Rutstein (1999) explained that calculations for postpartum durations were less biased if the analysis used child-based durations rather than woman-based durations. Selection of a single episode of births from the fertility history of a woman may introduce bias in the calculations of postpartum duration. For example, the duration of the postpartum period following the last birth tends to be longer than the average of all durations. In contrast, the duration related to the one before the last birth is likely to be shorter when setting a specific time interval, such as the last 36 months prior to a survey (Haggerty and Rutstein 1999). The formulae are:

Numerator: number of last births in the 3 years preceding a DHS survey for which mothers aged 15-39 were either in postpartum amenorrhea, abstaining or insusceptible at the time of interview, by number of months since birth

Denominator: number of all births in the last 36 months for which mothers aged 15-39 at the time of survey, by number of months since birth.

The numerator and denominators were grouped by two-month group and then each was smoothed by a three-group moving average. Then the proportions of births for which mothers were in postpartum amenorrhea, abstaining or insusceptible were obtained by two-month group. Median durations were obtained as follows.

$$\text{Median} = M_{I-1} + (P_{I-1} - 0.5)/(P_{I-1} - P_I) * (W_I)$$

where

p_i is a proportion of women in amenorrhea, abstinence or insusceptibility for the first group, where the proportion is below 0.5;

p_{i-1} is a proportion of women in amenorrhea, abstinence, or insusceptibility for the group preceding p_i;

m_{i-1} is a midpoint value for the preceding group; and

w_i is a time width of the group taken as the difference between the midpoint values of the current group and the preceding group (usually two months).

For instance, in the 2003 Burkina Faso DHS survey, 53.0 per cent of women whose last child was aged 18-19 months were postpartum insusceptible, and 46.8 per cent of women whose last child was aged 20-21 were postpartum insusceptible. The median duration of postpartum insusceptibility was calculated as below:

$$\text{median} = 18.5 + (0.53 - 0.5) / (0.53\text{-}0.468) \times 2 = 19.5 \text{ months}$$

Only the last one of multiple births was considered. The other births were ignored in both the numerators and denominator.

8.2.3. Index of sterility (C*f*)

The index of sterility is intended to estimate the fertility-inhibiting effects of primary and secondary sterility.

$$Cf = 1 - f$$

where f is defined as a proportion of infecund women among sexually active women aged 15-39.

Women who were not active, but either pregnant, postpartum abstaining, or in postpartum amenorrhea, were excluded since they were apparently not infecund.

The DHS defines an infecund woman in low contraceptive prevalence countries as a woman who is not using any contraceptives and displays the following features: (a) one who has declared a hysterectomy or is menopausal; (b) one who is neither in postpartum amenorrhea nor pregnant, but has not had a menstruation for at least last six months, has never menstruated, or her last menstruation has occurred before her last birth; or (c) one who has not had a birth in the preceding five years, has never used contraception, and her first marriage has been more than five years prior to the survey (Rutstein and Rojas 2006; Rutstein and Shah 2004).

This definition combines behavioural and self-reported infecundity. The measurement may have both upward and downward biases (Vaessen 1984). Women who were using family planning may be, in fact, infecund at the time of the survey. However, as most of the surveys examined do not have calendar data on contraceptive use, the information on the timing of family planning use is not available. As the contraceptive prevalence was low in most of the countries analysed, large biases were probably not introduced. On the other hand, women who were regarded as infecund, may not actually be infecund. Some of them might not had had live births in the past five years because of long-term abstinence, induced abortion, spousal separation, illness or failure to report contraceptive use. Some might have been practicing permanent abstinence after having a grandchild. Induced abortions are less likely to play a large part in creating an upward bias, as most of the induced abortions in Africa occur among young women in order to delay the beginning of childbearing (Shah and Ahman 2010). Moreover, some very young women aged 15-19 may have been reported as infecund because of not having had a child or having started menstruation. However, they are unlikely to have been initiated into sexual activity; thus, they were excluded from the index of the sexually active. The open interval of the duration of marriage does not reveal whether the woman has been continuously exposed to sexual activity since the marriage first took place. However, Larsen has argued that the open interval is more appropriate in Africa, since infecund women are likely to be separated or divorced (Larsen 1995).

In this analysis, infecund women among all sexually active women were identified. This index includes the total effects on infecundity including primary and secondary sterility. However, compared with other estimates using the original Bongaarts' framework, this measurement is likely to be lower due to focusing only on sexually active women and women under 40 years old (Stover 1998). The original index sometimes exceeded 1.0 because it assumed that primary infecundity was three per cent in the population. In contrast, the revised index would capture infecund women more adequately since it focuses on the women at risk.

8.2.4. Index of contraception (C*u*)

The original Bongaarts' equation added the sterility factor, 1.08, in order to adjust for the overlap between sterility and contraceptive use. Stover (1998) has suggested that the sterility factor be removed. This is because sterility is taken into account by the index of sterility. Furthermore, some sterilised women are already infecund in some regions, such as in India. Since sterility is measured by the index of sterility, the adjustment factor 1.08 was removed for this analysis. Women using only lactational amenorrhea as a contraceptive method were considered non-users in this study, as the effect is covered in the index of postpartum infecundability (C*i*).

Another consideration for the Bongaarts' method is the overlap between contraceptive use and amenorrhea. While the overlap generally seems modest (Curtis 1996; Stover 1998), there is evidence that this 'double-protection' is common in Zimbabwe (Brown 2007; Sambisa and Curtis 1997). Use of pills is very common and women resume the use during postpartum amenorrhea. The adoption of hormonal methods often induces bleeding. While the overlap is prevalent in Zimbabwe, there is little information for other countries. As suggested in Stover's paper, the following formula was used:

$$Cu = 1 - (u - overlap) * e$$

where *u* is prevalence of current contraceptive use;

e is average use-effectiveness of all contraceptive methods;

overlap is proportions of women who were using family planning, but gave a birth within the past 6 months and reported as being in postpartum amenorrhea at the time of the survey.

Six months were chosen because many mothers start to introduce weaning after 6 months, and some amenorrhea can be induced by use of some type of hormonal methods, particularly injectables.

Average effectiveness *e* was calculated as a weighted average of the method-specific use-effectiveness levels *e (m),* with the weights equal to the proportion of women using a given method*, u (m).* In order to take into account the variations in the overlap between the methods and postpartum amenorrhea, the average effectiveness was obtained as below.

$$e = [\sum e(m) * \{u(m) - overlap(m)\}]/u$$

8.2.4.1. Definition of prevalence

In the original formula, contraceptive prevalence was measured among married women. Since the index of marriage was revised, this analysis has followed Stover's suggestions.

Contraceptive prevalence was measured among women aged 15-39 who had had sex in the past 28 days, were fecund and were using any kind of contraceptive method. The prevalence is likely to be higher among all sexually active women rather than merely married women (Stover 1998). The differences are probably much higher in Africa, because the use of contraception among single women is higher than that among married women (Cleland et al. 2006).

8.2.4.2. Effectiveness of contraceptive methods

Contraception does not protect women from pregnancy unless couples use the method which they have chosen, effectively and consistently. In Bongaarts' original formulation, he estimated average use-effectiveness based on the studies in the Philippines. However, they were rough estimates due to limited data (Bongaarts 1982). Recently, there have been are more studies on use-effectiveness, contraceptive failure rates or discontinuation rates (Ali and Cleland 1995; Bradley, Schwandt and Khan 2009; Stover, Bertrand and Shelton 2000).

Table 8.1 presents the use-effectiveness, for 12 months, for major contraceptive methods derived from several studies. The data in Bongaarts (1982) were derived from a national survey in the Philippines, and the data in Ali et al. (1995) and Blanc et al. (2002) were the 12-month failure rates from the DHS surveys in developing countries. The estimates in Trussell et al. (2007) were based on the US populations. The estimates in Trussell et al. (2007) were slightly lower in all methods except IUD. It is interesting to note that the estimates from developing countries were generally slightly higher than those from the US population. This might have resulted from a selection bias.

Table 8.1: Average use-effectiveness by contraceptive method

	Trussell et al. (2007)[10]	Bongaarts (1982)[11]	Ali et al. (1995)[12]	Blanc et al. (2002)[13]
Male/Female sterilisation	0.9985 (male) 0.995(female)	1.00	na	na
Pill	0.92	0.90	0.94	0.95
IUD	0.99	0.95	0.97	0.98
Injectable	0.97	Na	0.99	0.98
Implant	0.95	Na	na	na
Diaphragm[14]	0.84	na	na	na
Male/Female condom	0.85 (male) 0.79 (female)	na	0.92	0.93
Withdrawal	0.73	na		0.85
Periodic abstinence[15]	0.75	na		0.82
Other	na	0.70		na

However, it is perhaps likely that the data quality from developing countries may not be as high as in the study in the United States. Bradley et al. have articulated the limitations of the calendar data which were also used in the studies by Ali et al. and Blanc et al. (Bradley et al. 2009). The contraceptive prevalence derived from the calendar data were consistently lower than the prevalence obtained from current status data. The differences in prevalence have implied that all contraceptive use may not be covered in the calendar data. Moreover, the reasons for discontinuation of contraception could be ambiguous. Some women might misreport their contraceptive failure (unplanned pregnancy) as a desired pregnancy or give other reasons for discontinuation. Others might not report failure, as pregnancy during the period had ended as an induced abortion. Bradley et al. have examined the effects of these biases, and suggested that the failure rates from the calendar data appeared underestimated by 5 per cent. Given the potential biases in the estimates from developing countries, this study selected more rigorous and conservative estimates of the use-effectiveness from the US population.

[10] Effectiveness of typical use in the US population (Trussell 2007)
[11] This is based on the data from the Philippines (Laing 1978)
[12] Six countries from North Africa, Latin America and Asia were included in the studies
[13] Fifteen countries were included.
[14] The effectiveness of diaphragm and form or jelly is considered to be 0.85 in the analysis.
[15] Standard days methods© has been introduced Rwanda, Benin and Madagascar, but the prevalence is still low. The effectiveness was considered as the same as periodic abstinence.

With regard to periodic abstinence (PA), as discussed in Chapter 7, the proportions of women with correct knowledge of the fertile period varied across the countries. This indicates that the effectiveness of PA is different across countries. Thus, a new measurement for use-effectiveness for PA was introduced in this analysis. The effectiveness was calculated as the weighted average of use-effectiveness (0.75), with the weights equal to the proportion of women who had correct knowledge of the fertile period.

Abstinence is not listed in the questions on current family planning use, in the standard DHS questionnaire. This method seems to be covered by the category of 'other' method. Therefore, the prevalence is generally very low (under 1.0 per cent). Some surveys, such as the Senegal DHS 1986 and the Cameroon DHS 1991, specifically asked women if they used ‘abstinence’, meaning postpartum abstinence. Thus, the use of abstinence in the current contraceptive variable was ignored since the effects should be covered by the index of postpartum infecundability.

Similarly, reasonable data on the effectiveness of folk family planning methods were not available. The prevalence was actually low, ranging from 0 per cent in Rwanda to 2.9 per cent in Niger. The effectiveness was considered as 0.0 for this study.

8.2.5. Index of abortion (C*a*)

As reviewed in the previous chapter, reliable population data are not available in the region. Therefore, the estimates of this index were considered as 1.0 for this study, as many studies on the proximate determinants selected have done so (Guengant and May 2001, 2009; Rutstein 2002).

8.2.6. Potential fertility (PF)

Bongaarts defines the level of fertility, in the absence of fertility-inhibiting factors, as total fecundity. As infertility is incorporated in Stover’s revision, he has redefined it as potential fertility (PF). He has estimated that PF among women aged 15-49 is between of 18 to 24. I arbitrarily selected 20 as PF for this study, because it made easier to compare the projected TFR with the Loess estimates. Although the selection of PF is rather subjective, Stover appears to have estimated PF as residual combined with C*a*. As the aim of this analysis to compare the trends, this requires reader to interpret the result with caution.

8.3. Results

The estimates of all the indices for the 63 DHS Surveys are available in Appendix 2.

8.3.1 Index of sexual activity (C*x*)

Figure 8.1 presents the indices of women who are sexually active, by survey, by country. The results show relatively low levels and large variability in sexual activity across the countries. In Ghana, Senegal, Rwanda, Namibia and Zimbabwe less than 60 per cent of women had had sex in the past four weeks in the most recent surveys. In contrast, 76 per cent of women were sexually active in Mali. All the countries except Madagascar, Malawi and Zambia exhibit some decline over the years. Ghana, Namibia and Zimbabwe saw a decline by more than 15 per cent since the 1980s.

