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Age at first birth, completed fertility, and literacy skills in sub-Saharan Africa

Afua Durowaa-Boateng
Vienna Institute of Demography, Wittgenstein Centre for Demography and Global Human Capital (IIA-SA, ÖAW, University of Vienna)
afua.durowaa-boateng@oeaw.at

Éva Beaujouan
Department of Demography, University of Vienna, Wittgenstein Centre for Demography and Global Human Capital (IIASA, ÖAW, University of Vienna)
eva.beaujouan@univie.ac.at

DEMO Centre de recherche en démographie
IACCHOS Institut d'analyse du changement dans l'histoire et les sociétés contemporaines
UCLouvain

https://doi.org/10.14428/rqj2024.12.01.03 · @2026 Afua Durowaa-Boateng & Eva Beaujouan
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Abstract - Résumé

Abstract

While education contributes to delayed first births and reduced fertility, substantial disparities remain between women with primary and secondary education in sub-Saharan Africa. Many women who complete primary education in the region do not acquire basic literacy skills, likely due to limitations in education quality. Although school enrolment rates—particularly at the primary level—have increased, literacy rates have not risen as much. This gap raises the question of whether literacy acquisition, irrespective of formal education, influences fertility behaviour. Using Demographic and Health Survey (DHS) data, this study examines the impact of literacy skills, independent of education level, on two indicators of female cohort fertility, age at first birth and completed fertility, in 38 sub-Saharan African countries. Literacy does not significantly delay the age at first birth among women of a given education level. However, in countries where literacy among primary-educated women is widespread, a modest delay is observed, likely reflecting indirect social influences or diffusion processes rather than a direct effect of literacy. Yet, among women with primary education, the timing effects do not persist after accounting for years of schooling. Additionally, literate women with no formal education tend to have fewer children than illiterate women with no education or only primary education. Overall, the association between literacy and fertility is small compared with the gradient between education and fertility, and appears to be partly driven by the number of years of schooling.

Keywords: *Literacy, Sub-Saharan Africa, Education, Cohort fertility, Age at first birth.*

Résumé

Si l'éducation contribue à retarder l'âge du premier enfant et à réduire la fécondité, des écarts importants persistent en Afrique subsaharienne entre les femmes ayant un niveau d'éducation primaire et secondaire. Nombre de celles qui achèvent leur scolarité primaire n'acquièrent pas les compétences de base en lecture, probablement en raison de la qualité limitée de l'enseignement. Bien que les taux de scolarisation – en particulier au niveau primaire – aient augmenté, les taux d'alphabétisation n'ont pas progressé dans les mêmes proportions. Ce décalage soulève la question de l'influence de l'acquisition de la lecture, indépendamment du niveau d'éducation formel, sur les comportements de fécondité. À partir des données des Enquête démographique et de santé (EDS), cette étude analyse l'impact des compétences en lecture, indépendamment du niveau d'éducation, sur deux indicateurs de la fécondité des cohortes féminines, l'âge au premier enfant et la fécondité achevée, dans 38 pays d'Afrique subsaharienne. L'alphabétisation ne retarde pas significativement l'âge au premier enfant parmi les femmes d'un même niveau d'éducation. Toutefois, dans les pays où l'alphabétisation des femmes ayant un niveau primaire est répandue, un léger retard est observé, reflétant probablement des effets sociaux indirects ou des processus de diffusion plutôt qu'un impact direct de la lecture. Cependant, parmi les femmes ayant un niveau primaire, ces effets sur le calendrier ne persistent pas après contrôle du nombre d'années de scolarisation. Par ailleurs, les femmes alphabétisées sans éducation formelle tendent à avoir moins d'enfants que les femmes illettrées sans éducation ou ayant un niveau primaire. Globalement, le lien entre alphabétisation et fécondité reste faible comparé au gradient entre éducation et fécondité, et semble en partie expliqué par le nombre d'années de scolarisation.

Mots-clés: *Alphabétisation, Afrique subsaharienne, Éducation, Fécondité par cohorte, Âge au premier enfant.*

Introduction

Researchers recognise education as a key driver of fertility decline, with higher educational levels associated with fewer children and delayed childbearing (e.g. DeCicca & Krashinsky 2017; Shapiro & Tenikue 2017; Sobotka et al. 2017; United Nations 2019). In sub-Saharan Africa, policies have promoted educational expansion—particularly at the primary level—to improve literacy, economic outcomes and gender equality. These efforts coincided with reductions in fertility rates, amid growing concerns about rapid population growth (Caldwell & Caldwell 1987; Grant 2015). While these policies have contributed to increased school enrolment (UNICEF 2023), their impact on skill acquisition, particularly in literacy and numeracy, remains inconsistent (Nishimura & Byamugisha 2011). The disconnect between expanding enrolment and limited skill acquisition underscores the importance of examining how literacy, an essential component of education, shapes fertility behaviour.

Educational attainment reflects both the length and quality of schooling; however, schooling alone does not guarantee literacy. In West and Central Africa, many women complete primary education without acquiring literacy skills (Smith-Greenaway 2015), revealing a significant disparity between formal attainment and actual competencies. Conversely, some women may acquire literacy outside the formal education system through literacy programmes (Maruatona 2008; Post 2016), potentially altering their fertility behaviour. Literacy, therefore, can develop both within and outside formal schooling, and may function as a distinct determinant of fertility.

Literacy tests, often used as proxies for education quality, measure an individual's ability to read and write. Altinok et al. (2018) argue that literacy reflects not only the duration of schooling but also the effectiveness of instruction. Stronger literacy skills may enhance women's economic empowerment and access to reproductive health information, thereby influencing fertility outcomes (Caldwell 1980). As a core component of human capital, literacy contributes to broader social and economic processes, from labour market participation to economic growth (Lutz et al. 2021; Reiter 2022).

Despite the central role of education in shaping fertility, the independent effect of literacy remains underexplored. Previous research in sub-Saharan Africa has shown that fertility tends to decline after secondary education (Bongaarts 2010; Obeng Gyimah 2003). However, more recent studies suggest that fertility is also beginning to decline among women with basic education, albeit to a lesser extent (Durowaa-Boateng et al. 2023; Schoumaker & Sánchez-Páez 2024). Still, wide disparities persist between women with basic and higher education (Schoumaker & Sánchez-Páez 2024). Similarly, the relationship between education and age at first birth varies across sub-Saharan Africa and over time (Grant 2015; Mahy & Gupta 2001). These patterns may reflect not only differences in education levels but also in literacy acquisition across groups.

This study investigates the relationship between literacy and fertility behaviour across sub-Saharan African countries. Adopting a cohort approach to reflect reproductive behaviour over the life course, it examines cohort-completed fertility and mean age at first birth. The analysis compares these indicators across literacy levels among women with no or primary education and across broader education levels. In light of the disparity in skill acquisition at the primary level, the study also explores fertility behaviour by years of schooling and literacy status among women with primary education.

BACKGROUND

Education influences female fertility through multiple mechanisms. One key pathway is the number of years spent in school, which often delays the transition into adulthood (Schultz 1997). Beyond delaying marriage and childbearing, formal education provides women with skills—especially literacy—that broaden their life opportunities and inform reproductive decision-making (LeVine et al. 2011; Parikh & Gupta 2001). Education is associated with various fertility-related factors, including contraceptive use, marriage and childbirth timing, postpartum behaviours and child survival rates (e.g. Bongaarts 2010; Ferré 2009; Kirk & Pillet 1998; Lutz et al. 2018). It also enhances employment opportunities and earnings potential, raising the opportunity cost of childbearing and, in turn, reducing fertility ambitions (May & Rotenberg 2020).

