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Childbearing Trajectories in a West African Setting: A Sequence Analysis Approach

Hilde Bras, Adrien Remund, and Valérie Delaunay

ABSTRACT The lagging fertility transition in West Africa has important repercussions for global population growth but remains poorly understood. Inspired by Caldwell and colleagues' fertility transition framework, as well as by subsequent research, we examine diversity in women's holistic childbearing trajectories in Niakhar, Senegal, between the early 1960s and 2018 using a sequence analysis approach. We evaluate the prevalence of different trajectories, their contribution to overall fertility levels, and their association with women's socioeconomic and cultural characteristics. Four trajectories were observed: "high fertility," "delayed entry," "truncated," and "short." While the high fertility trajectory was most prevalent across cohorts, delayed entry grew in importance. The high fertility trajectory was more common among women born between 1960 and 1969 and was followed less often by divorced women and those from polygynous households. Women with primary education and those from higher status groups were more likely to experience delayed entry. The truncated trajectory was associated with lack of economic wealth, polygynous households, and caste membership. A short trajectory was related to lack of agropastoral wealth, divorce, and possibly secondary sterility. Our study advances knowledge on fertility transitions in Niakhar—and Sahelian West African contexts more generally—by showing the diversity of childbearing trajectories within high fertility regional contexts.

KEYWORDS Fertility transition • Childbearing trajectories • Sequence analysis • West Africa • Sub-Saharan Africa

Introduction

While most regions in sub-Saharan Africa have started to experience fertility decline, in some parts, most notably in West Africa, fertility has remained persistently high (Bongaarts 2017; Bongaarts and Casterline 2013; Garbett et al. 2021; Mbacké 2017; Timæus and Moultrie 2020). In an influential article, Caldwell and colleagues (1992) argued that African fertility transitions should be thought of as a new type of transition, distinct from Asian and European ones. First, fertility reductions would take place among women of all ages, across the entire age schedule. Second, African transitions would be characterized by young adult women postponing first childbearing to stay

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longer in school, which could act as a bridge to work in the modern sector. Third, fertility decline would result mainly from women's efforts to lengthen birth intervals by using contraception to substitute for abstinence, rather than from limiting childbearing. At the same time, however, women would still have large families, which could be explained by the importance of descent lineage, polygyny, the material benefits of large families, and weak family planning programs, resulting in different constraints on premarital and extramarital sexuality, differences in marital stability, and different emphases on the need and reasons for birth spacing (Caldwell et al. 1992).

Caldwell and colleagues' (1992) propositions have sparked much research on various African countries. Yet, little attention has been devoted to the diversity that may exist within societies. For instance, women in Niger between 2010 and 2015 bore an average of 7.4 children, a high level of fertility that has remained stable for decades (Spoorenberg and Maga 2018). However, recent research reveals that certain groups of Nigerien women have started to postpone first childbearing, leading to a compression of fertility at higher ages (Spoorenberg and Maga 2018). The case of Niger illustrates that subpopulations may practice varying reproductive strategies but reach similar high levels of fertility. Hence, high fertility—like low fertility—is a composite that consists of various subpopulations with different reproductive cultures around timing of first childbirth, spacing, and last birth. Compositional demography focuses on such diversity and contends that to understand fertility transitions, or their lagging behind, more subtle modes of analysis are needed, which are directed to the subpopulations from which these patterns have emerged (Bras 2021; Kreager 2011; Kreager et al. 2019; Szreter and Garrett 2000). Our aim in this article is to trace such diversity in a West African regional setting characterized by lagging fertility decline. What different childbearing trajectories can be discerned, how do these trajectories contribute to overall fertility levels, and in what ways are they associated with different socioeconomic and cultural characteristics of women and their households?

In the following section, we summarize the debate on reproductive management and introduce our approach. Next, we describe the historical, socioeconomic, and cultural context of the Senegalese Niakhar region for which we analyze childbearing trajectories of cohorts of women born between 1948 and 1978. We then describe our data, measures, and methods. Exploiting sequence analysis and cluster analysis, we generate four types of childbearing trajectories from the data, trace historical changes in their prevalence between the early 1960s and 2018, study the relation between these trajectories and aggregate patterns of fertility change using a decomposition analysis, and gauge the association between cluster membership and women's individual and household characteristics. Finally, we evaluate the empirical and theoretical payoff of examining diversity in childbearing trajectories for understanding the lagging fertility transition in Niakhar and in Sahelian West African contexts more generally.

Background

The Debate on Reproductive Management

Following research by the European Fertility Project (EFP) on the historical European fertility decline in the 1980s, a debate developed about whether fertility transitions could be accounted for by couples increasing the intervals between births ("spacing") (Anderton and Bean 1985; Santow 1995; Szreter and Garrett 2000; Van Bavel 2004; Van Bavel and Kok 2004) or by limiting childbearing at younger ages ("stopping") (Knodel 1987; Knodel and van de Walle 1979). Stopping behavior at a certain age was thought to result from the spread of novel contraceptive behaviors (mainly withdrawal) (Knodel 1987; Knodel and van de Walle 1979) or from the diffusion of new attitudes toward having children (Aries 1980; Caldwell 1982). Couples achieved spacing by intentionally lengthening birth intervals until their previous child had reached a certain age or developmental milestone, such as weaning or walking (Anderton and Bean 1985; Santow 1995; Szreter and Garrett 2000; Van Bavel 2004; Van Bavel and Kok 2004).

The debate reemerged in the 1990s in response to the lagging fertility decline in sub-Saharan Africa, which was described as "a new type of transition" (Caldwell et al. 1992). According to Caldwell and colleagues (1992), fertility transitions in African societies could be characterized by the use of modern contraceptives for later starting and spacing of childbearing by all ages of women, who still wanted large families. In the subsequent literature, Timæus and Moultrie (2008) introduced the notion of "postponement" to describe fertility control that is neither stopping nor spacing. In their research, they observed women who postponed pregnancy and childbearing for long periods, resulting in median birth intervals of up to five years. While spacing is a scheduled form of reproductive management, postponement is characterized by ad hoc behavior. It reflects a desire to avoid childbearing without clear goals for long-term fertility and is related to the uncertainties and constraints that women encounter in different spheres of life, including financial precariousness, housing shortages, health-related matters, and family and relationship problems (Hayford and Agadjanian 2019; Moultrie et al. 2012; Timæus and Moultrie 2008). In line with this, the term "curtailment" was coined to characterize the reproductive behavior of women who stop childbearing for nondemographic reasons—that is, without targeting a particular family size (Timæus and Moultrie 2020).

