Paper prepared for the UAPS 2015 conference, Johannesburg

Session 25: Case Studies of Exceptionally Low and High Fertility Rates

Record high fertility in sub-Saharan Africa

in a comparative perspective

Michel Garenne (1,2,3)

1) Institut de Recherche pour le Développement (IRD), UMI Résiliences, Bondy, France
2) MRC/Wits Rural Public Health and Health Transitions Research Unit, School of Public Health, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg
3) Institut Pasteur, Epidémiologie des Maladies Emergentes, Paris, France

Updated: October 28, 2015

Contact: Michel.Garenne@pasteur.fr / mgarenne@hotmail.com

Word count: Total = 5300

Paper: 4300; Abstract: 122

Keywords: 10; References: 33

Tables: 5; Figures: 2

Abstract

The study documents two cases of extremely high period fertility in sub-Saharan Africa: Kenya (1965-69) and Niger (1982-86). In both cases, total fertility in rural areas reached 9 children per woman, as high as among the Hutterites of North-America (1921-1940). However, the complete family size never exceeded 8.0 children per woman in Kenya (cohorts 1939-1946) and 8.2 children per woman in Niger (cohorts 1960-1967). Compared with the Hutterites, in both African countries the age pattern of fertility was earlier and with a lower mode, age at marriage was earlier, birth intervals were longer because of long breastfeeding, and secondary sterility was higher after the 5th birth. Other proximate determinants of fertility seemed similar in the three populations. Implications for modeling are discussed.

Key words: Natural fertility; Maximum fertility; Proximate determinants; Nuptiality; Infertility; Secondary sterility; Breastfeeding; Kenya; Niger; Hutterites; sub-Saharan Africa.

Introduction

The concept of natural fertility was introduced in 1961 by Louis Henry to characterize the situation of populations who were not limiting their family size, in contrast to others who were using various means of birth control in order to limit the number of children ever-born to their desired number. [Henry 1961] Natural fertility covers a wide variety of situations, with average levels per woman ranging from 4 children or less to 8 children or more. Variations in natural fertility are due to a wide array of factors: biological factors, that is the various elements of reproductive health (primary and secondary sterility, nutrition, diseases, etc.), as well as behavioral factors, such as marriage (age at marriage, proportion ever-marrying), sexual taboos (premarital taboo, post-partum abstinence), coital frequency, forced separation of spouses, etc. A wide body of literature covers those issues. [Diggory et al. 1988; Garenne & Frisch 1994; Leridon 1977; Leridon & Menken 1979; van de Walle 1988]

The common framework for studying variations in fertility in general, and natural fertility in particular, is the so-called “proximate determinants” framework. This framework classifies the main factors influencing human fertility, including contraception and induced abortion. This framework was introduced in 1956 by Kingsley Davis and Judith Blake, and has been further refined by numerous authors, in particular John Bongaarts. [Davis & Blake 1956; Bongaarts 1976, 1978, 1980; Bongaarts & Potter 1983] Among biological factors, two factors may strongly affect natural fertility: nutrition and diseases. The effect of nutrition on menarche and fecundity has been extensively studied. [Chowdhury1978; Frisch 1975, 1978, 1984, 1990; Frisch & Revelle 1971; Frisch et al.1980; Menken et al. 1981; Wyshak & Frisch 1982] The effect of sexually transmitted diseases, of tuberculosis, and of some tropical parasitic diseases (e.g. malaria, trypanosomiasis, shistosomiasis, etc.) is also well documented, with major implications for Tropical Africa. [McFalls & McFalls 1984; Retel-Laurentin 1978] Since these earlier studies, HIV/AIDS emerged, with also an impact on infertility. Among behavioral factors, besides nuptiality, two factors are of particular relevance for sub-Saharan Africa: breastfeeding and post-partum abstinence. [Page & Lesthaeghe 1981]

Natural fertility has been well documented in historical populations of Europe (France, Switzerland, England, Germany, Sweden, etc.) and overseas European populations, in particular in North America. The world record of outstandingly high fertility is owned by the

Hutterites, an Anabaptist sect living in Northern Dakota. This group originated from Moravia, who migrated to Russia and later to North America in the second part of the 19th century. [Eaton & Mayer 1953] This is a small size rural population, well nourished, with almost universal marriage, short birth intervals, and record high fertility (9 children per woman). This population is used in demography as a reference set for modeling natural fertility and for assessing the extent of controlled fertility. [Coale and Trussell 1974] Another population with extremely high fertility is the Quebec population of the 19th century, with almost as high total fertility. [Charbonneau 1979; Eijkemans et al. 2014]

