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Where Does the Sahelian Fertility Transition Stall? Higher-Order Parity Progression in Burkina Faso, Mali, and Niger

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Abstract

The total fertility rate (TFR), the usual summary of fertility transitions in sub-Saharan Africa, obscures the parity-specific structure of reproductive change. This study asks where in the parity distribution the transition stalls. We use the 2021 Burkina Faso, 2023–2024 Mali, and 2021 Niger Demographic and Health Surveys, covering 44,559 women aged 15–49 years, combining cohort parity progression ratios (PPRs), an exact Shapley decomposition of cross-national gaps in mean parity, life-table PPRs, and discrete-time hazard models fitted to 74,885 parity episodes. Progression through the first three parities was almost identical across countries (cohort PPRs 0.97–0.99). Divergence began at the third-to-fourth transition and widened with each successive parity: the sixth-to-seventh PPR was 0.68 in Burkina Faso, 0.82 in Mali, and 0.89 in Niger. Transitions from parity three onwards accounted for 90.5% of the Burkina Faso–Niger gap and 116.0% of the Burkina Faso–Mali gap. The three countries occupied distinct regimes. In Niger, progression changed little at any parity over two decades. In Mali, the hazard of progression was 15–20% lower than in Niger at every parity, with no parity interaction, consistent with generalised postponement. In Burkina Faso the deficit deepened with parity, from a hazard ratio of 0.67 at the first transition to 0.55 at the seventh, while the median waiting time rose from 37 to 46 months, indicating parity-specific limitation superimposed on postponement. The Sahelian fertility differential is therefore generated among women who already have three or more children, a group largely beyond the reach of adolescent-focused programmes.

1. Introduction

The Sahel region contains one of the world's last major concentrations of pre-transitional fertility. Niger, Mali, Chad, and Burkina Faso have maintained total fertility rates (TFRs) above five children per woman, even as most of sub-Saharan Africa has experienced sustained decline (Bongaarts, 2017; Kirk & Pillet, 1998; Schoumaker, 2019; Tabutin & Schoumaker, 2020). These nations are also among the poorest and most fragile in the region, making the pace of fertility transition directly relevant to schooling, labour markets, and food security (Ezeh et al., 2012; Guengant & May, 2013). Two broad explanations dominate the existing literature. The first focuses on proximate determinants, particularly delayed entry into union, later sexual debut, and rising contraceptive prevalence, as the primary drivers of change (Bongaarts, 1978; Bongaarts & Casterline, 2013). The second emphasises ideational and institutional factors, including women's schooling, the effectiveness of family planning programmes, and the persistence of pronatalist norms (Bongaarts, 2020; Casterline & Agyei-Mensah, 2017; Kravdal, 2002; Lesthaeghe, 1989).

Both explanations are typically assessed using the TFR. While convenient, this measure omits crucial information. The TFR is a synthetic average across the reproductive career and cannot differentiate between a regime where women begin childbearing late and cease early, and one where they start early and stop late. Two populations with identical TFRs may occupy very different positions in the parity distribution, and two populations with identical ages at first birth may differ by two children in completed fertility. Therefore, identifying where a transition stalls requires a different question: not why fertility is high, but at which birth orders progression fails to decline (Casterline, 2001; Cleland & Machiyama, 2017).

1.1. Parity progression as the architecture of a fertility transition

Completed cohort fertility is the outcome of a sequence of conditional decisions, each one the probability that a woman who has reached a given parity proceeds to the next. The relationship between those probabilities and completed fertility is an identity rather than a model, so any change in completed fertility must operate through one or more of them. The arithmetic is unforgiving at low parities. Where progression to the first three births is close to

universal, as it is throughout the Sahel, even a large proportional change at those transitions moves completed fertility very little, whereas a modest change at parity five or six is amplified by the entire chain of prior progression. Locating a stalled transition therefore requires attention to the birth orders where the leverage lies.

Parity progression ratios (PPRs) were introduced by Henry and adapted to survey data by Rodríguez and Hobcraft (1980), Brass and Juárez (1983), Ní Bhrolcháin (1987), and Feeney and Yu (1987). They also separate quantum from tempo. Two women who both go on to another birth contribute equally to the cohort PPR, but one who waits 30 months and one who waits 60 months differ in their contribution to period fertility and in the number of births they can accumulate before the end of the reproductive span (Casterline & Odden, 2016). Life-table PPRs computed over a fixed window, conventionally 60 months, capture both dimensions at once, while the median waiting time to the next birth isolates tempo (Rodríguez & Hobcraft, 1980; Rutstein, 2002).

1.2. Competing accounts of the African transition

Early explanations of African fertility decline posited that it would mirror the European pattern of parity-specific stopping (Caldwell et al., 1992). Subsequent research, however, challenged this expectation. Moultrie et al. (2012) argued that African declines have primarily resulted from the lengthening of birth intervals across all parities, a regime they termed 'postponement without a target family size'. Timæus and Moultrie (2013, 2020) formalised this argument, distinguishing limitation, curtailment, and postponement as separate pathways to lower fertility. Under postponement, PPRs exhibit a uniform and modest decline, accompanied by a substantial increase in waiting times; conversely, under stopping, PPRs fall sharply and selectively at high parities.

These competing accounts have not been tested systematically in the Sahel. Existing analyses have concentrated on aggregate stalls (Bongaarts, 2006; Ezeh et al., 2009; Schoumaker, 2019; Shapiro & Gebreselassie, 2008), on the proximate determinants (Bongaarts & Casterline, 2013), or on the adolescent segment of the reproductive career (Garenne, 2008; Hertrich, 2017). The higher parities, where the arithmetic of the transition has the greatest leverage, have received little attention. The omission matters, because the two accounts imply distinct and testable signatures. Postponement predicts a downward shift in the hazard of progression that is common to all parities, together with longer waiting times throughout. Limitation predicts a shift that steepens with parity, so that progression falls furthest at the highest birth orders. A parity-by-country interaction in a hazard model therefore discriminates directly between the two, and the profile of median waiting times across parities provides an independent check on the same distinction.

1.3. Study setting, objectives, and hypotheses

Burkina Faso, Mali, and Niger offer an unusually clean comparison. They share a savannah ecology, a predominantly Muslim and rural population, comparable levels of female schooling, and a common colonial and administrative heritage, yet their fertility levels differ by close to two children per woman. They differ in the maturity of their family planning programmes, Burkina Faso having invested earlier and more consistently in service delivery and in lowering the financial barriers to contraception (Bongaarts, 2011, 2020). No programme data are analysed here, so this contrast frames the comparison rather than explaining it. Because the three countries appear to occupy different stages of the same transition, comparing them substitutes variation across space for variation across time. That substitution is an interpretative device rather than an established fact, and the analysis therefore also examines change within each country over the two decades preceding its survey.