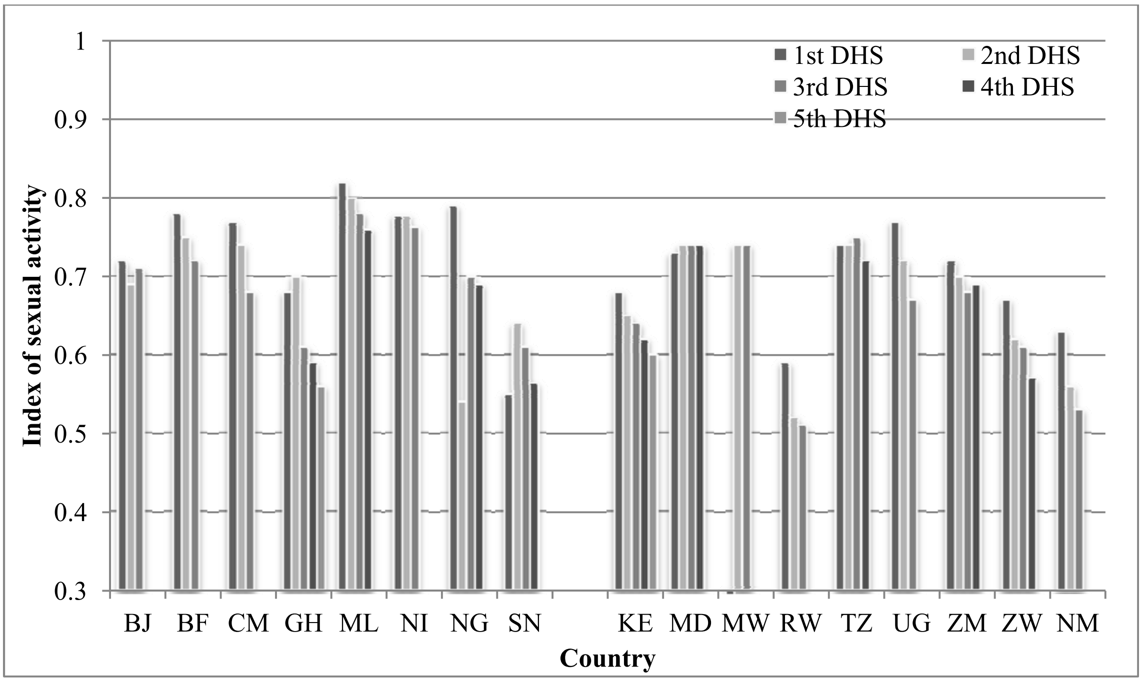


Figure 8.1: Index of sexual activity, by country, by survey

The decline is likely due to the later initiation of first sex, as discussed in Chapter 7. These trends have been observed in other sub-Saharan African countries and most developing countries (Blanc and Way 1998). Ghana and Senegal are good examples (see Table 7.1 in Chapter 7). Later sexual debut is likely to be associated with the improvement of women's education (Gupta and Mahy 2003). HIV/AIDS prevention programmes may have a substantial impact on the timing of initiation of sexual intercourse among adolescents (Stoneburner and Low-Beer 2004; Westoff 2007). As discussed in Chapter 7, lower proportions of non-virgin single and formerly married women had sex in the past month prior to the survey.

Explanations of the decline in Namibia are likely different. Sexual debut was earlier and proportions of married women declined significantly. Among women who were sexually active, only about 50 per cent were married and living with their partners, and 30 per cent of them were never-married. This is different from the decline in Ghana where proportions of virgin women increased and the proportion of married women, living with their partners, remained at the same level. The proportion of women in postpartum insusceptibility has declined too. The decline in Zimbabwe may also be due to different mechanisms. There were little changes in age at sexual debut. But the proportion of formerly married women exceeded 12 per cent at the latest survey (see Table 7.3 in chapter 7), and there were fewer married women staying apart from their partners. Furthermore, fewer formerly married women had sex in the past month (see Figure 7.3 in Chapter 7).

The results did not clearly present sub-regional patterns, where the coital frequency is usually lower in Western Africa. There is probably no change or a small increase in recent sexual activity in Western Africa as noted by Westoff and also in Chapter 7 (Westoff 2007). These trends may be partly linked to the shorter duration of postpartum abstinence as discussed later.

8.3.2. Index of postpartum infecundability (C*i*)

Figure 8.2 shows the indices of postpartum insusceptibility by country, by survey. The inhibiting effects have been strong; generally stronger than the effects of the index of sexual activity. The effects were the strongest in Burkina Faso, with 0.5, and weakest in Kenya. Generally, Western Africa revealed a stronger inhibiting effect of the index due to substantially prolonged postpartum insusceptibility, compared with Eastern Africa. All Western African countries show significant and clear increase. The index in Benin, Ghana, Nigeria and Senegal increased by 10 per cent. On the other hand, Eastern Africa saw little decline.

In other words, the inhibiting effects of postpartum infecundability have substantially decreased. If other conditions were the same, these changes would have increased fertility. However, it has in general been assumed that this effect was offset by the postponement of marriage. While this assumption is correct in other regions, it has not necessarily been verified at all stages of fertility transitions in the African context (Guengant and May 2009). The sharp decline in the index of sexual activity in Ghana, may have offset the increase in the index of postpartum insusceptibility. However, the changes in the index of sexual activity were not significant in the other countries as shown in Figure 8.1. As discussed later, the reduced inhibiting effects of postpartum insusceptibility may be associated with the deceleration of fertility decline.

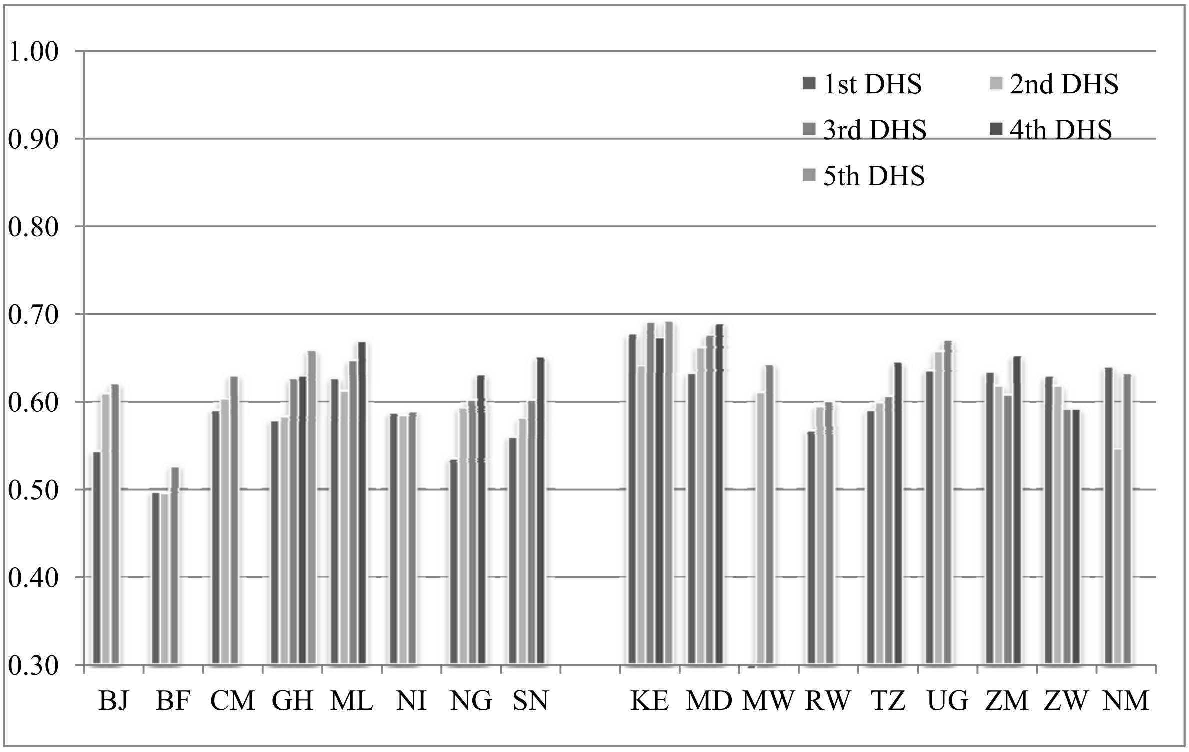


Figure 8.2: Index of postpartum infecundability, by country by survey

8.3.3. Index of sterility (C*f*)

Figure 8.3 shows the index of sterility. Generally, the index was higher, indicating that the inhibiting effects of sterility were not very high compared with the two previous indices. Infertility was more prevalent in Cameroon, Mali, Niger, Nigeria, Senegal and Tanzania, as suggested in the earlier research. However, these were the countries which experienced significant decline over the years. Overall, the index has increased over the years, reaching only 10 per cent effect of inhibiting factors.

Compared with the age-standardised estimates shown in Table 7.6 in Chapter 7, the estimates presented here are lower. As Stover has noted, it is likely due to the fact that I focused only on sexually active women aged 15-39. Moreover, the estimates in

Chapter 7 focused only on women who have never used any family planning in their lives.

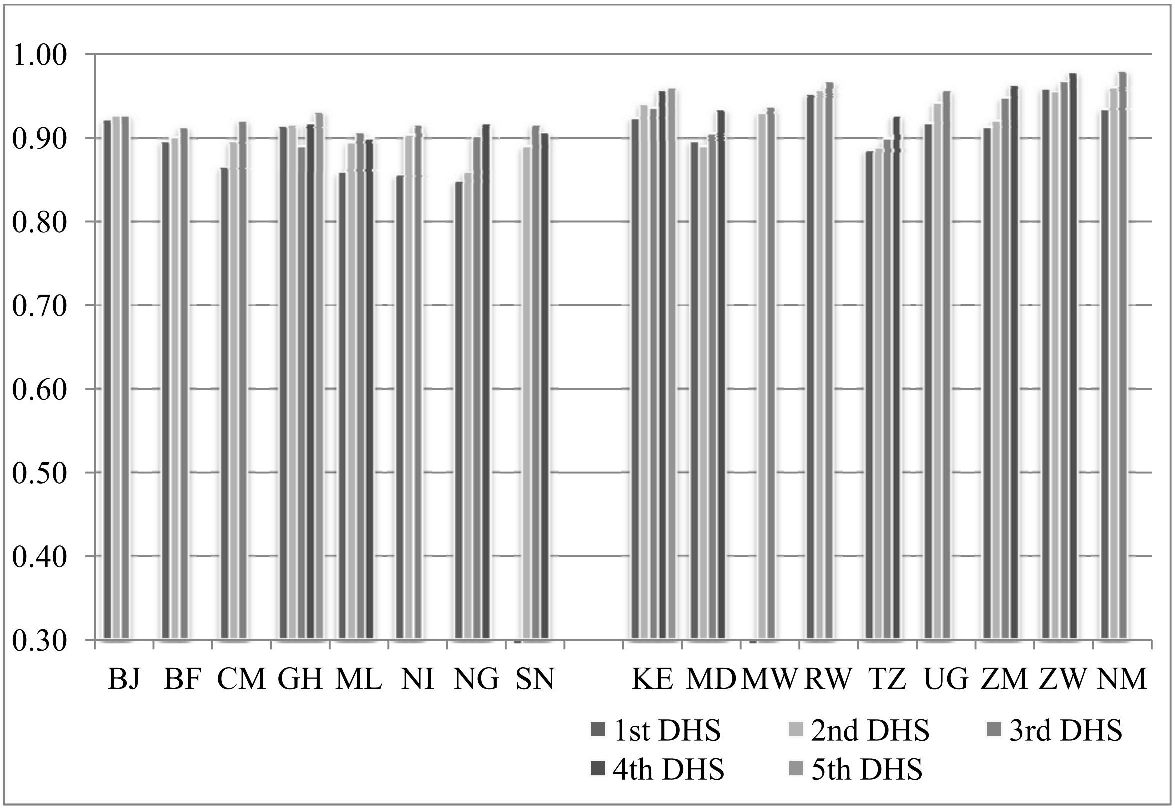


Figure 8.3: Index of Sterility, by survey, by country

8.3.4. Index of contraception (C*u*)

8.3.4.1. Contraceptive prevalence

Figure 8.4 shows contraceptive prevalence of modern and traditional methods by survey. Generally Eastern Africa has higher prevalence and showed increases all the country except Kenya and Rwanda. The prevalence in Zimbabwe has almost reached 70 per cent. On the other hand, the prevalence has been much lower in Western Africa and showed little increase. Also it was clear that many women in Benin and Cameroon have largely relied on traditional method. The prevalence has been low considerably in Mali, Niger, Nigeria and Senegal.