If European populations are well studied, much less research has been done on African populations. Currently, African countries have the highest fertility in the world, declining slowly over the past 30 years. This period of fertility decline occurred after a period of rising fertility, associated with improving health and nutritional status, going back probably to the early days of colonization at the beginning of the 20th century. Most important in sub-Saharan Africa was the quasi-disappearance of large pockets of primary sterility following diseases control programs (preventive and curative) and the introduction of modern medicines (antibiotics, antimalarial drugs in particular). A literature search on natural fertility in Africa leads only a few titles. [Cantrelle & Leridon 1971; Khalifa 1986; Regassa 2006; Thibon 1988] Furthermore, the period of peak fertility has been little studied, not counting the fact that it varies from country to country and between urban and rural areas. [see Garenne 2008 for details]

The aim of this paper is to document cases of record high fertility in sub-Saharan Africa, to compare them with the Hutterite reference, and to analyze as much as possible their patterns, and the proximate determinants associated with these very high values.

Data and Methods

Data were derived from Demographic and Health Surveys (DHS), the main source of information on fertility trends and proximate determinants in Africa. In some cases, data were taken from published sources (DHS final reports) or from the Stat-Compiler module of the DHS program web site, and in other cases tabulations were produced from the individual datasets. Period fertility was estimated by computing age-specific fertility rates by 5-year age

group and yearly periods. In some cases, fertility rates were cumulated to age 40 for studying trends. Cohort fertility was computed directly from children ever-born, sometimes also cumulated to age 40 for studying trends. Details of the procedures were presented elsewhere. [Garenne 2008]

A number of proximate determinants were considered. In most instances, estimates were taken from DHS reports. In some cases, indicators were recomputed. Premarital fertility (the proportion of births that occurred before first marriage) was obtained by straightforward tabulation, as was the mean age at last birth. Median age at puberty and at menopause were obtained by linear-logistic regression on the corresponding proportion of women age 15-20 in the first case, and age 40-49 in the last case. Comparative data pertaining to the Hutterites were taken from the original publication. [Eaton & Meyer, 1953] This document contains however little information on proximate determinants.

Results

Overview

Fertility levels vary considerably in rural areas of sub-Saharan Africa. In published statistics from DHS surveys, the TFR ranges from 3.9 (South Africa, 1998) to 8.1 (Niger 2012), with a mean of 6.2 children per woman. Several countries appear as having very high fertility, defined by TFR≥ 7.0 in rural areas: in East-Africa: Uganda (7.6), Zambia (7.5), Kenya (7.1), Burundi (7.0); in Sahelian West-Africa: Niger (8.1), Mali (7.4), Senegal (7.1), Burkina Faso (7.0); in Coastal West-Africa: Liberia (7.5), Togo (7.3), Ghana (7.0), in Central Africa: Angola (7.8), Congo (7.0). These data are based on fertility rates in the 3-year period before the surveys, conducted at various time between 1985 and 2014, and therefore cover selected periods, differently for each country, depending on the time at which the survey was taken. [source: DHS web site, StatCompiler, accessed September 30, 2014]

Peak period fertility

A more precise estimation of peak fertility levels is provided by a reconstruction of cumulated fertility by age 40. In brief, age-specific fertility rates are computed for the 10 years before the survey from age 12 to 39, and cumulated to age 40, which gives a deeper insight into past fertility trends. [Garenne 2008] According to this reconstruction, peak fertility (TFR(40) $\geq$ 7.0) occurred in about the same list of countries, but often at earlier periods than those covered by the 3 years before DHS surveys. In East-Africa, four countries stand out: Kenya, Zambia, Uganda, and Rwanda. In Kenya, peak fertility in rural areas occurred in 1965-69, in Zambia in 1974-78, in Rwanda in 1980-84, in Uganda in 1970-74. In Sahelian West-Africa, four countries stand out: Niger (1975-79), Mali (1987-1991), Burkina Faso (1977-1981), and Senegal (1979-83). In Coastal West-Africa, three countries stand out: Togo (1976-80), Cote d'Ivoire (1978-82), and Benin (1986-90). In most of those countries fertility underwent a serious decline after the period of peak fertility. However, rural fertility stayed at high levels in Niger, Uganda, and Zambia. (Table 1)

Table 1: Situations of peak period fertility in African DHS surveys (rural areas)

