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Primary infertility in African censuses: Potential and limits of IPUMS samples

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Abstract

The study presents an analysis of infertility from African censuses available in the IPUMS-international data base. Infertility (childlessness) was defined as no live birth at the end of the reproductive period. Six countries with at least three censuses were selected: Kenya, Malawi, South Africa, Zambia, Mali and Burkina-Faso. In the last three countries, data were found to be inconsistent, and therefore discarded. The proportion of infertile women born between 1940 and 1960 ranged from 3.8% in Kenya, 3.9% in Malawi to 7.3% in South Africa. In all three countries infertility was declining for cohorts born between 1900 and 1950. In South Africa, prevalence of infertility was rising significantly for cohorts born between 1950 and 1970. Comparison with DHS surveys conducted in the same countries showed lower value of terminal infertility for the same cohorts. Reasons for discrepancies between census and survey data are further explored.

Key Words: Infertility; Childlessness; Census, DHS survey; sub-Saharan Africa; IPUMS-international

Introduction

Infertility is a worldwide public health problem that has attracted the attention of demographers, physicians, gynecologists, activists and international organizations. Sub-Saharan Africa seems to be the continent the most affected by infertility, although proper data are lacking for precise comparisons with other continents. [Boivin et al. 2007; Cates et al. 1985; Healy et al. 1994; Leke et al. 1993 ; Mascarenhas et al. 2012 ; Sciarra 1994]

The concept of infertility covers two different situations: primary infertility (no live birth at all), and secondary infertility (inability to conceive after having had at least a birth). This study focuses on primary infertility in Africa. An abundant literature has addressed the situation of primary infertility in Africa, from the early years of direct observation of colonial authorities, of early demographic surveys conducted in the 1960's, to the more recent censuses and DHS surveys. These sources are often divergent, leading to a wide range of conflicting estimates. [Adadevoh 1974; Barlovatz 1955; Belsey 1977; Ericksen & Brunette 1996; Frank 1983, 1987; Larsen & Menken 1989, 1991; Larsen 1995, 1996, 2000, 2005; Pantazis & Clark 2013; Retel-Laurentin 1972, 1974, 1978; Romaniuk 1967, 1968; Rutstein et al. 2004]

Situations of highly prevalent primary infertility were documented in areas as diverse as central Africa (Gabon, Congo, Central African Republic) and West Africa (Burkina Faso, Western Nigeria), usually for women born before 1950, but not for later cohorts. Beyond genetic and physiological factors, highly prevalent primarily infertility is usually due to infectious diseases, in particular: sexually transmitted infections (chlamydia, gonorrhea, syphilis, tuberculosis, HIV, etc.), and parasitic diseases (shistosomiasis, trypanosomiasis, malaria, etc.). [McFalls & McFalls 1974] Pockets of high prevalence of infertile women (say 10% or more) that were concentrated in selected areas of Central and West Africa seem to have largely disappeared in recent years.

In addition to biological factors, some behavioral factors seem to now interfere with changes in age at first birth associated with late marriage. In particular in urban areas of Southern Africa, women delay their first marriage to well above 30 years, or even never marry, so that a first birth is less likely to occur because of lower fecundability after age 35, as it is the case in developed countries. This recent phenomenon remains poorly documented.

The aim of this study is to assess the feasibility of measuring levels and trends in primary infertility from census data in Africa. Census data are rarely used in infertility studies because they are often considered unreliable, or simply are ignored by students and scholars interested in the topic who come from medical or public health sciences. Furthermore, individual census data necessary for such studies were rarely available to researchers until recently, when the IPUMS-international project started to archive and standardize (harmonize) census data all over the world. [see IPUMS web site for details] This study aims at starting filling this gap.

Data and Methods

Case definition of infertility

From a demographic perspective, primary infertility is defined as the fact for a woman of not having had a live birth by the end of her reproductive period, that is by age 50 years. This definition includes therefore the case of women who could not have a live birth despite being exposed to unprotected sexual intercourse for whatever biological reason (from the woman or her partner), and the case of women who either were not exposed to sexual intercourse or who always had protected intercourse for whatever behavioral reason. This definition therefore differs from biological sterility, that can be shown medically or by proper epidemiological study, and from very low fecundability, shown by lack of conception after several months of exposure (12, 18, 24 months, 3 years, 5 years, 7 years, or any other duration), both cases being often labelled in the literature as 'infertility', improperly from a demographic perspective.

For this study, the prevalence of infertility was measured by the proportion of women age 40 and above in the general population who never had a live birth. Age 40 was selected instead of age 50 primarily for practical purposes since many surveys stop at age 50, and since this selection provides data on 10 additional yearly cohorts. This choice is justified in the Annex, because very few African women have a first birth after age 40 (and in most countries even after age 35). Among the 36 countries for which DHS surveys conducted in Africa are available, only 0.04% of women had a first birth after age 40 (range 0 to 0.1%). So, prevalence of infertility at age 40 and above will be considered as equivalent to terminal infertility by age 50.

