Correspondence to:

Tom Moultrie

Centre for Actuarial Research
University of Cape Town
Private Bag X3
7701 Rondebosch
South Africa

Tom.Moultrie@uct.ac.za

Birth intervals and fertility decline in Africa

"Birth intervals and fertility in Africa"

Tom A. Moultrie, Takudzwa S. Sayi and Ian M. Timæus

Abstract

We investigated birth interval dynamics in 24 African countries using data from 76 Demographic and Health Surveys conducted since 1986. Controlling for selection bias in the birth history data using the Brass-Juárez method and regression models produces almost identical results. Birth intervals have lengthened in every country examined. This analysis uncovered a distinctive and previously undocumented pattern of childbearing that is prevalent across sub-Saharan Africa. After allowing for time trends in birth interval length, the lengthening of birth intervals in almost every country varies little by women's age or parity. Moreover, in several countries, birth intervals are now too long to be explicable by birth spacing contingent on the age of women's youngest child. Rather, women are postponing births for other reasons. These findings offer empirical support for the idea that the fertility transition in sub-Saharan Africa will follow a different pattern from that observed elsewhere.

Key words fertility decline; Africa; birth intervals; birth spacing; birth control; family planning

Introduction

The study presented in this paper examined birth interval dynamics in 24 sub-Saharan African countries. In earlier work (Moultrie and Timæus 2002; 2003), we documented both the slow pace of fertility decline in South Africa and the evolution from the 1960s through to the 1990s of a pattern of exceedingly long birth intervals in the country. The primary focus of this article is the investigation of whether birth intervals elsewhere in Africa are also lengthening in a way not seen in the course of the contemporary fertility transitions in other parts of the world.

Writing soon after the onset of fertility transition in sub-Saharan Africa, Caldwell *et al.* (1992) predicted that fertility decline in the region might follow a different path from Europe and Asia, dropping at all ages and parities simultaneously. Our research on South Africa suggests that the fall in fertility and lengthening of birth intervals there have followed this pattern (Moultrie and Timæus 2002). However, if birth intervals are changing in a way that is not mediated by parity, this suggests that limitation of family size is not a primary consideration in women's family formation strategies.

For several decades now, motivations for contraceptive use in developing countries have been assumed to fall into one of two exclusive categories: stopping and spacing. We have argued that, in order to explain birth intervals as long as those observed in South Africa, this two-way typology must be expanded to include a third motivation for contraceptive use, postponement (Timæus and Moultrie 2008). Postponement is delaying having another birth for reasons other than the age of one's youngest child (i.e. spacing) or one's existing family size (i.e. stopping). Although the concept of postponement is relatively commonplace in the literature on contemporary fertility in Western countries (for example, Berrington 2004; Breton *et al.* 2005; de Cooman *et al.* 1987; Friedlander *et al.* 1980) and has been discussed previously in the context of developing country fertility—for example, by Lightbourne (1985), Agadjanian (2005), and Johnson-Hanks (2004; 2007)—it has failed to take root in the latter literature. Our 2008 paper deals extensively with the theoretical and historical literature on the topic of postponement, both in Africa and elsewhere, drawing *inter alia* on the work of Ware (1976), Bledsoe *et al.* (1998), Anderton and Bean (1985) and Knodel (1987). We do not repeat this discussion of the concept and literature relating to it here.

While the level of fertility in South Africa is markedly lower than anywhere else in continental sub-Saharan Africa (recent estimates suggest a national total fertility rate of around 2.3 children per woman), the observations that the South African fertility decline conforms to the Caldwell *et al.* (1992) conjecture and seems to result from widespread postponement of births raise the question of whether the South African experience is *sui generis*, or whether patterns of fertility elsewhere in the continent are similar. Might there be an 'African pattern' of fertility decline and (if so) what might the implications of this be for future fertility change in the region? The study presented in this paper addressed these questions by investigating the age and parity dynamics of birth intervals in the course of the African fertility transition. In doing so, we also considered the role of contraception in shaping birth interval lengths across the region. The concluding section of the paper reflects upon the implications of the results for broader narratives of African fertility transitions.

Data and methods

The study analysed data from 76 publically available Demographic and Health Surveys (DHS) conducted since 1986 in 24 sub-Saharan African countries (Table 1). While this set of countries was intended to be comprehensive, it is not encyclopaedic; island nations that form part of the African region (i.e. Cape Verde, Comoros, Madagascar and São Tomé) have been omitted, as have those sub-Saharan African countries that have conducted only one DHS.

<Table 1 about here>

Birth history data such as those collected in DHS are subject to intrinsic selection biases. Because the histories are collected from women aged less than 50, the data are only representative of all births occurring in the population for the period immediately before the survey. The reports on earlier dates refer to an increasingly youthful cohort of women. Women who reach a particular parity by any age less than 50 are selected, by definition, for higher fertility than all women who will eventually reach that parity. They tend, therefore, to progress to their next birth more rapidly than women of all ages. Furthermore, even for women of a given age, the intensity of this selection bias will vary over time if the ages at which women start childbearing or the length of their lower-order birth intervals are changing. Unless one can adjust for these selection effects, birth history data cannot be used to investigate trends in parity progression or the length of birth intervals. Thus, DHS reports only present birth interval statistics for the five-year period preceding the survey (Rutstein and Rojas 2003).