Region	Country	Period of peak fertility			Cumulated fertility by age 40
		Begin		End	
East Africa					
	Kenya	1965	-	1969	7.93
	Zambia	1974	-	1978	7.30
	Rwanda	1980	-	1984	7.23
	Uganda	1970	-	1974	7.13
West Africa, Sahel			-		
	Niger	1975	-	1979	8.28
	Mali	1987	-	1991	7.92
	Burkina Faso	1977	-	1981	7.56
	Senegal	1979	-	1983	7.27
West Africa, Guinea gulf					
	Togo	1976	-	1980	7.32

Cote d'Ivoire	1978	-	1982	7.26
Benin	1986	-	1990	7.19

NB: Countries with cumulated period fertility by age 40 > 7.0 over a 5-year period. Source: reconstruction from DHS surveys.

Two countries stand out with exceptionally high fertility: Kenya and Niger, which were selected for the in-depth analysis. In Kenya, rural fertility, measured by TFR(40), increased in the 1950's, peaked in 1965-69, stayed close to the maximum level until 1982, before declining to reach 4.3 in 2010. So, the situation of rural Kenya in the late 1970's (at time of the WFS survey) was close to that during the peak of fertility. In Niger, rural fertility increased markedly in the 1950's and 1960's, peaked in 1975-79, declined somewhat until 1987, then increased again to peak again around 2006, before resuming its decline. So, in this case also, the situation in the 1990's appears as similar to that that occurred at time of the peak fertility.

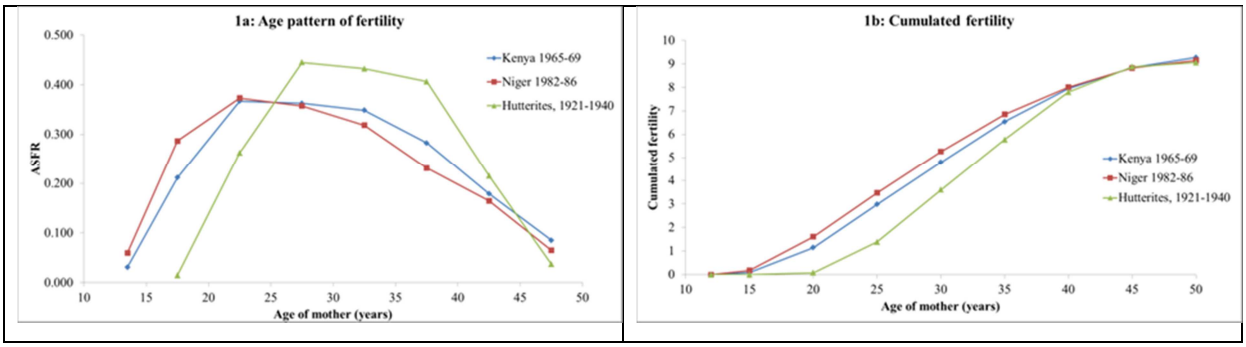
Age patterns of peak period fertility

For the three situations of outstanding fertility (Kenya, Niger and the Hutterites), the levels of cumulated fertility at age 50 appeared as equivalent (TFR= 9.28, 9.16, and 9.07 respectively). Note that due to limited sample size, these differences were not statistically significant: the 95% confidence intervals were: 8.98-9.57 in Kenya, 8.88-9.44 in Niger, and 8.60-9.53 for the Hutterites.

The age patterns of fertility during the period of peak fertility differed between the three populations. Compared with the Hutterites, the two African populations had an earlier fertility (mean age at birth: 30.1 years in Kenya, 28.8 years in Niger vs 32.3 years for the Hutterites), a lower and earlier peak (367 per 1000 at age 20-24 years in Kenya, 373 per 1000 at age 20-24 years in Niger vs 445 per 1000 at age 25-59 years for the Hutterites), and an earlier decline of fertility rates with age. As will be seen with more details later, these differences were due to earlier marriage in Africa compensated by higher secondary infertility. Values of age-specific fertility rates in the last age group (45-49) were questionable: they appeared higher in the two African populations. This might be real, but is more likely to be due to age over-statement in Kenya and Niger, since the age trend should reach 0 around age 50. In terms of cumulated fertility, the three populations reached the same

level, with an earlier start but a smaller slope for Niger and the opposite for the Hutterites, Kenya being close to Niger. (Figure 1, Table A1)

Figure 1: Age pattern of fertility and cumulated fertility, 3 situations of record-high fertility