Census data

This study is based on individual records of census data from sub-Saharan Africa available in the IPUMS database. [see IPUMS web site for details] As will be seen below, these are imperfect data, which needed to be validated before an assessment of infertility could be made. Therefore, countries were selected when they had at least three censuses available in the database in order to check internal consistency. When three or more censuses indicated similar or consistent values of infertility they could be considered for final analysis, and otherwise they were discarded. Since infertility was not constant overtime in most countries, the main check was to compare prevalence of infertility for the same cohorts, a cohort being defined as the woman's year of birth. As a result, six countries were selected in the IPUMS database: two countries in Eastern Africa (Kenya, Malawi), two countries in Southern Africa (South Africa, Zambia), and two countries in Western Africa (Burkina Faso, Mali).

Many African censuses (although not all) have a question on the number of children ever-born for each surveyed woman. This number is coded in integer values: 0, 1, 2, 3, etc. up to Pmax, or unknown, 'Pmax' being the maximum parity, usually a number in the range of 15 to 20 children ever-born. Therefore, the prevalence of infertility was calculated as the proportion of women with 0 children ever-born among women with known parity (0 to Pmax), excluding therefore the unknown parity. In some censuses, unknown numbers of children ever-born are coded as 99 or another special code, and are easy to identify. In other censuses, unknown parity is recoded by some kind of imputation computer program, usually not documented, so that corrections or verifications cannot be made a posteriori. In such cases, the precision of the recoding depends on the imputation method, and the way the unknown category was coded (coding 99 when the woman has had children but the number is unknown and when it is unknown whether the woman had a birth or not are not identical for statistical purposes). In some censuses imputation of missing values was obviously not properly done, often creating abnormally high number of women with no live birth. This could happen when missing values were left blank and recoded as zero, or when imputation was not done specifically by age but all over the reproductive period, leading again to abnormally high numbers of women with no live birth (women age 40 could be treated as if they were women age 12). With respect to age range, some censuses included the question on children ever-born for all women age 12 and above, others stop at age 50, 60, 70 or 80 years. Therefore the cohort analysis of infertility may be based on 10, 20, 30, 40 or 50 yearly cohorts, depending on the census. When possible, the average level of infertility at a given census was defined for women age 40-79, which leads to large numbers and small confidence intervals.

Cohorts (woman's year of birth)

Since the date of birth was not included in most censuses, cohorts were defined by the difference between the census year and the age. For instance, a woman age 41 in a census conducted in 2001 was assumed to be born in 1960. This study focuses on long term trends, and therefore attempted at reconstructing trends in prevalence of infertility for women born between 1900 (age 80 in 1980) and 1970 (age 40 in 2010). In some cases, data on women born before 1900 are also available for the earlier censuses, as in Kenya and South Africa.

Comparison with DHS surveys

In addition to the analysis of census data, comparison was made with DHS surveys conducted in the same countries. [see DHS web site for details] These surveys are considered highly reliable, since they are based on full maternity histories, and not only on the simple question of children ever-born as in a census. Here again, prevalence of infertility was defined as the proportion of women in the age group 40-49 with no live birth. The comparison between census and DHS surveys is not straightforward, however. Firstly, DHS surveys are based on a sample of households in which at least one women age 15-49 lives, a procedure

which tends to select more fertile women and to exclude in particular marginal women (living alone, handicapped, in institution, etc.) who in principle are included in the census. Secondly, the maternity histories sometimes include stillbirths counted as live births who died shortly after delivery, whereas in a census a live birth dying shortly after delivery might be not counted among the children ever-born. Therefore, one expects discrepancies in the proportion of infertile women between censuses and DHS surveys.

Methods

Methods for this study were straightforward statistical and demographic methods. Prevalence of infertility was first computed by yearly cohort, and by 10-year cohorts, and plotted on graphics. Results from several censuses in the same country were then compared. If found compatible, cohorts trends were searched for, either ascending (increasing prevalence) or descending (decreasing prevalence). Lastly, comparison was made with DHS surveys among overlapping cohorts. Since census samples include large numbers, statistical significance is not an issue here and is not presented.