Methods that seek to address the problem of selectivity in birth history data have followed one of two paths. The first was proposed by Hobcraft and colleagues (Rodríguez and Hobcraft 1980; Hobcraft and McDonald 1984; Rodríguez *et al.* 1984; Hobcraft and Rodríguez 1992). This approach uses life tables to deal with the censoring of all open birth intervals at the date of the survey and addresses the selection effect that results from the truncation of the age range observed as a consequence of only interviewing women aged less than 50 at the time of the survey by disaggregating the analysis by control variables that influence the intensity of selection: age, age at first birth and the length of the previous interval are the three main such controls. The main limitation of this approach is that it has been shown that single controls may not prevent selection from influencing estimated trends (Hobcraft and Rodríguez 1992) but that a life table based analysis that divides the data by multiple explanatory and control variables simultaneously inevitably fragments them, yielding estimates that are too imprecise to be of use.

Brass-Juárez method

The alternative approach is the paired-cohort comparison method described by Brass and Juárez (1983). This involves artificially truncating the data for each cohort of women five years before the survey. The remaining data reflect women's experience up to the current ages of the adjacent younger cohort. The essential mechanism of the method is easily explained by reference to the accumulated fertility of women as represented on the Lexis plane. The birth histories of a cohort of women aged 35-39 at the time of a survey, for example, can be truncated five years before the survey to reflect their fertility up to age 30-34 (the vertical-shaded area on Figure 1), which can then be compared with the experience of 30-34 year old women at the survey date (the hatched area on Figure 1). Since the two areas are equal (the black-shaded area in Figure 1 for the older women having been omitted), they represent identical portions of two adjacent cohorts' fertility experience. This experience can be measured in terms of parity progression ratios (as originally proposed by Brass and Juárez) or median parity-specific birth intervals (the extension proposed by Aoun (1989a; 1989b).

<Figure 1 about here>

The comparison of the fertility experience of the two cohorts is achieved by means of what Brass and Juárez term 'indices of relative change,' the ratio of the fertility measure between two adjacent cohorts at the same attained age. The impact of changes in ages at first birth and the length of lower-order intervals on the proportion of women achieving higher order parities is small in any five-year period. Thus, controlling for age group and parity leaves the data on adjacent cohorts more-or-less equally subject to selection on fecundity and the indices of relative change can be treated as indices of fertility change.

Brass and Juárez show that, by combining life table approaches to deal with censoring with the chaining of these indices of relative change downward from cohorts of women who are completing their childbearing (that is, women who are aged 45-49) to younger age groups, one can produce projected parity progression ratios and projected B_xs (the proportion of women expected to progress to a subsequent birth within x months of their preceding birth). To demonstrate how this works algebraically, consider the parity progression ratios of women aged 45-49 at a survey. Using the data collected in a birth history, it is possible to determine both the women's current parity progression ratios for each parity, n, PPR(n, 45-49), and the parity progression ratios that these women had five years earlier when they were aged 40-44, PPR^t(n, 40-44), where the superscript t indicates that the birth history has been truncated by five years. Women aged 40-44 at the survey (that is, in the next younger cohort) would have observed parity progression ratios PPR(n, 40-44). The 'index of relative change' is given by PPR(n, 40-44)/ PPR^t(n, 40-44), and is an indicator of the change in parity progression at parity n between the two cohorts. If this observed relative change persists for their last five years of childbearing, women aged 40-44 at the time of the survey will end up with a proportionately adjusted parity progression ratio at the time that they finish childbearing five years after the conduct of the survey. Their projected parity progression ratio is therefore given by PPR(n, 45-49) × PPR(n, 40-44)/ PPR^t(n, 40-44). Iteratively multiplying together these indices of relative change for successively younger cohorts and applying them to the observed parity progression ratios of women aged 45-49 produces a series of projected parity progression ratios by parity and cohort.

The derivation of projected median birth intervals is a relatively simple extension of the logic underlying the Brass-Juárez method: instead of chaining the proportion of women having a subsequent birth within—say—60 months of her previous birth (thereby deriving projected B_{60}s), Aoun (1989a; 1989b) shows how projected median birth intervals can be derived using the median value of each life table from the original method's input data. We have extended this framework still further by suggesting that the approximate location in calendar time of a given interval equals the mean birth date of the birth that results in that interval being closed (Moultrie and Timæus 2002). Since the projected component of the Brass-Juárez method is kept fairly small, the extent of any bias introduced into the estimated time locations will also be small.

Four aspects of the Brass-Juárez method (and its extensions) have limited its application in the demographic literature. First, the method was published in a relatively inaccessible journal, which has reduced the reach of the idea. Second, although it has intuitive appeal for the manner in which it seeks to address selection bias once one understands it, the method's logic is initially somewhat difficult to grasp. Third, the method is computationally intensive. Finally, although it allows one to estimate the aggregate trend in fertility, it is difficult to reformulate the approach as a multivariate regression model. It is unsuited, therefore, to detailed investigations of fertility differentials or of the extent to which proximate or distal determinants account for fertility decline.

Regression model of birth intervals

To return to the first strategy for avoiding selection bias, a carefully specified regression model can circumvent the main limitations of Hobcraft's approach by introducing sufficient controls to adjust for selection bias, yet still yield estimates of sufficient precision from DHS data to allow one to investigate fertility trends and their determinants. The paper presents an evaluation of the Brass-Juárez model against such a model that demonstrates that these two ways of dealing with selection bias produce essentially the same results.

One advantage of the extended retrospective nature of birth history data is that substantial overlaps exist between the periods reported on in the birth histories collected in successive surveys of the same country. In order to make use of this fact, data from multiple DHS in the same country have been aggregated into a single event-exposure file, preserving the normalised weights and the information on survey design needed to estimate confidence intervals and statistical significance accurately. A disadvantage of this strategy is that the ability to compare and contrast the data from different surveys in the same country is lost.