We address three key questions. First, at which parity transitions do these three countries diverge, and how much of the cross-national gap in completed fertility is attributable to each transition? Second, does this divergence

operate through quantum, tempo, or both? Third, at which parities has progression demonstrably declined over the two decades preceding the surveys?

We test three hypotheses. H1: cross-national differences in completed fertility within the Sahel are concentrated at parity three and above rather than at entry into motherhood. H2: the country furthest advanced in the transition shows a parity-graded rather than a uniform deficit in progression, together with lengthening waiting times, indicating that limitation is superimposed on postponement rather than replacing it. H3: the decline in progression over the two decades preceding the surveys is graded by parity. We also examine whether the magnitude of that decline orders the three countries by their stage in the transition, although this ordering is descriptive and is not formally tested.

The study makes three contributions. First, it provides a systematic parity-transition account of the fertility differential within the central Sahel. Second, it applies an exact decomposition that attributes gaps in mean parity to individual transitions without leaving a residual, which sequential substitution cannot do because the mapping from PPRs to mean parity is multiplicative and therefore order-dependent. Third, it shows that postponement and parity-specific limitation are better read as successive phases of a single transition than as competing descriptions of it.

2. Methods

2.1. Data

We use the individual recode (IR) files of the most recent nationally representative Demographic and Health Survey (DHS) available for each country. The 2021 Burkina Faso survey interviewed 17,659 women aged 15–49 years in 514 sampling clusters, the 2023–2024 Mali survey 17,202 women in 407 clusters, and the 2021 Niger survey 9,698 women in 280 clusters covering the eight regions of the country, giving a pooled sample of 44,559 women. All three surveys collected a complete retrospective birth history under the standard DHS stratified two-stage cluster design. Sampling frames, questionnaire modules, and interviewer training follow common DHS protocols, so the three birth histories are directly comparable (Croft et al., 2018).

All estimates are weighted by the individual sampling weight (v005 divided by 1000000). Variance estimation treats the primary sampling unit (v021) as the cluster and the stratum supplied for sampling-error estimation as the stratum. Because the analysis compares countries rather than describing the three populations jointly, weights are applied within country and are not rescaled to relative population size.

2.2. Episodes, exposure, and censoring

Parity is the number of live births reported by the woman. Episodes are defined by deliveries rather than by children, so that a multiple delivery, which accounts for 1.7% of deliveries in the pooled birth histories, advances parity by two without generating a spurious zero-length interval. The episode for the transition from parity i to parity i + 1 opens at the delivery that brought the woman to exactly parity i and closes either at the next delivery, which is the event, or at the interview. Durations are the difference in completed months between the two century month codes recorded in the birth history. The transition to a first birth is retained in the cohort and decomposition analyses but excluded from the life-table and hazard analyses, because its exposure begins with menarche and entry into union rather than with a preceding birth and is therefore not comparable with the later intervals.

The period analyses are restricted to index births occurring 5 to 19 years before the interview. Every episode in this window is observed for a full 60 months, so no episode is right-censored within the observation window, and censoring in the hazard models is administrative, occurring only at 60 months. The lower bound guarantees complete observation and the upper bound limits exposure to the recall error that affects the earliest years of retrospective birth histories.

Covariates are harmonised across surveys and comprise the mother's age at the index birth (under 25, 25–29, 30–34, and 35 years and above), educational attainment (none, primary, secondary or higher), the household wealth quintile, urban or rural residence, whether the index child had died before the interview, whether the woman had no surviving son at the index birth, and the period of the index birth (5–9, 10–14, and 15–19 years before the survey). Educational and wealth categories are those constructed by The DHS Program and are comparable across surveys. The youngest maternal age category is defined as under 25 rather than under 20 years because virtually no woman reaches parity six or seven before age 20, so the finer category produces empty cells and quasi-complete separation in the models for the highest transitions.

2.3. Analytical strategy

The analysis proceeds in four steps. The first estimates the quantum of childbearing from completed cohorts. The second attributes the cross-national gaps in quantum to individual parity transitions. The third separates quantum from tempo in period terms. The fourth models the waiting time to the next birth and tests whether the country differences are uniform across parities or graded by parity.

2.3.1. Cohort parity progression ratios and implied mean parity

A PPR is the conditional probability that a woman who has reached a given parity proceeds to the next one. For each country, the cohort PPR for the transition from parity i to parity i + 1 is the weighted proportion of women who reached at least parity i + 1 among those who reached at least parity i:

$$a_i = \Sigma_j w_j I(p_j \geq i + 1) / \Sigma_j w_j I(p_j \geq i) \quad (1)$$

where p_j is the parity of woman j and w_j her sampling weight. Ratios are estimated separately for women aged 45–49 years, who have effectively completed childbearing and provide the cleanest measure of quantum, and for women aged 40–44 years, whose ratios indicate the direction of cohort change. Because the younger group has not entirely completed childbearing, the difference between the two groups is an upper bound on true cohort change. Standard errors are obtained by Taylor linearisation accounting for weighting, stratification, and clustering.

Implied mean completed parity is reconstructed from the estimated sequence as

$$M(a) = \Sigma_{k=1}^{K} \Pi_{i=0}^{k-1} a_i, \text{ with } K = 9 \quad (2)$$

The chain is truncated at nine births because the eighth-to-ninth ratio is the highest transition estimated with acceptable precision. Implied mean parity therefore lies slightly below the observed mean number of children ever born in the same age group, without affecting the ranking of the three countries (Feeney & Yu, 1987; Ní Bhrolcháin, 1987; Zeman et al., 2018).

2.3.2. Attributing cross-national gaps to individual transitions

The quantity to be decomposed is the gap in implied mean parity between two countries, and the components are the individual parity transitions. The mapping in Eq. (2) is multiplicative rather than additive: a_i enters every term of the sum from k = i + 1 onwards, so the contribution of a given transition depends on the values at which the remaining ratios are held. Sequential, or stepwise-replacement, schemes switch the transitions one at a time from the lowest to the highest parity while freezing the remainder at the reference values (Barkalov, 1999; Zeman et al., 2018). Such schemes are exhaustive, but the contribution attributed to each transition depends on the order of substitution, which is a modelling choice rather than a property of the data. Andreev et al. (2002) generalised stepwise replacement to aggregate demographic measures including PPRs, and Das Gupta (1993) addressed the same difficulty by averaging over standardisation orders.