Peak cohort fertility

Since fertility underwent major changes in Africa, it was important to compare period fertility with cohort fertility, that is the complete family size (CFS). Here again, in order to compare cohorts, the number of children born by age 40 was computed, labeled CEB(40). In DHS datasets, peak cohort fertility (CEB(40)> 7.0) occurred basically in the same countries, with the addition of Chad and Cote d'Ivoire, for cohorts of women born in the 1940's and 1950's, somewhat later in Niger and Chad. Here again Kenya and Niger appeared as outstanding, one more justification for their selection for the in-depth case study, although Zambia and Mali could have qualified as well. A cumulated number of children of 7.5 at age 40 corresponds to a CFS of 8.3 at age 50, which is below the world record of the Hutterites (CFS = 9.0 for cohorts born in 1865-1904). In fact no African country reached the level of cohort fertility achieved by the Hutterites with a statistically significant test. (Table 2)

Table 2: Situations of peak cohort fertility in African DHS surveys (rural areas)

Region	Country	Cohort of peak fertility		Cumulated fertility by age 40
		Begin	End	
East Africa				
	Zambia	1944	1948	7.56
	Kenya	1944	1948	7.45
	Rwanda	1946	1950	7.39
	Uganda	1940	1944	7.38
West Africa, Sahel				
	Niger	1965	1969	7.75
	Mali	1953	1957	7.46
	Chad	1960	1964	7.19
	Senegal	1954	1958	7.13
	Burkina Faso	1950	1954	7.09
West Africa, Guinea gulf				
	Togo	1942	1946	7.12
	Benin	1952	1956	7.01

NB: Countries with cumulated cohort fertility by age 40 > 7.0 over 5-years of cohorts.
Source: reconstruction from DHS surveys.

Three case studies of record fertility

The remainder of this paper deals with Kenya and Niger, in comparison with the Hutterites. Periods of peak fertility were 1965-69 for Kenya, 1982-86 for Niger, and 1921-41 for the Hutterites. The period TFR was the same in the three cases, with similar number of births and confidence intervals. Cohorts of peak fertility were 1939-46 for Kenya, 1960-67 for Niger and 1865-1904 for the Hutterites. The cohorts do not precisely match the periods of peak fertility, but are close for both African countries. For the Hutterites, many of the women in the selected cohorts had birth before 1921, which matters little because fertility appeared very steady in the case: TFR and CFS do match, which was not the case in Africa, where

period TFR underwent ups and downs and exceeded corresponding CFS. Cohort fertility was significantly higher among the Hutterites compared with both African countries. (P< 0.001 in both cases). (Table 3)

Table 3: Selected cases studies of record fertility

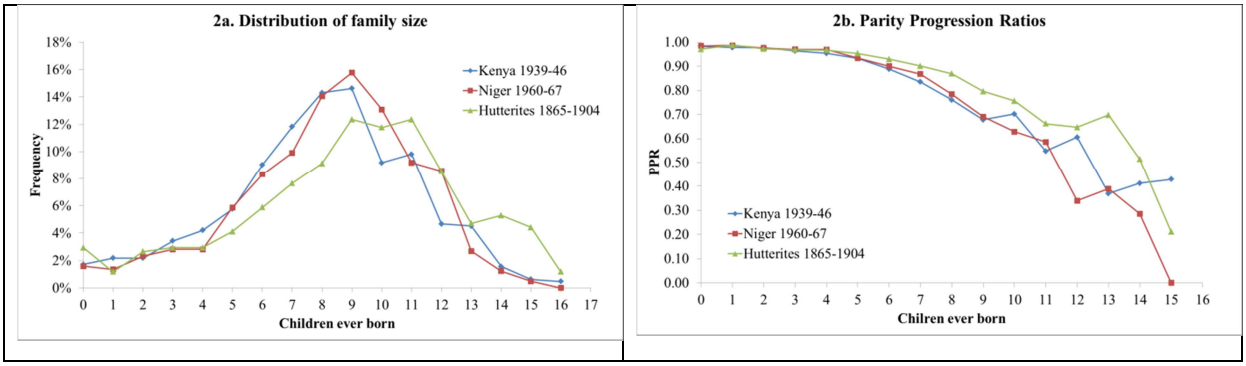
	Kenya	Niger	Hutterites
Period fertility			
Period	1965-1969	1982-1986	1921-1940
Nb of births	6317	5913	4869
Total fertility rate	9.28	9.16	9.07
Confidence interval	±0.30	±0.28	±0.27
Cohort fertility			
Cohorts	1939-46	1960-67	1865-1904
Nb of women	643	818	340
Complete family size	7.98	8.22	8.97
Confidence interval	±0.24	±0.20	±0.39

NB: Width of confidence interval is calculated as 1.96 times the standard error.