Since the start of the debate, there has been disagreement about the methods to detect different forms of reproductive management (Friedlander et al. 1999; Timæus and Moultrie 2008). Initially, the EFP researchers developed a set of standard measures to detect fertility control: the Coale–Trussell model (Coale and Trussel 1974, 1978). They separated age-specific marital fertility rates into two components: the level of marital fertility relative to the natural fertility standard (M) and the extent of deliberate control at later parities (m). The m parameter was interpreted as a measure of the extent of family limitation—namely, deliberate control of marital fertility to obtain desired family size. It became the standard measurement of fertility control but was unable to detect spacing or other forms of fertility control (Van Bavel 2004). Moreover, these measures, which were designed for cross-sectional aggregate data, were unable to unravel the mechanisms of spacing and stopping at the individual level. The longitudinal individual-level studies, which analyzed birth intervals using event-history analysis (Tsuya et al. 2010; Van Bavel 2004; Van Bavel and Kok 2004), were an improvement. Despite this more flexible method, it remained difficult to disentangle spacing and stopping. Subsequently, Alter (2007, 2016) and Cilliers and Mariotti (2021) applied the cure model to separately measure spacing and stopping and their associated factors in one model. In an impressive study using survival analysis and period measures of parity progression, Timæus and Moultrie (2020) categorized 83 low-income countries according to the predominant form of stopping (limitation, curtailment, or mixed) and the degree of postponement or spacing during the last 50 years.

Strikingly, most studies within this literature have focused on the timing of single markers of reproduction, such as first birth, last birth, and birth intervals. Yet, societal changes affect reproductive careers as a whole, not just the separate transitions of which they are part. The notion of trajectories or "social pathways" (Bras et al. 2010; Elder et al. 2003; Macmillan 2005) captures this idea of life course dynamics that take place over extended periods of (life)time. Moreover, the endogenous causality (Mayer 1987), or biographic opportunity costs (Birg et al. 1991; Schumacher et al. 2013), of life courses is better examined by investigating holistic trajectories than through the study of separate events.

A Trajectory-Based Approach

Here, we propose an alternative method to understand the diversity in childbearing patterns, which involves changing the unit of analysis from childbearing "events" to childbearing "trajectories." Trajectories are holistic series of events and states that may, for instance, cover women's entire reproductive life span. A trajectory-based approach captures life course dynamics that take place over extended periods (Elder et al. 2003; Macmillan 2005). It has become an established method for studying demographic phenomena (Barban and Sironi 2019), for instance, pathways of household formation, migration trajectories, and occupational careers (Bras et al. 2010; Elder 1994; Elder et al. 2003; Giele and Elder 1998; Huinink and Kohli 2014). Surprisingly, it has rarely been applied to investigate fertility, although recently a number of studies on reproductive trajectories have appeared (Bras and Schumacher 2019; Darak et al. 2015; Schumacher et al. 2013).

By studying childbearing in terms of trajectories instead of separate events, we can gauge the multiple behavioral components of transitional fertility at the same time: starting, spacing, stopping, postponing, and curtailing. As we inductively generate these trajectories from the data, in principle, myriad types of trajectory can emerge from our analysis. Hence, by uncovering diversity in women's reproductive trajectories and associated factors, we aim to advance understanding of the lagging fertility transition in the region.

Setting

Our analysis focuses on Senegal's Niakhar region, located in the larger rural Fatick (formerly Sine-Saloum) region, 135 kilometers east of Dakar. The study site of the Niakhar Health and Demographic Surveillance Study (HDSS) covers 203 square kilometers, is situated in the Sahelian-Sudanese climatic zone, and suffers from frequent droughts. Eight villages have been under continuous surveillance since 1962; another 30 villages were added in 1983. Although the region is rural, the three largest villages can be considered semi-urban, with health facilities, a weekly market, and daily buses to Dakar (Delaunay et al. 2013; Delaunay et al. 2002).

The Sine-Saloum region was one of the cradles of capitalist development of groundnut culture in Senegal under French colonial rule, when the area underwent deep economic and social changes (Klein 1968; Yade 2007). The Serer ethnic group—comprising 97% of the population—traditionally practiced an intensive two-field system of agriculture, whereby one field was devoted to millet and the other was left fallow and used to pasture cattle. With the development of the groundnut trade, groundnuts were planted third in rotation (Klein 1968). The economic development of the region during colonial rule changed the laboring roles of men and women, as well as gender relations. Men started to exploit small plots where they cultivated food crops (cowpeas, hibiscus, and rice) on their own separate income account, while women ran small businesses (Yade 2007). Serer peasants also kept cattle to manure their fields, and the successful peasant's surplus went into purchasing more cattle (Klein 1968).

Since the 1970s, however, the region has experienced stagnating agricultural resources and declining rainfall, resulting in subsistence crises. A drop in groundnut prices, reduction in state subsidies, limitation of credit for the purchase of inputs and agricultural equipment, and lack of infrastructure, all of which slow commercial exchanges, have together put a brake on the development of commercial agriculture (Adjamagbo and Delaunay 2018:199). Therefore, seasonal migration to the cities—particularly Dakar—has intensified (Adjamagbo and Delaunay 2018). For instance, in 2000, 40% of all adult men and 26% of adult women spent several months per year away from the area for seasonal migration (Wade et al. 2005).

The Serer people, like many West African ethnic groups, have traditionally been a socially stratified society with distinct status groupings of nobles, free peasants, and caste groups, including griots (bards) and artisans (metal, weaving, pottery, leather, and wood workers) (Adjamagbo and Delaunay 2018; Klein 1968; Tamari 1991). The bilateral kinship system and former practice of matrilineal inheritance uniquely characterize the Serer (Klein 1968). In religious terms, Niakhar is more diverse than other Senegalese regions, comprising Muslims (76%), Christians (21%), and groups adhering to African traditional religions (Bousmah 2017). The matrimonial system is polygamous, with half of all married women in 2000 being in a polygamous union (Wade et al. 2005). The age at marriage—on average 18 years for women and 25 years for men in 1984—has steadily increased over recent decades (Adjamagbo and Delaunay 2018). Consequently, premarital sexual behavior has risen, although the norm among the Serer is to remain celibate until marriage. Marriages have become more often "enforced," with wives being pregnant before marriage (Adjamagbo and Delaunay 2018). Divorce and remarriage remain frequent in the region, as they are in Senegal in general (Bouland 2021; Lemardeley et al. 1995).