Results

1. Kenya

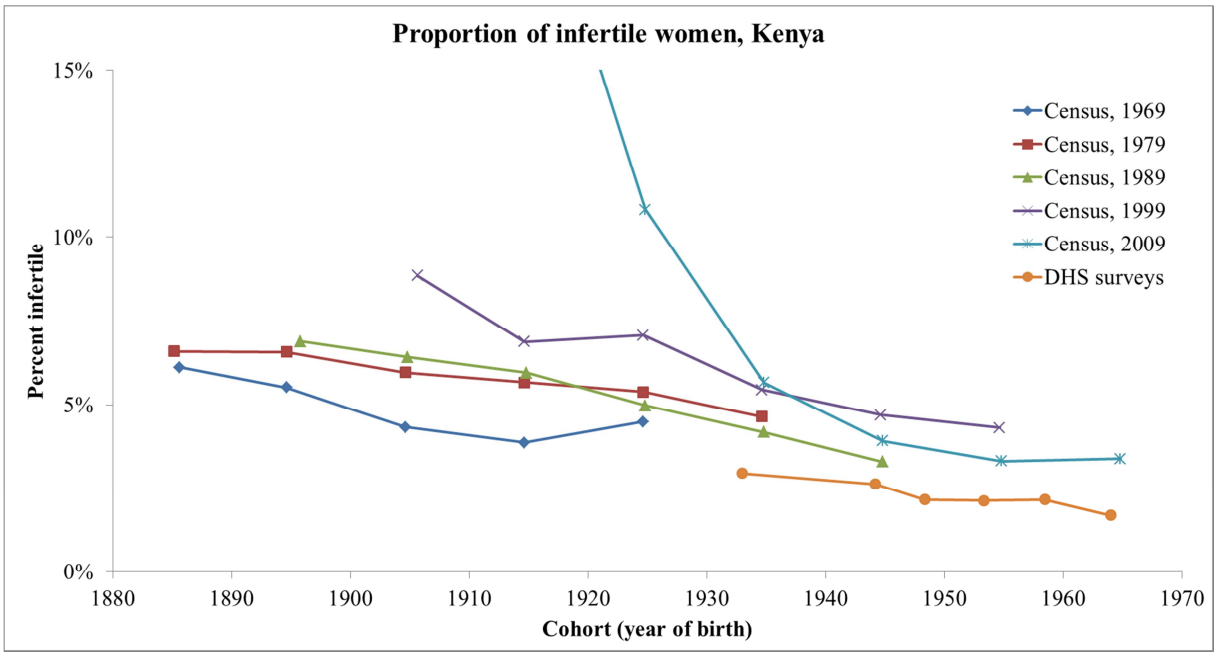
Kenya conducted five population censuses that are available in the IPUMS database. They were conducted regularly, 10 years apart from 1969 to 2009. All contain a question on children ever-born that allow one to compute the prevalence of infertility (Table 1). The sizes of IPUMS samples were very large, ranging from 40 000 to 300 000 women age 40 and above. Overall, the prevalence of infertility among women age 40-79 was 4.7%, with some minor fluctuations by census.

Table 1: Prevalence of infertility in Kenya, by census and cohort

	Census year				
	1969	1979	1989	1999	2009
Number of women	40717	760417	71616	102421	300104
Percent infertile	4.4%	5.2%	4.1%	4.9%	3.7%
Cohorts					
1880-89	6.1%	6.6%			
1890-99	5.5%	6.6%	6.9%		
1900-09	4.3%	6.0%	6.4%	8.8%	
1910-19	3.9%	5.7%	6.0%	6.9%	19.7%
1920-29	4.5%	5.4%	5.0%	7.1%	10.8%
1930-39		4.6%	4.2%	5.4%	5.7%
1940-49			3.3%	4.7%	3.9%
1950-59				4.3%	3.3%
1960-69					3.4%

NB: Women age 40-79 in all censuses

Figure 1: Levels and trends in infertility, Kenya



Results from the five censuses were, however, not identical when compared by cohort. (Table 1, Figure 1) For the same 10-year cohorts the proportion of infertile women tended to increase with the recall period. In addition, compared with the 1979 census, estimates of infertility tended to be somewhat lower in the 1969 census, similar in the 1989 census, somewhat higher in the 1999 census and in the 2009 census. Above age 80, data were broadly consistent with trends, although with wide fluctuations, with the exception of the 2009 census

for which data above age 80 were unreliable. Despite inconsistencies, data from the Kenyan censuses indicated a decline in infertility from cohorts born between 1900 and 1950, followed by a stable level for cohorts born between 1950 and 1970. Data from DHS surveys indicated similar trends, but a lower prevalence of infertility for cohorts born between 1935 and 1965.