Parity progression ratios at peak cohort fertility

The distribution of children ever-born for cohorts with peak fertility allowed one to compute parity progression ratios. In all three populations the maximum number of births per woman was 16 children ever-born. Compared with the Hutterites, the two African populations had a lower modal value (9 children), and more women with 5-9 children (55.5% in Kenya, 53.9% in Niger, vs 29.7% among the Hutterites), and less women with 10 children or more (30.8% in Kenya, 35.2% in Niger, vs 48.2% among the Hutterites). This indicates higher frequency of secondary sterility among both African populations. (Figure 2a)

Figure 2: Distribution of births and parity progression ratios.



Another way at looking at infertility is to compare parity progression ratios. The two African populations appeared again similar, with only minor differences, not statistically significant. Primary sterility was the same in the three populations: 1.7% in Kenya, 1.6% in Niger, vs 2.9% among the Hutterites, none of the difference being significant. Secondary sterility from 1 to 5 children (the probability of having less than five children if already had one) was also the same, with no significant difference (12.2% in Kenya, 9.4% in Niger, vs 10.0% among the Hutterites). However, secondary sterility from 5 to 10 (the probability having less than ten children if already had five) was significantly higher in the two African populations: 64.3% in Kenya, 60.5% in Niger, vs 44.8% among the Hutterites ($P< 10^{-8}$ and $P< 10^{-6}$ respectively). Parity progression ratios were similar in the three populations up to birth order 5, but significantly lower thereafter in both African populations compared with the Hutterites. This shows that acquisition of secondary sterility occurred earlier in Africa, the mean age at the 5^{th} birth being about 27 years in Kenya and Niger.

Proximate determinants

This section compares proximate determinants in the three countries. Of course, precise data at time of the peak fertility were not always available, and proxies were used instead. All data are shown in Table 4.

Nuptiality

Terminal celibacy, defined as being never-married at age 40-49 was rare in all three cases: 1.6% in Kenya (1988 and 1993 DHS surveys), 0.1% in Niger (1992 and 1998 DHS surveys), and 1.7% among the Hutterites (1926-1940). Median age at first marriage was

different in the three situations, spaced by some 3 years each: very early in Niger (14.9 years), medium for Africa in Kenya (18.2 years), and typical of European populations of that time among the Hutterites (21.2 years). Note that a 3-year difference in age at marriage may mean one additional birth, and explains the gap of 2 children at age 20 between Niger and the Hutterites. (see Figure 1b)

Premarital fertility

The gap in age at first marriage between Niger and Kenya translated into a minor difference in children ever-born by age 20 because premarital fertility (defined as birth before first marriage) was prevalent in Kenya, whereas it hardly existed in Niger, where first marriage follows shortly puberty, and first intercourse occurs at time of first marriage. In Kenya, some 20.2% of births to mothers aged less than 20 in the 1960's and 1970's were premarital, whereas the corresponding proportion for Niger was 2.8% only. [Garenne & Zwang 2006] Universal and early marriage was possible in Niger because of the high prevalence of polygyny (36.4%), higher than in Kenya.

Contraception

Contraceptive use was probably non-existent among Hutterites women living before 1940, very rare in rural Niger in the 1980's and rare in Kenya in the 1960's. Contraceptive prevalence available in the four DHS surveys of Niger and the five DHS surveys in Kenya predicted by linear-logistic regression a contraceptive prevalence of 0.4% in Niger and 7.8% in Kenya (possibly overestimated by the model), which is unlikely to have had any major impact. Of course, there is no data on induced abortion in any of the three populations. Frequency of intercourse seemed average in Kenya (53.8% of women having intercourse in the past 4 weeks), somewhat lower than in Niger (67.0%), a small difference probably without much impact on fertility.