Marital fertility in the Niakhar region has been high on average since the 1960s, although a slight decrease has set in since the 1990s. The average total fertility rate (TFR) was 6.9 children per woman between 1963 and 1967, reached a peak of 7.9 between 1984 and 1988, and decreased to 6.4 by 2009–2011 (Buiatti 2012). In the larger Fatick region, the prevalence of contraceptive use was low, with less than 2% of women in 1999 using modern methods (Delaunay et al. 2013), but increased to 10% by 2010 (Adjamagbo and Delaunay 2018). In the mid-1990s, Niakhar was not severely afflicted by HIV. The incidence of STDs was high, however, and was found to be related to the number of previous marriages and urban migrations (Lemardeley et al. 1995).

The situation in the Niakhar region—characterized by an increase in seasonal urban migration of young people in the 1980s and 2000s—is similar to other West African Sahelian contexts, such as Mali (Hertrich and Lesclingand 2013), where population growth is strong and environmental constraints dim future prospects. However, compared with some rural areas that have experienced extensive rural exodus, the Serer of the Niakhar region are characterized by a strong attachment to the land (Lericollais 1992, 1999). Although young people migrate to look for work, they maintain strong ties with the village by contributing to the survival of families and the development of the village.

Data and Methods

Data

The Niakhar HDSS was founded in 1962 and is still active today—one of the oldest demographic laboratories in sub-Saharan Africa, providing high-quality longitudinal microdata (Delaunay et al. 2013; Delaunay et al. 2002). For each resident, it collects individual, household, and compound information, and identifies residents' parents, relationship to the household head, and spousal relationships. Births, deaths, migrations, and pregnancies are systematically recorded every four months, on average. Individual characteristics (sex, age, ethnic group, religion, and marital status) are collected as well. The database also includes two indicators of socioeconomic status at the household level (economic wealth and agropastoral wealth).

Women who out-migrate from the region for 11 months or more without returning are lost from observation; however, if they return to Niakhar for at least one month per year, they are still considered resident and all their births—even those that took place elsewhere—are registered. Hence, the sample comprises sedentary women as well as those active in seasonal migration—the most common form of mobility in this region (Adjamagbo and Delaunay 2018).

We used the 2018 release of the Niakhar HDSS, which contains data for 2,586 women born between 1948 and 2002 and observed from age 15. We selected women born before 1978 (i.e., aged 40 at the last observation in 2018), which led to a final sample of 621. This threshold reflects a compromise between trajectory completion and sample size. If we had selected women observed until age 50, the sample would have been reduced to 247 trajectories, of which only 205 were complete. If we had expanded to women observed until age 35, the sample would have increased to 1,030 trajectories, of which 952 were complete; however, by doing so, we would have missed a significant part of the end of childbearing trajectories. Stopping the observation at age 40 allowed us to observe women almost up to the end of their reproductive careers, while maintaining a large enough sample size to conduct regression analyses. The age-specific number of children ever born by cohort supports this choice in the sense that, at age 40, most cohorts had reached their final cohort TFR (cTFR). This might not be completely true for the most recent cohorts (1968–1972 and 1973–1978), but in the case of the former, an average of only 0.5 children were born after age 40. Thus, we are covering almost the entire reproductive career.

Measures

Our dependent variable reflects different types of childbearing trajectories, the construction and analysis of which were carried out with the tools of state sequence analysis (Ritschard and Studer 2018). Each woman's childbearing trajectory is characterized by 26 yearly states, from age 15 to age 40, describing her current childbearing status. Instead of considering each parity as a specific state, we reduced the number of possible states to four: the "silent phase" before the first birth; "active childbearing," which corresponds to having a child in the last 12 months; "birth interval," which corresponds to being between two births; and the "stopping phase," when the current number of children is equal to the final number of children. This choice was dictated by theoretical and practical considerations. Theoretically, these states are reflecting the five mechanisms previously found to shape childbearing histories (starting, spacing, stopping, postponing, and curtailing) and to eventually produce the parities and completed family size.

Practically, in sequence analysis, it is generally advisable to avoid handling too many different states. Accounting for all possible parities would lead to 17 states (15 parities + silent + stop) and would thus mean distinguishing sequences mostly on whether they include the highest (and rarest) birth orders. Hence, working on parities would reduce the complexity of reproductive careers to the single dimension of maximum family size.

Figure 1 displays four actual examples of childbearing histories encoded as state sequences. Woman 49 stayed only one year in the silent phase and had her first child at the age of 16 (i.e., between her 16th and 17th birthdays). She then experienced a two-year birth interval before having her second child at age 19, and followed almost exactly the same rhythm until the age of 39, when she had her ninth and last child. At the age of 40, she had reached her final family size. Woman 225 spent a longer period in the silent phase, having her first child at age 21. She had two years until her next birth and followed practically the same rhythm until age 38, when she had the last of her seven children and then entered the stopping phase of her trajectory at age 39. Woman 206 also had seven children in total but started and finished earlier (ages 18 and 35, respectively). Finally, Woman 482 had only four children. Similar to Woman 225, she experienced a relatively long silent phase and had her first child at age 21; however, her childbirth trajectory lasted only 10 years, as she had her last child at age 31 and then entered the stopping phase. Of these four women, she is the only one who experienced more than two successive years without a birth—between her third and fourth children.

We included several independent variables related to the woman herself and her household. Women's characteristics included birth cohort, religion (Muslim, Catholic, Protestant, and traditional African religion), highest educational level (Koranic school, primary school, secondary school or higher, or no education), and migration status (whether she migrated before age 15). Given that Serer society is a polygynous society in which wife inheritance (levirate) is common (Garenne and Van de Walle 1989), women may live together in a compound with (many) cowives. Because the data set did not include information on women's (changing) rank in polygamous marriages, we included a variable that measured the average number of women in the compound where the index woman resided during her reproductive trajectory.