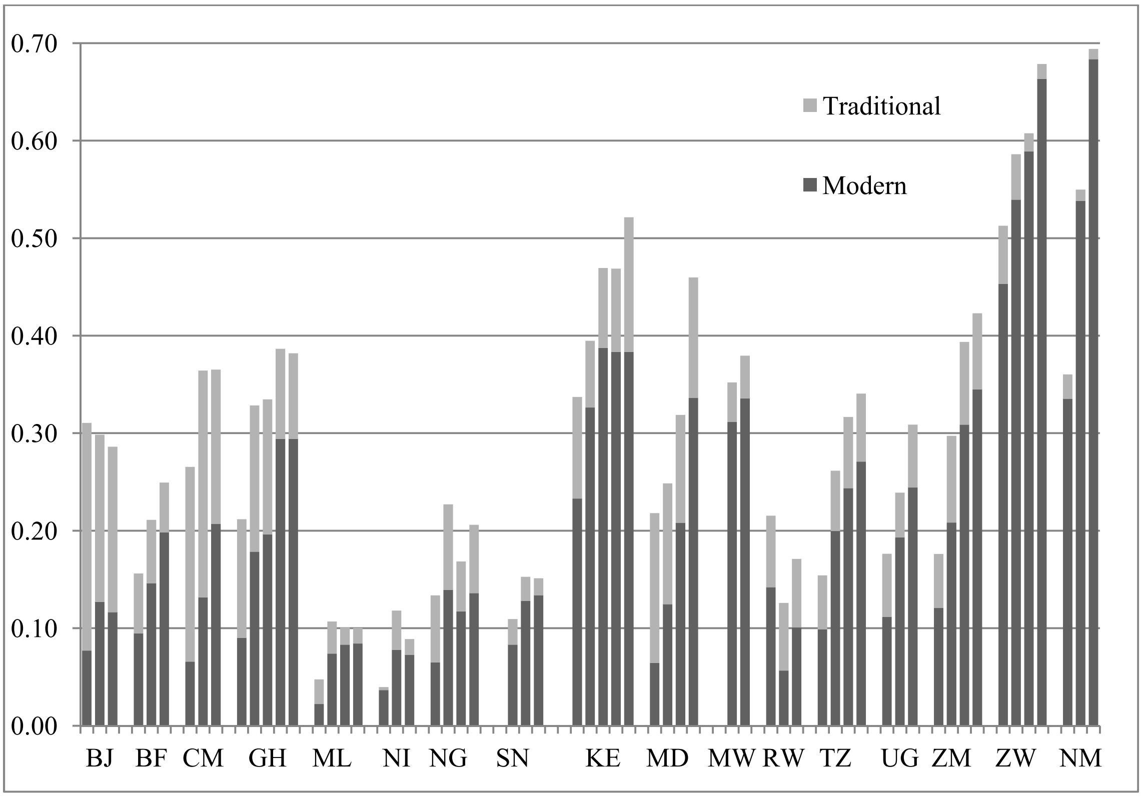


Figure 8.4: Contraceptive prevalence, by survey and by country

8.3.4.2. Average use-effectiveness of contraceptives

Table 8.2 presents average use-effectiveness of PA. The overall mean was 0.31, which is considerably lower than the effectiveness in the US population (0.75) (Trussell 2007). Furthermore, effectiveness varied from 0.09 in the 1988 Zimbabwe DHS to 0.68 in the 2004 Madagascar DHS surveys. Regardless of the widespread use of PA, the effectiveness in Benin and Cameroon was low, indicating high failure rates. Moreover, no improvement has been observed over years.

Table 8.2: Revised average use-effectiveness of periodic abstinence

country	DHS1	DHS2	DHS3	DHS4	DHS5	Mean
Benin	0.45	0.47	0.45			0.46
Burkina Faso	0.36	0.27	0.30			0.31
Cameroon	0.55	0.55	0.42			0.51
Ghana	0.47	0.40	na	0.35	0.43	0.41
Kenya	0.28	0.29	0.27	0.23	0.25	0.26
Madagascar	0.60	0.54	0.68	0.61		0.61
Malawi	na	0.16	0.12			0.14
Mali	0.41	0.40	0.38	0.39		0.39
Namibia	0.15	0.10	0.15			0.13
Niger	0.39	0.26	0.49			0.38
Nigeria	0.39	0.22	0.25	0.24		0.27
Rwanda	0.25	0.26	0.30			0.27
Senegal	na	0.39	0.39	0.43		0.40
Tanzania	0.18	0.29	na	0.30		0.26
Uganda	0.38	0.21	0.24			0.27
Zambia	0.18	0.24	0.23	0.23		0.22
Zimbabwe	0.09	0.36	0.19	0.09		0.18

Table 8.3 shows average use-effectiveness of all methods. The overall mean was 0.77, ranging from 0.59 in the 1987 Mali DHS to 0.89 in Namibia (2000 and 2006), Niger (1992) and Zambia (2007).

Table 8.3: Average use-effectiveness of contraceptives by survey, by country in the 17 sub-Saharan African countries

country	DHS1	DHS2	DHS3	DHS4	DHS5	Mean
Benin	0.68	0.74	0.71			0.71
Burkina Faso	0.68	0.70	0.77			0.72
Cameroon	0.66	0.67	0.70			0.68
Ghana	0.66	0.71	0.62	0.81	0.79	0.72
Kenya	0.72	0.82	0.81	0.80	0.86	0.80
Madagascar	0.71	0.76	0.86	0.86		0.80
Malawi	na	0.86	0.88			0.87
Mali	0.59	0.71	0.80	0.79		0.73
Namibia	0.86	0.91	0.89			0.89
Niger	0.82	0.54	0.70			0.68
Nigeria	0.66	0.70	0.73	0.73		0.70
Rwanda	0.76	0.67	0.78	na		0.74
Senegal	na	0.74	0.82	0.82		0.79
Tanzania	0.74	0.82	0.80	0.83		0.80
Uganda	0.65	0.80	0.82			0.76
Zambia	0.75	0.77	0.81	0.87		0.80
Zimbabwe	0.83	0.83	0.86	0.86		0.85

Source: DHS surveys. Own analysis.

The effectiveness has generally increased in all the countries, except in Niger and Rwanda. In Burkina Faso and Senegal, traditional family planning methods seem to have been replaced by modern methods.

Figure 8.5 shows contraceptive indices for the 17 countries. The trends and levels varied considerably across the populations. In Eastern Africa, the inhibiting effects of contraceptives were stronger, and have increased. That is, the indices declined over the years. For instance, in Namibia the index declined by 45 per cent in the 10 years. In contrast, the indices were considerably higher in Western Africa. In Ghana, alone, the index made a substantial decline, but increased slightly in the latest survey. This deceleration or reversals in contraceptive indices were found in Benin, Cameroon, Ghana, Mali, Niger, Nigeria Senegal and Kenya. In Kenya, stagnation was clear during the period when the Loess estimation showed deceleration in TFR.

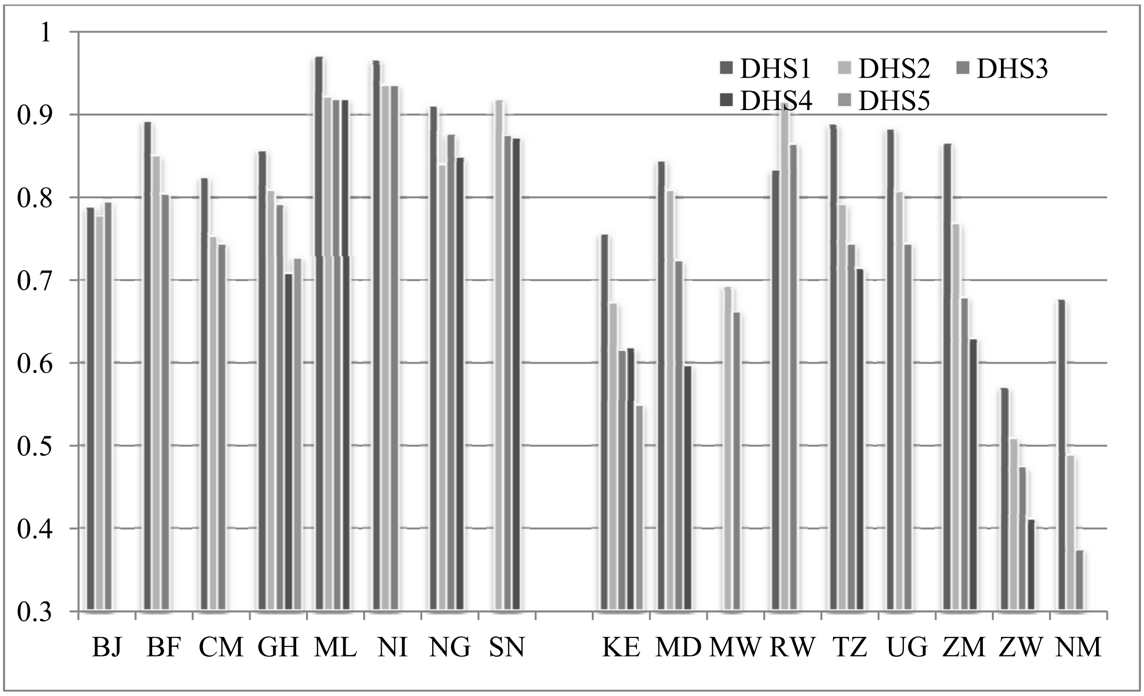


Figure 8.5: Contraceptive Index by country, by survey

8.3.5. Total fertility rates

8.3.5.1. Overall trends

Figure 8.6 presents the TFR estimates projected from the indices of the proximate determinants, using the modified Bongaarts' formulae, and the Loess TFR estimates for the 17 countries. A majority of the countries showed continuous fertility decline: Burkina Faso, Cameroon, Madagascar, Namibia, Senegal, Uganda and Zimbabwe. The good examples are Cameroon, Madagascar and Senegal, where clear declines were seen. Madagascar experienced more than one child decline in both estimates between 1992 and 2008.

Stagnation was found in Ghana (2003-2008), Kenya (1998-2003), Malawi (2000-2004), Tanzania (1996-2004) and Zambia (2001-2007). While the TFR declined by 0.7 children in the early 1990s, the level of fertility remained the same since then in Tanzania. Zambia's TFRs dropped by almost 2 children between the 1992 and 2001 surveys, and slightly increased in the 2000s. In Mali and Niger, the levels of TFR fluctuated at high levels. Furthermore, Benin saw an unusual increase over the years. The projected TFR increased from 5.7 to 6.5 in 10 years in Benin. The countries with failures of decline (Benin, Kenya, Malawi, Nigeria and Zambia) observed deceleration in the Loess trends. On the other hand, the projected TFR in Zimbabwe showed a continuous decline.

8.3.5.2. Relationship of proximate determinants to fertility

The figures for all the indices and surveys are shown in Appendix 2. On average, the index of sexual activity women between the first and latest surveys declined by about 14 per cent. The index of contraception changed by 21 per cent. The changes varied across the countries. There are several countries which clearly have experienced 'classical' fertility decline, where contraceptive use and the postponement of marriage is strong and offset the weakened inhibiting effects of postpartum susceptibility and infertility. This pattern, with the stronger effect of contraception, has been found in fertility declines in East and Southern Africa. Decline in Western Africa, at least in Cameroon and Senegal, was more likely attributable to changes in the proportions of those sexually active. There was no significant change in the index of contraception. In other countries, such as Benin and Nigeria, improvement in infertility and the shorter duration of postpartum infecundability was not offset by the other determinants. While 13 per cent of the decline of those sexually active was observed, there was an increase in postpartum infecundability by 18 per cent and sterility by eight per cent. The contraception index declined slightly in Nigeria. This seems to contribute to the stagnation of fertility declines in the two countries.