Table 4: Selected proximate determinants of fertility, selected case studies

	Proximate determinant	Kenya	Niger	Hutterites
Nuptiality	Terminal celibacy	4.4%	0.1%	1.7%
	Median age at marriage	18.4	14.9	21.2
	Polygyny	31.9%	36.4%	None
	Premarital births	20.2%	2.8%	Low
Behavior	Contraceptive use	7.8%	0.4%	None
	Frequency of intercourse	53.8%	67.0%	?
Susceptibility	Primary infertility	1.7%	1.6%	2.9%
	Secondary infertility 1-5	12.2%	9.4%	10.0%
	Secondary infertility 5-10	64.3%	60.5%	44.8%
	Puberty (years)	15.0	15.5	?
	Menopause (years)	49.9	50.1	?
	First birth (years)	18.9	17.8	
	Last birth (years)	39.8	39.3	~40
Birth intervals	Mean length (months)	31.4	30.3	?
	Breastfeeding	20.9	21.0	Short
	Post-partum amenorrhea	11.6	16.4	?
	Post-partum abstinence	3.2	2.2	Short
	Infant mortality (/1000)	62	208	39
Anthropometry	Height (cm)	159	160	?
	BMI (kg/m²)	21.7	20.3	?

Source: DHS reports, and calculations from DHS datasets, rural areas only. Average from the two earlier DHS surveys (e.g. Kenya 1988, 1993; Niger 1992, 1998). Age at puberty and menopause obtained by linear-logistic regression. Mean age at last birth calculated for cohorts 1927-1939 in Kenya, and 1960-1967 in Niger.

Infertility

As mentioned above, primary infertility was low and similar in the three populations (range 1.6 to 2.9%), as secondary infertility from birth order 1 to 5 (range 9.4% to 12.2%). Secondary infertility for higher birth orders (> 5) differed significantly, which higher values

for both African populations (see Figure 2b). Median age at puberty seemed stable in Kenya and Niger around 15 years, which was probably close to that of North Americans at the turn of the 20th century. [Wyshak & Frisch 1982] In the case of the Hutterites, age at puberty mattered little since marriage occurred much later and there was virtually no premarital fertility. Age at menopause seemed also stable in Kenya and Niger, around 50 years, again similar to that of North Americans in the early years of the 20th century. [Garenne & Frisch 1994] Age at first birth followed the age at marriage in both African populations. In Kenya, age at last birth was stable for cohorts before 1940 (39.8 years), then tended to decline reflecting the onset of family planning. In Niger, age at last birth was increasing, probably because declining secondary infertility, and reached 39.3 for cohorts born in the 1960's. So, at time of peak fertility both African populations seemed comparable to North American populations in terms of the exposure period from puberty to menopause.

Birth intervals

Birth intervals were long in both African populations: 31.4 months in Kenya and 30.3 months in Niger, typical of most African populations where duration of breastfeeding is extended (20.9 months in Kenya, 21.0 months in Niger). In both Kenya and Niger post-partum abstinence was short (3.2 months and 2.2 months respectively). So, durations of post-partum amenorrhea and of the non-susceptible period were long, mainly because of long breastfeeding. No data on birth intervals are available for the Hutterites, but they must have been much shorter in order to reach age-specific fertility rates as high as 450 per 1000. A rough estimate based on age-specific fertility rates at age 20-34 gives birth intervals shorter by 6 months than those in African countries.

Health and nutrition

Health was obviously different in African countries. Kenyan and Nigerian women were relatively tall (160 cm), as most adults belonging to Sahelian groups. However, their BMI was relatively low: 21.7 and 20.3 kg/m² respectively, probably lower than that of North American women living at the beginning of the 20th century. This might account, at least in part, for lower fecundity, longer post-partum amenorrhea associated with long breastfeeding, and possibly more frequent secondary sterility. In terms of diseases, North American women

at that time were probably free of any serious disease causing infertility. The periods during which both African populations were studied were free of HIV/AIDS, a serious cause of infertility at the end of the 20th century. Malaria, a disease which may cause spontaneous abortion, is highly prevalent and severe in Niger, less so in Kenya, Obviously, this had no major demographic impact, since Niger had record high fertility, as it is the case of other Sahelian countries such as Mali, Burkina-Faso and Senegal, also affected by severe malaria.

Discussion

This study presented two cases of record high period fertility, in Kenya and Niger, where rural populations had a total fertility (TFR) equivalent to that of the Hutterites living in North America in the first part of the 20th century, considered as the maximum of human fertility. However, the strategies followed by these populations to reach 9 children per women were somewhat different. The African populations achieved high levels of fertility by very early marriage, compensated somewhat by premarital fertility in Kenya, despite long birth intervals associated with long breastfeeding, and despite higher secondary infertility associated with lower health and nutritional status. The Hutterite population chose later marriage and shorter birth intervals, made possible by better health and nutritional status.