2. Malawi

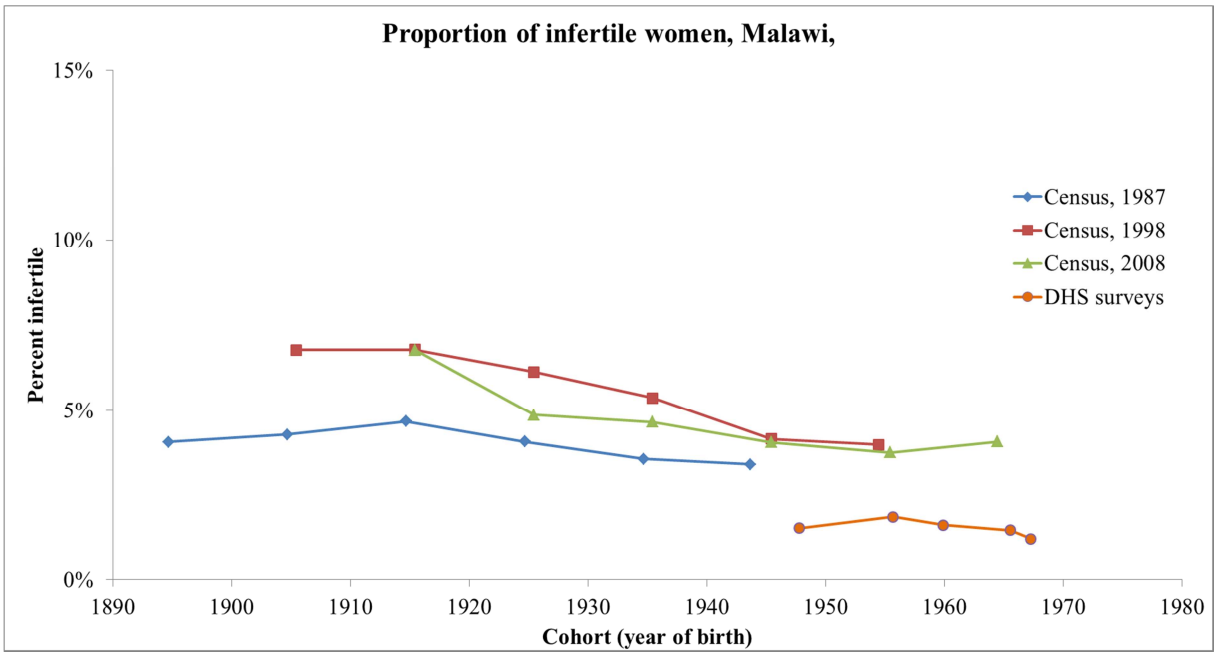
Malawi conducted three population censuses that are available in the IPUMS database. They were conducted regularly, almost 10 years apart from 1987 to 2008. All contain a question on children ever-born that allow one to compute the prevalence of infertility (Table 2). The sizes of IPUMS samples were also large, ranging from 69 000 to 99 000 women age 40 to 79. Overall, the prevalence of infertility among women age 40-79 was 4.2%, with some minor fluctuations by census.

Table 2: Prevalence of infertility in Malawi, by census and cohort

	Census year		
	1987	1998	2008
Number of women	69095	79027	98912
Percent infertile	3.8%	4.7%	4.1%
Cohorts			
1880-89	4.1%		
1890-99	4.3%	6.8%	
1900-09	4.7%	6.8%	6.8%
1910-19	4.1%	6.1%	4.9%
1920-29	3.6%	5.4%	4.7%
1930-39	3.4%	4.2%	4.1%
1940-49		4.0%	3.8%
1950-59			4.1%
1960-69			

The three censuses, however, were not fully compatible when compared by cohort. (Table 2, Figure 2) For the same 10-year cohorts the proportion of infertile women tended to increase with the recall period, although not regularly. In addition, compared with the 2008 census, estimates of infertility were lower in the 1987 census, but higher in the 1998 census. Above age 80, estimates of infertility tended to level-off. Despite inconsistencies, data from the Malawian censuses indicated a decline in infertility from cohorts born between 1900 and 1950, followed by a stable level for cohorts born between 1950 and 1970, as in Kenya. Data from DHS surveys indicated a lower prevalence of infertility for cohorts born between 1945 and 1965.