In much of sub-Saharan Africa, women's education remains a strong determinant of fertility preferences and behaviours (Bongaarts 2020; Schoumaker 2017). Yet, beyond individual educational levels, societal dynamics also shape reproductive behaviour. One key mechanism is the diffusion process, whereby less-educated women adopt the fertility behaviours of their more educated peers (Adhikari et al. 2024; Kravdal 2001). As more women attain higher levels of education, societal norms and expectations shift—often towards smaller families and delayed childbearing (Bongaarts 2010; Colleran et al. 2014). In contexts where many women are literate—even if they did not complete formal schooling—greater awareness of family planning options tends to emerge. This can lead to widespread behavioural change, with new norms diffused to lower-educated women (Kravdal 2001, 2002). Consequently, societies with a higher proportion of educated or literate women tend to exhibit lower fertility rates (Colleran et al. 2014; Kravdal 2012; Parikh & Gupta 2001).

The distinctive strength of literacy—whether acquired through formal education or not—lies in its capacity to improve comprehension and decision-making (Gee 1989; McMillan & O'Neil 2012). LeVine et al. (2011) showed that mothers who could recognise and understand words in health messages, whether in media or print, had better child health outcomes and lower child mortality, which can ultimately influence completed fertility. Literacy also supports the ability to understand contraception and family planning information, thereby enabling women to regulate fertility more effectively (Bongaarts 2010).

While Universal Primary Education (UPE) and Education for All (EFA) policies significantly increased school enrolment (UNICEF 2023), completion rates remain low. Many students face challenges that prevent them from finishing primary education, including resource shortages, repetition and the limited enforcement of compulsory education (Chimombo 2005; Lewin 2009). The rapid expansion of education systems has often outpaced infrastructure and staffing, contributing to poor teaching quality in government-owned or funded (public) schools (Bold et al. 2017; Heneveld & Craig 1996).

Despite the provision of free public education, private primary schools are widespread across sub-Saharan Africa (Uwakwe et al. 2008). Private primary schools usually have higher enrolment and perform better than government-funded schools—particularly in numeracy and literacy—due to lower teacher–student ratio, greater teacher commitment and improved facilities (Romuald 2023; Tooley & Dixon 2005).

The resulting dual system of private and public education reinforces disparities in skill acquisition at the same educational level (Cheema 2024; Kouamo 2024). While net enrolment rates increased from 60.2% to about 75% from 2000 to 2009 (Ritchie et al. 2023), this did not translate into equivalent gains in literacy. Literacy among young women improved only modestly, from 57% in 2000 to 60.9% in 2010 (Roser & Ortiz-Ospina 2018). This modest rise may be partly explained by literacy statistics capturing a broader population, including older cohorts who are unlikely to benefit from recent educational reforms. Among school-age children, challenges—such as teacher shortages and the recruitment of untrained personnel—continue to affect learning outcomes (Somerset 2009).

Based mostly on Caldwell's (1980) thesis linking mass schooling and fertility decline, universal primary education was expected to reduce fertility (Lloyd et al. 2000). However, empirical evidence has been mixed. For instance, Grant (2015) found that education expansion in Malawi did not significantly delay age at first birth, although it did reduce ideal family sizes, potentially reducing completed fertility (Behrman 2015). Grant (2015) also observed a decline in education quality during this expansion, suggesting that dropout rates and poor schooling environments may limit the fertility-related benefits of UPE. These findings indicate that both education and literacy—especially at the primary level—can have varying effects on age at first birth and completed fertility, depending on quality and context.

Sub-Saharan Africa has a wide variety of cultural and institutional settings. Fertility behaviours are influenced not only by education and literacy but also by broader cultural norms, such as attitudes toward polygamy (Cleland et al. 1994; Hayase & Liaw 1997). West and Central African countries including Mali, Niger, Nigeria, Chad and the Central African Republic, where polygamy is more prevalent, tend to report higher total fertility rates and lower ages at first birth. In contrast, countries in Southern Africa, such as Namibia and South Africa, where polygamy is less common, exhibit lower total fertility rates (Fenske 2015; Rossi 2019; Schoumaker 2017; Tabutin et al. 2004; United Nations Population Division n.d.). This diversity highlights the need to examine fertility outcomes within diverse country contexts.

Finally, the timing of completion of education appears to be a key factor in entering parenthood (Adu Boahen & Yamauchi 2018; Kim 2023; Neels & De Wachter 2010; Neels et al. 2017; Ní Bhrolcháin & Beaujouan 2012). Notably, the impact of education, years of schooling, and literacy on female fertility varies, as demonstrated in the case of Malawi's education policies. Therefore, when studying the role of literacy skills in shaping age at first birth and completed fertility at the primary level, it is important to consider how years of schooling, which reflects women's school progression, may influence the relationship between literacy and fertility outcomes.

The main research question (RQ) we aim to answer is: At a given level of education, is literacy associated with age at first birth and completed fertility in sub-Saharan African countries?

We summarise the sub-research questions, which supplement our main research question, as follows:

RQ1: Among women with no education and primary education, do literate women have fewer children and at a later age than non-literate women?

RQ2: Do literate women with primary education have the same mean age at first birth and completed fertility as secondary-educated women?

RQ3: Do we observe different or similar patterns in these relationships depending on the prevalence of literacy among women with a primary education in each country?

RQ4: Do years spent in schooling at the primary education level reduce or change the effects of literacy?

DATA

This study uses data from the Demographic and Health Surveys (DHS), a series of nationally representative surveys conducted in more than 90 low- and middle-income countries (Rutstein & Rojas 2006). The DHS is the most comprehensive and reliable source of demographic and educational data in these settings. We use data from 38 sub-Saharan African countries, spanning survey waves conducted between 1986 and 2019 (see Appendix A, Table A1 for the full list).

To analyse fertility outcomes, we construct two datasets. For age at first birth, we use the Birth Recode (BR) file, which links child-level data to maternal characteristics. We include only firstborn children born before their mothers turned 40, and whose mothers were aged 40–50 at the time of the survey. This captures typical fertility patterns, as fewer than 1% of first births occur after age 40 in the region (Dunlop et al. 2018). For completed fertility, we use the Individual Recode (IR) file, selecting women aged 40–50 and using the total number of children ever born as our outcome.

Explanatory variables:

In our study, we use the following variables:

Level of education at the time of the survey. The DHS categorises education levels as no education, primary education, secondary education, and higher education. This variable captures the highest level of education reported by respondents at the time of the survey. This is the highest level of education that they attended, without necessarily completing it. In the analysis, women with higher education are retained despite their small sample size because they represent a socially and demographically distinct group of women, irrespective of the age at first birth (Mahy & Gupta 2001). Furthermore, while higher education may (rarely) be attained post-childbearing, we retain it as a distinct category to reflect different fertility and literacy profiles.

Literacy skills at the time of the survey. The DHS assesses literacy skills using a card with four simple sentences, presented in a language the respondent is likely to understand—often an official or local language—to ensure broad linguistic coverage1[1] (MEASURE DHS 2008). This method is widely considered reliable and