<Table 1 about here>

In each data set, birth intervals for each woman were disaggregated into a series of event-exposure records, with an event defined as the closing of the birth interval by a subsequent birth and exposure broken down by the duration since the previous birth. In order to capture the shape of the hazard function, separate segments were created starting at 9, 18, 24 ... 66, 72, 84, 96, and 108 months since the previous birth. Only the intervals of parous women were modelled, not the timing of the first birth. Birth intervals of women who had undergone sterilisation were treated as truncated at the date of sterilisation (if the relevant data were available), or from the date of the immediately preceding birth (when they were not).

As has already been pointed out, all DHS birth history data on fertility are subject to substantial selection effects. The key controls for selectivity bias that enable one to measure trends are to include both the birth order of the index child and the mother's age group at the beginning of each segment of each birth interval as covariates (Rindfuss *et al.* 1982). Each birth interval segment was then situated on the Lexis plane using an indicator that identifies the five-year quinquennium of calendar time (1960–64; 1965–69; ... ; 2005–9) in which that segment began. In addition, attained parity was interacted with calendar time measured continuously to assess whether evidence existed of family limitation, operationalized as more rapid fertility decline at certain parities than others.

It should be noted that Rindfuss *et al.* (1982) caution that this strategy may fail to eliminate selection bias if age, order or calendar time interact with other determinants of interval length. They advise, therefore, that the analysis should be restricted to intervals initiated in a recent window of time prior to the collection of the birth histories, or that trends should be examined by looking only at intervals initiated by younger women. However, this concern seems more relevant to detailed analyses of the determinants of interval length than to the analysis presented here, which was designed only to describe the overall pattern of change in birth intervals in each country.

The model was extended to identify the relative effects of two crucial proximate determinants of birth interval length on the time trend in birth intervals by specifying binary variables that indicate, at the birth of each of a woman's children, whether she had ever been married, and whether she had ever used a modern method of contraception. The former variable was derived by comparing the mother's reported date of first marriage with the date of the index child's birth; the latter using the mother's reported number of living children at the time of her first use of a modern contraceptive method. The contraceptive use variable is not perfectly suited to our purpose since the question asked in DHS surveys relates to *living* children at first use. Thus, a woman's parity (which includes live-born children who have died) at first use may not be known exactly. Consider, for example, a woman with four children ever born, the second of which died before the third was born. If she reports that the number of children living at first use was two, then she may have begun using contraception after the birth of either her second or third, child. In such a situation, we assumed that she began using contraception at the earlier point in time. To allow ever-users and non-users of contraception to have different duration-specific patterns of progression to the next birth, the contraceptive use indicator is interacted with interval duration measured at the centre of each segment and its square.

The other covariates included in the model yield a more detailed description of how birth intervals, and the hazards of closing a birth interval, have changed over time. This permits the identification of the dominant birth control strategy (stopping, spacing or postponing) underlying the drop in fertility in different populations. One consequence of postponement is that fertility declines less at long interval durations than at shorter ones (Timæus and Moultrie 2008). To capture this, the indicator variables for segments of the birth interval were supplemented with measures of interval duration at the middle of each segment and its square that were allowed to interact with the five-year calendar periods. The effects of the two proximate determinants included in the models (first marriage and ever-use of contraception) were also allowed to interact singly and jointly with the indicators of calendar time.

Thus, the full regression model is

$$\begin{aligned}\ln\big(f(P,X,D,T,C,M)\big) = {} & \beta_0 + \beta_{1,n}\cdot P_n + \beta_{2,i}\cdot X_i + \beta_{3,j}\cdot D_j + \beta_{4,k}\cdot T_k + \beta_{5,n}\cdot P_n\cdot T + \beta_6\cdot T_k\cdot D \\ & + \beta_7\cdot T_k\cdot D^2 + \beta_8\cdot C + \beta_9\cdot M + \beta_{10}\cdot C\cdot M + \beta_{11}\cdot C\cdot D + \beta_{12}\cdot C\cdot D^2 \\ & + \beta_{13}\cdot C\cdot T_k + \beta_{14}\cdot M\cdot T_k + \beta_{15}\cdot C\cdot M\cdot T_k + \varepsilon\end{aligned}$$

where P_n is a set of variables indicating the women's parity ($n \geq 1$); X_i is a set of variables indicating the women's five-year age group; D_j is a set of variables identifying the birth interval segments (j = 9, 18, 24 ... 66, 72, 84, 96, and 108 months since the previous birth); D is duration measured continuously at the centre of each segment of an interval; C indicates whether the women had ever used contraception at the time of the index birth; M indicates whether the women had ever been married at the time of the index birth; T_k is a set of variables indicating the five-year period in which segment D_j commences; T is calendar time measured continuously; and ε is an error term.

The impact of these covariates on the hazard of closing a birth interval in each segment was estimated using a piecewise log-rate model fitted using conventional Poisson regression techniques (see, for example, Yamaguchi (1991)) in combination with the survey data (*svy*) routines in *Stata* to calculate the standard errors more accurately. We also experimented with using either a gamma frailty model or negative binomial regression to allow for heterogeneity in women's fecundity. Unfortunately, such models sometimes failed to converge, which may indicate that the variables used to eliminate selection biases also capture much of the variation in fecundity between women or may reflect the sparseness of the data matrices. When these models did converge, their coefficients and their standard errors differed little, and in no substantively important ways, from those in the models used to produce the results presented here.