The Shapley value is the general solution to this problem and is applied here in exact form. Let N denote the set of n = 8 transitions from 0→1 to 7→8, and let a□ and a□ be the estimated PPR vectors of the two countries compared. For any subset S of N, let a□ be the vector whose element i equals a_i□ if i belongs to S and a_i□ otherwise, and define v(S) = M(a□) − M(a□), so that v(∅) = 0 and v(N) is the total gap Δ. The contribution of transition i is its marginal contribution averaged over all orderings in which the transitions may be switched:

$$\varphi_i = \Sigma\, [\, |S|!\,(n - |S| - 1)! / n!\,]\, [\, v(S \cup \{i\}) - v(S)\,],\ S \subseteq N \setminus \{i\} \quad (3)$$

This allocation is the unique one satisfying efficiency, so that the contributions sum exactly to Δ with no residual, symmetry, and the null-player property, under which a transition with the same ratio in both countries contributes zero (Shapley, 1953; Shorrocks, 2013). Because n = 8, all 256 subsets are enumerated and no approximation is required. The decomposition is symmetric in the two countries: reversing them reverses the signs of the contributions but not their magnitudes.

The decomposition is applied to mean parity truncated at eight births because the eighth-to-ninth ratio rests on comparatively few women still at risk and would add estimation noise to every contribution. The gaps decomposed in Table 4 are therefore slightly smaller than the differences in implied mean parity reported in Table 3, which also include that transition. The contributions are exact accounting quantities conditional on the estimated PPRs; sampling variability in the ratios is not propagated into them, so they are reported as point estimates. They also differ in kind from the rate and composition components obtained when period fertility is decomposed by partnership status or other population characteristics (Reimondos et al., 2025), since the components here are successive behavioural transitions within a single reproductive sequence.

2.3.3. Life-table progression and waiting times

Cohort PPRs describe childbearing that occurred, on average, 15 to 25 years before the survey, and they conflate the probability of continuing with the speed of continuation. A life-table measure computed over a fixed window separates the two: the probability of a further birth within the window measures quantum, and the median waiting time measures tempo (Rodríguez & Hobcraft, 1980; Rutstein, 2002). Weighted Kaplan–Meier survivor functions are estimated separately by country and by parity transition, from the first-to-second through to the seventh-to-eighth, and two quantities are read from each function:

$$PPR_{60} = 1 - \hat{S}(60) \text{ and } t_{50} = \min\{\, t : \hat{S}(t) \le 0.5 \,\} \quad (4)$$

Because the analytical window guarantees 60 months of observation for every episode, the survivor function is unaffected by right-censoring within that window, and the Kaplan–Meier estimator is retained so that both quantities are read from a single function. Confidence intervals are percentile intervals from a stratified non-

parametric bootstrap that resamples primary sampling units with replacement within strata, with 200 replicates. Resampling whole clusters reproduces the two-stage design and preserves the dependence between the several episodes contributed by the same woman (Kolenikov, 2010). The life-table analysis uses 74,885 parity episodes.

2.3.4. Multivariate models of the waiting time to the next birth

The hazard models serve one purpose: to establish whether each country's deficit in progression relative to the least advanced country is uniform across parities, as generalised postponement implies, or steepens with parity, as parity-specific limitation implies, once composition is held constant. Each episode is expanded into six-month person-periods and censored at 60 months, giving at most ten periods per episode. A complementary log-log link is used, so that the discrete-time model corresponds to an underlying continuous-time proportional hazards model and exp(β) is interpretable as a hazard ratio (Prentice & Gloeckler, 1978; Allison, 2014):

$$\log[-\log(1 - h_{ijt})] = \alpha_t + \beta' x_{ij} \quad (5)$$

where h_{ijt} is the probability that episode j of woman i ends in period t given survival to the start of that period, and α_t is a full set of duration dummies, leaving the baseline hazard unrestricted. Niger is the reference country throughout, being the least advanced in the transition and the natural baseline against which movement is measured.

Two specifications are estimated. Transition-specific models are fitted separately for each parity transition, because both the risk set and the composition of the women at risk change from one transition to the next. A pooled model over transitions 1→2 to 7→8 then adds parity dummies, country dummies, and their full interaction:

$$\log[-\log(1 - h)] = \alpha_t + \Sigma_p \gamma_p P_p + \Sigma_c \delta_c C_c + \Sigma_{p,c} \theta_{pc}(P_p \times C_c) + \beta' x \quad (6)$$

with parity one in Niger as the reference. The parity-by-country interaction terms provide the direct test of H2: terms that are jointly indistinguishable from unity indicate a uniform proportional displacement, whereas terms declining monotonically with parity indicate a deficit graded by parity.

All estimates are weighted by the individual sampling weight, and standard errors are clustered on the primary sampling unit, which also absorbs the dependence between episodes contributed by the same woman. The analytical sample comprises 74,885 parity episodes and 253,741 person-periods, and is identical to that used for the life-table analysis. Statistical significance is assessed at a two-sided $p < 0.05$. No correction for multiple testing is applied, so isolated significant coefficients are interpreted with caution and the argument rests on the pattern of estimates across parities rather than on any single test. All estimation was carried out in Stata 19.

2.3.5. Selection into high parity and sensitivity analysis

Women who reach high parity are selected on fecundity, on early entry into union, and on short preceding intervals, so the composition of the risk set changes as parity rises. Models of birth intervals that ignore this heterogeneity tend to understate postponement at high parities (Timæus & Moultrie, 2013). Conditioning on maternal age at the index birth, on the survival of that child, and on the period of occurrence absorbs part of this selection but not all of it. Comparisons between countries at the same parity are less exposed to the problem than comparisons across parities within a country, because selection operates in the same direction in all three populations, and the country contrasts carry the central argument. As a further check, the trend analysis is repeated on index births to mothers aged 25–34 years, an age band in which all three countries have substantial exposure at every parity (Table S3).

2.4. Ethical considerations

The study analyses secondary data made publicly available by The DHS Program and its national partners, and no further ethical approval was required. Authorisation to use the datasets was granted by The DHS Program.

3. Results

3.1. Fertility levels and the onset of childbearing

Table 1 summarises the three samples, which are closely comparable in age structure and wealth distribution. Niger is more rural (82.6% against 67.5% in Burkina Faso) and less schooled (69.8% of women with no formal education against 58.3%). Table 2 reports the fertility profile, with the complete age-specific schedule in Table S2. The TFR for the three years preceding each survey is 4.44 in Burkina Faso, 6.05 in Mali, and 6.21 in Niger, a spread of 1.77 children.

The onset of childbearing does not account for this spread. Mean children ever born among women aged 15–19 years is 0.16 in Burkina Faso, 0.26 in Mali, and 0.25 in Niger, so Mali and Niger are indistinguishable at the youngest ages, and the median age at first birth differs by a single year (20 years in Burkina Faso, 19 years in Mali and Niger). Early childbearing is common everywhere, with the proportion whose first birth occurred before age 18 ranging from 25.4% to 44.1%. The Burkina Faso–Niger gap is 0.52 children at ages 20–24 years but 1.78 children at ages 45–49 years: only 29% of the eventual differential is in place by the early twenties, and the remaining 71% accumulates after the first two or three births.