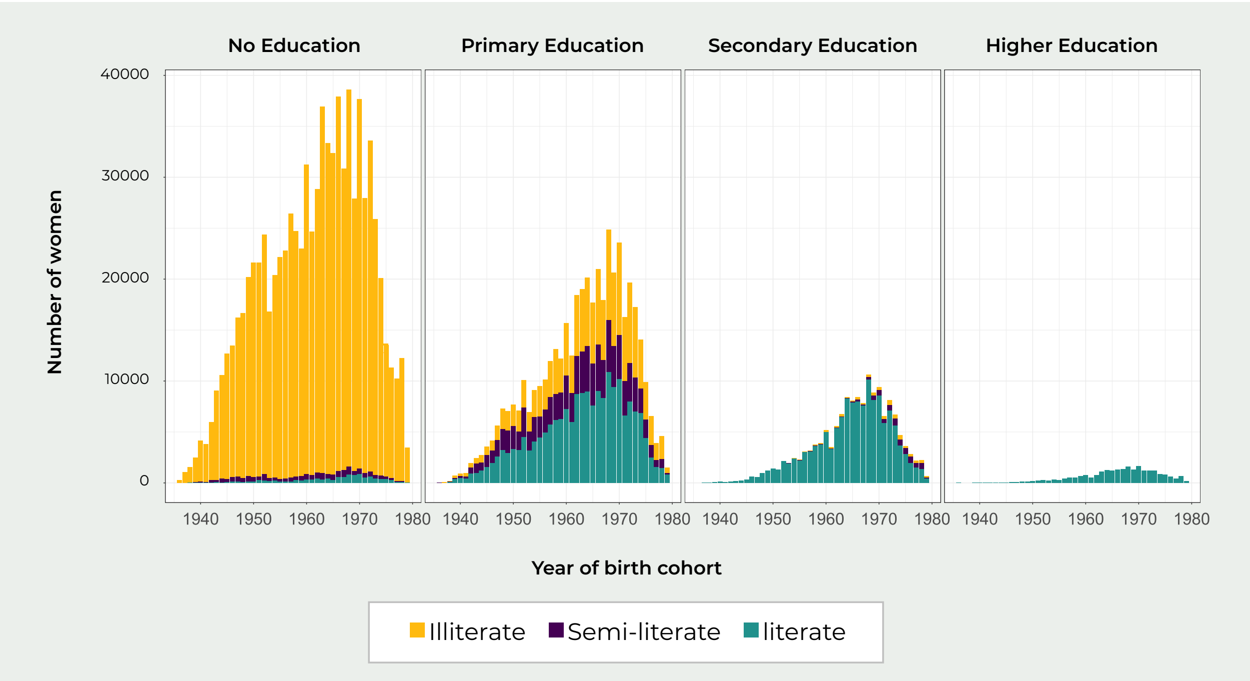
[1] It is unclear whether the literacy test was conducted in the official language of the respondent's country or in a local language used in health services. This distinction is important because literacy in different languages may influence access to family planning information.

valid for cross-country comparisons (MEASURE DHS 2008; Oye et al. 2016). We categorise women who could read all sentences as literate, those who could read some sentences as semi-literate, and those unable to read as illiterate. Since the literacy test was conducted at the time of the survey rather than at first birth, we assume minimal skill attrition. This assumption aligns with the empirical findings of Barrett and Riddell (2016), who demonstrated that literacy skills generally remain stable for people in their 20s to 40s. Literacy tests for women with secondary education were only introduced in later survey rounds, starting with the seventh DHS phase. Given our longer-term approach, we do not use the information available in the latest surveys on literacy among women with secondary education: assessing literacy only among less-educated women is sufficient for our analysis.

The education and literacy skill composite variable combines respondents' education level and literacy status. Following Pritchett and Sandefur (2020), we construct this measure exclusively for women with no or primary education. The composite variable produced eight categories: no education and literate, no education and semi-literate, no education and illiterate, primary education and literate, primary education and semi-literate, primary education and illiterate, secondary education, and higher education. Secondary and higher education groups are included in our models to enable meaningful comparisons with lower-educated groups.

Year of birth of the woman represents her birth cohort, allowing us to control for changes in first birth timing and completed fertility over time. A cohort approach is adequate as cohort measures reflect actual reproductive behaviour, avoiding the distortions that arise from tempo shifts in period-based measures (Myrskylä et al. 2013). Figure 1 presents the weighted number of women in the final sample by birth cohort, literacy skills, and education level.

Figure 1: Composition of the sample by birth cohort, literacy and education level, women aged above 40 at survey time.



Most women in our sample from sub-Saharan Africa had no formal education (Figure 1). The majority of these women are illiterate. For women with primary education, a substantial proportion are either illiterate or semi-literate. We show the literacy level of women with secondary education for information. As seen, only the latest birth cohorts have this information, but most of them are literate. Women with higher education represent a small fraction of the sample.

Outcome variables:

Our first outcome variable is age at first birth. The DHS calculates this using the mother's reported date of birth and the birthdate of their first child. A well-documented data quality issue in DHS surveys is age heaping, where respondents round birth years to the nearest zero or five, leading to systematic misreporting (Al Zalak & Goujon 2017; Schoumaker 2011). To minimise the impact of heaping, we implement statistical adjustments in our analysis (details in the Method section).

Our second outcome variable is number of children ever born. The DHS derives this variable from full birth histories, including all sons and daughters—living, deceased, or living elsewhere. It uses multiple verification steps to cross-check responses and resolve inconsistencies during the interview process ("The DHS program" n.d.; MEASURE DHS 2008).

Weighting

We apply DHS survey weights (v005, but rescaled, that is, v005/1,000,000) using the "svydesign" and "svytable" functions from the R package survey (Lumley 2020) to ensure representativeness. These weights account for sampling design and non-response, ensuring that our estimates reflect national populations. We do not apply additional weights for national population sizes in order to preserve survey-based comparability across countries. Indeed, we aim to describe patterns across national contexts, rather than to estimate a single population-average effect for the region weighted by country size. This choice ensures that each survey contributes equally to the estimation, avoiding dominance of a few large countries (e.g., Nigeria) and preserving comparability across countries.

We then generate weighted frequency tables, capturing the total number of children ever born and age at first birth, disaggregated by the variables of interest: literacy status, educational attainment, birth cohort, and survey year. This process is applied separately to each country and survey wave listed in Appendix Table A1. Finally, we combine data from all survey waves and countries to construct a unified dataset for analysis. Weighted means were calculated using the unified data grouped by year of birth, education level, literacy status, survey year, and, where necessary, years of schooling. Survey year was retained as an identifier during the aggregation step to ensure that survey weights and sample designs were applied separately within each survey wave. We do not, however, include survey year as a covariate in the models; we instead rely on country fixed effects and cohort smooths. We excluded cases from all datasets where respondents, despite reporting higher education, were classified as illiterate or semi-literate, as such discrepancies likely resulted from misreporting. The modelling excludes groups with a single observation and weighted sample size below two to reduce instability. The final sample sizes for both data sets are presented in Appendix A, Table A2.

METHOD

Modelling approach

We employ generalised additive models (GAMs) to analyse fertility outcomes due to their flexible and interpretable approach to modelling non-linear trends in demographic data (Ellison et al. 2022). GAMs are particularly well-suited to this study, which examines both completed fertility (a count outcome) and mean age at first birth (a continuous variable), as they allow for smooth, data-driven relationships without imposing rigid parametric forms. This flexibility is useful, as reproductive behaviours across cohorts are unlikely to follow simple linear or quadratic trajectories (see Appendix B, Figure B1 for the non-linear relationship of mean age at first birth by cohort).

GAMs offer a more integrated and interpretable framework for capturing these complexities. In our specifications, country-specific smoothing terms $s(\mathit{Year\ of\ birth})_{country}$ allow cohort effects to vary flexibly across countries, capturing the heterogeneity of fertility transitions. These smoothing functions fit continuous curves to the data and reveal non-linear patterns that standard parametric models may obscure (Wood 2017).

Model specifications

We use a multi-country model with country-specific fixed effects to account for contextual differences. The country fixed effects help to account for time-invariant unobserved heterogeneity between countries, which may include fertility norms, policies, and institutional context. Under this specification, we can examine within-country variation in the association between education, literacy, and fertility outcomes. To address RQ1 and RQ2, we estimate separate GAMs for age at first birth and completed fertility. The first model estimates the expected age at first birth as a function of education, literacy, and country-specific factors.

$$E\big(\text{age at first birth}\big) = \beta_0 + \beta_i \cdot \text{Education and literacy skill}_i + \beta_j \cdot \text{Country}_j + \sum_p \beta_p \Big(s\,(\text{Year of birth})_{\text{country}}\Big). \quad (1)$$

Similarly, the second model estimates the total number of children ever born, using the same set of predictors:

$$E(\text{number of children ever born}) = \beta_0 + \beta_i \cdot \text{Education and literacy skill}_i + \beta_j \cdot \text{Country}_j. + \sum_p \beta_p \Big(s(\text{Year of birth})_{\text{country}}\Big). \quad (2)$$

These models allow us to analyse variations in the mean age at first birth and completed fertility across different education and literacy levels. For clarity in presentation, we use a categorical variable approach. We use a composite education and literacy variable to capture the joint effect of both factors while reducing multicollinearity and the risk of over-fitting inherent in interaction models. In the presentation of all the models' results, the composite variable "Primary Education and Literate" remains the reference category. An alternative interaction model (Appendix D) confirms our main results, demonstrating that the level of education remains the dominant predictor of fertility outcomes. Our models assume a normal distribution for the link function[2]. The survey-weighted number of women (N) is used as a frequency weight in the GAMs using the "bam" function. This way, the modelled means closely approximate the weighted individual-level estimates.