Comparison of the two approaches

The central focus of this paper is on the long-term trend in birth interval lengths by age and parity: the statistical models just described and the Brass-Juárez approach were each used to confirm the robustness of the other. There is, however, a significant difference in the operationalization of age under the two approaches. The Brass-Juárez method uses the age of the woman at the survey (irrespective of her age at confinement); the regression model uses the age of the woman at the start of each interval segment. This means that the results are only comparable at younger ages and relatively low parities. Specifically, the adjusted results from the regression model for women aged 25-29 (at the start of each segment) at parities two to four have been compared with those from the Brass-Juárez method for the same parities and age group (at the survey), since the cohort of women aged 25-29 at the survey having these births in a given period of time will overlap to a considerable extent with women contributing to the period measure and aged 25-29 at the time of that birth.

The results are presented graphically rather than by tabulating the full regression models for each country, each of which contains approximately 80 parameters. To do so, the linear estimators produced by the regression model were used to derive adjusted fertility rates that were converted into conventional life table measures by treating them as central rates of decrement and converting them into probabilities of decrement by duration of interval using the exponential approximation. From these fitted probabilities, one can calculate life tables for the birth intervals initiated in each period of calendar time. The use of the exponential conversion, which is predicated on the assumption that the rates of decrement are constant between x and $x+n$, is consistent with the assumption of piecewise constancy in the estimation of the hazard of giving birth.

Note that this approach takes the analysis a significant way towards the estimation of parity-age-duration total fertility rates (PADTFR), as originally described by Rallu and Toulemon (1994). A paper published recently by Retherford *et al.* (2010) also seems to offer a similar approach to modelling family formation dynamics.

As a summary measure of birth interval length, we derived the median time to the next birth for each life table. This is the expected duration by which 50 per cent of birth intervals (for a given maternal age and parity cohort in a given period of calendar time) are closed. This median value should be similar to the projected median birth intervals produced by the Brass-Juárez approach with appropriate time locations, since both methods seek to largely eliminate the effects of selectivity. Focusing on a summary measure of birth interval length, the median, attenuates to a large degree any variation in birth intervals introduced by errors in the data. It is not surprising, then, that the results achieved from modelling each country separately using aggregated data from multiple surveys, or each survey separately (results not shown) produce trends in median birth interval length that are, to all intents and purposes, identical.

Results

Estimates of the median duration of birth intervals, for women aged 25-29 and parities two to four, produced using the Brass-Juárez method and comparable adjusted estimates from the regression model are shown in Figure 2. These low-order birth intervals have lengthened in all countries, with the largest increases observed in the countries of Southern Africa: South Africa, Namibia, Zimbabwe and Lesotho. More importantly for our argument, however, materially the same results were produced by both methods. Thus, having controlled explicitly for selection effects in the regression model, there would appear to be no bias in the results produced by the Brass-Juárez method relative to a formally-specified statistical model. Of course, consistency does not in itself necessarily mean that all selection effects have been removed: the two approaches might just be adjusting for selectivity to an equal degree. However, given the differences between the methods (including their respective period and cohort orientations to measurement), this is improbable.

<Figure 2 about here>

Figure 3 shows the results from the application of the Brass-Juárez method for one country in each of Sahelian, West, East and Southern Africa, analysed by age, parity and calendar time. (Similar figures for all the other countries listed in Table 1 are shown in Figures A1–A6 in the Appendix: the choice of these four countries is essentially arbitrary). Data from different DHS surveys in the same country are shown by different grey-scale and weight lines. Different birth cohorts (represented by age group at the survey) are indicated by different markers (squares, triangles, etc.). Parity is represented by the points along each line – the first point on any given line always representing the transition from first to second birth; the second, the transition from second to third, and so on. Thus, to the extent that birth intervals increase with age and parity, one would expect the lines for different cohorts to run parallel to each other, with the lines for older cohorts and points for higher parities lying above those for younger cohorts and lower parities at the same date. However, to the extent that the increase in birth intervals represents a period effect common to all ages and parities, one would expect the lines to be superimposed.

<Figure 3 about here>

In both Figure 3, and Appendix Figures A1-A6, the data from different surveys representing equivalent cohorts of women are strongly congruent: this gives confidence in the quality of the data analysed. Thus, while it is commonly held that some DHS data sets are distinctly problematic, the birth history data collected from one survey to the next in most of these countries are highly consistent. However, the sudden lengthening of the most recent (i.e. the last point shown) birth intervals in many surveys, followed by the reestablishment of the previous trend in subsequent surveys, probably results from the well-documented problem of omission and backward shifting of the dates of most recent births in women's birth histories (Schoumaker 2010; 2011).

It is also clear that there is a wide variation in the trajectory of birth intervals in sub-Saharan Africa: focusing on the four countries shown in Figure 3, they have lengthened most in Zimbabwe, and least in Burkina Faso. Examination of the data for the other 20 countries in the Appendix shows that, in the 1960s and 1970s, median birth intervals in all countries were between about 27 and 33 months, which is what one would expect in non-contracepting populations in which a lengthy period of breastfeeding is normal (Potter 1963). They tended to be longest in coastal West Africa, where the duration of postpartum abstinence was traditionally much longer (Page and Lesthaeghe 1981). Since then, birth intervals have increased across sub-Saharan Africa except in some of the Sahelian countries.