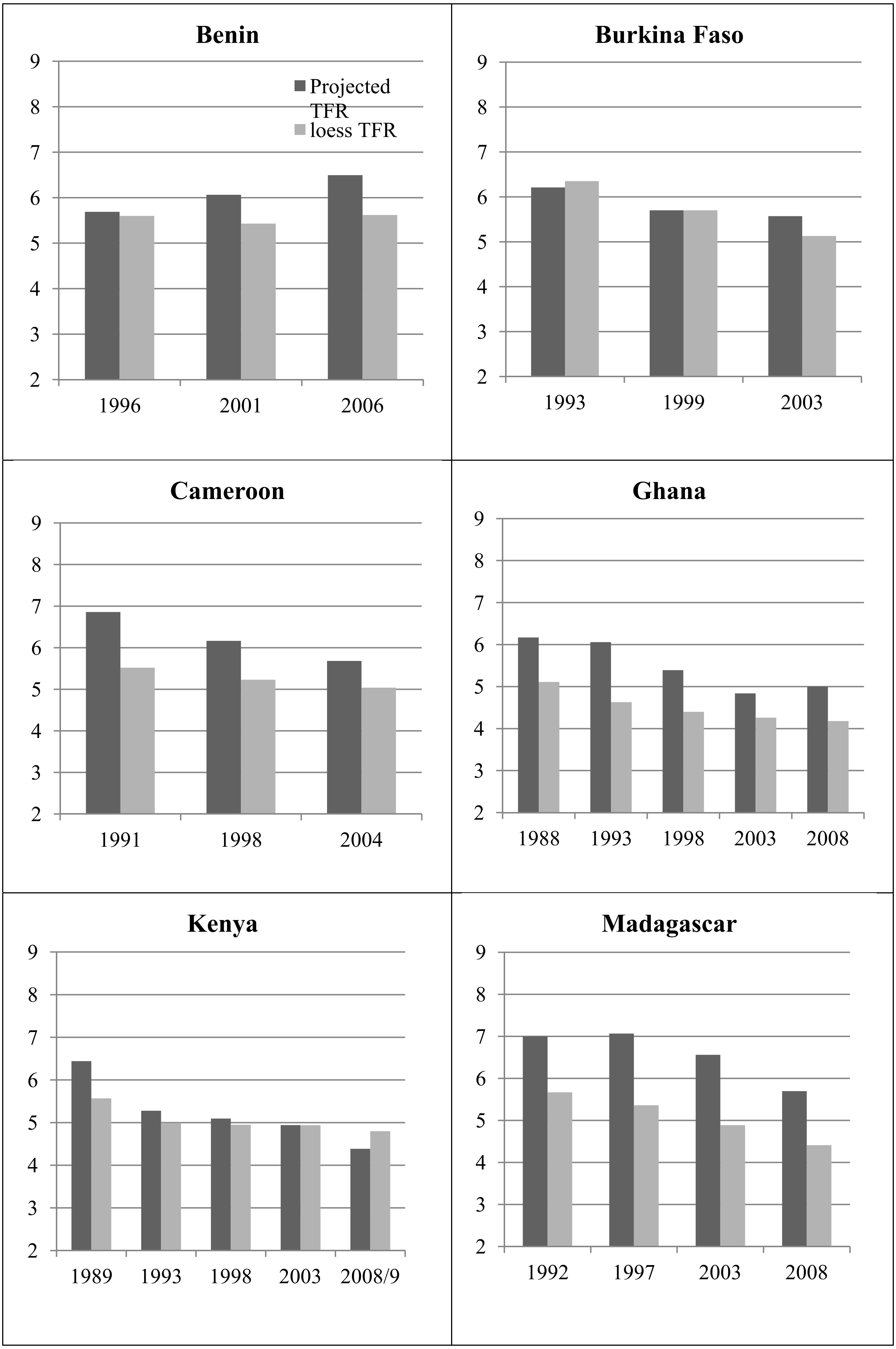
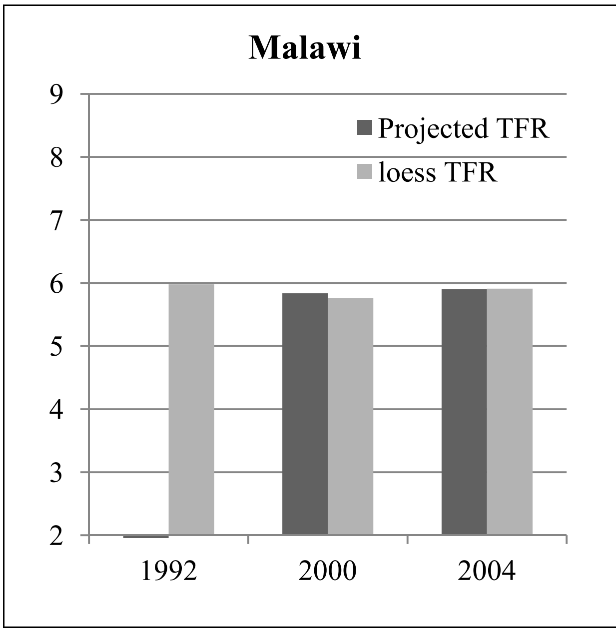


Figure 8.6: Projected and Loess TFRs (15-39), by survey by country


Malawi
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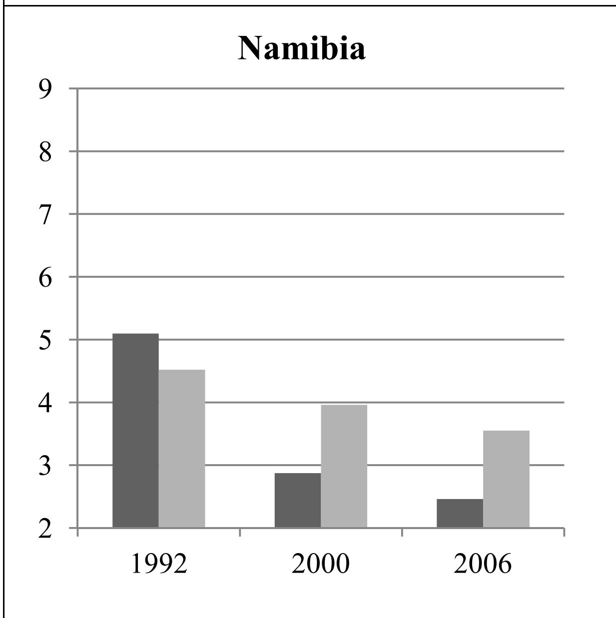
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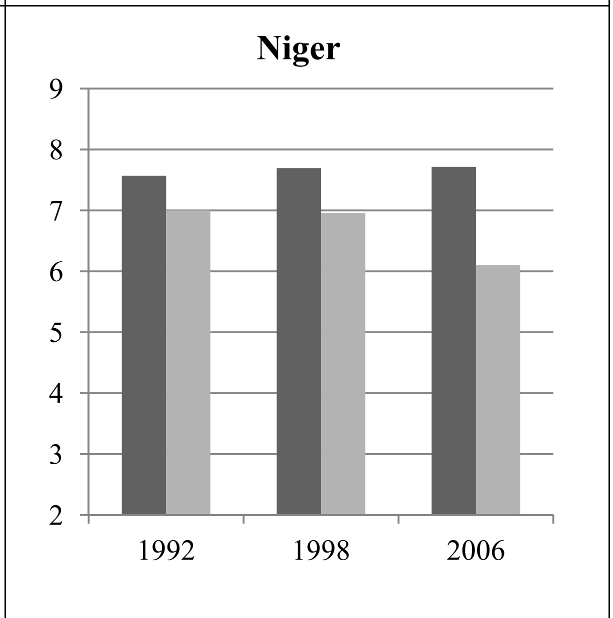
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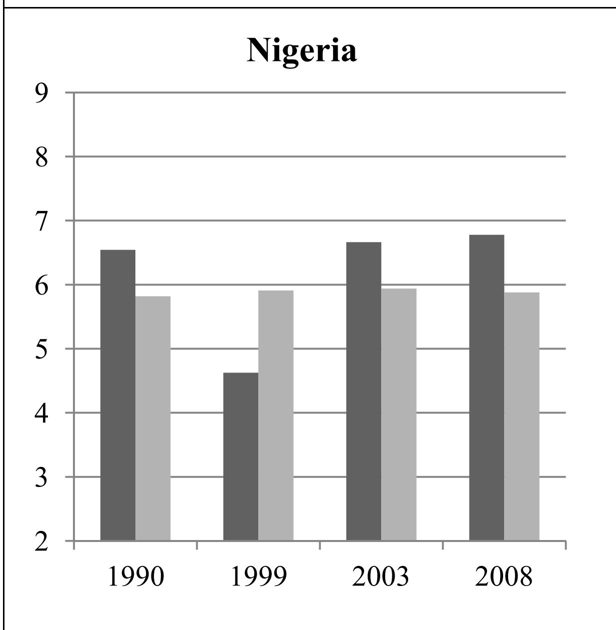
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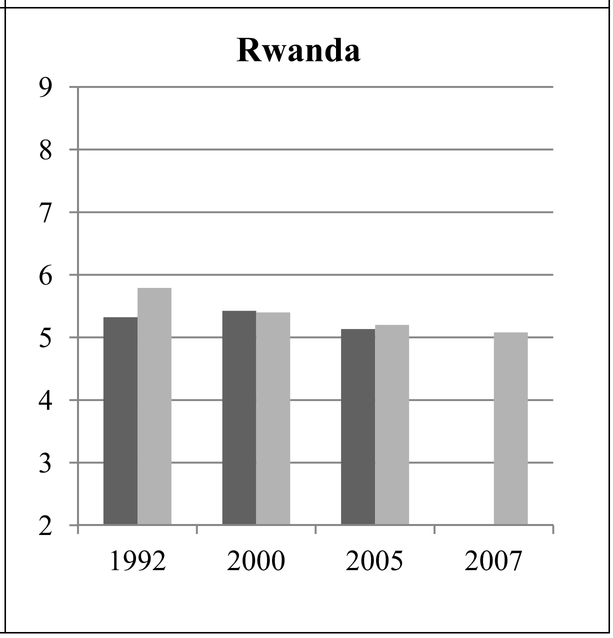
2003
2008


Rwanda
9
8
7
6
5
4
3
2
1992
2000
2005
2007

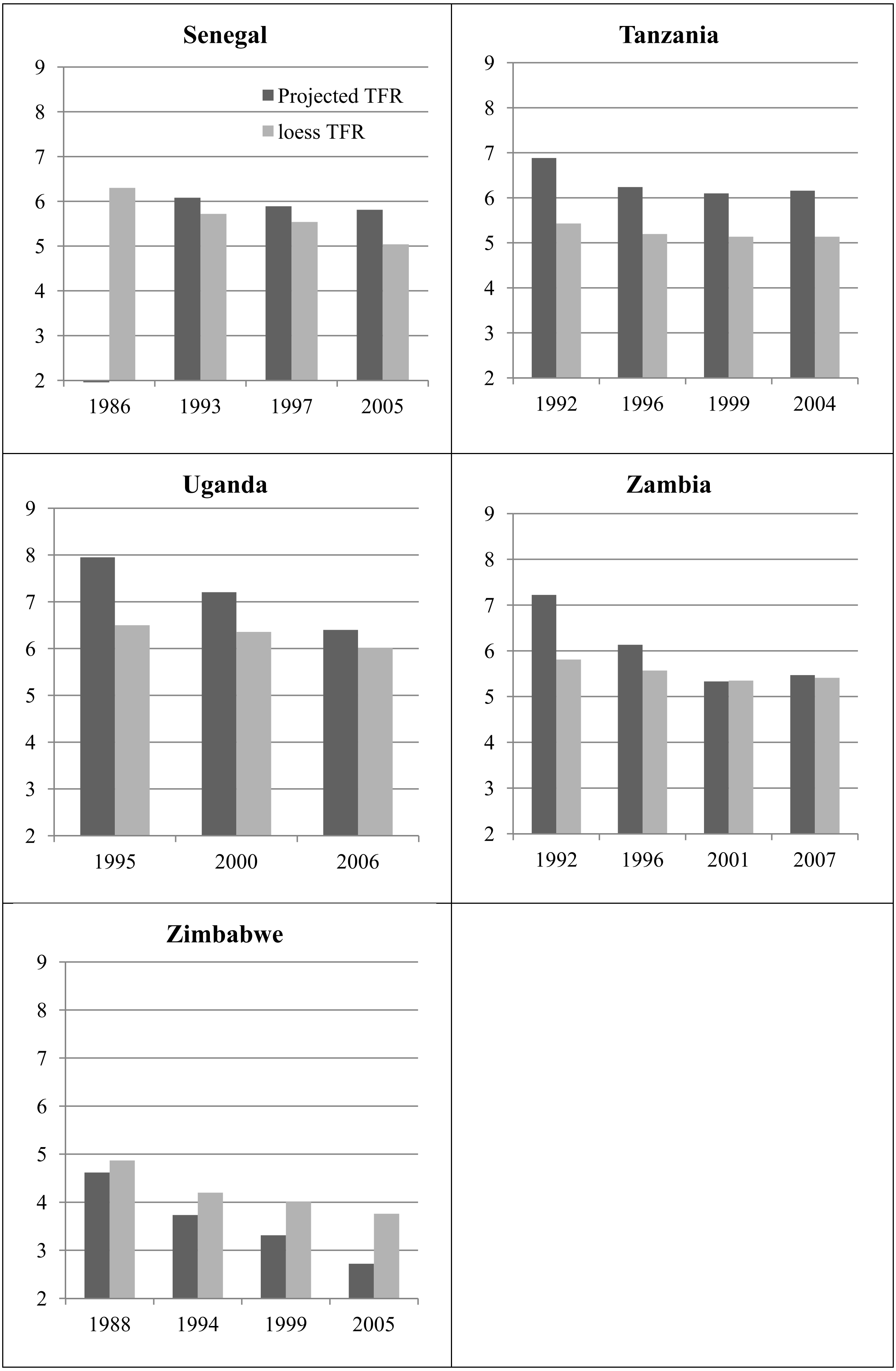


Figure 8.6: Projected and Loess TFRs (15-39), by survey and by country (continued)