Incorporating literacy prevalence at the country level

To address RQ3 and its hypotheses, we examine the importance of literacy prevalence at the country level. We classify countries based on primary education literacy prevalence, using a 60% threshold—consistent with reported literacy rates in sub-Saharan Africa (Roser & Ortiz-Ospina 2018). This threshold reflects the regional average and distinguishes between settings where primary education is more or less likely to result in literacy. Countries are categorised as having widespread literacy (≥60% of women with a primary education are literate) or limited literacy (<60%). We estimate separate models for high- and low-literacy-prevalence countries to determine whether the relationship between fertility and literacy among low-educated women differs depending on literacy prevalence. A three-way interaction was considered but not implemented because of concerns about model overfitting and difficulty in interpreting higher-order interactions.

The GAMs for this analysis are specified as follows:

$$E\,(\text{age at first birth}) = \beta_0 + \beta_i \cdot \text{Education and literacy skill}_i + \beta_j \cdot \text{Country}_{\text{literacy prevalence group}j} + \sum_p \beta_p \left(s(\text{Year of birth})_{\text{country}_{\text{literacy prevalence group}}} \right). \quad (3)$$

$$E\,(\text{number of children ever born}) = \beta_0 + \beta_i \cdot \text{Education and literacy skill}_i + \beta_j \cdot \text{Country}_{\text{literacy prevalence group}j} + \sum_p \beta_p \left(s(\text{Year of birth})_{\text{country}_{\text{literacy prevalence group}}} \right). \quad (4)$$

Focusing on primary-educated women

To assess how schooling duration influences literacy and fertility, we further analyse women with primary education. Prior research suggests that some women remain functionally illiterate even after five years of schooling (Smith-Greenaway 2015). Since surveys conducted after 2000 provide consistent data on years of schooling, we restrict our analysis to this period to mitigate bias[3]. Our models for primary-educated women include years spent in school as a predictor:

$$E(\text{age at first birth}) = \beta_0 + \beta_i \cdot \text{Education and literacy skill}_i + \beta_k \cdot \text{Years in school}_k + \beta_j \cdot \text{Country}_j + \sum_p \beta_p \left(s\,(\text{Year of birth})_{\text{country}} \right). \quad (5)$$

$$E(\text{number of children ever born}) = \beta_0 + \beta_i \cdot \text{Education and literacy skill}_i + \beta_k \cdot \text{Years in school}_k + \beta_j \cdot \text{Country}_j + \sum_p \beta_p \left(s\,(\text{Year of birth})_{\text{country}} \right). \quad (6)$$

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[2] We use the R package "mgcv" and function "bam" by Wood (2017). We model the mean number of children ever born and mean age at first birth within each cohort–education–literacy cell. These means are continuous, so we model them using a Gaussian GAM. Gaussian GAMs are computationally stable, interpretable, and effective for smoothing trends. A Poisson model, by contrast, may suffer from overdispersion, leading to biased estimates of fertility variability.

[3] We excluded all values above 90 to remove any variation of the missing code (99).

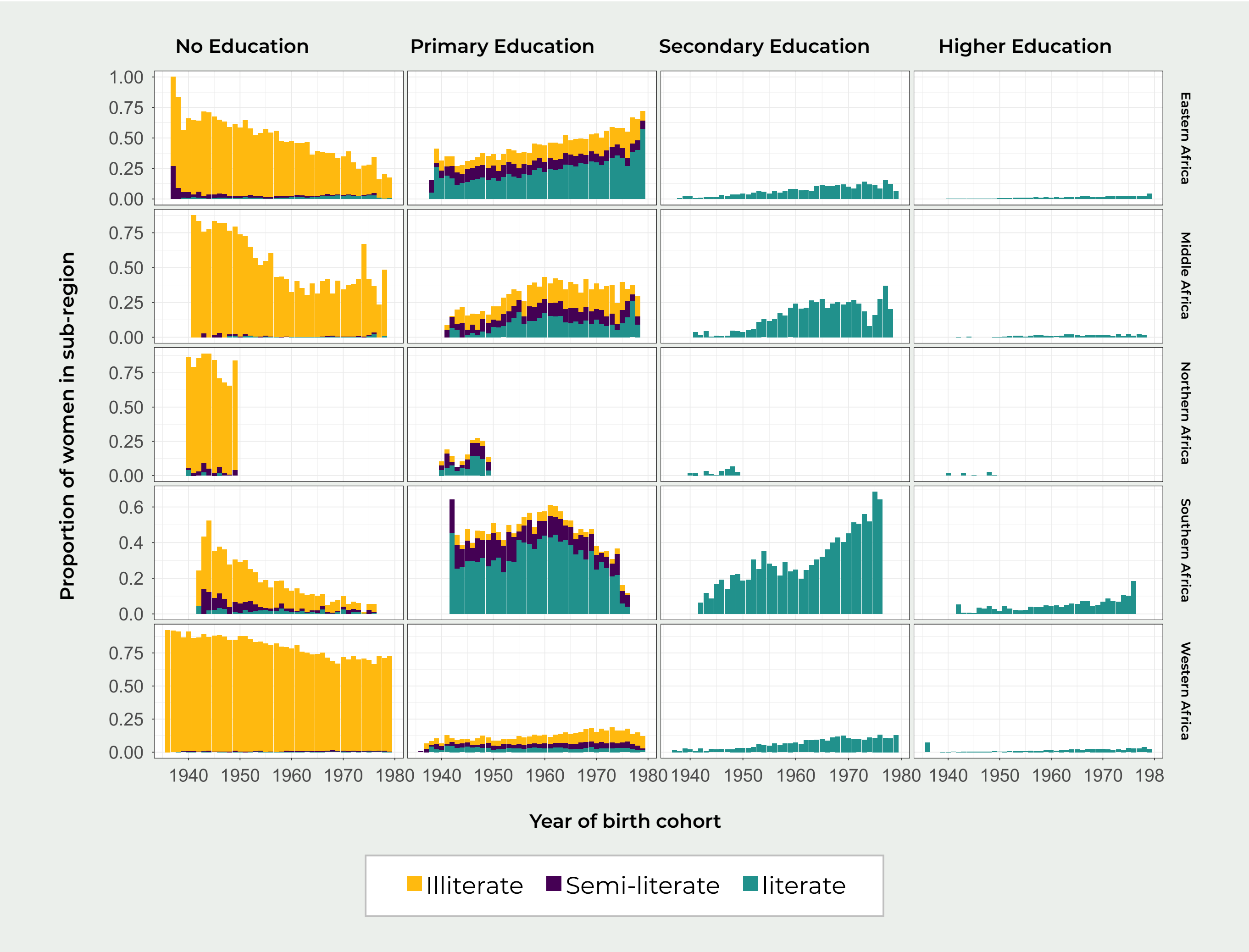
Our models yield expected mean values for age at first birth and total number of children in all categories of the variables. We do not include control variables such as employment and marital status in the models for two reasons. First, these statuses fluctuate throughout life, and we know them only at the time of the survey, making it difficult to isolate their pre-childbearing effect. Second, while excluding these variables limits causal interpretation, our focus is on uncovering broad demographic patterns rather than causal mechanisms.