Birth intervals have lengthened most in South Africa (although the most recent reliable DHS data for the country are now more than a decade out of date), where the estimates from the regression model suggest that the median birth interval among women aged 25-29 at low parities may have risen to about 6 years by the late-1990s (see Figure 2). Median birth intervals in Lesotho, Namibia and Zimbabwe have also increased to the length seen in South Africa in about 1990, reaching 4.5 years a decade later. Moreover, the median birth interval in Ghana has risen to almost 4 years. Birth intervals in countries with higher total fertility and lower contraceptive use prevalence have also lengthened, but to a lesser extent.

Despite these differences in the extent to which birth intervals have lengthened, the overall pattern of increase is fundamentally similar. In all four countries shown in Figure 3 (and the estimates for the other 20 countries analysed tell the same story), the median length of birth intervals is largely independent of women's age and parity, and appears to be almost entirely a function of calendar time. In other words, older women progressing to higher-order parities at the same time as younger women progressing to lower-order parities exhibit very similar birth intervals. The main exceptions to this pattern are older women at high parities, whose median birth intervals tend to be a little longer, which probably results from diminishing fecundity with age. In addition, Lesotho, as well as exhibiting a steep period trend, exhibits a fairly clear tendency for the lines representing older cohorts to lie above and to the right of those for younger cohorts, which may be indicative of a degree of parity-specific birth control.

The estimates from the regression model (as well as more detailed analyses of nine countries in Southern and Eastern Africa (Moultrie *et al.* 2009)) show that the lengthening of birth intervals has been brought about largely by means of increased use of contraception. Birth intervals have lengthened most in the countries with the highest levels of contraceptive use. Moreover, as can been seen from Figure 4, which presents fitted estimates for parity two to four women aged 25–29 years for a different set of four example countries from across sub-Saharan Africa, the birth intervals of women who stated that they had not used a modern method of contraception by the time of the index birth have only increased slightly, while those of women who had used contraception, have increased by far more. Appendix Figure A7 shows that this is also true of the other sub-Saharan African countries analysed here. Thus, even though contraceptive use remains low across many countries in the region, the observed lengthening of birth intervals is largely attributable to the increased adoption of contraception.

It is a little surprising that the median birth intervals of women who have reportedly never used contraception at the time of an index birth have risen at least slightly in many countries. This could mean that our regression model is over-correcting for selection bias, so that past fertility is underestimated. However the same pattern has been noted in an application of the Brass-Juárez method to Zimbabwe (Sayi 2009). Therefore, this seems unlikely. It seems more likely that either other proximate determinants of birth interval length (for example, breastfeeding patterns, termination of pregnancy, increased spousal separation, or marital dissolution) are responsible, or that ever-use of modern contraceptive methods is underreported.

<Figure 4 about here>

The full results from the regression analysis (not shown) further confirm that parity and age are generally not significant determinants of birth interval length in the countries studied: the fitted coefficients for different parities and age groups respectively do not differ significantly from each other.

Implications for the African fertility transition

Nearly twenty years ago, Caldwell *et al.* (1992) proposed that the African fertility transition would be different from that undergone elsewhere in that fertility would decline at all ages and parities simultaneously as women and couples adopted modern contraceptive methods to achieve desired spacing intervals. The results presented here show that, as fertility has begun to fall in sub-Saharan Africa, birth intervals have indeed been lengthening, and have done so independently of either age or parity, in almost every country studied.

Johnson-Hanks (2007) rightly cautions against inferring individuals' aspirations and intentions from aggregate data, especially where the theoretical model used to divine those behaviours is imported from another cultural milieu. Using cohort data from the DHS, she shows that conventional diagnostics of natural and controlled fertility are misleading in the African countries she studied. Instead, drawing also on her ethnographic research, she argues that much African reproduction is characterized by a third, 'not intermediate, but frankly different' fertility regime (Johnson-Hanks 2007, p.1036), a family-building strategy that is determined in the face of adversity, unpredictability, or—in McNicoll's (1996) terminology—the absence of 'regularity'. Factors that might lead women to want to delay becoming pregnant might include concerns about relationship stability, their own and others' health, money, and housing (Timæus and Moultrie 2008).

This line of reasoning is similar to that advanced by us elsewhere to explain the evolution of exceptionally long birth intervals in South Africa:

> the pattern of change in birth intervals in South Africa is inconsistent with the hypothesis that parity-specific fertility limitation has been the dominant force driving the country's fertility transition. Most women's decisions to avoid childbearing have been contingent neither on their parity (i.e., limitation) nor on the age of their youngest child (i.e., spacing in the conventional sense). (Timæus and Moultrie 2008, p.502)

In the main, our and Johnson-Hanks' arguments are similar. The fairly strong parity effects in her results (c.f. Figures 8 and 9 of Johnson-Hanks (2007)) may arise because no control for calendar time appears to be included in her analysis. This distinction apart, her conclusions lend weight to ours: 'African women's birth intervals differ less by parity than do the intervals of European and North American women' (Johnson-Hanks 2007, p.1028).

Thus, a simple contrast between controlled and natural fertility may obscure more than it reveals in Africa; there is merit instead in trying to understand the dynamics of the African fertility transition in terms of stopping, spacing and postponing behaviours. The lengthening of birth intervals documented here clearly results from birth control: it is associated with ever-use of modern contraceptive methods and such long birth intervals will seldom occur 'naturally'. Equally clearly, it is not a birth control strategy aimed at limiting family sizes, but neither is it birth control contingent on the age of the youngest child. Postponement is a third birth control strategy. Even in South Africa, the country with the longest birth intervals, no evidence of widespread parity-specific family size limitation exists. As Johnson-Hanks (2007, p.1027) observes, '[a]pparently, the calculus of conscious choice can and does take a variety of forms, only one of which is parity-specific control.'