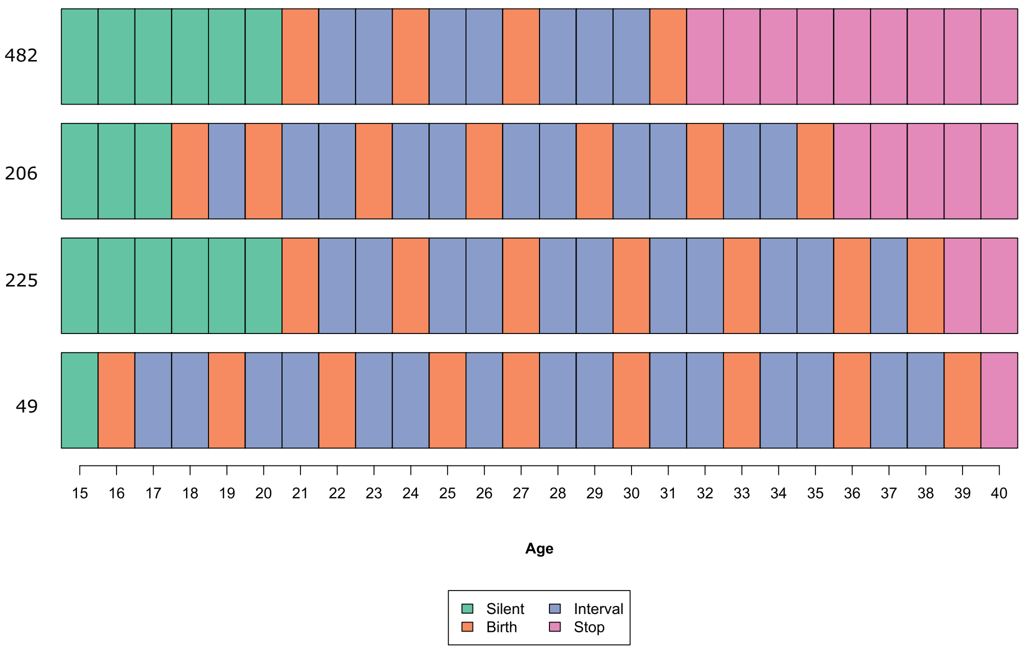

Fig. 1 Four examples of childbearing trajectories

Because previous research has found that postponement can be related to the breakup of relationships because of a husband's death or divorce (Hayford and Agadjanian 2019), we also included two dummy variables that capture whether women were divorced or became widowed during their reproductive life span. In addition, a caste variable was included to measure the legally banned but still influential social stratification in this rural population (Klein 1968; Ross 2008). The variable distinguishes between free peasants; (semi)noble groups (Koumakh, DB Tiédo, Dep DB); and caste groups, including griots and artisans, as well as non-Serer people.

The HDSS data contain variables of household economic wealth and household agropastoral wealth. These variables are based on information about households' belongings, which was collected through a dedicated questionnaire in 2003 (Adesu and Houngbegnon 2012); the variables were constructed using multiple correspondence analysis (MCA). The 12 variables contributing to the economic wealth indicator include measures of access to water and toilets, quality of building materials, and possession of household goods (e.g., television, phone, cooking plate, solar panels). The nine variables contributing to the agropastoral wealth indicator relate to the possession of tools (e.g., cart, hoe) and animals (e.g., horse, cattle). Both indicators are weighted averages based on the loadings of the MCA and are standardized to fall within a range of 0–1. They measure distinct aspects of wealth, as shown by their weak correlation, which apply to different types of households that depend on agriculture for their living or not. Important for us, while economic wealth is negatively associated with the number of children, agropastoral wealth shows a positive association (Delaunay 2017). This difference probably reflects the importance of children in the workload of pastoral households. This indicator, which was available only for

Table 1 Descriptive statistics of data and variables

	Mean/Proportion	Standard Deviation
Birth Cohort		
1948–1959	.21	
1960–1969	.22	
1970–1973	.28	
1974–1977	.30	
Religion		
Muslim	.76	
Catholic	.17	
Protestant	.04	
Traditional African religion	.03	
Caste		
Free peasants	.77	
Koumakh	.21	
DB Tiédo	.10	
Dep DB	.04	
Griots	.03	
Artisans	.08	
Non-Serer	.05	
Unknown	.03	
Education		
None	.87	
Koranic school	.03	
Primary school	.09	
Secondary school or more	.02	
Migration Before Age 15	.09	
Economic Wealth	0.14	0.19
Agropastoral Wealth	0.70	0.22
Mean Number of Women in Compound	7.39	5.37
Divorced	.04	
Widowed	.03	
N Trajectories	621	
N Trajectories With All Independent Variables	615	

Source: Niakhar database (release 2018).

2003, measures wealth in the household of residence—that is, the marital household. Although it measures wealth at different ages across birth cohorts (ages 25–55), in this rural context, socioeconomic positions are unlikely to change dramatically after the transition to adulthood.

Table 1 shows that more than three-quarters of all women in our sample were Muslim, a sizable minority were Catholic (17%), and much smaller proportions were Protestant or members of traditional African religions. About 9% of all women migrated before the age of 15. Almost 87% had no education; 9% had primary education, 3% had attended Koranic school, and 2% had secondary education or more. The mean number of women (cowives and others) with whom index women coresided during their reproductive lives was 7.4. Some 4% of women had experienced a divorce; this percentage is low because of selection, given that divorced women always migrate outside the household—and often outside the surveillance system.

Almost 3% of women experienced the death of a husband between ages 15 and 40. About three fourths of women came from households belonging to the free peasants group, 21% lived in the Koumakh group, 10% in the DB Tiédo group, and 4% in the Dep DB group. Some 8% of all women belonged to the artisan caste and 3% to the griot caste. Households had an average economic wealth score of 0.14, while their average agropastoral wealth score was 0.70.

Analysis

In recent decades, sequence analysis has become a popular technique to analyze biographies, in complement to event-history analysis, and its contribution to demography is now firmly established (e.g., Barban and Sironi 2019; Bras et al. 2010).[1] Although many procedures can be used to study state sequences, the most common consists of three steps: (1) computing distances between sequences, (2) using these distances to group the sequences into homogeneous and meaningful types using cluster analysis, and (3) studying the association of explanatory variables with the membership of these groups.

In their meta-analysis, Studer and Ritschard (2016) identified dozens of different distance measures proposed over the years, which emphasize different characteristics of sequences. They underline three main characteristics: sequencing (states ordering), duration (time spent in each state), and timing (when—at what age—each state is experienced). In our case, sequencing does not matter because all birth histories have the same basic structure: each woman starts in the silent phase, then alternates between active childbearing and birth intervals, and ends with the stopping phase. We tested several distance metrics, some of them putting more emphasis on timing (Hamming distance), on duration (OMSpell), or equally on both (SVRspell). The metric providing the most meaningful clustering was by far the one most sensitive to duration, most likely because of the definition of our four states, in which timing of first and last births can be defined as duration. There is indeed a one-to-one relationship between the age at first and last birth and the duration of the silent and stopping phases, respectively. Moreover, sensitivity to duration is important to differentiate birth histories that are more or less affected by spacing or postponing behaviors. For these reasons, we computed the distances between sequences with the OMSpell metric, which is an extension of optimal matching, applied to spells of states (subsequences), and proposed by Studer and Ritschard (2016). We used a time-warping parameter $e=1$, substitution costs defined on the transition rates (min. = 0.65; max. = 2), and indel costs equal to 1. We computed the distance matrix with the TraMineR package in R (Gabadinho et al. 2011).