RESULTS

Level of education and literacy by sub-region

Figure 2 presents the distribution of respondents' education and literacy levels across subregions and birth cohorts. The proportion of women with no formal education has steadily declined across all regions, with primary education becoming more prevalent and a notable increase in secondary education in Southern Africa.

Figure 2: Level of education and literacy, distribution by birth cohort and sub-region, among women above age 40 at the time of survey



Illiteracy rates have decreased across all sub-regions, but disparities remain. Middle, Eastern, and Western Africa continue to have significantly higher proportions of illiterate women—especially among those with no formal education—compared to Southern Africa, where illiterate women with primary education are less common. Additionally, Southern Africa consistently exhibits higher literacy rates across all education levels, while Western Africa has the lowest literacy rates. In Sudan (Northern Africa)[4], the majority of women without formal education are illiterate. Across all sub-regions and birth cohorts, women with higher education remain a small minority, likely reflecting persistent disparities in educational access and quality.

Mean age at first birth and completed fertility by education and literacy skill

Table 1 examines the relationship between education, literacy, and fertility outcomes, controlling for other factors (Appendix C1). The composite education and literacy skill variable is used to assess whether literacy affects fertility timing and completed fertility within educational groups.

Among women with no or primary education, being illiterate is associated with higher completed fertility. Furthermore, among literate women, those with no formal education and those with primary education show similar patterns in both the mean age at first birth and completed fertility; however, the wider confidence intervals suggest that these comparisons should be interpreted with caution.

Table 1: Coefficients and 95% confidence intervals for the estimated mean age at first birth and total number of children

Parameter	Mean age at first birth (Equation 1)		Mean number of children (Equation 2)	
Intercept	23.03	[15.53;30.53]*	6.11	[5.80;6.42]*
No Education and Illiterate	−0.17	[−0.24;−0.11]*	0.67	[0.62;0.72]*
No Education and Semi-literate	−0.22	[−0.41;−0.03]*	0.30	[0.16;0.44]*
No Education and Literate	0.11	[−0.13;0.34]	0.01	[−0.16;0.18]
Primary Education and Illiterate	−0.06	[−0.15;0.02]	0.39	[0.33;0.45]*
Primary Education and Semi-literate	0.00	[−0.09;0.10]	0.05	[−0.01;0.12]
Primary Education and Literate	RC		RC	
Secondary Education	1.41	[1.33;1.50]*	−1.33	[−1.39;−1.28]*
Higher Education	4.01	[3.85;4.17]*	−2.57	[−2.65;−2.48]*

*** $p < 0.001$; ** $p < 0.01$; *$p < 0.05$; Reference Category (RC).
The full model is available in Appendix C1; we present here the intercept, the coefficients of the variable that combines education and literacy, and the coefficient of the groups with secondary and with higher education.

However, regardless of literacy level, primary-educated women tend to have lower mean ages at first birth and higher completed fertility than women with secondary education. These results suggest that literacy may be associated with fertility outcomes, but does not offset the impact of education level: the strongest fertility-limiting effects occur among women with secondary and higher education rather than among literate women with no or primary education.

[4] Sudan is included as sub-Saharan Africa in the DHS database but classified under the UN as Northern Africa (United Nations Statistics Division n.d.).

The role of literacy prevalence in primary education for fertility outcomes

Table 2 presents separate models of age at first birth for countries with "widespread" vs. "limited" literacy prevalence among women with primary education, as described in the Method section. In countries with widespread literacy, illiterate women tend to have earlier ages at first birth compared to their literate counterparts. In contrast, in countries with limited primary-level literacy, literacy status has no significant effect on mean age at first birth, suggesting that other structural factors, such as economic conditions or cultural norms, may play a more decisive role. Across all contexts, women with secondary education experience later ages at first birth than those with only primary education, regardless of literacy prevalence. Overall, the relationship between literacy and the age at which a woman has her first child is modest and context-dependent.

Table 2: Coefficients and 95% confidence intervals for the estimated average age at first birth from the selected GAM for countries with limited and widespread literacy prevalence in primary education

Parameter	Widespread		Limited	
Intercept	21.99	[20.62;23.35]*	22.83	[15.48;30.19]*
No Education and Illiterate	−0.57	[−0.67;−0.47]*	−0.01	[−0.10;0.08]
No Education and Semi-literate	−0.15	[−0.43;0.13]	−0.22	[−0.46;0.03]
No Education and Literate	0.19	[−0.08;0.45]	−0.21	[−0.60;0.18]
Primary Education and Illiterate	−0.40	[−0.56;−0.23]*	0.08	[−0.03;0.18]
Primary Education and Semi-literate	−0.22	[−0.37;−0.08]*	0.15	[0.03;0.27]*
Primary Education and Literate	RC		RC	
Secondary Education	1.57	[1.43;1.70]*	1.46	[1.35;1.57]*
Higher Education	4.36	[4.05;4.67]*	4.03	[3.84;4.23]*

*** $p < 0.001$; ** $p < 0.01$; *$p < 0.05$; Reference Category (RC).
The full model is available in Appendix C2; we presented here the intercept, the coefficients of the variable that combines education and literacy, and the coefficient of the groups with secondary and higher education for areas with limited and widespread literacy prevalence within primary education.

Table 3: Coefficients and 95% confidence intervals for completed fertility in countries with widespread and limited literacy prevalence in primary education

Parameter	Widespread		Limited	
Intercept	5.68	[4.69;6.68]*	6.05	[5.74;6.36]*
No Education and Illiterate	0.44	[0.36;0.51]*	0.76	[0.70;0.83]*
No Education and Semi-literate	0.22	[0.02;0.43]*	0.36	[0.19;0.54]*
No Education and Literate	−0.01	[−0.21;0.18]	−0.06	[−0.33;0.22]
Primary Education and Illiterate	0.25	[0.13;0.38]*	0.47	[0.40;0.54]*
Primary Education and Semi-literate	0.11	[0.01;0.22]*	0.07	[−0.01;0.15]
Primary Education and Literate	RC		RC	
Secondary Education	−1.39	[−1.48;−1.30]*	−1.26	[−1.33;−1.19]*
Higher Education	−2.37	[−2.53;−2.22]*	−2.57	[−2.68;−2.46]*

*** $p < 0.001$; ** $p < 0.01$; *$p < 0.05$; Reference Category (RC).
The full model is available in Appendix C3; we present here the intercept, the coefficients of the variable that combines education and literacy, and the coefficient of the groups with secondary and higher education for areas with limited and widespread literacy prevalence within primary education.

Table 3 presents the results for completed fertility by country's literacy prevalence. We find that literate women tend to have fewer children than illiterate women in both country groups. Women with secondary education have consistently lower fertility across all contexts. Literacy alone is insufficient to achieve fertility patterns similar to those of women with secondary education, but among less educated women, those who are literate are also those who have fewer children. These results suggest that while literacy is associated with lower fertility within education groups, secondary education remains the strongest factor in reducing fertility.

Primary education, years of schooling, and fertility outcomes

To answer our last question (RQ4), we focus only on primary-educated women in surveys conducted after 2000, where data on years of schooling are available.

Table 4 presents the results from models 5 and 6, which examine whether the relationship between literacy and fertility outcomes remains after controlling for school duration. The models that do not control for length of schooling provide a benchmark against which we can assess whether the observed association between literacy and fertility outcomes is explained by variation in time spent at school.

The results show that longer schooling is associated with delays in first births and a reduction in completed fertility. Once school duration is accounted for, the effect of literacy on both fertility indicators weakens. Years of schooling account for much of the variation in fertility timing, reducing the stand-alone effect of literacy. Once controlling for years of schooling, a modest delay in age at first birth is observed among illiterate women with primary education compared to their literate counterparts. This pattern may reflect grade repetition or delayed school progression rather than a direct influence of literacy. Overall, these results emphasise that years of schooling—not just literacy—are crucial in shaping fertility timing and outcomes.