A number of analysts have suggested that the fertility decline in several African countries may have stalled, or at least slowed, in the last two decades. One possible explanation for this phenomenon might have been that the decline in fertility observed in those countries to date had been the consequence not of family size limitation but of sustained tempo effects brought about by increasing use of contraception to achieve longer birth intervals (Bongaarts and Feeney 1998; Bongaarts 1999). Had the pattern of increasing birth intervals levelled off, this would have provided a neat explanation and validation of the stalled fertility transition. Postponement, however, unlike spacing, is not a self-limiting phenomenon. The evidence presented here suggests that birth interval lengths have not levelled off either in the countries frequently cited as having stalled fertility declines (Ghana, Kenya and Zimbabwe) or in any other country studied. Thus, the explanation for the stall—if there is indeed one: Schoumaker (2009) makes a strong argument that such stalls may not have occurred in the first place—must lie in a different realm.

Equally, it is unlikely that the lengthening of birth intervals observed in the data is related somehow to the spread and prevalence of HIV. Most of the data from the birth history files analysed here predate by some time the advent of the HIV epidemic. Even in the high prevalence countries of Southern and Eastern Africa, birth intervals had lengthened markedly before AIDS became sufficiently widespread to have a significant impact on aggregate fecundability. Thus, while the investigation of fertility dynamics and childbearing strategies in populations experiencing HIV epidemics is a matter of great interest, it can explain only a small part of the lengthening of birth intervals across Africa, which has been concentrated largely among those women who have used modern methods of contraception.

The impact that spacing of childbearing contingent on the age of the youngest child can have on total fertility is limited. However, in several of the countries examined (South Africa, Zimbabwe, Namibia, Lesotho, and Ghana), recent median birth intervals have increased to four years or more. It is difficult to account for intervals of this length by an increased preference for birth spacing since that would imply that caring for young children dissuades women from getting pregnant long after those children have been weaned and learnt to walk. Our proposal is rather that they are postponing having another baby for other reasons—the 'third way' alluded to by Johnson-Hanks. (The impression of postponement cannot arise as a consequence of the mixing of groups of stoppers and spacers in any given population since, as we have noted before, 'to emulate postponement requires a population comprised almost exclusively of limiters at early durations and of spacers at the longest durations' (Timæus and Moultrie 2008, note 7)).

Birth intervals in South Africa and Namibia are considerably longer than elsewhere in the region and these findings leave unanswered the question of whether these two countries are distinctively different from other countries in sub-Saharan Africa, or whether they are harbingers of future changes in fertility and family formation elsewhere in the region. Nevertheless, the fact that, across the 24 countries studied, median birth intervals have lengthened largely independently of either age or parity provides empirical support for our contention that the African fertility transition is distinctively different.

Is Africa different?

Is the pattern unique to Africa? The limited historical data available for developed countries at the onset of their fertility transitions means that even less is known about these countries than those in developing countries today. Despite trenchant criticism from various perspectives (for example, Blake 1968; Szreter 1993; Santow 1995), much of the demographic literature still regards it as axiomatic that fertility decline is parity dependent (for example, Pressat and Wilson 1985; van de Walle 1992). Hence, data from other parts of the world analysed using the same techniques as outlined above should reveal a very different pattern of changes in birth intervals by time, age and parity.

A range of studies of historical Europe have found that reductions in fertility during the early part of the transition were concentrated at low parities (for example, Anderton and Bean 1985; Henry 1961; Knodel ;1987; Wrigley *et al.* 1997). One study whose results we can present in a way that enables them to be compared with those from Africa comes from early twentieth century Spain. Reher and Sanz-Gimeno (2007) analysed administrative data from Aranjuez and present data on median birth intervals. Reading their data points and recasting them in the way adopted here shows that, in this setting, birth intervals after about 1925 lengthened much more at older ages and higher parities than among women in the early stages of family building (Figure 5). Such a pattern conforms to the conventional understanding of a transition from natural to controlled fertility implicitly assumed in much of the demographic literature. While high-quality demographic data of the sort available from the DHS programme in developing countries do not exist for historical developed country populations, the data from Spain and elsewhere suggest that the African experience may be markedly different from that of transitional Europe.

<Figure 5 about here>

A second, contemporary, source of comparative data comes from the DHS surveys conducted in four countries elsewhere in the developing world, analysed in exactly the same way as the sub-Saharan African countries. Results are presented in Figure 6 from Egypt, Peru, the Philippines and Vietnam. This heterogenous group of countries all show a markedly different dynamic from that of the countries presented in Figure 3 and Appendix Figures A1-A6. Clearly, age and parity are important in determining the length of birth intervals and, in the case of the data from Vietnam, the Philippines and Peru, indicate that the lengthening of birth intervals levelled off at about 40 months. The data for Egypt are somewhat more complicated with some women now having intervals as long as those observed in other African countries. However, this population is best described as having very large differentials in birth intervals by parity combined with a modest increase in interval length over time. This is the reverse of the pattern of change characteristic of sub-Saharan Africa demonstrated earlier.

<Figure 6 about here>

No horizontal asymptote in the length of the median birth interval equivalent to that seen in Vietnam, Peru or the Philippines has emerged in the African countries with the longest median birth intervals, let alone other African countries. Thus, based on the experience of contemporary developing countries outside sub-Saharan Africa, it appears that the African fertility transition is indeed distinctive. If women are postponing births, there is no necessary reason why median birth intervals in other African countries could not rise to, or exceed, the durations already observed in Southern Africa. However, to the extent that fertility decline is being driven by the spacing of their births, it may be a self-limiting process. Thus, the distinction between spacing and postponement has important implications for the future trend in fertility and population growth in Africa.