We used the resulting pairwise distances between sequences to identify clusters of similar birth histories. To this end, we used a hierarchical clustering technique (Ward), which has the advantage of providing objective criteria for the choice of the number of

[1] For those not familiar with sequence analysis, we refer to such methodological readings as Gabadinho and Ritschard (2016), Studer and Ritschard (2016), Studer (2013), and Gabadinho et al. (2011), and to applications to different life course dimensions, including fertility (Bras and Schumacher 2019; Darak et al. 2015).

clusters. According to the average silhouette width (ASW), which measures the homogeneity of the clusters and the distance between them, the solution with four clusters was clearly the best. The point biserial correlation, which computes Pearson's correlation between the pairwise distances and the pairwise cluster membership, suggested a possible other solution with six clusters, but this would have led to excessively small clusters. Thus, we cannot exclude that, even though all four clusters are meaningful; some could be further divided if we had a larger sample at our disposal. Finally, we compared our solution with the result of a similar four-cluster solution from a partition around medoids (PAM) technique. This showed similar results, but the Ward clusters were slightly more homogeneous, as measured by the ASW (essentially thanks to a better distinction of the cluster of short birth histories). We computed the cluster analysis with the WeightedCluster package in R (Studer 2013).

Using descriptive statistics, we calculated and visualized the percentage of women per cohort in each of the trajectories. To estimate the respective contribution of the cluster composition per cohort (i.e., the share of each type of trajectory in each cohort) and of changes in fertility levels within these clusters to the overall change in fertility levels across cohorts, we applied Kitagawa's decomposition technique on cohort- and cluster-specific mean numbers of children per woman (Kitagawa 1955). Finally, we used the results of the cluster analysis (i.e., the four clusters) as dependent variables in binary logistic regression analyses. Although, to a certain extent, this results in a loss of information, previous research has fruitfully employed the same analytic strategy (Barbiano di Belgiojoso and Terzera 2018; Bras and Schumacher 2019; Fulda 2016; Madero-Cabib 2015).

Results

Childbearing Trajectories

A four-cluster solution was retained, dividing reproductive trajectories into types that can be qualified as high fertility, delayed entry, truncated, and short (Table 2; see Figure A1 in the online appendix for a visual representation).

Cluster 1 contains women following the high fertility trajectory. What is striking in this cluster is the extremely long reproductive phase and the very short silent and stopping phases. On average, women following this pathway had a first child at age 17.2 and stopped at age 38.6. They bore the most children of all four trajectory groups, with an average of 8.8 by age 40. Compared with the three other trajectories, birth intervals in this group were the shortest, on average (mean, 2.7 years).

The delayed entry group comprises women who started childbearing at a somewhat later age (on average, 21.5 years). In terms of spacing and the end of their reproductive career, they did not differ much from women following the high fertility trajectory: on average, the delayed entry group had their last child at age 38.5 and a mean birth interval of 2.9 years. However, because of their later start, they reached an average final parity of 6.9 children—almost two fewer children than women in the high fertility group.

The third cluster—truncated—consists of women who bore on average 6.8 children, as many as those in the delayed entry group. Their mean age at the start of

Table 2 Characteristics of the different types of childbearing trajectories

Trajectory	Mean Age at First Birth	Mean Age at Last Birth	Mean Birth Interval (years)	Mean Parity	*n*
High Fertility	17.2	38.6	2.7	8.8	268
Delayed Entry	21.5	38.5	2.9	6.9	141
Truncated	17.0	34.4	3.0	6.8	163
Short	24.0	30.3	3.6	2.8	49

Source: Niakhar database (release 2018).

childbearing was 17.0 years (as young as the high fertility group) and their average birth interval was 3.0 years (similar to the delayed entry group). What is characteristic of this group, however, is the much longer stopping phase: women stopped childbearing around age 34.4, which is at least four years earlier than the high fertility and delayed entry groups. Note that this cluster's quality is the only problematic one, with an ASW of 0.06 (not shown), which means that it is quite heterogeneous. The comparison of our clustering with the one based on the PAM algorithm also showed that 90% of the disagreements concerned transfers between the high fertility and truncated clusters, which highlights the somewhat arbitrary threshold between late and early stopping.

Finally, women in the short trajectory cluster have both a long starting phase and a long stopping phase: on average, they started childbearing at age 24.0 and stopped at age 30.3 (only six years of childbearing). Moreover, their birth intervals are relatively long (on average, 3.6 years). Hence, it is not surprising that the completed fertility of these women (at age 40) was very low—an average of only 2.8 children.

The Role of Trajectory Types in the Change of Overall Fertility

Figure 2 depicts for each birth cohort the percentage of women in the different trajectories. The delayed entry trajectory became considerably more important across cohorts: whereas only 16% of all women in the oldest cohort experienced this pathway, more than a quarter of all women in the youngest cohort did. However, in the two latest cohorts, delayed entry as a pathway plateaued. At the same time, the high fertility trajectory rose in prevalence between the oldest and the second oldest cohorts and then declined steeply. This so-called "ski-jump" pattern of increasing fertility preceding fertility decline (Dyson and Murphy 1985; Van de Walle 1974) confirms previous research on declining infant mortality and fertility change in Niakhar (Delaunay et al. 2006; Delaunay et al. 2001). The truncated trajectory declined over time but increased again as of the 1970–1973 cohort. Finally, the short trajectory shows a varying pattern across cohorts, with no signs of increase in the youngest cohorts.

How much of the overall change in TFR can be attributed to change in the distribution of women across trajectories or to change in completed fertility within trajectories? Figure 3, based on the results of the decomposition analysis, shows the change in cTFR across cohorts, which is positive between the 1950s and 1960s (0.47 child per woman) and later negative but slower (–0.31 child per woman from 1965 to 1978).