Table 4: Coefficients and 95% confidence intervals for age at first birth and completed fertility only for primary education

Parameter	Mean age at first birth (Equation 5)		Mean age at first birth		Mean number of children (Equation 6)		Mean number of children	
Intercept	21.38	[19.03;23.74]*	21.41	[19.12;23.70]*	6.35	[5.42;7.28]*	6.27	[5.28;7.26]*
Primary Education and Illiterate	0.21	[0.11;0.30]*	-0.06	[-0.14;0.02]	0.19	[0.12;0.27]*	0.47	[0.41;0.54]*
Primary Education and Semi-literate	0.18	[0.09;0.28]*	0.05	[-0.04;0.14]	-0.05	[-0.12;0.02]	0.08	[0.01;0.15]*
Primary Education and Literate	RC		RC		RC		RC	
Years of schooling: 0	-0.21	[-0.50;0.07]			0.11	[-0.11;0.32]		
Years of schooling: 1	-0.31	[-0.47;-0.14]*			0.34	[0.22;0.47]*		
Years of schooling: 2	-0.25	[-0.39;-0.11]*			0.26	[0.15;0.37]*		
Years of schooling: 3	-0.20	[-0.32;-0.07]*			0.25	[0.15;0.34]*		
Years of schooling: 4	-0.18	[-0.30;-0.05]*			0.13	[0.04;0.23]*		
Years of schooling: 5	RC				RC			
Years of schooling: 6	0.04	[-0.08;0.15]			-0.13	[-0.22;-0.05]*		
Years of schooling: 7	0.47	[0.33;0.61]*			-0.43	[-0.53;-0.33]*		
Years of schooling: 8	0.93	[0.73;1.14]*			-0.76	[-0.90;-0.61]*		
Years of schooling: 9	1.62	[0.27;2.97]*			-1.34	[-2.24;-0.44]*		
Years of schooling: 10+	3.39	[1.26;5.53]*			-2.22	[-3.41;-1.02]*		

*** $p < 0.001$; ** $p < 0.01$; *$p < 0.05$; Reference Category (RC).
The full model is available in Appendix C4; we presented here the intercept, the coefficients of the variable that combines education and literacy only for primary education, and the coefficient of the years spent in schooling.

DISCUSSION AND CONCLUSION

This study examines the role of literacy and education in shaping mean age at first birth and completed fertility in sub-Saharan Africa. The analyses consistently highlight that education level is the strongest predictor of fertility outcomes. Regardless of literacy status, women with secondary or higher education experience later first births and lower completed fertility than less-educated women. Years of schooling also play a role in fertility outcomes. The longer women remain in primary school, the later their first birth and the fewer children they have, underscoring the crucial role of school duration in shaping reproductive behaviours. These findings reinforce previous research showing that education, particularly from the secondary level, is a strong driver of fertility reduction (Bongaarts 2010; Shapiro 2012; Shapiro & Tenikue 2015).

Among women of a given education level, literacy has a significant effect, although modest as its magnitude is smaller than the effect of progressing to secondary or higher education. In particular, among women with no or only primary education, those who are literate tend to have fewer children than their illiterate counterparts. One plausible explanation, though untested in this study, is that literate women may better understand print and media messages about family planning. This access to information may enable them to make informed reproductive choices (Iacoella et al. 2022; LeVine et al. 2011). The relationship between individual literacy and first birth timing appears to vary with the country's literacy prevalence. In areas where literacy is limited, it does not significantly alter the timing of first births among less-educated women. By contrast, in countries with widespread literacy prevalence, literate women tend to postpone childbirth slightly more than their illiterate counterparts. This delay may reflect processes such as diffusion, social learning, and better employment opportunities, among other factors (Adhikari et al. 2024; Asongu et al. 2021; Kravdal 2012). In some countries, a significant proportion of women with primary education remain illiterate, which may help explain why fertility differences between women with no education and those with primary education are smaller than expected. Conversely, in countries with widespread literacy, women who remain illiterate despite having attended primary school likely represent a small, highly selected group (for example, women from more rural areas or with more traditional family values). Consequently, the significant differences observed between literate and illiterate women may partly reflect the characteristics of this select subgroup rather than the impact of literacy itself.

An unexpected finding emerges when controlling for the length of schooling: illiterate women with primary education display a higher mean age at first birth than their literate counterparts. This pattern has been documented in least-developed countries (Martin 1995). Several possible explanations can be proposed for this pattern. Women with some literacy may be perceived as more desirable in the marriage market, leading to earlier marriage and childbearing (Qian & Qian 2017). Alternatively, illiterate women may remain in school longer because of repetition linked to poor performance. This extended time in school increases their total years of schooling, subsequently delaying their entry into marriages and age at first birth (Ndaruhutse 2008; Wills 2023). However, even when school duration is controlled for, literate women still have fewer children than women with lower literacy levels, particularly those who were illiterate. According to the "quality over quantity" theory, investments in human capital, such as literacy, raise the opportunity cost of childbearing, leading to lower fertility rates (Becker et al. 2010). Supporting this view, Jun and Lee (2014) demonstrated that education quality influences reproductive decisions, while Kim (2023) provided evidence from sub-Saharan Africa aligning with this mechanism.

Despite the insights and results from our study, it has several limitations. First, we were unable to control for contraceptive use, which may mediate the observed relationship between literacy and fertility (LeVine et al. 2011). Future studies incorporating contraceptive use data and examining family planning practices by literacy level could provide deeper insights into the mechanisms linking literacy, education, and fertility behaviour. In addition, we classified countries by primary-level literacy prevalence using a 60% threshold, reflecting the regional average. While this represents a useful heuristic, we acknowledge that literacy outcomes exist along a continuum. Future research could adopt an alternative way to model literacy prevalence in order to better capture contextual nuance.

Another limitation is the inability to account for the exact age at which women completed their education, despite evidence that this significantly influences first birth timing (Ní Bhrolcháin & Beaujouan 2012). A clearer understanding of school attendance patterns and education quality would further enhance interpretations of the impact of literacy. Irregular school attendance, particularly in rural areas, can hinder literacy acquisition (Akyeampong et al. 2007). Although our study incorporates years of schooling for primary-educated women, it cannot assess school attendance quality, which is difficult to measure in large datasets. We acknowledge that relying on literacy alone as a measure of education quality is a limitation; nonetheless, this approach enables a direct assessment of its link to fertility.

Even with a modest association and potential selection effect, literacy appears to be linked to later and lower fertility among the least educated groups, possibly through increased awareness of contraceptives and family planning options (Iacoella et al. 2022; LeVine et al. 2011). However, once years of schooling are taken into account, its association with the timing of first birth among primary-educated women largely disappears and can even be reversed. Taken together, these findings suggest that while expanding access to secondary schooling remains a pathway to later childbearing and lower fertility, ensuring that primary schooling results in functional literacy can also contribute to fertility decline, possibly through improved women's reproductive autonomy.

DATA AVAILABILITY STATEMENT

DHS data are publicly available. The data is available for download after registration and can be found at: https://dhsprogram.com/data/available-datasets.cfm.

REFERENCES

Adhikari, S., Lutz, W., & Kebede, E. (2024). Forecasting Africa's fertility decline by female education groups. Proceedings of the National Academy of Sciences, 121(46), e2320247121. https://doi.org/10.1073/pnas.2320247121

Adu Boahen, E., & Yamauchi, C. (2018). The effect of female education on adolescent fertility and early marriage: Evidence from free compulsory universal basic education in Ghana. Journal of African Economies, 27(2), 227–248. https://doi.org/10.1093/jae/ejx025

Akyeampong, K., Djangmah, J., Oduro, A., Seidu, A., & Hunt, F. (2007). Access to basic education in Ghana: The evidence and the issues. CREATE Country Analytic Review.