Figure 2: Levels and trends in infertility, Malawi



3. South Africa

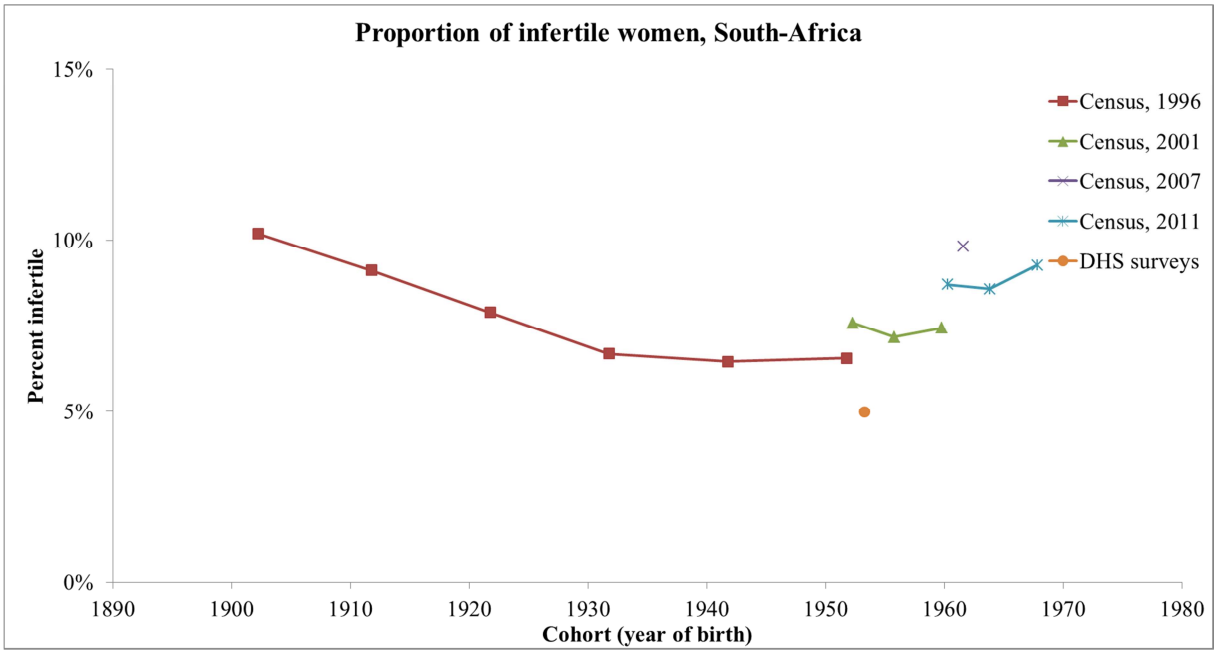
South Africa conducted four population censuses that are available in the IPUMS database, conducted in 1996, 2001, 2007 and 2011. Note that the 2007 operation, called "Community Survey" was based on a sample, and not a full scale census. Other censuses are also available in South Africa, conducted in 1970, 1980, 1985 and 1991. Some are incomplete, since they did not include parts of current South Africa (the former homelands), and only one (the 1980 census) included questions on children ever-born. However, the 1980 census was totally incompatible with the others with respect to infertility, with an outstandingly high proportion of women with no live birth. So, the following analysis is based solely on the four IPUMS samples. All contain a question on children ever-born that allow one to compute the prevalence of infertility (Table 3). However, only the 1996 census provides full information for women age 40 and above, whereas the question on children ever-born was restricted to women age 15-50 in the other censuses, so that only the age group 40-50 is available for the analysis of infertility. Overall, the prevalence of infertility among women age 40 and above was 7.7%, with serious variations by census. (Table 3)

Table 3: Prevalence of infertility in South Africa, by census and cohort

	Census year			
	1996	2001	2007	2011
Number of women	404609	225855	66746	263385
Percent infertile	6.7%	7.4%	9.8%	8.9%
Cohorts				
1880-89	10.2%			
1890-99	9.1%			
1900-09	7.9%			
1910-19	6.7%			
1920-29	6.4%			
1930-39	6.5%	8.2%		
1940-49		7.3%	17.9%	
1950-59			9.2%	8.6%
1960-69				8.9%

NB. Only the 1996 census contains data on women age 40 and above; others contain only data from age 40 to 50.

Figure 3: Levels and trends in infertility, South Africa



With respect to trends, South Africa shows a unique pattern of first declining infertility, from cohorts of women born in 1900 to 1950, then a rising infertility up to the last cohorts born in 1970 (age 41 in 2011). Although there are some inconsistencies in the recent data (census of 2001 to 2011), the increasing trend appears clearly in Figure 3. The 2007

sample is somewhat at odds with the others, most likely because of the sampling procedure. As in the other countries, the 1998 DHS survey gives a lower value for infertility.

4. Zambia

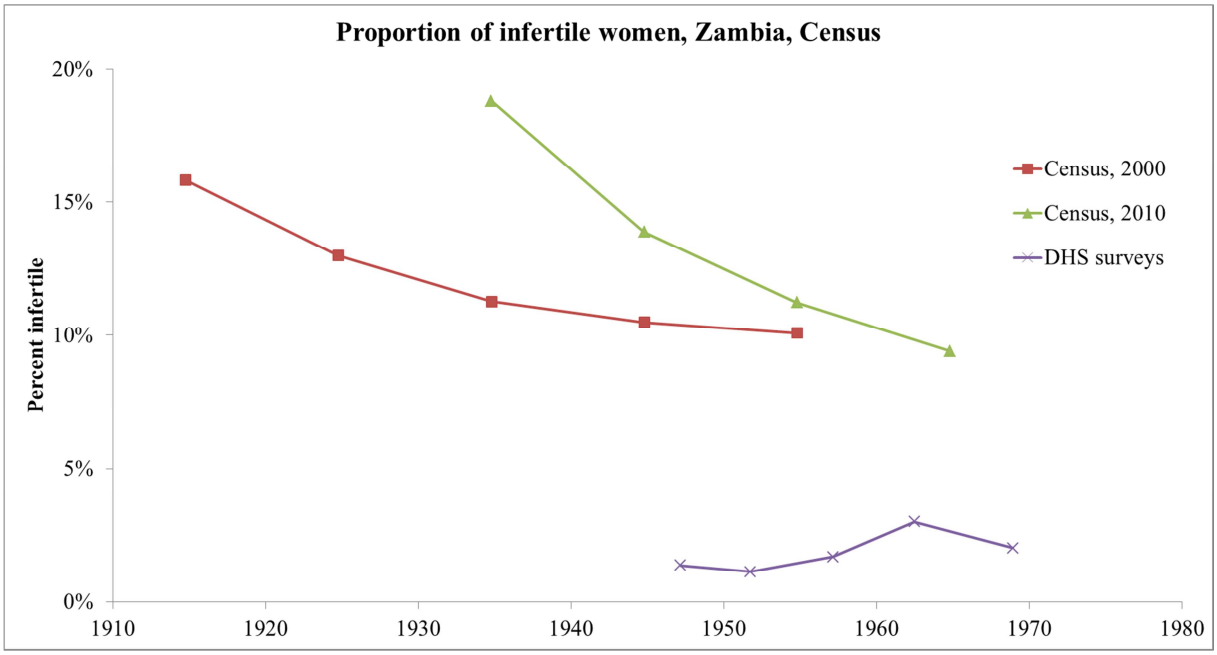
Zambia conducted three population censuses that are available in the IPUMS database, conducted regularly every 10 years in 1990, 2000, and 2010. All three contain a question on children ever-born that allow one to compute the prevalence of infertility (Table 4). The first census (1990) led to an obvious overestimation of infertility. So, only the last two censuses (2000 and 2010) were considered. Overall, the prevalence of infertility among women age 40 and above was 11.0%, basically the same in both censuses. (Table 4)