8.3.5.3. Consistency in levels of projected and Loess TFR estimates

As the proximate determinants framework was not intended to project accurate TFRs, it was expected that there might be some differences between the projected and the Loess estimates. Overall, the projected TFRs were higher than the Loess estimates. Abortion may play a role in the discrepancies. As in the case of most studies, the index of abortion was not included. In Africa, abortion is legally allowed only in cases where it is necessary to save a woman's life. However, it is not uncommon in Africa. Evidence shows that many young unmarried women seek induced abortion because of the risk of interruptions in education and unemployment, and the social stigma of raising a child born outside marriage. Furthermore, the high contraceptive discontinuation rate and the high proportion of those unmarried among sexually active women may be attributable to the discrepancies. This will be further discussed in the next section.

8.4. Discussion

The Loess estimations concluded that six countries (Benin, Kenya, Malawi, Nigeria, Zambia and Zimbabwe) slowed down the fertility decline between the early 1980s and the early 2000s. Two countries (Ghana and Rwanda) showed slower but constant decline, after rapid declines in the 1990s. Another two countries (Burkina Faso and Madagascar) experienced acceleration and three countries (Cameroon, Namibia and Senegal) displayed constant decline. Four countries (Mali, Niger, Uganda and Tanzania) were regarded as being in the early stage of fertility transitions.

8.4.1. Consistency in the trends of projected and Loess TFR estimates

To what extent were projected TFRs consistent with the Loess trend estimation? Table 8.4 summarises the changes of decline by the two estimates, by country. On the whole, the two TFR estimates depicted the consistent directions in the fertility trends in most of the countries. In more than a half of the countries, i.e. Kenya, Malawi, Zambia, Burkina Faso, Cameroon, Madagascar, Namibia, Senegal, Mali, Niger and Tanzania, the projected TFRs showed the same trends as the Loess estimation. The consistency was relatively high. While in Cameroon, Madagascar and Tanzania the two TFR estimates appear to have the same trends at almost the same pace, the paces were different in the other countries. In Burkina Faso and Senegal the projected TFRs declined slower than the Loess trend estimates, while in Namibia the projected TFRs declined faster. Mali and Niger did not see any changes in the projected TFRs, while the Loess estimates suggested the initiation of the transition. Although the projected TFR estimates in Tanzania declined in the first inter-survey period, there was little change afterwards.

Table 8.4: Comparison of Loess and projected TFRs based on the proximate determinants framework in 17 sub-Saharan African countries

		Trends of projected TFR based on the proximate determinants framework			
		Decline/ Deceleration	Decline	No change	Increase
Loess estimates	Deceleration	Kenya Malawi Zambia	Zimbabwe	Nigeria	Benin
	Acceleration/ Constant decline	Ghana	Burkina Faso Cameroon Madagascar Namibia Senegal	Rwanda	
	Pre-transition		Uganda	Mali Niger Tanzania	

Several countries (Benin, Ghana, Nigeria, Rwanda, Uganda and Zimbabwe) revealed discrepancies in the trends between the two estimates. The discrepancies in the levels of fertility were more significant in five countries (Benin, Madagascar, Mali, Namibia and Zimbabwe). The potential factors related to the discrepancies are: (a) incidence of abortion; (b) high contraceptive discontinuation rate; and (c) low or high proportion of unmarried women among all sexually active women.

Variations in level and trends in the incidence of abortion may be a major explanation for the discrepancies, as the abortion index was not incorporated into the analysis. Sub-Saharan Africa has the highest incidence rate in the world: 31 unsafe abortions are taken place per 1,000 women aged 15-44 years every year, and 16 pregnancies among 100 live births end in unsafe abortion (WHO 2007). There may even be increases in West and Middle Africa recently (Shah and Ahman 2010).

It is suggested, for instance, that about one fifth or one forth of women of reproductive age in Nigeria have attempted an abortion (Bankole et al. 2008; Okonofua et al. 1999). The young women have an overriding fear of infertility which they believe may be caused by contraception. On the other hand, abortion is perceived to have only a limited effect on future fertility (Otoide, Oronsaye and Okonofua 2001). This practice might have increased in recent years because female enrolment in secondary education has increased sharply from 16 per cent in 1990 to 37 per cent in 2008 in the data. However, the contraceptive prevalence has not changed much (Bankole et al. 2008). Moreover, although there is limited evidence, abortion might not be uncommon and may diminish the increase in the projected estimates in Benin (Capo-Chichi and Juarez 2003). The high urbanisation rate (over 40 per cent) may have made abortion services easier to access. While young unmarried women were the group who seek abortions in sub-Saharan African countries, married women aged 20-34 years also seem to seek abortions to limit the number of children in Benin (Alihonou, Goufodji and Capo-Chichi 1996). The gap between the projected TFR and Loess TFR may be partly explained by induced abortions. However, it is difficult to measure the impact of abortion.

Second, the ineffective use of contraceptives may account for the large discrepancies between the Loess and projected TFRs. Most increases in contraceptive use in Africa have occurred among unmarried women. One study showed that younger women had a much higher discontinuation rate than married women (Blanc et al. 2009). While the prevalence of condom use has increased over the years, its use may not be consistent. Some may use condoms mainly to prevent HIV or other STIs. For instance, the use of condoms has rapidly increased up to 17 per cent since 2000 in Namibia. There may, however, be inconsistent use.

Furthermore, the estimates of average use-effectiveness of contraceptive methods from the US population, which was used in this analysis, may be too high for some African populations. In addition, there may be variations in the discontinuation rate across the countries studied. The discontinuation rates of pills are higher than that of injectables in some countries and in the US populations. In contrast, the discontinuation rate is lower than that of injectables in Zimbabwe (Bradley et al. 2009). One study undertaken in Kampala among 18-35 year old women shows that there is a higher discontinuation of injectables than pills in Uganda as well as in Zimbabwe (Nandaa et al. 2011). The top reason for the discontinuation was the side effects. This high discontinuation rate may be related to the discrepancies between the two estimates in Namibia, Madagascar, Uganda and Zimbabwe. The faster decline in projected TFR than the Loess estimates in Namibia and Zimbabwe may be due to high contraceptive discontinuation or high inconsistent use of condom and other contraceptive methods.

Third, the proportions of unmarried and married women among sexually active women may influence the discrepancies. As described in Chapter 7, the proportion of married women living with their husbands has substantially decreased in Namibia (31.2 in 1992 to 26.2 in 2000 and to 24.8 per cent in 2006 among all women aged 15-39). Among all sexually active women, only about 50 per cent were married and living with their husbands and 30 per cent of them were never-married. In contrast, 70-80 per cent of women were married and living with their husbands in Zimbabwe, and over 90 per cent in Mali and Niger were among those who were sexually active. Therefore, sporadic sexual behaviour among unmarried women is probably not the major reason for the discrepancy in these countries.

Fourth, there might be a time lag to fertility response to changes in the proximate determinants. For instance, stagnation in the projected TFR was observed between 2003 and 2008, in Ghana, due to stagnation or a small reversal of the contraceptive index. While the projected TFR stagnated during this period, the Loess TFR showed decline. Fertility might take time to respond to the changes. Otherwise, the incidence of abortion may have increased during this period in Ghana.

In Rwanda, because of the lack of data on recent sex in the 2007 interim DHS survey, only the trends between 1992 and 2005 were incorporated for this analysis. There was no substantial change in both estimates during this period.

8.4.2. Patterns of decline

There are several countries which clearly have ‘classical’ fertility decline where the inhibiting effects of contraceptive use and sexual activity is strong, and offset the weakened inhibiting effects of postpartum susceptibility and infertility. This pattern with stronger effect of contraception has been found in fertility declines in East and Southern Africa. Decline in Western Africa, at least in Cameroon and Senegal, were more likely attributable to change in proportions of sexually active. There was no significant change in index of contraception in Western Africa.

Deceleration was found in Benin, Kenya, Malawi, Nigeria and Zambia. These countries exhibited the following features: (1) stagnation of increase in contraceptive prevalence; (2) decrease in duration of postpartum abstinence; and/or (3) improvement of sterility. A combination of the first two reasons may explain the deceleration in Benin; mainly (1) and a little effect of (3) seem linked with the trends in Kenya. Nigeria's fertility trends could be explained by the combination of the three factors. In Zambia, while contraceptive prevalence continued to increase, the inhibiting factor of sterility was slightly weakened by about 4 per cent. Furthermore, an increase in sexually active women, particularly among those married living with their husbands, may have an impact on the deceleration. Malawi had only two data points due to the lack of sexual activity data and it is difficult to see the trend of the projected TFRs.

8.4.3. Limitations

The study applied Stover's revision of the proximate determinants of fertility with some proposed modifications. Fertility inhibiting effects of contraceptives were isolated more accurately than the original model, premarital sexual behaviours were taken into account and the average use-effectiveness was re-calculated. The trends of projected TFR showed relatively consistent trends as ones of the Loess estimation. The modification seems to adequately depict the fertility trends.

However, there are limitations. First, as mentioned earlier, the projection of TFRs is not intended to provide accurate estimates. It is intended to assess the extent to which changes in proximate determinants support the Loess trends of fertility changes. Some discrepancies in the level of fertility were expected. Furthermore, as only the data on the status at the time of the survey were available, there were only 3-5 point estimates in each country. Description of the trends had to depend on the slope between the two point estimates. As extensively discussed in Chapter 4 and 5, I have to admit that this is a fairly simple way to examine trends. The slope may be affected by different levels of data quality across the surveys. As each index may have biases, the projected TFR may be over or underestimated.

In addition, the average-use effectiveness may be under or overestimated. Due to the inconsistent and limited evidence of the effectiveness of contraception, I used the estimates from the US population based on Trusell et al.(2007). As discussed earlier, it may be too high and there may be variations across and within countries, as well as over time.

There may be variations in coital frequency among women who were regarded as sexually active. Due to the lack of data on coital frequency, I examined the proportion of women who had had sex at least once in the past 28 days. There might be large variations in coital frequency, which might have an impact on fertility. As discussed earlier, unmarried women's sexual activity is more likely to be sporadic than married or co-habiting women. For instance, the discrepancies between projected and Loess TFRs in Namibia may be explained by the large proportion of women who are sexually active but unmarried. .

Furthermore, potential fertility was arbitrarily set as 20 for all the surveys because there is no data on the variation in potential fertility. Therefore, it is not possible to provide accurate estimates using Bongaarts' framework.

Nevertheless, the results provide valuable evidence in order to understand the mechanisms of recent fertility decline in Africa.