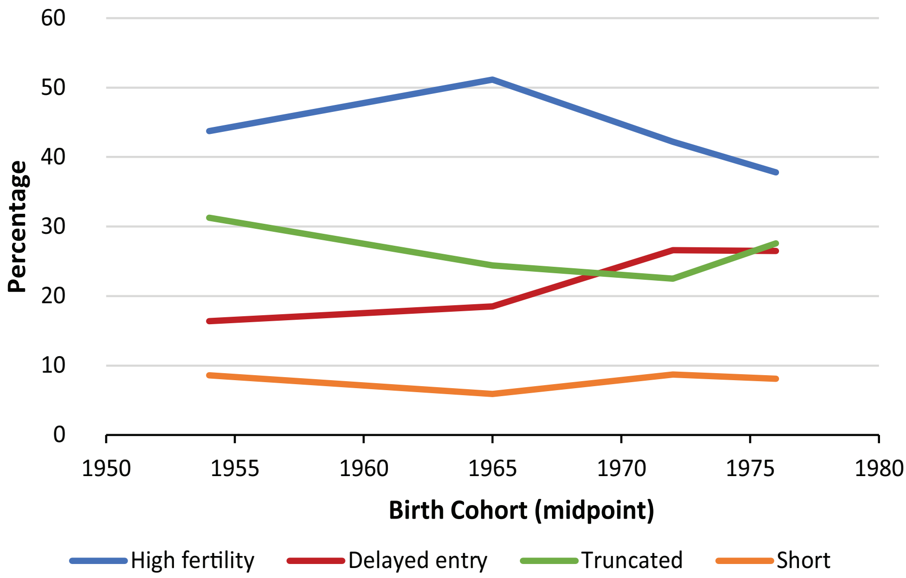

Fig. 2 Percentage of women with different reproductive trajectories by birth cohort (N=615)

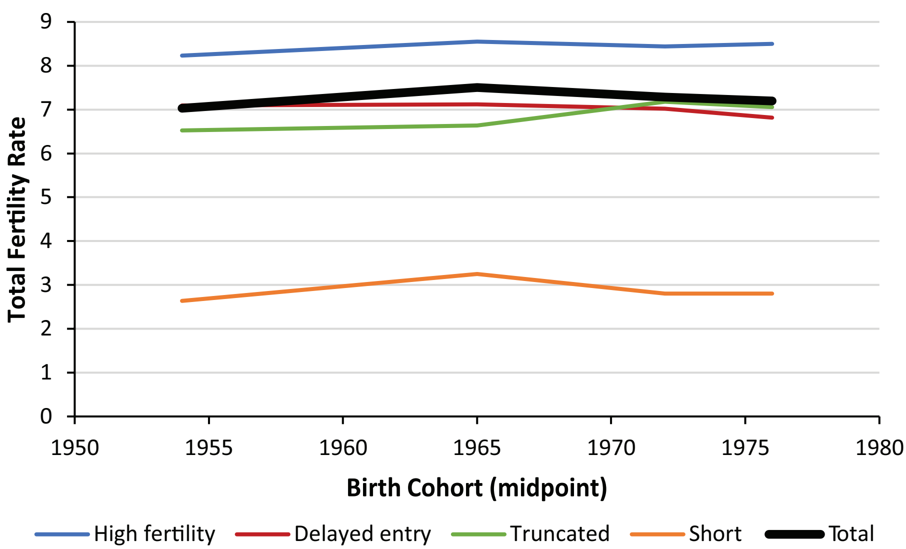

Fig. 3 Development of cohort TFR by cluster

Our results (Figure 3) indicate that this typology of trajectories explains 33–100% of the change in total fertility across cohorts, depending on which cohorts are compared. The compositional effect (indicated as C in Figure 4) contributes 51%, 109%, and 36%, respectively, to the annual change in cTFR across cohorts. This alone is a clear sign that our typology captures an important share not only of the between-individual fertility behaviors, but also of the overall trends in fertility level in the

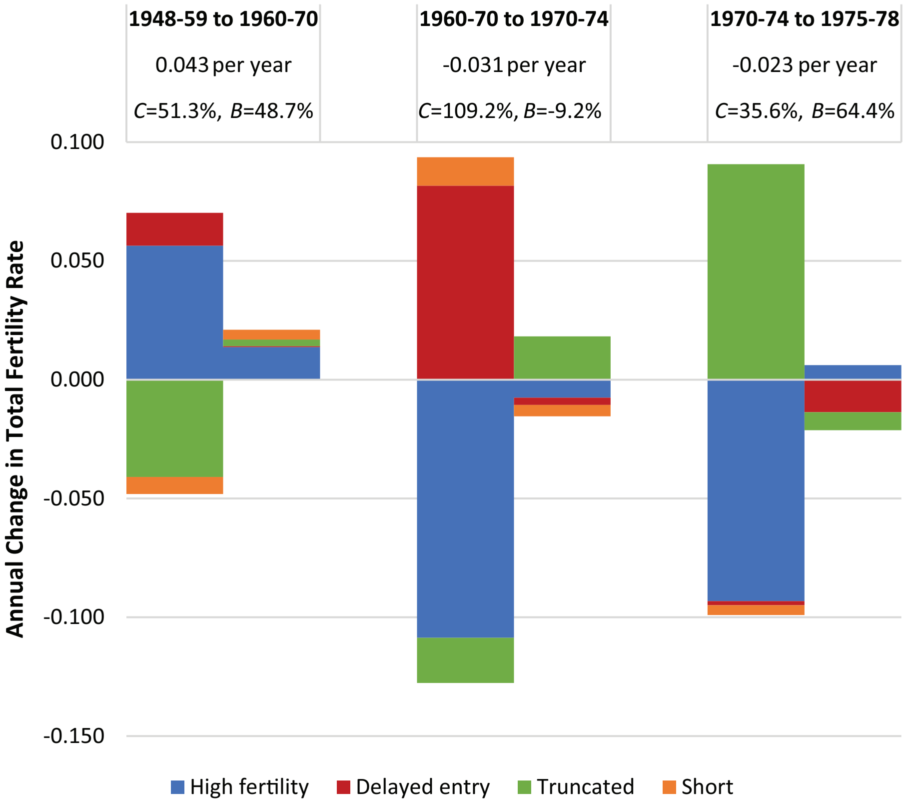

Fig. 4 Decomposition of the pace of the change in TFR across cohorts into cluster composition (*C*) and behaviors within clusters (*B*)

Niakhar region. Across time, behavioral changes within clusters (indicated as *B* in Figure 4) do, however, also contribute to overall changes in fertility levels.

For the cohorts born in the 1950s and 1960s, cluster composition and within-cluster behaviors contribute equally to the rise in cTFR (51% vs. 49%). Moreover, while all clusters experience a small increase in their TFR, the high fertility trajectory accounts for two thirds of this behavioral change. The 0.47-child-per-woman increase between cohorts born in the 1950s and 1960s is, thus, equally due to a larger proportion of women following high fertility trajectories and to these trajectories producing more children.