Conclusions

The analysis presented here confirms that the pattern of birth intervals described in our earlier papers on South African fertility is not an artefact of the methods of analysis employed: the regression-based approach to controlling for selection in the DHS birth histories produces results essentially identical to those produced by applying the Brass-Juárez method.

Although there is huge variation in the overall level of fertility across sub-Saharan Africa (with total fertility ranging from nearly eight children per woman in Niger to around 2.3 in South Africa), across both space and time, in very different social, political, economic and cultural conditions, and in almost every country studied, birth intervals are largely independent of mother's age and parity. By contrast, data from selected developing countries in other regions, and from Europe early in its fertility transition, exhibit very different patterns.

Caldwell *et al.* (1992) speculated that the African fertility transition would run a somewhat different course from that observed elsewhere in the developing world—that fertility change would happen at all ages and parities simultaneously. Across the region, wherever fertility has begun to change, this pattern is evident in our results. This suggests that the sub-Saharan African fertility transition is currently being driven by postponement and is following a fundamentally different path from earlier fertility transitions.

Notes

1. Tom Moultrie is Associate Professor of Demography at the Centre for Actuarial Research, University of Cape Town, South Africa. Email: tom.moultrie@uct.ac.za. Takudzwa Sayi is a graduate student at Princeton University. At the time of preparation and writing of the original manuscript, she was a Research Assistant at the Centre for Actuarial Research, University of Cape Town, South Africa. Ian Timæus is Professor of Demography, Population Studies Group, London School of Hygiene & Tropical Medicine, United Kingdom.

2. Earlier versions of this paper were presented at the XXVI IUSSP International Population Conference in Marrakech (2009) and the PAA Annual Meeting in Dallas (2010). We thank the discussant and participants at those two meetings, as well as three anonymous reviewers for this Journal whose insights have improved the paper greatly.

References

Agadjanian, Victor. 2005. Fraught with ambivalence: Reproductive intentions and contraceptive choices in a sub-Saharan fertility transition, *Population Research and Policy Review* 24(6): 617-645.

Anderton, Douglas L. and Lee L. Bean. 1985. Birth spacing and fertility limitation: A behavioral analysis of a nineteenth century frontier population, *Demography* 22(2): 169-183.

Aoun, Samar. 1989a. *An Assessment of the Paired Comparison Procedure for Measuring Early Changes in Fertility in Syria, Tunisia and Yemen Arab Republic.* Centre for Population Studies Research Paper 89-2. London: Centre for Population Studies, London School of Hygiene & Tropical Medicine.

Aoun, Samar. 1989b. A Comparative Study of Fertility Change in Tunisia, Syria and Yemen AR. Unpublished PhD thesis, University of London, London.

Berrington, Ann. 2004. Perpetual postponers? Women's, men's and couple's fertility intentions and subsequent fertility behaviour, *Population Trends*(117): 9-19.

Blake, Judith. 1968. Are babies consumer durables? A critique of the economic theory of reproductive motivation, *Population Studies* 22(1): 5-25.

Bledsoe, Caroline, Fatoumatta Banja, and Allan G. Hill. 1998. Reproductive mishaps and Western contraception: An African challenge to fertility theory, *Population and Development Review* 24(1): 15-57.

Bongaarts, John. 1999. The fertility impact of changes in the timing of childbearing in the developing world, *Population Studies* 53(3): 277-289.

Bongaarts, John and Griffith Feeney. 1998. On the quantum and tempo of fertility, *Population and Development Review* 24(2): 271-291.

Breton, Didier, France Prioux and Catriona Dutreuilh. 2005. Two children or three?: Influence of family policy and sociodemographic factors. *Population (English Edition)* 60(4): 415-445.

Brass, William and Fatima Juárez. 1983. Censored cohort parity progression ratios from birth histories, *Asian and Pacific Census Forum* 10(1): 5-12.

Caldwell, John C., Israel O. Orubuloye, and Pat Caldwell. 1992. Fertility decline in Africa: A new type of transition?, *Population and Development Review* 18(2): 211-242.

De Cooman, Eric, John Ermisch and Heather Joshi. 1987. The next birth and the labour market: A dynamic model of births in England and Wales. *Population Studies* 41(2): 237-268.

Henry, Louis. 1961. Some data on natural fertility, *Eugenics Quarterly* 8(2): 81-91.

Friedlander, Dov, Zvi Eisenbach and Calvin Goldscheider. 1980. Family-size limitation and birth spacing: The fertility transition of African and Asian immigrants in Israel. *Population and Development Review* 6(4): 581-593.

Hobcraft, John and John McDonald. 1984. *Birth Intervals.* WFS Comparative Studies 28. Voorburg, Netherlands: International Statistical Institute.

Hobcraft, John and Germán Rodríguez. 1992. Methodological Issues in the Life Table Analysis of Birth Histories, in A. G. Hill and W. Brass (eds.), *The Analysis of Maternity Histories.* Liège, Belgium: IUSSP, pp. 53-95.

Johnson-Hanks, Jennifer. 2004. Uncertainty and the second space: Modern birth timing and the dilemma of education, *European Journal of Population* 20(4): 351-373.