8.5. Conclusions

This chapter set out to apply the modified formulae of Bongaarts' proximate determinants framework to the 17 countries, and then to explore whether changes in proximate determinants support the Loess fertility trends.

The projected TFRs showed consistent directions of trends in most of the countries studied. The findings suggest that there was clear deceleration or reversals in projected TFR in the countries where the Loess TFR showed deceleration of fertility decline. The countries include Benin, Kenya, Malawi, Nigeria and Zambia. However, the projected estimates in Zimbabwe appeared to decline continuously. Therefore, the results of the two estimation approaches suggest that at least the former 5 countries have experienced deceleration of fertility decline over years.

This study suggests that there is no single pattern in the relationship between changes in proximate determinants and fertility. Deceleration of fertility may be due to combinations of stagnation of contraceptive use, improvement of infertility, shorter postpartum abstinence, and possibly an increase of sexually active women within marriage. Therefore, while expanding contraceptive use, it is important to observe the levels and trends of the other proximate determinants. For instance, while postpartum abstinence is unlikely to substantially lengthen any more, the duration of postpartum amenorrhea would depend on the future direction of the practice of breastfeeding. Furthermore, the fact that sexual activity within marriage seems to be increasing, suggests an increasing need for family planning for couples in stable unions.

Regardless of several limitations, this analysis sheds light on recent changes in proximate determinants, and subsequently reconstructed TFRs. Moreover, this helps us to examine whether the Loess trends are supported by changes in proximate determinants, and which proximate determinants were drivers of fertility trends in the countries studied.

Chapter 9 :DISCUSSION

This chapter provides discussion of the findings presented in the earlier chapters of this thesis. The first section describes the limitations of the data and analysis in this study. The second section provides main findings and discussions for three pillars of the study: data quality assessment; re-assessment of fertility trends; and proximate determinants analysis in the 17 sub-Saharan African countries. The implications for our knowledge of fertility decline in sub-Saharan Africa are discussed, followed by recommendations for policies and future research.

9.1. Limitations

This research is entirely based on the data from the Demographic and Health Surveys. Although it is one of the most reliable sources of nationally-representative fertility-related data in the countries studied, there are limitations. One of the major sources of non-sampling error, age displacement, was adjusted under the assumption that transference occurs across the boundary year for child health questions. However, it is possible that estimation could occur over a two year period. Other problems also exist in the data, one of which is the omission of live births. Omission could be serious, especially if the births of children who died in infancy are systematically underreported. As discussed extensively in Chapters 2, 4 and 5, it is difficult to quantify and to differentiate between omissions and age displacement of births. Therefore, omission was not adjusted in this research. For example, omission in the 1999 Nigeria DHS was substantial, as indicated in the DHS report. There was an obvious trough after the boundary year. The TFR was considerably lower compared with the estimates derived from the 2003 Nigeria DHS, as depicted in Chapter 5. The TFR in the 5-year period prior to the survey may be underestimated by 14 per cent (National Population Commission [Nigeria] 2000), though severe omissions at this level are unlikely to occur according to the assessment of parity by birth cohort and by survey (Machiyama 2010). Moreover, omission is most likely to occur among women aged 40-49 with high parity (Arnold 1990). To the extent that this is true, our estimates of the partial TFR (15-39) are unlikely to severely be affected by the omission of births. This problem may be addressed by comparing the age distributions of data with those in the census data, but it is beyond the scope of this thesis.

In light of the estimation of long-term fertility trends, Loess regression has been used in this study. Loess is an increasingly used smoothing method, running a linear regression with the highest weight on data points close to the time point of interest and smaller weights according to the distance from the time point of interest. In other words, it is much more flexible than linear regression. With regard to the flexibility of Loess smoothing, selection of the minimum and maximum values of α, the degree of smoothing, is somewhat arbitrary, as is the density of α values between these limits (Silverwood and Cousens 2008). While in most cases this will not seriously affect the point estimates, the uncertainty areas could be affected. But this analysis represents a distinct improvement on relying entirely upon a single, arbitrarily chosen value of α as in Machiyama (2010), and the results obtained appear to provide plausible uncertainty intervals.

In addition, the current Loess method may have smoothed out minor fluctuations, such as brief stalls. The use of small α values allows the capture of short-term changes in trend, but when they are pooled with the estimates/predictions corresponding to larger α values any such hiatus in the downward trend may disappear. In Chapter 5 it is demonstrated how the α affects the overall trends in Kenya. The results have shown that use of the maximum α value of 1.0 effectively picked up the short-term plateauing of fertility in Kenya. Moreover, if more substantial stalls occurred, the method should capture them. As most short-term stalls are likely to be spurious, caused by age displacement of children, omission or other errors, this characteristic of the method is not necessarily a deficiency.

The proximate determinants analysis of fertility is fairly simple and descriptive, but has not been done recently using Stover's revision and reasonable modifications at this scale. The variables used may be affected by data errors. With regard to the analysis, as mentioned earlier, the projection of TFRs is not intended to provide accurate estimates, but to assess the extent to which changes in proximate determinants support the Loess trends of fertility changes. Some discrepancies in the level of fertility were expected. Furthermore, as only the data on the status at the time of the survey were available, there were just 3-5 point estimates for each country. Description of the trends had to depend on the slope between these limited number of data points. As extensively discussed in the earlier studies in Chapters 4 and 5 the method used for fertility trend estimation is a fairly simple way to examine a trend. The slope may be affected by different levels of data quality across the surveys. Each index may have biases, causing over or under estimation of the projected TFR. The variation in incidence of abortion was not able to taken into account in the analysis, due to the limited reliable data. The abortion index was regarded as 1 in the analysis and could not take into account the variations across countries and over time.

Lastly, this study assessed the fertility trends at national level and some of the discussion made for a given country might need care when generalising for the entire country. For instance, Nigeria has very diverse populations with more than 370 identifiable ethnic groups under a federal government with some degree of autonomy in each state (National Population Commission (NPC) [Nigeria] and ICF Macro 2009). Each of the countries studied is diverse in terms of culture, education, social and economic development. There is abundant evidence of large differences in fertility trends, particularly in urban and rural areas (Garenne 2008; Shapiro and Gebreselassie 2008) and within socio-economic and geographical groups (Ezeh et al. 2009). In fact, clear differences in patterns of fertility decline between urban and rural areas have been found in the course of researching this thesis(Machiyama 2010), though this study focused on fertility changes at national level, and increased the number of countries studied to 17. The strength of this study lies in the coverage of one third of the countries in sub-Saharan Africa.

9.2. Main findings and discussion

The significance of this research is that the results provide compelling evidence of deceleration of fertility decline in five sub-Saharan African countries. The next section summarises and discusses the building blocks of the evidence.

9.2.1. DHS data quality

By extending Pullum's work (2006), assessment of age and date misreporting were performed in datasets from 63 DHS surveys conducted in 17 sub-Saharan African countries. The levels of data quality were generally high and appeared to have been improved, except for the prevalence of age displacement of children. The extent of the error was not constant within countries: some recent surveys contained more instances of child age displacement than the earlier surveys. This indicates that recent fertility trends presented in the earlier studies, which used the face values of the TFR estimates from the DHS reports, were likely to be affected by this error. Furthermore, the fertility trend estimation by single calendar year exhibited a clear effect of age displacement and discrepancies in the TFR estimates from successive surveys during overlapping periods. This would suggest that a TFR estimate derived from only one DHS risks being underestimated.

Not only fertility estimates, but also child mortality estimates would be affected by the age displacement and omission of live births. It is important to note that age displacement among children who had died was more pronounced in some of recent surveys. The latest surveys in Kenya, Madagascar, Mali, Niger and Tanzania contained over 30 per cent of age displacement among early deaths following live births. For instance, Kenya celebrated a rapid decline in child mortality after the release of the 2008 Kenya DHS, following increased mortality over two decades. The displacement among deceased children was 34 per cent (see Chapter 4). This error certainly needs to be adjusted, to avoid severe underestimation of child mortality. As concern has been growing (Murray et al. 2007; Sullivan 2008), more care is needed in estimating child mortality.

9.2.2. Fertility trends in 17 sub-Saharan African countries

The Loess regression model was fitted to the data points by single calendar year after adjusting for common errors. These methods produce both robust trend estimates and uncertainty intervals. Kenya is examined in detail, as the stalling of fertility decline has been reported there most often. No established fertility decline has halted entirely in Africa, but in six countries, Benin, Kenya, Nigeria, Malawi, Zambia and Zimbabwe, the pace of decline has more than halved since the 1980s. The results suggest fewer countries show such trends than previously thought (Bongaarts 2006, 2008; Garenne 2008; Shapiro and Gebreselassie 2008).

While it is certainly possible to have a short-term stall during transition (Gendell 1985), it is important to have a *long view*. The issue now is how fast fertility declines over the long term. Because change in TFR is often too slow to detect a significant change during only a few years, concentration on examining short-term changes may provide a misleading picture of fertility transition. The results of this study confirm that fertility has continued to decline once transition has started. No country has entirely halted fertility decline above a TFR of four. However, the issue was slowing the pace, as suggested by the earlier studies (Bongaarts 2002b; Casterline 2001b). As found in Guatemala between the late 1980s and the late 1990s, fertility decline in sub-Saharan Africa is considerably slower than in other regions. One study has shown that the pace of decline is strongly associated with the pace in the previous five-year period (Bos and Bulatao 1990). The pace of decline may be decelerated or have a short-term lull, but it is likely to see gradual deceleration rather than a sudden complete halt in the course of fertility decline. Constant examinations of pace of fertility decline are crucial.

The earlier studies of fertility stalls in Africa often relied on unadjusted simple average TFR estimates for an aggregate of three or five years preceding each survey (Askew et al. 2009; Bongaarts 2006, 2008; Ezeh et al. 2009; Shapiro and Gebreselassie 2008; Westoff and Cross 2006). This approach is vulnerable to age transfer of children, particularly when such transfer is more pronounced in some surveys than others. Demographers in the past were preoccupied by the possibility of data errors. WFS undertook data quality evaluation for all its surveys and published a detailed methodological report for each. While dissemination of the reports and datasets has become much faster, this era has given way to one in which many users of DHS data accept them as the 'truth' without the need for error detection or adjustment. This thesis raises the alert against such a trusting and naive approach.

9.2.3. Changes in the proximate determinants in 17 sub-Saharan African countries

The projected TFRs showed consistent direction in trend with the Loess estimation in most of the countries studied. The findings suggest that the projected TFR have failed in the same periods in most of the countries where the Loess TFR estimates showed deceleration of fertility decline. The countries include Benin, Kenya, Malawi, Nigeria and Zambia. In contrast, the projected TFR estimates in Zimbabwe appeared to decline continuously. This might be due to ineffective use of contraceptives and high discontinuation rates, as discussed in Chapter 8. Results of the two estimation approaches suggest that at least five countries have experienced deceleration of fertility decline in past years.

The results suggest that in the countries studied, the inhibiting effect of postpartum infecundability is usually the strongest. On average this factor has reduced fertility by 40 per cent, followed by sexual activity (30 per cent) and contraception (25 per cent). The effect of infertility seems lower than previously thought (Bongaarts et al. 1984; Frank 1983). The effects of abortion were unable to be estimated in this study.

The changes in each proximate determinant varied substantially across countries. The index of sexual activity has changed dramatically in Ghana, Namibia and Zimbabwe, while the effects of postpartum infecundability reduced by over 14 per cent in Nigeria, Benin and Ghana. While the duration of postpartum amenorrhea has not changed substantially except in Ghana, the duration of postpartum abstinence has considerably shortened in Western Africa. Nigeria, Niger and Zambia have reduced infertility. Lastly, changes in contraceptive index were most significant in Namibia, Madagascar and Zimbabwe.

There are visible indications of increase in sexual activity within marriage. There was a more than 10 per cent increase in the proportion of sexually active women, among all married women living with their partners in Mali, Nigeria, Cameroon and Ghana in the past two to three decades. The proportion increased by over 20 per cent in Mali between 1987 and 2006. This may be a sign of changes in relationships between couples.