Al Zalak, Z., & Goujon, A. (2017). Assessment of the data quality in demographic and health surveys in Egypt (tech. rep.). Vienna Institute of Demography Working Papers.

Altinok, N., Angrist, N., & Patrinos, H. A. (2018). Global data set on education quality (1965-2015). World Bank Policy Research Working Paper, (8314). https://doi.org/10.1596/1813-9450-8314

Asongu, S. A., Nounamo, Y., Njangang, H., & Tadadjeu, S. (2021). Gender inclusive intermediary education, financial stability and female employment in the industry in sub-Saharan Africa. Finance Research Letters, 43, 101968. https://doi.org/10.1016/j.frl.2021.101968

Barrett, G. F., & Riddell, W. C. (2016). Ageing and literacy skills: Evidence from Ials, All and PIAAC. https://doi.org/10.2139/ssrn.2803849

Becker, S. O., Cinnirella, F., & Woessmann, L. (2010). The trade-off between fertility and education: Evidence from before the demographic transition. Journal of Economic Growth, 15, 177–204. https://doi.org/10.1007/s10887-010-9054-x

Behrman, J. A. (2015). Does schooling affect women's desired fertility? evidence from Malawi, Uganda, and Ethiopia. Demography, 52(3), 787–809. https://doi.org/10.1007/s13524-015-0392-3

Bold, T., Filmer, D., Martin, G., Molina, E., Rockmore, C., Stacy, B., Svensson, J., & Wane, W. (2017). What do teachers know and do? Does it matter? Evidence from primary schools in Africa. Does it Matter. https://doi.org/10.1596/1813-9450-7956

Bongaarts, J. (2010). The causes of educational differences in fertility in sub-Saharan Africa. Vienna yearbook of population research, 31–50. https://doi.org/10.1553/populationyearbook2010s31

Bongaarts, J. (2020). Trends in fertility and fertility preferences in sub-Saharan Africa: The roles of education and family planning programs. Genus, 76(1), 32. https://doi.org/10.1186/s41118-020-00098-z

Caldwell, J. C. (1980). Mass education as a determinant of the timing of fertility decline. Population and development review, 225–255. https://doi.org/10.2307/1972729

Caldwell, J. C., & Caldwell, P. (1987). The cultural context of high fertility in sub-Saharan Africa. Population and development review, 409–437. https://doi.org/10.2307/1973133

Cheema, J. R. (2024). Difference in literacy between private and public schools: Evidence from a survey of 61 economies. International Journal of Research in Education and Science, 10(2), 218–240. https://doi.org/10.46328/ijres.3351

Chimombo, J. P. G. (2005). Quantity versus quality in education: Case studies in Malawi. International review of education, 51, 155–172. https://doi.org/10.1007/s11159-005-1842-8

Cleland, J., Onuoha, N., & Timaeus, I. (1994). Fertility change in sub-Saharan Africa: A review of the evidence. The onset of fertility transition in Sub-Saharan Africa. Ordinal editions, Liège, 1–20. https://doi.org/10.2307/2137637

Colleran, H., Jasienska, G., Nenko, I., Galbarczyk, A., & Mace, R. (2014). Community-level education accelerates the cultural evolution. https://doi.org/10.1098/rspb.2013.2732

DeCicca, P., & Krashinsky, H. (2017). The effect of education on overall fertility (tech. rep.). National Bureau of Economic Research. The DHS program. (n.d.). https://dhsprogram.com/data/data-processing.cfm#:~:text=For%5C%20 the%5C%20DHS%5C%20surveys%5C%2C%5C%20this,process%5C%20survey%5C%20and%5C%20census%5C%20data.

Dunlop, C. L., Benova, L., & Campbell, O. (2018). Effect of maternal age on facility-based delivery: Analysis of first-order births in 34 countries of sub-Saharan Africa using demographic and health survey data. BMJ open, 8(4), e020231. https://doi.org/10.1136/bmjopen-2017-020231

Durowaa-Boateng, A., Yildiz, D., & Goujon, A. (2023). A Bayesian model for the reconstruction of education-and age-specific fertility rates. Demographic Research, 49, 809–848. https://doi.org/10.4054/DemRes.2023.49.31

Ellison, J., Berrington, A., Dodd, E., & Forster, J. J. (2022). Investigating the application of generalized additive models to discrete-time event history analysis for birth events. Demographic Research, 47, 647–694. https://doi.org/10.4054/DemRes.2022.47.22

Fenske, J. (2015). African polygamy: Past and present. Journal of Development Economics, 117, 58–73. https://doi.org/10.1016/j.jdeveco.2015.06.005

Ferré, C. (2009). Age at first child: Does education delay fertility timing? the case of Kenya. The Case of Kenya (February 1, 2009). World Bank Policy Research Working Paper, (4833). https://doi.org/10.1596/1813-9450-4833

Gee, J. P. (1989). What is literacy. Journal of education, 171(1), 18–25. https://doi.org/10.1177/002205748917100102

Grant, M. J. (2015). The demographic promise of expanded female education: Trends in the age at first birth in Malawi [Publisher: Wiley Online Library]. Population and development review, 41(3), 409–438. https://doi.org/10.1111/j.1728-4457.2015.00066.x

Hayase, Y., & Liaw, K.-L. (1997). Factors on polygamy in sub-Saharan Africa: Findings based on the demographic and health surveys. The Developing Economies, 35(3), 293–327. https://doi.org/10.1111/j.1746-1049.1997.tb00849.x

Heneveld, W., & Craig, H. (1996). Schools count: World bank project designs and the quality of African primary education. https://doi.org/10.1596/9974

Iacoella, F., Gassmann, F., & Tirivayi, N. (2022). Which communication technology is effective for promoting reproductive health? television, radio, and mobile phones in sub-Saharan Africa. PLoS One, 17(8), e0272501. https://doi.org/10.1371/journal.pone.0272501

Jun, B., & Lee, J. (2014). The tradeoff between fertility and education: Evidence from the Korean development path (tech. rep.). FZID Discussion Paper.

Kim, J. (2023). Female education and its impact on fertility. IZA World of Labor. https://doi.org/10.15185/izawol.228.v2

Kirk, D., & Pillet, B. (1998). Fertility levels, trends, and differentials in sub-Saharan Africa in the 1980s and 1990s [Publisher: JSTOR]. Studies in family planning, 1–22. https://doi.org/10.2307/172178

Kouamo, R. N. (2024). School work performance in sub-Saharan Africa: A bivariate multilevel analysis. International Journal of Educational Research, 126, 102388. https://doi.org/10.1016/j.ijer.2024.102388

Kravdal, Ø. (2001). The importance of education for fertility in sub-Saharan Africa is substantially underestimated when community effects are ignored. Memorandum fra Økonomisk institutt, Universitetet i Oslo http://urn.nb.no/URN:NBN: no-7118

Kravdal, Ø. (2002). Education and fertility in sub-Saharan Africa: Individual and community effects. Demography, 39(2), 233–250. https://doi.org/10.1353/

dem.2002.0017

Kravdal, Ø. (2012). Further evidence of community education effects on fertility in sub-Saharan Africa. Demographic Research, 27, 645–680. https://doi.org/10.4054/DemRes.2012.27.22

LeVine, R. A., LeVine, S., Schnell-Anzola, B., Rowe, M. L., & Dexter, E. (2011). Literacy and mothering: How women's schooling changes the lives of the world's children. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780195309829.001.0001

Lewin, K. M. (2009). Access to education in sub-Saharan Africa: Patterns, problems and possibilities. Comparative Education, 45(2), 151–174. https://doi.org/10.1080/03050060902920518

Lloyd, C. B., Kaufman, C. E., & Hewett, P. (2000). The spread of primary schooling in sub-Saharan Africa: Implications for fertility change. Population and development review, 26(3), 483–515. https://doi.org/10.1111/j.1728-4457.2000.00483.x

Lumley, T. (2020). Survey: Analysis of complex survey samples [R package version 4.0].