Table 1
Characteristics of the study populations: women aged 15–49 years (weighted percentages)

Characteristic	Category	Burkina Faso	Mali	Niger
Age group	15–19	21.8	22.3	27.4
	20–24	18.4	19.5	18.5
	25–29	15.2	16.7	16.8
	30–34	14.3	13.7	12.8
	35–39	12.8	11.9	10.3
	40–44	10.1	9.1	8.4
	45–49	7.5	6.7	5.9
Education	No education	58.3	54.1	69.8
	Primary	14.2	16.9	14.6
	Secondary+	27.5	29.0	15.6
Wealth quintile	Poorest	17.4	17.5	19.1
	Poorer	18.3	18.1	18.6
	Middle	19.3	19.1	20.1
	Richer	20.3	21.2	20.2
	Richest	24.7	24.1	22.1
Residence	Urban	32.5	27.2	17.4
	Rural	67.5	72.8	82.6
Mean children ever born (15–49)		2.73	3.17	3.33
Mean age (years)		28.74	28.25	27.04
Number of women (unweighted)		17,659	17,202	9,698
Number of sampling clusters		514	407	280

Table 2
Cumulative and period fertility, and timing of first birth

Indicator	Burkina Faso	Mali	Niger
Mean children ever born, women aged 15–19	0.16 (0.008)	0.26 (0.012)	0.25 (0.017)
Mean children ever born, women aged 20–24	1.12 (0.026)	1.48 (0.031)	1.64 (0.056)
Mean children ever born, women aged 25–29	2.44 (0.039)	2.98 (0.044)	3.55 (0.087)
Mean children ever born, women aged 30–34	3.69 (0.049)	4.28 (0.053)	4.99 (0.115)
Mean children ever born, women aged 35–39	4.67 (0.061)	5.70 (0.074)	6.45 (0.124)
Mean children ever born, women aged 40–44	5.43 (0.070)	6.55 (0.083)	7.21 (0.154)
Mean children ever born, women aged 45–49	5.98 (0.076)	6.81 (0.117)	7.76 (0.214)
Total fertility rate, 0–35 months before survey	4.44	6.05	6.21
First birth before age 18 (%), women 25–49	25.4	35.1	44.1
First birth before age 20 (%), women 25–49	49.2	57.2	64.4
Median age at first birth (life table, years)	20	19	19

3.2. Cohort parity progression ratios

Table 3 reports cohort PPRs for women aged 40–44 and 45–49 years, and Fig. 1 displays the latter. Across the first three transitions the three countries are statistically and substantively indistinguishable, with ratios between 0.967 and 0.992 among women aged 45–49 years, and childbearing is close to universal in all of them.

Divergence begins at the third-to-fourth transition (0.923 in Burkina Faso, 0.943 in Mali, and 0.965 in Niger) and then widens monotonically, reaching 0.684, 0.817, and 0.888 at the sixth-to-seventh transition and 0.526, 0.648, and 0.768 at the eighth-to-ninth. The absolute Burkina Faso–Niger difference grows from 0.003 at entry into motherhood to 0.242 at the eighth-to-ninth transition. Implied mean parity, truncated at nine births, is 5.89 in Burkina Faso, 6.50 in Mali, and 7.14 in Niger. These values lie below the observed mean children ever born for the same women because the reconstruction stops at the ninth birth, and the ranking of the three countries is unaffected.

The comparison between the two age groups points the same way. In Burkina Faso the ratios for women aged 40–44 years lie below those for women aged 45–49 years at every transition above the second, and implied mean parity falls from 5.89 to 5.39 across the two cohorts. The corresponding declines are smaller in Mali (6.50 to 6.32) and Niger (7.14 to 6.78). Since the younger group has not entirely completed childbearing, these differences are an upper bound on true cohort change. Even so, change across successive cohorts is fastest where the transition is furthest advanced, and it is concentrated at high parities in all three countries.

Table 3
Cohort parity progression ratios by country and age group

Parity transition	Burkina Faso 40–44	Burkina Faso 45–49	Mali 40–44	Mali 45–49	Niger 40–44	Niger 45–49
0 to 1	0.986 (0.003)	0.984 (0.004)	0.983 (0.004)	0.972 (0.006)	0.972 (0.008)	0.981 (0.009)
1 to 2	0.978 (0.004)	0.979 (0.005)	0.972 (0.005)	0.978 (0.005)	0.978 (0.006)	0.992 (0.003)
2 to 3	0.952 (0.007)	0.967 (0.005)	0.966 (0.005)	0.969 (0.005)	0.980 (0.005)	0.978 (0.007)
3 to 4	0.878 (0.010)	0.923 (0.009)	0.939 (0.007)	0.943 (0.008)	0.968 (0.006)	0.965 (0.010)
4 to 5	0.830 (0.012)	0.866 (0.013)	0.905 (0.009)	0.905 (0.012)	0.921 (0.013)	0.929 (0.015)
5 to 6	0.718 (0.014)	0.807 (0.014)	0.858 (0.011)	0.891 (0.012)	0.896 (0.015)	0.908 (0.015)
6 to 7	0.663 (0.018)	0.684 (0.017)	0.767 (0.016)	0.817 (0.016)	0.849 (0.015)	0.888 (0.018)
7 to 8	0.529 (0.023)	0.618 (0.023)	0.733 (0.018)	0.777 (0.020)	0.775 (0.021)	0.821 (0.031)
8 to 9	0.429 (0.031)	0.526 (0.029)	0.635 (0.023)	0.648 (0.031)	0.673 (0.032)	0.768 (0.031)
Implied mean completed parity	5.39	5.89	6.32	6.50	6.78	7.14

3.3. Which transitions generate the cross-national gaps

Table 4 presents the Shapley decomposition of the cross-national gaps in mean parity truncated at eight births. On that basis the Burkina Faso–Niger gap is 0.95 children, against 1.25 children when the eighth-to-ninth transition is also counted. The first three transitions together account for 9.5% of the gap, and entry into motherhood contributes negatively (− 0.024 children). The transitions from parity three onwards account for the remaining 90.5%, with the largest single contribution at the sixth-to-seventh transition.

The Burkina Faso–Mali comparison is more striking. Entry into motherhood contributes − 0.076 children, since Malian women are slightly less likely than Burkinabè women to have a first birth at all, which taken alone would make Malian fertility the lower of the two, and the next two transitions contribute almost nothing. The entire 0.46-child gap, and more, is generated at parity three and above, which contributes 116.0% of the observed difference. H1 is therefore supported: within the Sahel, the fertility differential is not a differential in whether or when women begin childbearing but in how far they continue.