Deceleration of the projected TFR found in Benin, Kenya, Malawi, Nigeria and Zambia may be due to stagnation in contraceptive use, improvement of infertility, shorter postpartum infecundability, and possibly an increase of sexual activity within marriage. Stagnation of contraceptive use in Kenya has been suggested in earlier surveys (Cleland et al. 2006b; Ezeh et al. 2009). While there were concerns in the past that reduction of infertility, erosion of postpartum abstinence and shorter breastfeeding might increase fertility, few studies have discussed these proximate determinants by linking them with the recent deceleration of fertility decline (Anyara and Hinde 2006; Guengant and May 2009; Magadi and Agwanda 2010). Furthermore, changes in sexual activity among married couples have not been widely discussed and it is thought recent sexual activity has declined in Eastern and Southern Africa (Westoff 2007).

While expanding contraceptive use, it is important to observe the levels and trends of the other proximate determinants. For instance, while the length of postpartum abstinence is unlikely to substantially lengthen any further, duration of postpartum amenorrhea would depend on the future direction of the practice of breastfeeding. The ideal breastfeeding period for HIV-positive women recommended by the WHO has changed in past years, which may have influenced the practice in communities (Magadi and Agwanda 2010). Although the results of this study did not show reduction in duration of postpartum amenorrhea, DHS STATcompiler shows shorter breastfeeding periods in some parts of Zambia (Macro International Inc. 2011). Furthermore, the finding that sexual activity within marriage appears to be increasing suggests an increasing need for family planning for married and cohabiting couples in sub-Saharan Africa.

9.3. Implications

The strong evidence of the slower fertility decline in sub-Saharan Africa from this research suggests important implications for our knowledge of fertility decline in the region. Deceleration or a short-lull in decline has been found in Costa Rica, Guatemala, Egypt, the Philippines and Bangladesh (Bongaarts 2006; Casterline 2001b; Eltigani 2003; Gendell 1989). However, in no other region or sub-region has deceleration been common to this extent or at such a high level.

Some scholars have argued for the economic approach by claiming that economic downturn in the 1990s may cause the slow-down (Garenne 2007; Shapiro and Gebreselassie 2008), while others think this may trigger the onset of fertility decline in some countries (Caldwell et al. 1992). This claim may be at least partly rejected by observing the case of Zambia. Zambia's economy has grown rapidly since 2000 by over five per cent per annum in GDP, resulting in it being re-classified as a middle-income country by the World Bank in early 2011 (World Bank 2010). Not only the mining industry but also agriculture has grown rapidly, due to intensive foreign investment. It is important to note that these dramatic economic changes have been made in some of poorest rural provinces, such as North-Western and Northern provinces, bringing dramatic social and economic changes with more young people migrating from the rest of the country to these regions. However, TFR in Zambia appears to have slowed down in the 2000s, as shown in Chapter 5. Moreover, according to the UN data, Zambia's TFR is projected to increase between 2000 and 2020. Although data assessment is needed, the 2007 Zambia DHS shows that the TFR in rural area was significantly higher than that in the 2001/2 Zambia DHS. It was 6.9 [6.668-7.173] in 2001/2 and 7.5 [7.175-

7.775] (Central Statistical Office (CSO) et al. 2009; Central Statistical Office [Zambia], Central Board of Health [Zambia] and ORC Macro 2003). On the other hand, Rwanda's economy has grown as fast as that of Zambia in the 2000s. Unlike Zambia, DHS reports have shown a significant increase in modern contraceptive prevalence, resulting in the TFR declining by over 1.5 children between 2005 and 2010. The TFR declined from 6.1 [5.885-6.266] in 2005 to 5.5 [5.288-5.741] in 2007/8 (Macro International Inc. 2011). This does not support the economic explanation, at least using GDP as a predictor.

Some have suggested that increased child mortality due to the HIV/AIDS epidemic may be an explanation (Magadi and Agwanda 2010; Westoff and Cross 2006). The effect of HIV/AIDS on fertility is complex. While HIV infection is associated with infertility, there is a myriad of social and economic factors connected to reproductive behaviour, decision-making as well as desired fertility. It is also influenced by availability and types of regimens of Preventing Mother-to-child Transmission of HIV (PMTCT) and ART and sexual and reproductive health programmes, and the HIV-status of their partners.

The earlier studies from sub-Saharan Africa suggested that the level of fertility among HIV infected women was lower by 25-40 per cent than for those not affected (Magadi and Agwanda 2010; Ryder et al. 1991; Zaba and Gregson 1998). However, a study in Kenya has suggested that a shorter breastfeeding period and higher desired fertility may have contributed to increased fertility in western Kenya. This may be due to the desire to have another child when one has died, or shorten breastfeeding practice. In addition to changes in WHO's recommendations of breastfeeding practice for HIV-positive women, loss of a child reduces the duration of breastfeeding, resulting in a greater need for postpartum contraception (Magadi and Agwanda 2010).

As childbearing is a central role of the woman's identity in many sub-Saharan African countries, inability to bear children may be attached to stigmatisation from families and communities. Some studies have reported that the desire for pregnancy has been shown to outweigh concerns about transmission of HIV to their partners (Awiti et al. 2010; Kisakye, Akena and Kaye 2010). Given the expansion of ART and PMTCT in recent years, decision-making has become more complex. Although a study in the United States reported that the use of ART did not affect pregnancy rates (Massad et al. 2004), one study from 11 sites in seven sub-Saharan African countries has shown significantly higher pregnancy rates among HIV-positive women on ART than HIV-infected women who were not on ART (Myer et al. 2010). The expansion and evolution of ART in sub-Saharan Africa may have modified the perception of HIV and HIV patients, and sexual and reproductive behaviour. However, the effects on population level are unknown.

As discussed in Chapter 2, strong lineage rather than the nuclear family may be one of the factors of the slow fertility decline in sub-Saharan Africa (Caldwell and Caldwell 1987; Mason 1997), in association with the lower level of socioeconomic development and weak family planning programmes. Reproductive-decision making has been strongly influenced by family members. Changes in family systems can play important roles with interaction with other factors (Mason 2001).

African family systems have been changing in the past decades. One of the significant factors affecting cohesion of kin systems is its fast urbanisation (Goody 1989; Tabutin and Schoumaker 2004). The urbanisation rate in 1950 was only 13 per cent. But the rate has increased significantly and reached over 30 per cent (Tabutin and Schoumaker 2004). Furthermore, over two thirds of urban inhabitants live in slums (UN-HABITAT 2003). Couples used to have separate rooms in order to practise postpartum abstinence. But in these living conditions, it is difficult to have separate rooms for husbands and postpartum wives, which makes it difficult for couples to practise postpartum abstinence for a long period (Capo-Chichi and Juarez 2003). Moreover, wives also increasingly fear that their husbands may seek extramarital sex and bring STI or HIV into the family (Desgrées-du-Loûa and Broub 2005; Zulu 2001).

The changes in living arrangements as well as the recent rapid improvement in female educational attainment may have had an impact on the relationships of couples and family members. Firstly, relationships between wives and husbands may have been changing. The strong lineage system has maintained the physical and psychological distance between wives and husbands through postpartum abstinence and polygyny (Lesthaeghe 1980). However, as shown in Chapter 7, the results showed that sexual activity among married women living with their husbands or partners appears to be on an upward trend. Moreover, a reduction of sexual activity among non-virgin unmarried and formerly married women, was observed in most countries except Namibia. This might be a sign that sexual activity is more confined to marriage than before, and reproductive decision-making has been moving from lineage to conjugal couples. Nevertheless, there is evidence that urban couples have difficulty in meeting the expectation in the kinship system to have more children and the individual desire to limit childbearing (Smith 2004).

One plausible explanation is provided in this study. In sub-Saharan Africa, other proximate determinants apart from contraception play significant roles. There are several countries which have the 'classical' pattern of fertility decline, where the inhibiting effects of contraceptive use and sexual activity have increased, offsetting the weakened inhibiting effects of postpartum insusceptibility and infertility. This pattern, with stronger effects of contraception, has been found in Eastern and Southern Africa. Rwanda is a good example in terms of the rapid increase of contraceptive use and postponement of marriage. Namibia has dramatically increased contraceptive use, while marriage itself is no longer the norm and a substantial proportion of women remain unmarried. The decline in Western Africa was more likely attributable to a change in postponement of marriage and sexual debut. There has been slight change in the index of contraception in the region.

The findings indicate that not only the change in contraceptive use, but also changes in postpartum infecundability and other proximate determinants affect the pace of decline unlike in other developing countries. As described in Chapters7 and 8, the effects of contraception and changes in age at first marriage have been smaller in sub-Saharan Africa. This is because postpartum infecundability has been the strongest inhibiting factor on African fertility. As shown in Chapter 8, stagnation of fertility decline in Benin, for instance, is likely due to stagnation of contraceptive and sexual activity indices which were not able to offset changes in postpartum infecundability and infertility. Given the strong effects of each proximate determinant and the inter-relationship with HIV/AIDS at individual and community levels, these findings suggest that African fertility decline is largely path-dependent, because each of the proximate determinants affects the pace of fertility decline variably.

Another important factor of explaining the deceleration of decline is weak family planning programme implementation in sub-Saharan Africa. As discussed in Chapter 2, African governments started to implement strong family planning programmes in the 1980s. Kenya was a successful country at that time. However, family planning has been de-emphasised in the broader concept of sexual and reproductive health and rights since the 1994 Cairo Conference. Furthermore, external funding has concentrated on prevention and treatment of HIV/AIDS and the related areas since the 1990s (UNFPA et al. 2005). This may have some impact on stagnation of contraceptive use in some countries, particularly in Kenya (Cleland et al. 2006b; Sinding 2008; Speidel et al. 2009).

These explanations, apart from the unique characteristics of proximate determinants, have not led to a firm conclusion. What is clear is that strong family planning implementation has been absent in nearly all sub-Saharan African countries in the past 15 years. We have observed that strong family planning programmes can induce steep and sustained fertility decline in less developed and less educated countries, such as in Indonesia in the 1970s, Bangladesh and Kenya in the 1980s . More recently, strong implementation has seen a dramatic decline in the TFR in Rwanda. While a firm conclusion of the mechanism of fertility decline has not yet drawn, we have known that effective family planning programmes will allow more couples to have choices as to whether, when, and how many children they want to have during their lives, leading to sustained fertility decline at national level.

9.4. Recommendations for policies and futures research

This study presents three sets of recommendations. Firstly, while more information about maternal and child health is needed, this is the time to consider the balance of quality and quantity of data we need from DHS. It is pointless to collect a large amount of inaccurate data. It is crucial to maintain a high quality of DHS data, particularly the quality of key indicators, such as fertility rates and child mortality. Date and age is essential data and needed for the calculation of most of health indicators. The DHS has produced highest quality of nationally-representative demographic and health information in less developed countries for over two decades. Nevertheless, some errors cannot be avoided in this type of cross-sectional national household survey. Strengthening the supervision of fieldwork may be needed to ensure the accuracy of surveys. Nevertheless, I would like to stress the importance of balancing the length of the survey questionnaire with the need to ensure data quality. At the same time, vital registration and health information systems should be improved to collect detailed data and take some roles from the DHS, while improvement has been neglected in the past three decades (Mahapatra et al. 2007). A coordination of governments, donors, international organisations and academic institutions, which have power in decision-making over the contents of the questionnaire, is needed.

Secondly, the Loess approach proposed in this thesis is useful for assessment of fertility trends using DHS data. Several organisations have produced fertility estimates and projections for a long term, but the estimation methods are very complex and require tremendous time and expertise, and others are not easy to reproduce. On the other hand, regardless of the limitations, the Loess approach outweighs the complex methods. The Loess approach provides plausible estimation with uncertainty areas. It needs only STATA or R, and does not require tremendous time to produce results. Another great strength is that the Loess approach can examine the trends at sub-national levels, such as urban and rural, and by the levels of women's education. This method is extremely useful for the future fertility estimation research.

Thirdly, more research on family structure and reproductive behaviours among married and cohabiting couples is needed. As suggested by an earlier study (Bongaarts and Bulatao 2000), marriage has been neglected in population research in Africa. There has been a profusion of studies of sexual behaviour among adolescents, but there is limited information for such behaviour among married couples (Cleland, Ali and Shah 2006a). Although premarital and extramarital sex is not uncommon, universal marriage is still the norm in most of the sub-Saharan African countries. Further information on sexual union and family structures, which affect reproductive decision-making and behaviour, will be valuable to deepen our understanding of African fertility. This will help us to identify the people in need of family planning.

Key Findings

(1) Errors in DHS data have affected the fertility trends in previous studies in sub-Saharan Africa.