Johnson-Hanks, Jennifer. 2007. Natural intentions: Fertility decline in the African Demographic and Health Surveys, *American Journal of Sociology* 112(4): 1008-1043.

Knodel, John. 1987. Starting, stopping and spacing during the early stages of fertility transition: the experience of German village populations in the 18th and 19th centuries, *Demography* 24(2): 143-162.

Lightbourne, Robert E. 1985. Individual preferences and fertility behaviour, in J. Cleland and J. Hobcraft (eds.), *Reproductive Change in Developing Countries: Insights from the World Fertility Survey.* Oxford: Oxford University Press, pp. 165-198.

McNicoll, Geoffrey. 1996. *Governance of Fertility Transition: Regularity and Duress*. Policy Research Division Working Paper No.85. New York: Population Council.

Moultrie, Tom A., Takudzwa S. Sayi, and Ian M. Timæus. 2009. Stopping, spacing and postponing: African patterns of fertility decline. Paper presented at the *XXVI IUSSP International Population Conference*. Marrakech, Morocco, 27 September - 2 October 2009.

Moultrie, Tom A. and Ian M. Timæus. 2002. *Trends in South African Fertility between 1970 and 1998: An Analysis of the 1996 Census and the 1998 Demographic and Health Survey*. Cape Town: Medical Research Council. Available http://www.mrc.ac.za/bod/trends.pdf. Accessed 1 May 2011.

Moultrie, Tom A. and Ian M. Timæus. 2003. The South African fertility decline: Evidence from two censuses and a Demographic and Health Survey, *Population Studies* 57(3): 265-283.

Page, Hilary J. and Ron Lesthaeghe (eds.). 1981. *Child-spacing in Tropical Africa: Traditions and Change*. London: Academic Press.

Potter, Robert G. 1963. Birth intervals: Structure and change, *Population Studies* 17(2): 155-166.

Pressat, Roland and Christopher Wilson (eds.). 1985. *The Dictionary of Demography*. Oxford: Blackwell.

Rallu, Jean-Louis and Laurent Toulemon. 1994. Period fertility measures: The construction of different indices and their application to France, 1946-89, *Population: An English Selection* 6: 59-93.

Reher, David Sven and Alberto Sanz-Gimeno. 2007. Rethinking historical reproductive change: Insights from longitudinal data for a Spanish town, *Population and Development Review* 33(4): 703-727.

Retherford, Robert D., Naohiro Ogawa, Riyika Matsukura, and Hassan Eini-Zinab. 2010. Multivariate analysis of parity progression-based measures of the total fertility rate and its components, *Demography* 47(1): 97-124.

Rindfuss, Ronald R., James A. Palmore, and Larry L. Bumpass. 1982. Selectivity and the analysis of birth intervals from survey data, *Asian and Pacific Census Forum* 8(3): 5-6,8-10,15-16.

Rodríguez, Germán and John Hobcraft. 1980. *Illustrative Analysis: Life Table Analysis of Birth Intervals in Colombia*. WFS Scientific Reports No. 16. Voorburg, Netherlands: International Statistical Institute.

Rodríguez, Germán, John Hobcraft, John McDonald, Jane Menken, and James Trussell. 1984. *A Comparative Analysis of Determinants of Birth Intervals*. WFS Comparative Studies 30. Voorburg, Netherlands: International Statistical Institute.

Rutstein, Shea and Guillermo Rojas. 2003. *Guide to DHS Statistics*. Calverton, MD: ORC Macro.

Santow, Gigi. 1995. Coitus interruptus and the control of natural fertility, *Population Studies* 49(1): 19-43.

Sayi, Takudzwa S. 2009. Fertility, birth intervals, and their proximate determinants in Zimbabwe. Unpublished MPhil thesis, University of Cape Town, Cape Town.

Schoumaker, Bruno. 2009. *Stalls and Reversals in Fertility Transitions in sub-Saharan Africa: Real or Spurious?* Documents de Travail du SPED [SPED Working Paper], Number 30. Louvain-la-Neuve: Université catholique de Louvain. Available: http://www.ucl.be/cps/ucl/doc/demo/documents/DT_SPED_30_corrige.pdf Accessed 6 May 2011

Schoumaker, Bruno. 2010. Reconstructing fertility trends in sub-Saharan Africa by combining multiple surveys affected by data quality problems Paper presented at the *Population Association of America 2010 Annual Meeting*. Dallas, TX, April 15-17, 2010.

Schoumaker, Bruno. 2011. Omissions of births in DHS birth histories in sub-Saharan Africa: Measurement and determinants Paper presented at the *Population Association of America 2011 Annual Meeting*. Washington D.C., March 31 - April 2, 2011.

Szreter, Simon. 1993. The idea of demographic transition and the study of fertility change: a critical intellectual history, *Population and Development Review* 19(4): 659-701.

Timæus, Ian M. and Tom A. Moultrie. 2008. On postponement and birth intervals, *Population and Development Review* 34(3): 483-510.

van de Walle, Etienne. 1992. Fertility transition, conscious choice, and numeracy, *Demography* 29(4): 487-502.

Ware, Helen. 1976. Motivations for the use of birth control: evidence from West Africa, *Demography* 13(4): 479-493.

Wrigley, E.A., R.S. Davies, J.E. Oeppen, and R.S. Schofield (eds.). 1997. *English Population History from Family Reconstitution 1580–1837*. Cambridge: Cambridge University Press.

Yamaguchi, Kazuo. 1991. *Event History Analysis*. Applied Social Research Methods Series. London: Sage Publications.

<APPENDIX FIGURES HERE>