The Mali–Niger comparison is the one partial exception, and is instructive for that reason. The first three transitions contribute 35.8% of the 0.49-child gap, appreciably more than in the other two comparisons, because Nigerien progression is marginally higher than Malian progression even at the earliest transitions. Even here, close to two-thirds of the gap is generated from parity three onwards. The concentration of divergence at high parities is thus a general feature of the comparison rather than an artefact of a single country pair.

Table 4
Shapley decomposition of cross-national gaps in mean parity truncated at eight births, women aged 45–49 years

Parity transition	Mali vs Burkina Faso	Niger vs Burkina Faso	Niger vs Mali
0→1	-0.076 (-16.5%)	-0.024 (-2.5%)	+ 0.057 (+ 11.7%)
1→2	-0.006 (-1.3%)	+ 0.068 (+ 7.2%)	+ 0.078 (+ 16.0%)
2→3	+ 0.008 (+ 1.7%)	+ 0.046 (+ 4.8%)	+ 0.039 (+ 8.1%)
3→4	+ 0.066 (+ 14.3%)	+ 0.147 (+ 15.5%)	+ 0.084 (+ 17.1%)
4→5	+ 0.098 (+ 21.3%)	+ 0.171 (+ 18.0%)	+ 0.073 (+ 14.9%)
5→6	+ 0.145 (+ 31.6%)	+ 0.189 (+ 20.0%)	+ 0.035 (+ 7.2%)
6→7	+ 0.147 (+ 31.9%)	+ 0.241 (+ 25.4%)	+ 0.094 (+ 19.3%)
7→8	+ 0.078 (+ 16.9%)	+ 0.110 (+ 11.6%)	+ 0.027 (+ 5.6%)
Total gap in completed parity	+ 0.461 (100%)	+ 0.948 (100%)	+ 0.488 (100%)

3.4. Quantum and tempo: life-table progression and waiting times

Table 5 reports life-table PPRs and median waiting times. The quantum gradient found in the cohort analysis reappears in period form and orders the countries by their stage in the transition. The probability of a further birth within 60 months falls by 23 percentage points across the seven transitions in Burkina Faso (0.824 to 0.593), by 10 points in Mali (0.860 to 0.756), and by 9 points in Niger (0.925 to 0.835). The Burkinabè deficit relative to Niger grows from 10.1 points at the first transition to 24.2 points at the seventh, whereas the Malian deficit is essentially constant, at 6.5 and 7.9 points respectively.

Tempo differs in the same direction. The median waiting time to the next birth is 28–31 months at every parity in Niger and 31–34 months in Mali, flat across the reproductive career in both. In Burkina Faso it is 37 months at the first transition and rises to 43, 44, and 46 months at the fifth, sixth, and seventh. Burkina Faso therefore differs from Niger on both dimensions, and from Mali chiefly in that its waiting times lengthen with parity whereas Malian waiting times do not.

This pattern is more informative than a simple ordering of fertility levels. Mali is displaced from Niger by a roughly constant amount at every parity, in both quantum and tempo, which is what generalised postponement in the sense of Moultrie et al. (2012) predicts: all women wait somewhat longer, but the decision structure across parities is unchanged. Burkina Faso is displaced by an amount that increases with parity, as expected when parity-specific limitation is added to that postponement.

Table 5
Life-table parity progression ratios within 60 months and median waiting times to the next birth

Parity transition	Burkina Faso: n	Burkina Faso: PPR 60m (95% CI)	Burkina Faso: median (months)	Mali: n	Mali: PPR 60m (95% CI)	Mali: median (months)	Niger: n	Niger: PPR 60m (95% CI)	Niger: median (months)
1 to 2	7,186	0.824 (0.815–0.835)	37	7,067	0.860 (0.850–0.870)	32	3,925	0.925 (0.915–0.935)	28
2 to 3	6,356	0.800 (0.790–0.812)	38	6,114	0.874 (0.864–0.884)	32	3,489	0.914 (0.899–0.927)	28
3 to 4	5,306	0.761 (0.748–0.773)	40	5,136	0.871 (0.860–0.880)	31	2,970	0.915 (0.903–0.927)	28
4 to 5	4,077	0.744 (0.727–0.761)	39	4,162	0.837 (0.822–0.848)	32	2,419	0.882 (0.864–0.898)	29
5 to 6	2,790	0.693 (0.675–0.711)	43	3,175	0.824 (0.806–0.839)	32	1,871	0.874 (0.851–0.891)	29
6 to 7	1,770	0.659 (0.631–0.690)	44	2,261	0.801 (0.782–0.819)	33	1,347	0.867 (0.847–0.892)	29
7 to 8	1,021	0.593 (0.563–0.623)	46	1,519	0.756 (0.729–0.784)	34	924	0.835 (0.800-0.862)	31

CI: Confidence interval; PPR: Parity progression ratio.

3.5. Trends in progression

Figure 2 and Table S1 disaggregate the life-table PPRs by the period of the index birth, and the three countries again separate cleanly. In Burkina Faso the decline between index births 15–19 years before the survey and those 5–9 years before it rises steadily with parity, from 5.2 percentage points at the first-to-second transition to 14.1 points at the fifth-to-sixth, 23.0 points at the sixth-to-seventh, and 31.4 points at the seventh-to-eighth. In Mali the same gradient is present but compressed, from 0.4 points at the first transition to 13.1 points at the seventh. In Niger there is little movement anywhere, the declines ranging from 0.7 to 7.0 points, with no change at all at the third-to-fourth transition.

Because women who reached high parity long before the survey necessarily did so at young ages, the earliest period is selected towards rapid reproducers, which could inflate the apparent decline. Two checks address this. Restricting the comparison to mothers aged 25–34 years at the index birth preserves the gradient in attenuated form (Table S3). The adjusted hazard models point the same way: relative to index births 10–14 years before the survey, the hazard ratio for index births 5–9 years before is 0.98 at the first transition and not distinguishable from unity, then 0.95, 0.92, 0.89, 0.92, 0.89, and 0.80 at successive transitions, all significant at conventional levels. H3 is therefore supported as regards the parity gradient of the decline. The ordering of the three countries by the

magnitude of that decline is consistent with their ranking by stage in the transition, but a three-way country-by-parity-by-period interaction was not estimated, so the ordering remains descriptive.

3.6. Multivariate models of the waiting time to the next birth

Table 6 reports hazard ratios from the parity-specific models, with Niger as the reference country. The contrast between the two comparison countries is the central result. The Malian hazard ratio moves within a narrow band across the seven transitions, from 0.837 at the first to 0.795 at the seventh, a displacement of roughly 15–20% that barely varies with parity. The Burkinabè hazard ratio falls from 0.674 to 0.551, a displacement that deepens from 33% at the first transition to 45% at the seventh. Both sets of estimates are net of maternal age, education, wealth, residence, child survival, sex composition, and period.