(2) A Loess approach allowing for the nature and quality of data gives better interpretation of the long-term fertility trends and allows for uncertainty in areas.

(3) The pace of fertility decline has decelerated in five mid-transitional countries, but no country has entirely halted the decline.

(4) The proximate determinants analysis suggests that there are various influences on fertility in sub-Saharan African, apart from, and often counteracting, the effect of contraception.

APPENDECIES

Appendix 1: List of surveys

Country	Year of survey	Phase of DHS	Weighted number of women aged 15-49	Weighted number of births to women aged 15-49	boundary year
Benin	1996	DHS-III	5,491	18,872	Jan-93
	2001	DHS-IV	6,219	19,246	Jan-96
	2006	DHS-V	17,794	56,204	Jan-01
Burkina Faso	1993	DHS-II	6,354	22,205	Jan-87
	1998/99	DHS-III	6,445	22,987	Jan-93
	2003	DHS-IV	12,477	41,270	Jan-98
Cameroon	1991	DHS-II	3,871	12,356	Jan-86
	1998	DHS-III	5,501	16,017	Jan-95
	2004	DHS-IV	10,656	29,287	Jan-99
Ghana	1988	DHS-I	4,488	14,216	Jan83/85
	1993	DHS-II	4,562	13,298	Jan-90
	1998	DHS-III	4,843	12,758	Jan-93
	2003	DHS-IV	5,691	14,412	Jan-98
	2008	DHS-V	4,916	11,431	Jan-03
Kenya	1989	DHS-I	7,150	26,231	Jan-83
	1993	DHS-III	7,540	23,881	Jan-88
	1998	DHS-III	7,881	22,813	Jan93/95
	2003	DHS-IV	8,195	22,548	Jan-98
	2008/09	DHS-V	8,444	22,605	Jan-03
Madagascar	1992	DHS-II	6,260	20,036	Jan-87
	1997	DHS-III	7,060	22,696	Jan-94
	2003/04	DHS-IV	7,949	23,388	Jan-98
	2008/09	DHS-V	17,375	49,613	Jan-03
Malawi	1992	DHS-II	4,849	16,882	Jan-87
	2000	DHS-IV	13,220	41,404	Jan-95
	2004	DHS-IV	11,698	35,451	Jan-99
Mali	1987	DHS-I	3,200	12,681	Mar-82
	1995/96	DHS-III	9,704	38,492	Jan-92
	2001	DHS-IV	12,849	49,285	Jan-96
	2006	DHS-V	14,583	52,529	Jan-01
Namibia	1992	DHS-II	5,421	13,206	Jan-87
	2000	DHS-IV	6,755	14,508	Jan-95
	2006/07	DHS-V	9,804	18,729	Jan-01
Niger	1992	DHS-II	6,503	25,047	Jan-87
	1998	DHS-III	7,577	29,784	Jan-95
	2006	DHS-V	9,223	36,860	Jan-01

Country	Year of survey	Phase of DHS	Weighted number of women aged 15-49	Weighted number of births to women aged 15-49	boundary year
Nigeria	1990	DHS-II	8,781	29,074	Jan-85
	1999	DHS-IV	9,810	23,375	Jan-96
	2003	DHS-IV	7,620	23,578	Jan-98
	2008	DHS-V	33,385	101,977	Jan-03
Rwanda	1992	DHS-II	6,551	20,106	Jan-87
	2000	DHS-IV	10,421	28,965	Jan-95
	2005	DHS-IV	11,321	30,376	Jan-00
(interim)	2007/8	DHS-V	7,313	18,965	Jan-02
Senegal	1986	DHS-I	4,415	14,389	Jan-81
	1992/93	DHS-II	6,310	20,815	Jan-87
	1997	DHS-II	8,593	26,366	Jan-94
	2005	DHS-IV	14,602	38,769	Jan-00
Tanzania	1991/92	DHS-II	9,238	28,687	Jan-86
	1996	DHS-III	8,120	25,063	Jan-91
(interim)	1999	DHS-IV	4,029	11,786	Jan-94
	2004/05	DHS-IV	10,329	30,076	Jan-99
Uganda	1995	DHS-III	7,070	24,086	Jan-91
	2000/01	DHS-IV	7,246	24,922	Jan-95
	2006	DHS-V	8531	30,154	Jan-01
Zambia	1992	DHS-II	7,060	21,920	Jan-87
	1996	DHS-III	8,021	24,358	Jan-91
	2001/02	DHS-IV	7,658	23,211	Jan-96
	2007	DHS-V	7,146	21,670	Jan-02
Zimbabwe	1988	DHS-I	4,201	12,405	Jan-83
	1994	DHS-III	6,128	16,495	Jan-91
	1999	DHS-IV	5,907	13,628	Jan-94
	2005/06	DHS-V	8,907	19,173	Jan-00

Appendix 2: Proximate determinants of fertility by survey by country

	Index of Proportion of women sexually active (C*x*)					Index of duration of postpartum infecundability (C*i*)					Index of sterility (C*f*)				
Benin	1996	2001	2006			1996	2001	2006			1996	2001	2006		
	0.72	0.69	0.71			0.54	0.61	0.62			0.92	0.93	0.93		
Burkina Faso	1992/3	1998/9	2003			1993	1999	2003			1993	1999	2003		
	0.78	0.75	0.72			0.50	0.50	0.53			0.90	0.90	0.91		
Cameroon	1991	1998	2004			1991	1998	2004			1991	1998	2004		
	0.77	0.74	0.68			0.59	0.60	0.63			0.91	0.92	0.89		
Ghana	1988	1993	1998	2003	2008	1988	1993	1998	2003	2008	1988	1993	1998	2003	2008
	0.68	0.70	0.61	0.59	0.56	0.58	0.58	0.63	0.63	0.66	0.91	0.92	0.89	0.92	0.93
Kenya	1989	1993	1998	2003	2008/9	1989	1993	1998	2003	2008/9	1989	1993	1998	2003	2008/9
	0.68	0.65	0.64	0.62	0.60	0.68	0.64	0.69	0.67	0.69	0.92	0.94	0.94	0.96	0.96
Madagascar	1992	1997	2003	2008		1992	1997	2003	2008		1992	1997	2003	2008	
	0.73	0.74	0.74	0.74		0.63	0.66	0.68	0.69		0.90	0.89	0.91	0.93	
Malawi	1992	2000	2004			1992	2000	2004			1992	2000	2004		
	-	0.74	0.74			0.67	0.61	0.64			-	0.93	0.94		
Mali	1987	1995	2001	2006		1987	1995	2001	2006		1987	1995	2001	2006	
	0.82	0.80	0.78	0.76		0.63	0.61	0.65	0.67		0.86	0.89	0.91	0.90	
Namibia	1992	2000	2006			1992	2000	2006			1992	2000	2006		
	0.63	0.56	0.53			0.64	0.55	0.63			0.93	0.96	0.98		
Niger	1992	1998	2006			1992	1998	2006			1992	1998	2006		
	0.78	0.78	0.76			0.59	0.58	0.59			0.86	0.90	0.92		
Nigeria	1990	1999	2003	2008		1990	1999	2003	2008		1990	1999	2003	2008	
	0.79	0.54	0.70	0.69		0.54	0.59	0.60	0.63		0.85	0.86	0.90	0.92	

	Index of Proportion of women sexually active (C*x*)					Index of duration of postpartum infecundability (C*i*)					Index of sterility (C*f*)				
Rwanda	1992	2000	2005	2007		1992	2000	2005	2007		1992	2000	2005	2007	
	0.59	0.52	0.51			0.57	0.60	0.60			0.95	0.96	0.97		
Senegal	1986	1993	1997	2005		1986	1993	1997	2005		1986	1993	1997	2005	
	-	0.64	0.61	0.56		0.56	0.58	0.60	0.65		-	0.89	0.92	0.91	
Tanzania	1992	1996	1999	2004		1992	1996	1999	2004		1992	1996	1999	2004	
	0.74	0.74	0.75	0.72		0.59	0.60	0.61	0.65		0.89	0.89	0.90	0.93	
Uganda	1995	2000	2006			1995	2000	2006			1995	2000	2006		
	0.77	0.72	0.67			0.64	0.66	0.67			0.92	0.94	0.96		
Zambia	1992	1996	2001	2007		1992	1996	2001	2007		1992	1996	2001	2007	
	0.72	0.70	0.68	0.69		0.63	0.62	0.61	0.65		0.91	0.92	0.95	0.96	
Zimbabwe	1988	1994	1999	2005		1988	1994	1999	2005		1988	1994	1999	2005	
	0.67	0.62	0.61	0.57		0.63	0.62	0.59	0.59		0.96	0.96	0.97	0.98	

Appendix 2: Proximate determinants of fertility by survey by country (continued)

	Index of contraception (Cu)					Total fertility					Total fertility reported in Loess				
Benin	1996	2001	2006			1996	2001	2006			1996	2001	2006		
	0.79	0.78	0.80			5.69	6.06	6.50			5.6	5.43	5.62		
Burkina Faso	1993	1999	2003			1993	1999	2003			1993	1999	2003		
	0.89	0.85	0.80			6.21	5.70	5.57			6.35	5.70	5.13		
Cameroon	1991	1998	2004			1991	1998	2004			1991	1998	2004		
	0.82	0.75	0.74			6.86	6.16	5.68			5.52	5.23	5.04		
Ghana	1988	1993	1998	2003	2008	1988	1993	1998	2003	2008	1988	1993	1998	2003	2008
	0.86	0.81	0.79	0.71	0.73	6.17	6.06	5.39	4.84	5.00	5.11	4.63	4.4	4.26	4.18
Kenya	1989	1993	1998	2003	2008/9	1989	1993	1998	2003	2008/9	1989	1993	1998	2003	2008/9
	0.76	0.67	0.62	0.62	0.55	6.44	5.28	5.09	4.94	4.39	5.57	4.99	4.95	4.94	4.80
Madagascar	1992	1997	2003	2008		1992	1997	2003	2008		1992	1997	2003	2008	
	0.85	0.81	0.72	0.60		7.00	7.07	6.56	5.70		5.67	5.36	4.89	4.41	
Malawi	1992	2000	2004			1992	2000	2004			1992	2000	2004		
	-	0.69	0.66			-	5.84	5.90			5.98	5.76	5.91		
Mali	1987	1995	2001	2006		1987	1995	2001	2006		1987	1995	2001	2006	
	0.97	0.92	0.92	0.92		8.57	8.09	8.41	8.42		6.73	6.56	6.23	5.95	
Namibia	1992	2000	2006			1992	2000	2006			1992	2000	2006		
	0.68	0.49	0.37			5.0973	2.87	2.46			4.52	3.96	3.55		

	Index of contraception (Cu)					Total fertility					Total fertility reported in Loess				
Niger	1992	1998	2006			1992	1998	2006			1992	1998	2006		
	0.97	0.94	0.94			7.57	7.69	7.72			7.00	6.96	6.10		
Nigeria	1990	1999	2003	2008		1990	1999	2003	2008		1990	1999	2003	2008	
	0.91	0.84	0.88	0.85		6.54	4.63	6.66	6.78		5.82	5.91	5.94	5.88	
Rwanda	1992	2000	2005	2007		1992	2000	2005	2007		1992	2000	2005	2007	
	0.83	0.92	0.87			5.32	5.42	5.13			5.79	5.4	5.2	5.08	
Senegal	1986	1993	1997	2005		1986	1993	1997	2005		1986	1993	1997	2005	
	0.00	0.92	0.87	0.87		-	6.08	5.89	5.81		6.3	5.72	5.54	5.04	
Tanzania	1992	1996	1999	2004		1992	1996	1999	2004		1992	1996	1999	2004	
	0.89	0.79	0.74	0.71		6.88	6.24	6.10	6.16		5.43	5.20	5.14	5.13	
Uganda	1995	2000	2006			1995	2000	2006			1995	2000	2006		
	0.88	0.81	0.74			7.95	7.20	6.40			6.50	6.36	6.01		
Zambia	1992	1996	2001	2007		1992	1996	2001	2007		1992	1996	2001	2007	
	0.87	0.77	0.68	0.63		7.22	6.13	5.33	5.47		5.81	5.57	5.35	5.41	
Zimbabwe	1988	1994	1999	2005		1988	1994	1999	2005		1988	1994	1999	2005	
	0.57	0.51	0.47	0.41		4.62	3.73	3.31	2.72		4.87	4.2	4.01	3.76	

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