In terms of cohort fertility, the two African populations did not reach exactly the level achieved by the Hutterites (also 9.0 children per woman at age 50). This indicates that the record high period fertility in Africa was transient, and in part due to a short term tempo effect. Earlier and later periods had lower fertility, and the periods during which fertility was at its maximum were relatively short, compared with the Hutterites where it lasted probably at least half a century. According to available data, no African population seems to have ever exceeded 8.5 children ever-born per woman for an extended period of time.

This study was based on data pertaining to the 1960-2010 period, that covered by DHS surveys. However, fertility is still increasing in some cases in Africa, or might reach new records in the future. This is in particular the case of Congo-Kinshasa (RDC), where rural fertility is still increasing, and to a lesser extent of Zambia and Uganda where rural fertility stayed at very high levels. Will we see new records in the future remains an open question.

This study focused on rural areas, where fertility was consistently higher than in urban areas in African populations, and where contraceptive use was much less prevalent and occurred later in time. The study may therefore have missed some interesting cases of high fertility in urban areas before 1960 (before family planning programs), where health and nutritional status was probably better than in rural areas, and where occasionally one might find also record high fertility.

These findings have some implications for modeling the fertility schedule. The model of natural fertility derived from the Hutterite experience starts at age 18, whereas in Africa fertility starts already at age 12 (most DHS surveys and most censuses include births down to age 12 years). The age band between 12 and 18 does not exist among the Hutterites, so natural fertility has to be derived independently. One way of doing it is to draw a line for 0 at age 12 to the value of marital fertility at age 18 found among the Hutterites. This strategy could be probably further refined by analyzing in-depth marital fertility in this age group in other populations, especially those with outstanding fertility.

The focus of this study was on empirical evidence of general fertility, whereas many historical studies on natural fertility deal with the theoretical model of marital fertility (assuming that all women marry at exact age 18). This was a deliberate choice for shedding light on the functioning of the fertility regimen in Africa, including age at marriage. In any case, the comparison of marital fertility between African and European populations raises a serious issue: that of age at marriage, legal or traditional. How to compare two populations if one allows marriage at age 12 and the other at age 18? If age 18 is selected, why ignoring what is happening before that age?

The two countries selected, Kenya and Niger, were on the top of the list of high fertility in Africa. However, some other countries could have qualified as well, with almost as high levels: Uganda, Zambia Rwanda and Burundi in Eastern Africa; Mali, Burkina Faso and Senegal in West Africa; in some of the Coastal West African countries (Benin, Togo in particular). Some other countries also present interesting features: Madagascar for instance had the largest recorded parity in DHS surveys (21 children ever-born), and Ethiopia very high fertility associated with early marriage despite little polygamy. Last, fertility varies also by region and by ethnic group, and could also exceed in certain cases the records presented in this study. These other cases deserve further attention and further research.

References

Bongaarts J. (1976). Intermediate fertility variables and marital fertility rates. *Population Studies (Cambridge)*; 30(2):227-241.

Bongaarts J. (1978). A framework for analyzing the proximate determinants of fertility. *Population and Development Review*; 4(1): 105-132.

Bongaarts J. (1980). Does malnutrition affect fecundity? A summary of evidence. *Science*; 208(4444): 564-569.

Bongaarts J, Potter RG. (1983). *Fertility, biology and behavior: an analysis of the proximate determinants*. New York, Academic Press.

Cantrelle P, Leridon H. (1971). Breast feeding, mortality in childhood and fertility in a rural zone of Senegal. *Population Studies*; 25(3):505-533.

Charbonneau H. (1979). Les régimes de fécondité naturelle en Amérique du Nord: bilan et analyse des observations. In: Leridon H, Menken J, eds. Natural fertility: patterns and determinants of natural fertility; proceedings of a seminar on natural fertility, Paris, March 1977. Liege, Ordina Editions, 1979. 441-91.

Chowdhury AKMA. (1978). The effect of maternal nutrition on fertility in rural Bangladesh. In Mosley W. (ed.) *Nutrition and human reproduction*. New York, Plenum Press: 401-410.

Coale AJ, Trussell TJ. (1974). Model fertility schedules: variations in the age structure of childbearing in human populations. *Population Index*, 40(2):185-257.

Davis K, Blake J. (1956). Social structure and fertility: an analytic framework. *Economic Development and Cultural Change*; 4(3):211-235.

Diggory P, Potts M, Teper S. (1988). *Natural human fertility: social and biological determinants*. Proceedings of the twenty-third annual symposium of the Eugenics Society. London, Macmillan Press.