The pooled model in Table 7 formalises the test. Taking parity one in Niger as the reference, none of the six interaction terms between parity and Mali is significant and all lie between 0.94 and 1.02, so the Malian deficit is a uniform proportional shift. The interaction terms between parity and Burkina Faso decline from 0.928 at parity two to 0.793 at parity seven, and all but the parity-four term are significant at the 5% level; the single departure from monotonicity is consistent with sampling variation rather than a genuine reversal. This supports H2: Mali is uniformly displaced from Niger while Burkina Faso is progressively displaced, so the two countries occupy different regimes rather than different points on the same regime. The full model is reported in Table S4.

The covariate structure is itself informative. Secondary or higher education reduces the hazard of progression at every parity, with hazard ratios between 0.74 and 0.81 and no clear parity gradient, indicating that schooling depresses progression across the whole reproductive career rather than acting specifically on limitation (Bongaarts et al., 2017). Death of the index child raises the hazard of the next birth substantially, with a hazard ratio of 1.70 at the first transition and 1.20–1.41 thereafter, the classic replacement effect. The absence of a surviving son raises the hazard at four of the seven transitions, with ratios between 1.06 and 1.29, and is indistinguishable from unity at the others. This indicates a modest son preference that operates once family size is already substantial, although the irregularity of the pattern across parities argues against over-interpreting it. Wealth effects are weaker and less consistent than educational effects.

Table 6
Discrete-time complementary log-log models of progression to the next birth, by parity transition

Covariate	1 to 2	2 to 3	3 to 4	4 to 5	5 to 6	6 to 7	7 to 8
Mali (ref. Niger)	0.837***	0.847***	0.850***	0.850***	0.834***	0.806***	0.795***
Burkina Faso (ref. Niger)	0.674***	0.630***	0.569***	0.616***	0.565***	0.560***	0.551***
Mother's age at index birth: under 25 (ref. 25–29)	1.115**	1.134***	1.111***	1.045	1.115*	1.075	1.182
Mother's age at index birth: 30–34	1.008	0.952	0.802***	0.813***	0.861***	0.840***	0.818**
Mother's age at index birth: 35+	0.686*	0.630***	0.544***	0.577***	0.585***	0.538***	0.590***
Primary education (ref. none)	0.925**	0.914**	0.906**	0.893**	0.897*	0.786***	0.841*
Secondary or higher education	0.739***	0.780***	0.792***	0.806***	0.746**	0.779*	0.755
Poorer quintile (ref. poorest)	0.947	0.923*	0.967	0.928	0.866**	0.912	0.929
Middle quintile	0.881***	0.897**	0.920*	0.904*	0.843***	0.854**	0.788***
Richer quintile	0.820***	0.837***	0.798***	0.818***	0.753***	0.720***	0.757***
Richest quintile	0.696***	0.756***	0.680***	0.634***	0.639***	0.732***	0.751*
Urban residence (ref. rural)	0.905**	0.814***	0.860***	0.849***	0.883*	0.852*	0.850
Index birth died (ref. survived)	1.697***	1.371***	1.381***	1.414***	1.275***	1.201**	1.291***
No surviving son at index birth	0.997	1.064**	1.127***	1.188***	0.953	1.289*	1.202
Index birth 15–19 years before survey (ref. 10–14)	0.977	0.991	1.004	1.011	1.110*	1.042	0.964
Index birth 5–9 years before survey	0.979	0.952*	0.915***	0.886***	0.916*	0.889**	0.800***
Episodes (n)	18,178	15,959	13,412	10,658	7,836	5,378	3,464

***p < 0.001; **p < 0.01; *p < 0.05.

Table 7
Pooled discrete-time model: country and parity-by-country interaction terms

Term	Hazard ratio	95% CI	p-value
Mali (ref. Niger)	0.836***	0.787–0.887	< 0.001
Burkina Faso (ref. Niger)	0.679***	0.641–0.719	< 0.001
Parity 2 (ref. parity 1)	1.032	0.971–1.097	0.314
Parity 2 x Mali	1.001	0.930–1.077	0.982
Parity 2 x Burkina Faso	0.928*	0.865–0.997	0.040
Parity 3 (ref. parity 1)	1.056	0.998–1.118	0.058
Parity 3 x Mali	1.016	0.951–1.087	0.632
Parity 3 x Burkina Faso	0.846***	0.790–0.907	< 0.001
Parity 4 (ref. parity 1)	0.990	0.919–1.067	0.801
Parity 4 x Mali	1.019	0.936–1.109	0.661
Parity 4 x Burkina Faso	0.922	0.847–1.004	0.061
Parity 5 (ref. parity 1)	1.032	0.952–1.118	0.449
Parity 5 x Mali	0.986	0.896–1.086	0.776
Parity 5 x Burkina Faso	0.830***	0.754–0.913	< 0.001
Parity 6 (ref. parity 1)	1.073	0.999–1.153	0.054
Parity 6 x Mali	0.951	0.871–1.038	0.262
Parity 6 x Burkina Faso	0.816***	0.737–0.903	< 0.001
Parity 7 (ref. parity 1)	1.030	0.923–1.150	0.597
Parity 7 x Mali	0.942	0.830–1.069	0.352
Parity 7 x Burkina Faso	0.793**	0.690–0.911	0.001

***p < 0.001; **p < 0.01; *p < 0.05. Abbreviation: CI: Confidence interval.

4. Discussion

This study asked where in the parity distribution the Sahelian fertility transition stalls. Three findings follow. Divergence between Burkina Faso, Mali, and Niger is generated almost entirely above parity two (H1). The three countries occupy qualitatively different regimes rather than three points on a single scale (H2). And progression has declined in a parity-graded way, and only where the transition is already under way (H3).

4.1. A high-parity phenomenon

The concentration of the gap above parity two has a direct implication for how fertility stalls are diagnosed. An aggregate indicator such as the TFR can remain flat while progression at the lowest parities holds constant and

progression at parities five to eight falls, or the reverse, and the two situations carry entirely different policy implications. The literature on stalled transitions (Bongaarts, 2006; Ezeh et al., 2009; Schoumaker, 2019) has largely proceeded at the aggregate level. The present results suggest that stall diagnosis should also be conducted at the level of the parity transition.

Niger illustrates the converse case. Its aggregate fertility has drifted downwards, yet progression has not shifted appreciably at any parity. One reading is that the aggregate change reflects compositional shifts rather than a change in reproductive decision-making, but the analysis presented here does not decompose the Nigerien TFR into rate and composition components, so this remains an inference to be tested rather than a finding.