For the cohorts born in the 1960s and the early 1970s, all of the decrease in cTFR is due to compositional change. The sharp decline in the share of the high fertility trajectory in combination with the increase of the delayed entry trajectory pulled down the overall fertility levels. During this period, the contribution to TFR of behaviors within clusters is still slightly positive (only because of truncated trajectories) but remains anecdotal compared with compositional changes. This compositional change signals, in our view, the start of a distinct African fertility transition in the sense proposed by Caldwell and colleagues (1992). Clearly, contrary to the case in Europe, where stopping was instrumental in the transition, delayed entry seems to have been the key change.

Finally, the further decrease in cTFR among cohorts born in the late 1970s is more complex, showing opposite compositional changes owing to a sudden rebound of the truncated trajectory at the expense of the delayed entry trajectory, which stopped rising. The rebound of the truncated trajectory is almost exactly paralleled by the continued decrease in the share of women entering the high fertility trajectory. Behavioral changes within clusters show a slight decrease of cTFR, especially among women in the delayed entry cluster, partly compensated by a small increase among the high fertility cluster. These changes might be related to the turmoil associated with structural adjustment programs and the economic hardship of the 1980s and 1990s, increased labor insecurities, and seasonal migration in the Niakhar region, as elsewhere in West Africa (Adjamagbo and Delaunay 2018; Weissman 1990). In this respect, women who tended to delay entry into motherhood likely adapted by further decreasing their fertility by also postponing their next child. This is a behavioral contribution that fits well with the postponement and curtailment of births described elsewhere (Hayford and Agadjanian 2019; Moultrie et al. 2012; Timæus and Moultrie 2008, 2020).

Regression Analyses

Binomial logistic regression analyses were conducted to examine the association of women's individual and household characteristics and cluster membership. We first estimated the odds of experiencing each of the four trajectories as compared to the other three (Table 3). Women born between 1960 and 1969 had a higher likelihood of following the high fertility trajectory than those born in 1974–1977, confirming the trend in Figure 2. This is in line with the peak fertility in Niakhar in the 1980s observed in previous studies (Buiatti 2012; Delaunay et al. 2006). Improved maternal and child health and subsequent lower infant mortality rates may be related to this. Another explanation is that during periods of drought in the region (i.e., between 1973–1974 and 1983–1984), fewer births were registered (Garenne et al. 2018:187). We also observe a negative relation between the average number of women coresiding in the compound—indicative of the size of polygynous households—and women's odds of following a high fertility trajectory. This confirms the sexual competition hypothesis, which assumes that completed fertility of women in polygynous households is lower than that of women in monogamous unions (Lardoux and Van de Walle 2003). It is also in line with previous evidence for Niakhar, which showed that completed fertility of polygamously married women was lower than that of monogamous wives, because of the higher average age of their husbands, implicating lower male fecundity and, to a lesser extent, lower coital frequency (Garenne and Van de Walle 1989). In addition, we find a negative association with divorce: women who divorced during their reproductive life span less often followed a high fertility trajectory.

Strong cohort effects are also found for the delayed entry trajectory. The results show a clear increasing trend across cohorts in the likelihood of women experiencing delayed entry into childbearing, as is also visible in Figure 2. The 1970–1973 cohort does not differ significantly from the 1974–1977 cohort, confirming the plateauing of the incidence of delayed entry among the youngest cohorts, as shown in Figure 2. The most important factor associated with delayed entry is education: in a society in which most women (87%) received no education at all, those with a primary school

Table 3 Odds ratios from binomial logistic regression analyses of factors associated with different types of childbearing trajectories ($N = 612$)

	High Fertility	Delayed Entry	Truncated	Short
Birth Cohort				
1948–1959	1.51	0.58†	1.07	0.70
1960–1969	2.07**	0.60†	0.83	0.39†
1970–1973	1.40	0.98	0.71	0.83
1974–1977 (ref.)	1.00	1.00	1.00	1.00
Religion				
Muslim (ref.)	1.00	1.00	1.00	1.00
Catholic	1.07	1.08	0.82	1.17
Protestant	1.19	0.98	0.58	2.21
Animist	0.91	0.82	1.83	0.00
Caste				
Free peasants (ref.)	1.00	1.00	1.00	1.00
Koumakh	0.79	2.88†	0.28	0.86
DB Tiédo	0.79	1.32	0.85	1.81
Dep DB	0.59	2.23†	0.95	0.62
Griots	0.80	0.45	2.76†	0.79
Artisans	0.33	0.79	5.53†	0.00
Non-Serer	2.62	0.00	3.08	0.00
Unknown	0.44	0.79	2.23	1.81
Education				
None (ref.)	1.00	1.00	1.00	1.00
Koranic school	0.56	1.08	1.00	2.29
Primary school	0.65	2.02*	0.85	0.84
Secondary school or more	0.85	1.39	0.42	2.11
Migration Before Age 15	1.01	0.88	1.10	1.05
Economic Wealth	1.06	2.45†	0.26*	2.18
Agropastoral Wealth	1.96	0.72	1.20	0.23*
Mean Number of Women in Compound	0.97†	0.97	1.06***	1.00
Divorced	0.24*	0.91	1.61	5.53***
Widowed	1.22	1.35	0.30	2.68
Constant	0.51†	0.43†	0.27**	0.19**
Nagelkerke R^2	.07	.06	.08	.12

Source: Niakhar database (release 2018).

†$p < .10$; *$p < .05$; **$p < .01$; ***$p < 0.001$

education (9%) delayed first childbearing significantly more often than those with no education. Women living in a number of higher status households also appeared to have delayed first childbearing. Women from the Dep DB caste—an elite group, located just below the nobles in the former social stratification of Serer society—had a higher likelihood of delayed entry. Women living in households belonging to the Koumakh group—which is responsible for the initiation rituals of youngsters' transition to adulthood—also had higher odds of delayed entry than those from free peasant households. Perhaps these women were more knowledgeable about informal contraceptive practices, or they were forerunners of changed attitudes toward reproduction. Finally, our results show that the higher the economic wealth of the household, the higher the likelihood that women experienced a delayed entry trajectory.