Table 4: Prevalence of infertility in Zambia, by census and cohort

	Census year		
	1990	2000	2010
Number of women	58244	64458	86408
Percent infertile	24.7%	10.6%	11.2%
Cohorts			
1900-09	42.2%		
1910-19	39.8%	15.8%	
1920-29	33.3%	13.0%	
1930-39	24.9%	11.3%	18.8%
1940-49	20.3%	10.5%	13.9%
1950-59		10.1%	11.2%
1960-69			9.4%

Trends by cohorts revealed large inconsistencies, with much higher values for the 2010 census compared with the 2000 census. (Figure 4) In addition, the prevalence of infertility was so much higher than in the DHS surveys that data could not be considered reliable.

Figure 4: Levels and trends in infertility, Zambia



5. Burkina-Faso

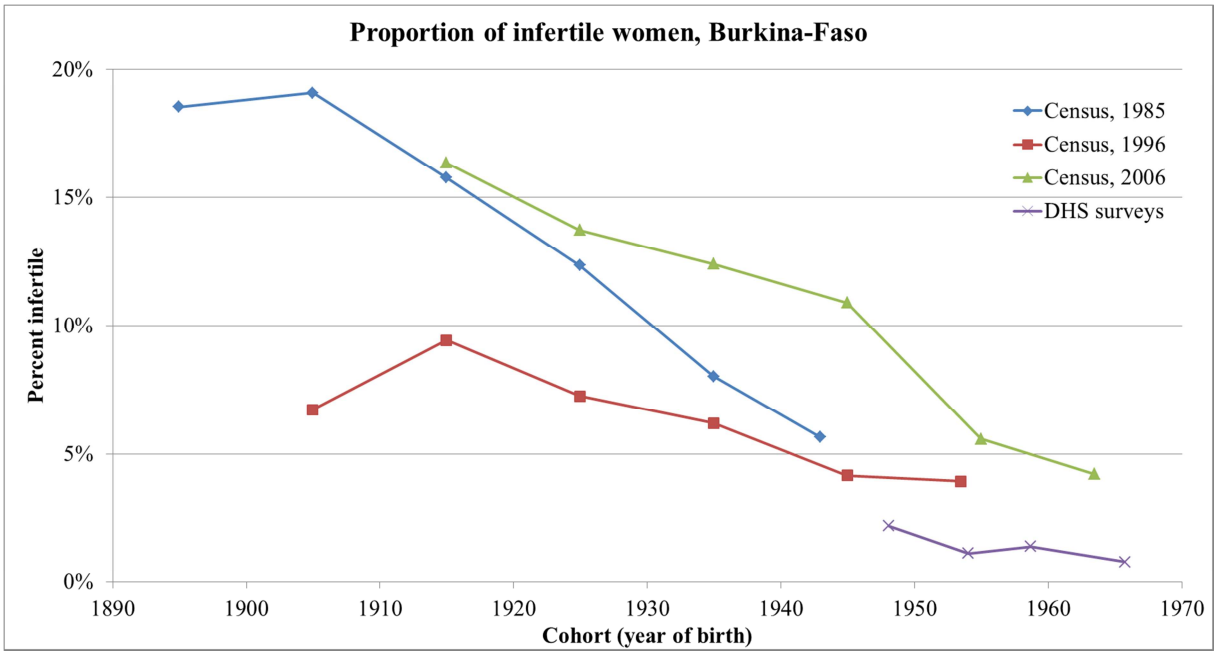
Burkina-Faso conducted three population censuses that are available in the IPUMS database, conducted regularly almost every 10 years in 1985, 1996, and 2006. All three contain a question on children ever-born that allow one to compute the prevalence of infertility (Table 5). Data were somewhat inconsistent, with the first census (1985) leading to a high value (9.4%), the second census (1996) to a low value (4.9%) and the third census (2006) to an average value (7.0%). Overall, the prevalence of infertility among women age 40 and above was 7.0%, basically the same as in the last census. (Table 5)