4.2. Why the third birth is the frontier

Several mechanisms are consistent with the concentration of divergence from parity three onwards. The first is the arithmetic of exposure. Women who reach parity three have typically done so in their mid-twenties in this setting, leaving some 20 years of potential exposure, so decisions taken at that point have far larger cumulative consequences than decisions taken at parity one. It is also the point at which the opportunity cost of an additional birth, in the schooling of existing children, in household resources, and in maternal health, becomes salient. Longitudinal evidence that stated preferences predict subsequent childbearing more strongly once family size is already substantial points in the same direction (Cleland et al., 2020).

The second is the structure of contraceptive supply. Family planning programmes in the Sahel have been organised around birth spacing and around maternal and child health entry points, with adolescents and young mothers as the principal target. High-parity women, who are older, more rural, and less likely to be in sustained contact with antenatal services, are comparatively poorly served, and the method mix available to them remains dominated by short-acting and traditional methods (Rossier & Corker, 2017; Sedgh et al., 2016). That the country furthest advanced in the transition is also the one where high-parity progression has fallen most is consistent with this reading, although no programme data are analysed here and the association cannot be attributed to programmatic effort (Bongaarts, 2011). The educational gradient reported above, which is present at every parity, is consistent with evidence that schooling shapes fertility desires as well as behaviour (Kebede et al., 2022; Kravdal, 2002).

The third is the replacement effect, which the models estimate directly. Where under-five mortality remains high, the death of a child sustains progression at exactly the parities where the transition would otherwise advance, linking the parity structure of fertility to child survival in a way that aggregate indicators obscure.

4.3. Three regimes rather than three levels

The clearest analytical result is that the three countries do not occupy three points on a single fertility scale. Taken together, the interaction tests and the tempo profiles point to three distinct regimes: a pre-transitional regime in Niger, where neither quantum nor tempo has moved; a postponement regime in Mali, where all intervals have lengthened uniformly and the decision structure across parities is unchanged; and a mixed regime in Burkina Faso, where parity-specific limitation has been superimposed on that postponement.

This qualifies the influential argument that African fertility decline proceeds through the lengthening of birth intervals rather than through parity-specific limitation (Moultrie et al., 2012; Timæus & Moultrie, 2020). The argument holds for the earlier phase of the transition, which Mali exemplifies, but it does not describe the later phase, which Burkina Faso has entered. The natural reading is sequential rather than exclusive: generalised

postponement comes first, and parity-specific limitation is superimposed on it as the transition matures. Because the sequence is inferred from three countries observed at a single point in time, it remains a hypothesis, and one that can be tested directly against repeated survey rounds within a single country and against a broader set of Sahelian and West African cases.

4.4. Policy implications

Three implications follow, subject to the descriptive nature of the evidence. First, indicators used to monitor fertility change in the Sahel should include parity-specific progression measures alongside the TFR, which cannot distinguish movement at the parities where movement matters most, nor separate behavioural change from compositional drift. Second, reproductive health programming that concentrates on adolescents and first-time mothers addresses the segment of the reproductive career where the three countries already resemble one another and where the scope for differentiation is arithmetically small; extending counselling, method choice including long-acting and permanent methods, and postpartum service contact to women who have already had three or more births would target the segment that actually generates the differential. Third, because progression at high parities responds strongly to the death of the previous child, child survival investment and fertility programming are complementary rather than sequential objectives.

4.5. Limitations

Several limitations qualify the findings. The three surveys were conducted between 2021 and 2024, so the comparison is not strictly synchronous, although the parity structures documented here move slowly enough that a two-year offset is unlikely to alter the ordering. Cohort PPRs estimated from women aged 45–49 years describe childbearing that occurred on average 15 to 25 years before the survey and therefore lag the current regime; the period life-table and hazard analyses address this and yield the same parity gradient, but the two sets of estimates describe different vintages of behaviour. Insecurity restricted fieldwork in parts of all three countries during the survey periods, so the least accessible areas are likely to be under-represented, and because those areas are typically rural and poorly served the estimates reported here may understate high-parity progression.

The analysis is also descriptive and decompositional. The Shapley contributions are exact accounting quantities rather than causal effects, and the hazard models identify associations under an assumption of no unmeasured confounding that is not defensible for variables such as fertility preferences, which are jointly determined with parity. Women observed at high parity are selected on fecundity and on short preceding intervals, so part of the parity gradient within a country may reflect the changing composition of the risk set rather than changing behaviour; the cross-country contrasts, on which the central argument rests, are far less exposed to this problem, and the restriction to mothers aged 25–34 years preserves the gradient. Finally, retrospective birth histories are subject to date displacement and omission, which affect the earliest years of recall most severely, and restricting the trend analysis to the 20 years preceding each survey limits but does not eliminate this concern. Extending the analysis to Chad and Mauritania, and to earlier survey rounds within each country, would allow the three regimes identified here to be tested both across the wider Sahel and over time.

5. Conclusion

Asking where fertility is high yields a different answer from asking where the transition is blocked. In Burkina Faso, Mali, and Niger, entry into motherhood is universal and early, and the first three parity transitions are essentially identical. Everything that separates a mean parity of 5.9 from one of 7.1 happens after the third birth.

The three countries also differ in kind and not only in degree. Niger has not moved appreciably at any parity. Mali has moved uniformly across parities, lengthening every interval without altering the structure of the reproductive career. Burkina Faso has moved progressively more at each successive parity, which is the signature of parity-specific limitation in its early stages. Postponement and limitation are therefore better read as successive phases of a single transition than as alternative routes through it, and a cross-section of the Sahel makes the sequence visible.

The practical consequence is that the segment of the reproductive career receiving the least programmatic attention in the Sahel, namely women who already have three or more children, is the segment where the transition is now being decided. Monitoring systems built on the TFR alone will not see this, and programmes built around adolescent and first-birth contact will not reach it.

Declarations

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Conflict of Interest

The authors declare no conflicts of interest.

Author Contributions

ARB: Conceptualisation, methodology, formal analysis, and writing – original draft. ARB, HB, and NAM: Writing – review and editing. All authors reviewed and approved the final version of the manuscript.

Ethics Approval and Consent to Participate

Not applicable. This study is based on de-identified, publicly available secondary data from the Demographic and Health Surveys Program. Ethical approval for each survey was obtained by the implementing institutions at the time of data collection, and informed consent was obtained from all respondents. Authorisation to use the datasets was granted by The DHS Program.

Consent for Publication

Not applicable.

Availability of Data

The datasets analysed are publicly available from The DHS Program upon registration at https://dhsprogram.com/data/. The analysis code, the constructed analytical files, and the Stata replication do-file are available from the corresponding author upon reasonable request.