Women following a truncated trajectory started early but also stopped childbearing relatively early. First, the greater the number of other women living on the compound, the higher the likelihood that women experienced a truncated trajectory, which is in line with the sexual competition hypothesis and prior evidence on polygyny and fertility among the Serer in Niakhar (Garenne and Van de Walle 1989; Lardoux and Van de Walle 2003). Second, the higher the household's economic wealth, the lower a woman's odds of experiencing a truncated trajectory. Third, women belonging to the griot and artisan castes had a higher likelihood than women from free peasant households of experiencing a truncated trajectory. Griots and artisans were considered inferior to free peasants and although they were allowed to farm and keep animals, they may have had less need for family labor than free peasants and nobles—groups traditionally associated with agriculture (Tamari 1991).

Finally, the short trajectory—characterized by both a late start and early stop of childbearing—was less often experienced by women in the 1960–1969 cohort than among women in the youngest cohort. Moreover, the higher the agropastoral wealth of the household, the lower women's likelihood of experiencing a short trajectory. Women from households with little agropastoral wealth were, thus, less able to sustain high fertility. Perhaps their natal families were less able to pay the bride wealth or able later, delaying their entry into childbearing; alternatively, they may have been in lesser need of many children as a source of productive labor. The short trajectory was strongly related to women's experiences of divorce, a common but disadvantageous experience in terms of women's well-being in Senegal (Lambert et al. 2017), which severely disrupted their childbearing trajectories. Another explanation may be that divorced women's fertility careers ended early because of secondary sterility; previous research has observed that divorcees in Niakhar had a high prevalence of STIs (Lemardeley et al. 1995).

Discussion

The lagged fertility transition in West Africa has important repercussions for global population growth but remains poorly understood. Inspired by Caldwell and colleagues' fertility transition framework, as well as subsequent research, we used a sequence analysis approach to examine diversity in women's childbearing trajectories, evaluated their contribution to overall fertility levels, and examined their association with women's socioeconomic and cultural characteristics. The different trajectories we observed and their change over time are intricately interwoven with the history, social structure, and economic development of the Niakhar region. The prominence of the high fertility trajectory is closely related to the commercialized agricultural and pastoral economy of Niakhar and the material benefits of large families; 78% of women belonged to the peasant social group, and almost all households engaged in agriculture (Masse et al. 2018). The rise of the high fertility trajectory, as well as the increase in fertility within this cluster among women born in the 1950s and 1960s, is a likely consequence of national improvements in public health, which led to decreased child mortality and secondary infertility, thus "unleashing" further fertility potential within a group of women with few options beyond traditional methods of birth spacing to control their fertility (Delaunay et al. 2002; Randall and

LeGrand 2003). At the same time, a subpopulation of women born in the 1960s and early 1970s who had received primary education and came from some of the higher social groups and economically wealthier households started to postpone first marriage and first childbearing, resulting in a decrease in fertility among this group. The economic crisis of the 1980s and 1990s—resulting from structural adjustment programs and leading to increased seasonal rural–urban migration—made reproductive careers more complex again, with more women in precarious conditions having truncated (i.e., stopping earlier) or delayed entry (i.e., postponing first birth) trajectories.

What are the empirical and theoretical payoffs of our sequence analysis approach? First, our analyses laid bare that beneath the surface of a slowly changing fertility regime, considerable variation in fertility trajectories existed. While some subpopulations experienced reduced fertility, other groups experienced an increase, thus canceling each other out in terms of aggregate fertility levels. Second, in contrast to fertility transitions in Europe and Asia, later age at first childbirth seems to have been the most important behavioral component of the early phase of this West African fertility transition, as Caldwell et al. (1992) and others have argued for other parts of sub-Saharan Africa (Bledsoe 1990, 2002; Johnson-Hanks 2006, 2007; Spoorenberg 2019) and North African countries (Fargues 1989). Third, this study uncovered a trajectory of low fertility in a high-fertility society—the short trajectory—in which women started late, extensively spaced their births, and stopped early, bearing an average of only 2.8 children. Such a childbearing pattern would have been very hard to observe with methods other than sequence and cluster analysis that inductively generate extant clusters from the data. Theoretically, the most important contribution of our approach is that it does not cut reproductive careers into separate components but conceptualizes quantum, timing, and spacing together in a holistic way justifying the endogenous causality of life courses (Mayer 1987). Thereby, it opens the door for more subtle explication and understanding of pathways to fertility change.

Our study has a number of limitations. First, we are aware of the dangers involved in analyzing and presenting data on behavior as revealing certain reproductive preferences, as Johnson-Hanks (2007) has so rightly put it. Ideally, our study should be complemented by qualitative research focused on unearthing the preferences and motivations of women following the different reproductive careers. A related downside to taking holistic childbearing trajectories as the unit of analysis is that less attention might be given to uncertainties and turning points during the process of childbearing over women's reproductive life span. Second, the quality of our models was limited by the sample size. Our modest sample resulted from the fact that full reproductive sequences (between ages 15 and 40) were needed; however, in general, samples in studies using sequence analysis are on average small because of computing time and memory capacity. Third, the truncated cluster suffered from heterogeneity; it was not as clearly distinct as the other clusters. Fourth, our sample of women is partly selective in that all women reached the end of their reproductive career. Those who died before reaching menopause may likely have had a lower socioeconomic and health status (Schoumaker 2014). Hence, the prevalence of the short and truncated trajectories is likely underestimated. Fifth, although our population contains both sedentary women and seasonal migrants, the fact that long-term out-migrants—who are usually more educated—are not included may have led to an underestimation of the delayed entry cluster and the decrease in fertility levels in the last cohorts.

We believe our study is the first to examine the lagging fertility transition in (West) Africa through the lens of a sequence analysis approach. Although our results are context-specific, the situation in Niakhar is similar to that in other Sahelian West African regions (Hertrich and Lesclingand 2013), and thus our findings may have a larger bearing for understanding the persistence of high fertility in the wider region. In other regional contexts and in earlier or later periods, distinct trajectories will certainly be found related to different subpopulations with different associated characteristics. Hence, future research may apply our sequence analysis approach to comparatively study childbearing trajectories of women across different regions in sub-Saharan Africa and over longer periods, exploiting, for instance, harmonized HDSS or Demographic and Health Surveys. ■

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Hilde Bras (corresponding author)
h.a.j.bras@rug.nl

Bras • Department of History, University of Groningen, Groningen, the Netherlands; https://orcid.org/0000-0003-4336-2346

Remund • Population Research Centre, University of Groningen, Groningen, the Netherlands; https://orcid.org/0000-0002-1616-2157

Delaunay • Institut de Recherche pour le Développement, Marseille, France, and Dakar, Senegal; https://orcid.org/0000-0003-2073-7176