Despite the large differences in levels, estimates by cohort indicated a declining trend, which were approximately parallel, and parallel to the trend found in the DHS surveys. However, levels in the DHS surveys were much lower than those found in the censuses. (Figure 5) Burkina-Faso is one of the countries with known high prevalence of infertility during the colonial period. [Retel-Laurentin 1972, 1974, 1978]

Table 5: Prevalence of infertility in Burkina-Faso, by census and cohort

	Census year		
	1985	1996	2006
Number of women	74697	86714	118025
Percent infertile	9.4%	4.9%	7.0%
Cohorts			
1890-99	18.5%		
1900-09	19.1%	6.7%	
1910-19	15.8%	9.4%	16.3%
1920-29	12.3%	7.3%	13.7%
1930-39	8.0%	6.2%	12.4%
1940-49	5.6%	4.2%	10.9%
1950-59		3.9%	5.6%
1960-69			4.2%

Figure 5: Levels and trends in infertility, Burkina-Faso



6. Mali

Mali conducted three population censuses that are available in the IPUMS database, conducted regularly every 11 years in 1987, 1998, and 2009. All three contain a question on children ever-born that allow one to compute the prevalence of infertility (Table 6). However,

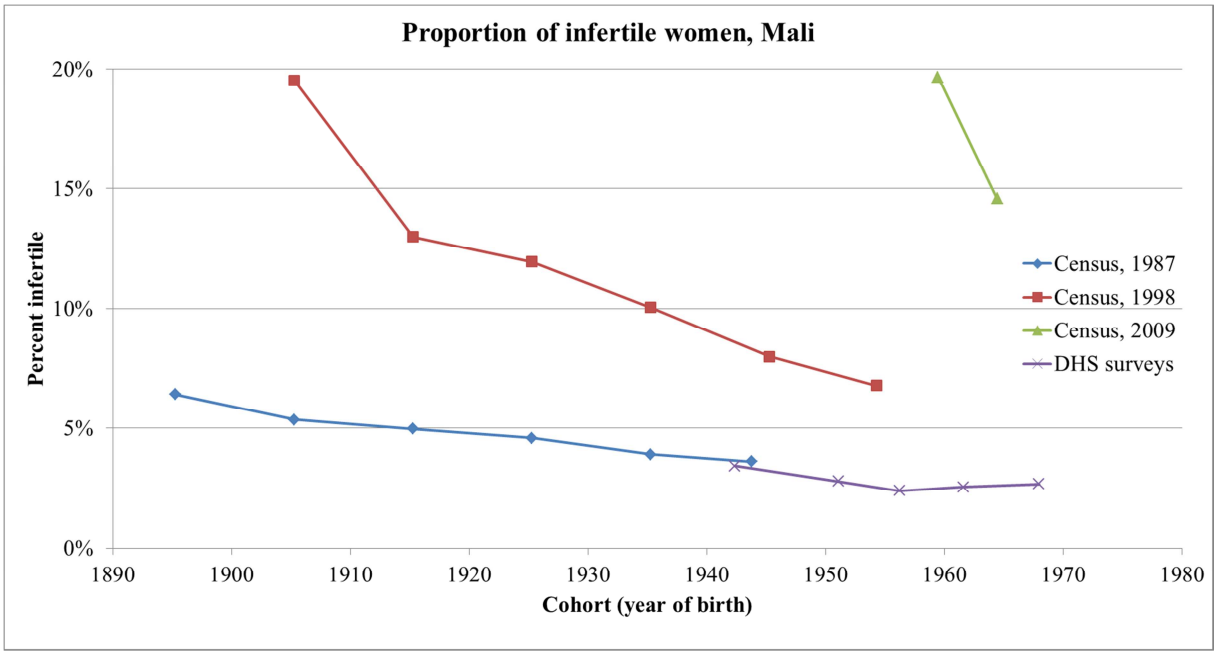
the 2009 census provides only data from age 40 to 49 years. Data from the three censuses were largely inconsistent, with increasing values of the prevalence of infertility with date of census, which is unexpected. Data are therefore considered as unreliable. (Table 6)

Table 6: Prevalence of infertility in Mali, by census and cohort

	Census year		
	1987	1998	2009
Number of women	66161	77750	48973
Percent infertile	4.1%	8.4%	15.4%
Cohorts			
1880-89			
1890-99	6.4%		
1900-09	5.3%	19.5%	
1910-19	5.0%	13.0%	
1920-29	4.6%	11.9%	
1930-39	3.9%	10.0%	
1940-49	3.6%	8.0%	
1950-59		6.8%	19.7%
1960-69			14.6%

NB: the 2009 census provides data only for women age 40-49

Figure 6: Levels and trends in infertility, Mali



Despite the large differences in levels, estimates by cohort all indicated declining trends, which were approximately parallel, and parallel to the trend found in the DHS surveys.