Further Disclosure

These findings have not been presented at a conference, nor has the manuscript been deposited in a preprint server. Generative artificial intelligence tools were used for language editing and to assist with analysis code. All analytical decisions, interpretations, and conclusions remain the authors' own, and the authors take full responsibility for the content.

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Figures

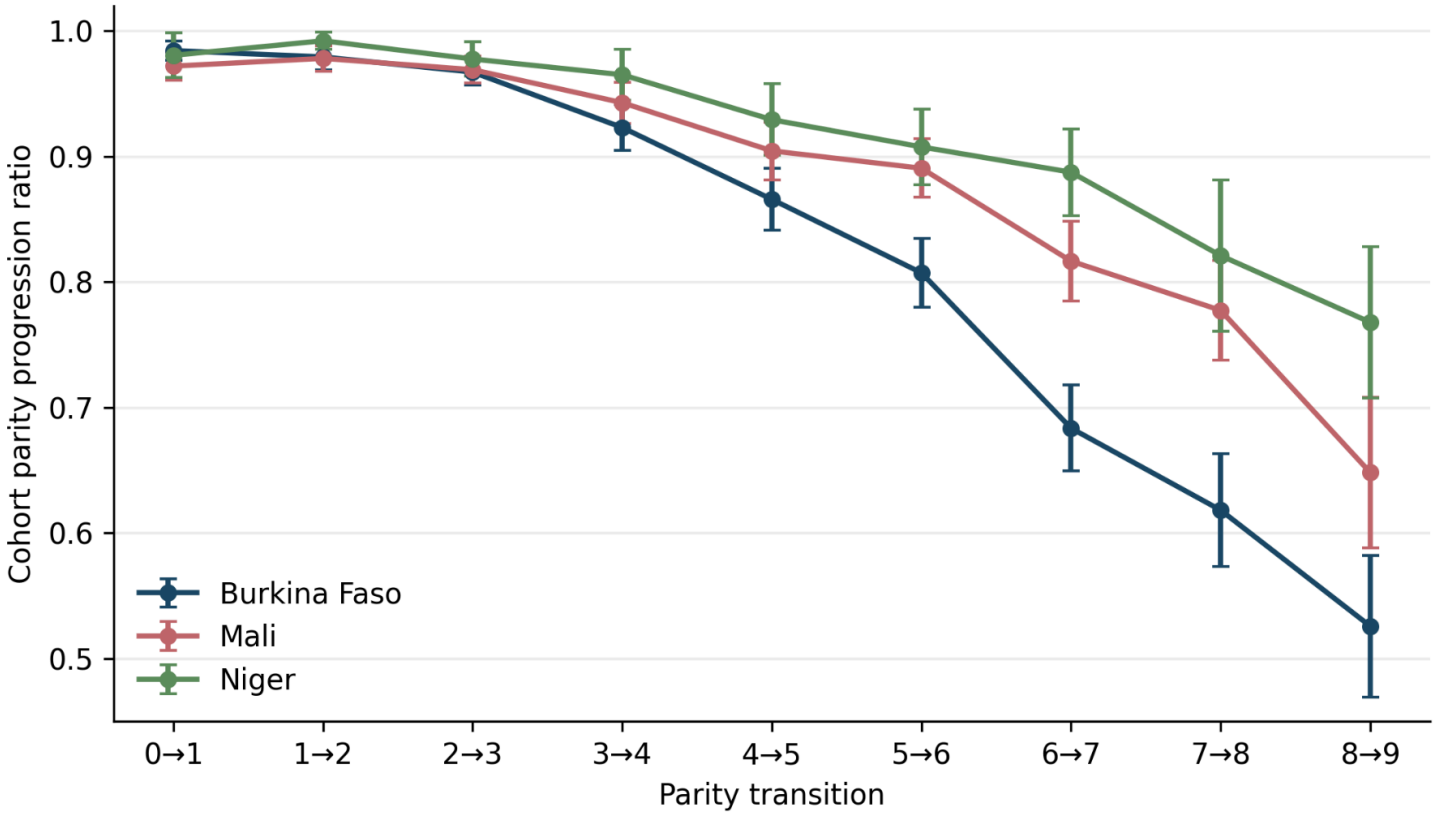


Figure 1

Cohort parity progression ratios among women aged 45–49 years, by country.

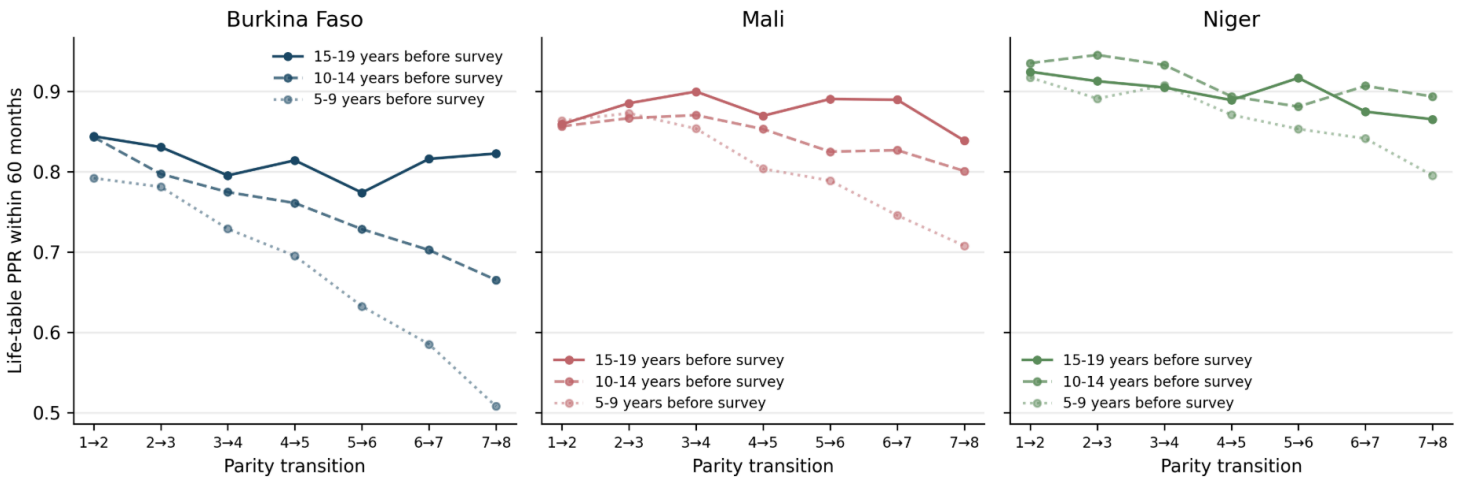


Figure 2

Life-table parity progression ratios by period of the index birth and country.

Supplementary Files

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- SupplementaryMaterials.docx