Eaton JW, Mayer AJ. (1953). The social biology of very high fertility among the Hutterites: the demography of a unique population. *Human Biology*; 25(3):206-264.

Eijkemans MJC, van Poppel F, Habbema DF, Smith KR, LeridonH, te Velde ER. (2014). Too old to have children? Lessons from natural fertility populations. *Human Reproduction*; 29(6): 1304-1312.

Frisch RE, Revelle R. (1971). Height and weight at menarche and hypothesis of menarche. *Archives of Diseases in Childhood*; 46(249):695-701.

Frisch RE. (1975). Demographic implications of the biological determinants of female fecundity. *Social Biology*; 22(1): 17-22.

Frisch RE. (1978). Population, food intake and fertility. There is historical evidence for a direct effect of nutrition on reproductive ability. *Science*; 199(4324): 22-30.

Frisch RE, Wyshak G, Vincent L. (1980). Delayed menarche and amenorrhea in ballet dancers. *New England Journal of Medicine*; 303(1):17-19.

Frisch RE. (1984). Body fat, puberty and fertility. *Biological Reviews* (Cambridge Philosophical Society); 59(2):161-188.

Frisch RE editor. (1990). *Adipose tissue and reproduction.* Basel: Karger, Progress in Reproductive Biology and Medicine, Vol 14.

Garenne M, Frisch R. (1994). Natural Fertility. In : *Infertility and Reproductive Medicine Clinics of North America*; 5 (2): 259-282.

Garenne M, Zwang J. (2006). *Premarital fertility and ethnicity in Africa*. DHS Comparative Reports No. 13. Calverton, Maryland, USA: Macro International Inc. 87 p.

Garenne M. (2008). *Fertility changes in sub-Saharan Africa.* DHS Comparative Report, No 18. Calverton, Maryland, USA: Macro International Inc. 128 p.

Henry L. (1961). Some data on natural fertility. *Eugenics Quarterly*; 8: 81-91.

Khalifa MA. (1986). Determinants of natural fertility in Sudan. *Journal of Biosocial Science*; 18(3): 325-36.

Leridon H. (1977). *Human fertility: the basic components*. Chicago: University of Chicago Press.

Leridon H, Menken J. (eds). (1979). *Natural Fertility*. Liege, Belgium, Ordina editions.

McFalls JA, McFalls MH. (1984). *Disease and fertility*. Orlando, Florida, Academic Press.

Menken J, Trussell J, Watkins S. (1981). The nutrition fertility link: an evaluation of the evidence. *Journal of Interdisctiplinary History*; 11(3): 425-441.

Page HJ, Lesthaeghe R. (1981). *Child spacing in tropical Africa. Traditions and change*. London: Academic Press.

Regassa N. (2006). Levels and patterns of natural marital fertility among low contraceptive communities of southern Ethiopia. *Demography India*; 35(2):247-261.

Retel-Laurentin A. (1978). Evaluation du rôle de certaines maladies dans l'infécondité: un example African. [Appraising the role of certain diseases in sterility]. *Population*; 33(1):101-119.

Thibon C. (1988). Fécondité naturelle et fécondité contrôlée: un aperçu de l'évolution de la fécondité au Burundi et dans la région des Grands Lacs, de la fin du XIXe siècle à nos jours. *Annales de Démographie Historique*; 1988/1(No 95): 79-92.

Van de Walle E. (1988). De la nature à la fécondité naturelle. *Annales de Démographie Historique*, 1988/1(No 95): 13-19.

Wyshak G, Frisch RE. (1982). Evidence for a secular trend in age of menarche. *New England Journal of Medicine*; 306(17):1033-1035.

Annex tables

Table A1: Fertility rates and cumulated fertility, 3 situations of outstanding fertility

		Population (rural) and Period		
	Age group /	Kenya	Niger	Hutterites
	Age limit	1965-1969	1982-1986	1921-1940
Age-specific fertility rates (/1000)				
	12-14	31	60	0
	15-19	211	287	15
	20-24	367	373	262
	25-29	363	357	445
	30-34	349	318	432
	35-39	283	231	406
	40-44	179	165	215
	45-49	85	65	37
Cumulated period fertility				
	15	0.09	0.18	0.00
	20	1.15	1.61	0.07
	25	2.99	3.48	1.38
	30	4.80	5.27	3.61
	35	6.54	6.86	5.77
	40	7.96	8.01	7.80
	45	8.85	8.83	8.88
TFR	50	9.28	9.16	9.07