Surprisingly, levels and trends in the DHS surveys were consistent with levels and trends found in the 1987 census. However, it was unclear whether any census could provide reliable estimates. (Figure 6)

7. Comparison with DHS surveys

Estimates of infertility in censuses could be compared with those of DHS surveys by selecting the corresponding cohorts. Results show that, on average, infertility in censuses is about three times that in DHS surveys. Infertility estimates are rarely compatible, and almost always higher in census data, with the sole exception of the 1987 census of Mali. In some countries such as Kenya or South Africa differences were moderate and realistic, whereas in others they tended to be very high and revealed census data problems, in particular in Zambia and in Burkina-Faso. (Table 7)

Table 7: Comparison of estimates of female infertility in censuses and DHS surveys

	Census year	Overlapping cohorts	Proportion infertile		
Country			Census	DHS surveys	RR
Kenya	1989	1928-1949	3.8%	2.5%	1.53
	1999	1928-1959	4.7%	2.4%	1.96
	2009	1928-1969	3.8%	2.2%	1.67
Malawi	1987	1943-1947	3.6%	1.5%	2.36
	1998	1943-1958	4.1%	1.8%	2.28
	2008	1943-1968	4.0%	1.7%	2.34
South-Africa	1996	1949-1958	6.6%	5.0%	1.33
	2001	1949-1958	7.3%	5.0%	1.47
	2007	1949-1958	12.1%	5.0%	2.43
Zambia	1990	1943-1950	20.1%	1.2%	
	2000	1943-1960	10.2%	1.4%	7.04
	2010	1943-1970	10.5%	1.8%	5.86
Burkina-Faso	1985	NA			
	1996	1944-1957	4.0%	1.4%	2.95
	2006	1944-1966	5.9%	1.4%	4.30
Mali	1987	1937-1944	3.2%	3.6%	0.91
	1998	1937-1958	7.7%	2.6%	2.90
	2009	1959-1968	15.4%	2.7%	5.75

Discussion

Out of the six countries investigated, three had consistent data, and provided reliable estimates of infertility, and the other three showed too many inconsistencies to conclude. In the three countries with reliable data, estimates of infertility for cohorts born between 1940 and 1960 ranged from 3.8% (Kenya) and 3.9% (Malawi) to 7.3%. (South Africa). These are values lower than those estimated by other methods, and probably more realistic for the general population. The moderate values found in Kenya and Malawi, where marriage is universal and early, are probably mostly due to biological factors, and are close to values found elsewhere. The higher values found in South Africa seem to have a behavioral component, probably due to frequent situation of late marriage or no marriage combined with efficient contraception.

All six countries revealed (when reliable) or suggested (even with deficient data) declining trends in infertility over the years, and in particular for women born between 1900 (who had most births in 1920-1940) and 1950 (births in 1970-1990). Most cases of infertility are in fact due to infectious and parasitic diseases in Africa, and with modern medicine, antibiotics in particular, and the overall improvement in health, one could expect a decline in sterility due to biological factors, and therefore a decline in infertility. This decline in infertility in census data was also found in DHS surveys: on average for 33 African countries, the proportion of infertile women declined from 8.1% for women born around 1930 to 3.1% for women born around 1955, and tended to increase slowly thereafter. (Author's calculations). This was confirmed by earlier analysis using a different methodology. [Larsen, 2000]

Only South-Africa revealed increasing trends for cohorts born after 1950, for reasons that need to be further investigated. This might be due to emerging or resurging infectious diseases (tuberculosis, HIV/AIDS, other STI's), or due to behavioral factors, in particular to the increasing proportion of women who marry late or remain never-married. Note that this increase in infertility is rather large, from 6% infertile women for the 1950 cohort to 10% for the 1970 cohort, going back to levels prevalent in the 1900 cohort.

As expected, there were differences between censuses and DHS surveys, almost always in the same direction: higher prevalence in census than in surveys. This discrepancy was in part expected, for reasons explained above. In countries with better data (Kenya, Malawi and South Africa) the magnitude of differences was moderate (1.7%, 2.2%, 3.7% respectively on average) and could be explained by selection factors, whereas in other countries differences were larger, revealing problems in census data in addition to expected discrepancies.

Overall, IPUMS census samples were found useful for studying infertility in Africa. In some countries census files could be used directly, whereas in others they obviously needed an adjustment. It is too unfortunate that, firstly, information on imputation was not kept in the censuses studied, which would have allowed one to further checking, and secondly that

imputation procedures were not documented. In theory, if women were interviewed in person in a census, there is no reason to think that one could not obtain reliable information on infertility. Of course, in practice women are not always asked personally (the head of household or another member may answer for them), coding of answers may not be optimal, data entry might be erroneous, and procedures for imputing missing values might not be adapted to the case of children ever-born. These are probably the reasons why so much discrepancy was found in some of the censuses investigated.

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Annex

Figure A-1: Probability for women of having their first birth by age ‘x’, fertile women, average of African DHS surveys.