Lutz, W., Goujon, A., Kc, S., Stonawski, M., & Stilianakis, N. (2018). Demographic and human capital scenarios for the 21st century: 2018 assessment for 201 countries. Publications Office of the European Union.

Lutz, W., Reiter, C., Özdemir, C., Yildiz, D., Guimaraes, R., & Goujon, A. (2021). Skills-adjusted human capital shows rising global gap. Proceedings of the National Academy of Sciences, 118(7), e2015826118. https://doi.org/10.1073/pnas.2015826118

Mahy, M., & Gupta, N. (2001). Trends and differentials in age at first birth in sub-Saharan Africa. presentation at the XXIVth IUSSP General Population Conference Session S, 43.

Martin, T. C. (1995). Women's education and fertility: Results from 26 demographic and health surveys. Studies in family planning, 187–202. https://doi.org/10.2307/2137845

Maruatona, T. (2008). Reflections on policies for mass literacy education in sub-Saharan Africa. International Review of Education/Internationale Zeitschrift Für Erziehungswissenschaft/Revue Internationale de l'éducation, 54(5/6), 745–754. https://doi.org/10.1007/s11159-008-9115-y

May, J. F., & Rotenberg, S. (2020). A Call for Better Integrated Policies to Accelerate the Fertility Decline in Sub-Saharan Africa [Publisher: Wiley Online Library]. Studies in Family Planning, 51(2), 193–204. https://doi.org/10.1111/sifp.12118

McMillan, L., & O'Neil, M. (2012). Literacy and social equity. Counterpoints, 406, 30–44.

MEASURE DHS. (2008). Demographic and health surveys model woman's questionnaire with HIV/AIDS and malaria modules.

Myrskylä, M., Goldstein, J. R., & Cheng, Y.-h. A. (2013). New cohort fertility forecasts for the developed world: Rises, falls, and reversals. Population and Development Review, 39(1), 31–56. https://doi.org/10.1111/j.1728-4457.2013.00572.x

Ndaruhutse, S. (2008). Grade repetition in primary schools in sub-Saharan Africa: An evidence base for change.

Neels, K., & De Wachter, D. (2010). Postponement and recuperation of

Belgian fertility: How are they related to rising female educational attainment? Vienna Yearbook of Population Research, 77–106. https://doi.org/10.1553/populationyearbook2010s77

Neels, K., Murphy, M., Bhrolcháin, M. N., & Beaujouan, É. (2017). Rising educational participation and the trend to later childbearing. Population and Development Review, 43(4), 667. https://doi.org/10.1111/padr.12112

Ní Bhrolcháin, M., & Beaujouan, É. (2012). Fertility postponement is largely due to rising educational enrolment. Population studies, 66(3), 311–327. https://doi.org/10.1080/00324728.2012.697569

Nishimura, M., & Byamugisha, A. (2011). The challenges of universal primary education policy in sub-Saharan Africa. Policy debates in comparative, international, and development education (pp. 225–245). Springer. https://doi.org/10.1057/9780230339361_12

Obeng Gyimah, S. (2003). A cohort analysis of the timing of first birth and fertility in Ghana [Publisher: Springer]. Population Research and Policy Review, 22(3), 251–266. https://doi.org/10.1023/A:1026008912138

Oye, M., Pritchett, L., & Sandefur, J. (2016). Girls' schooling is good, girls' schooling with learning is better. Background Paper for The Learning Generation. The Education Commission.

Parikh, K. S., & Gupta, C. (2001). How effective is female literacy in reducing fertility? Economic and Political Weekly, 3391–3398.

Post, D. (2016). Adult literacy benefits? New opportunities for research into sustainable development. International Review of Education, 62, 751–770. https://doi.org/10.1007/s11159-016-9602-5

Pritchett, L., & Sandefur, J. (2020). Girls' schooling and women's literacy: Schooling targets alone won't reach learning goals. International Journal of Educational Development, 78, 102242. https://doi.org/10.1016/j.ijedudev.2020.102242

Qian, Y., & Qian, Z. (2017). Assortative mating by education and hukou in shanghai. Chinese Sociological Review, 49(3), 239–262. https://doi.org/10.1080/21620555.2017.1288066

Reiter, C. (2022). Changes in literacy skills as cohorts age. Population and Development Review, 48(1), 217–246. https://doi.org/10.1111/padr.12457

Ritchie, H., Samborska, V., Ahuja, N., Ortiz-Ospina, E., & Roser, M. (2023). Global education. our world in data.

Romuald, N. K. (2023). An analysis of inequalities in school performance between public and private students in sub-Saharan Africa. International Journal of Educational Development, 100, 102802. https://doi.org/10.1016/j.ijedudev.2023.102802

Roser, M., & Ortiz-Ospina, E. (2018). Literacy [https://ourworldindata.org/literacy]. Our World in Data.

Rossi, P. (2019). Strategic choices in polygamous households: Theory and evidence from Senegal. The Review of Economic Studies, 86(3), 1332–1370. https://doi.org/10.1093/restud/rdy052

Rutstein, S. O., & Rojas, G. (2006). Guide to DHS statistics. demographic and health surveys. Maryland: ORC Macro Calverton.

Schoumaker, B. (2011). Omissions of births in DHS birth histories in sub-Saharan Africa: Measurement and determinants. Population Association of America.

Schoumaker, B. (2017). African fertility changes. Africa's population: In search of a demographic dividend (pp. 197–211). Springer.

Schoumaker, B. D., & Sánchez-Páez, D. A. (2024). Disruptions in educational progress and fertility dynamics by educational level: Unraveling the link between education and fertility stalls in sub-Saharan Africa. Population and Development Review, 50(1), 59–85. https://doi.org/10.1007/978-3-319-46889-1_13

Schultz, T. P. (1997). Demand for children in low income countries. Handbook of population and family economics, 1, 349–430. https://doi.org/10.1016/S1574-003X(97)80025-6

Shapiro, D. (2012). Women's education and fertility transition in sub-Saharan Africa. Vienna Yearbook of Population Research, 9–30. https://doi.org/10.1553/populationyearbook2012s9

Shapiro, D., & Tenikue, M. (2015). Women's education, infant and child mortality, and fertility decline in sub-Saharan Africa: A quantitative assessment. Luxembourg Institute of Socio-Economic Research (LISER) Working Paper Series, 7. https://doi.org/10.2139/ssrn.2717490

Shapiro, D., & Tenikue, M. (2017). Women's education, infant and child mortality, and fertility decline in urban and rural sub-Saharan Africa. Demographic Research, 37, 669–708. https://doi.org/10.4054/DemRes.2017.37.21

Smith-Greenaway, E. (2015). Educational attainment and adult literacy: A descriptive account of 31 sub-Saharan Africa countries. Demographic research, 33, 1015. https://doi.org/10.4054/DemRes.2015.33.35

Sobotka, T., Beaujouan, É., & Van Bavel, J. (2017). Introduction: Education and fertility in low-fertility settings. Vienna Yearbook of Population Research, 15, 1–16. https://doi.org/10.1553/populationyearbook2017s001

Somerset, A. (2009). Universalising primary education in Kenya: The elusive goal. Comparative Education, 45(2), 233–250. https://doi.org/10.1080/03050060902920807

Tabutin, D., Schoumaker, B. & Rabenoro, M. (2004). The demography of sub-Saharan Africa from the 1950s to the 2000s. Population, 59(3), 455–555. https://doi.org/10.3917/pope.403.0455

Tooley, J., & Dixon, P. (2005). Private education is good for the poor: A study of private schools serving the poor in low-income countries.

UNICEF. (2023). Education data [UNICEF DATA]. Retrieved November 23, 2023, https://data.unicef.org/resources/how-are-children-progressing-through-school/

United Nations. (2019). Potential impact of later childbearing on future population.

United Nations Population Division. (n.d.). Population division data portal [Accessed: 2023-8-29]. https://population.un.org/dataportal/home

United Nations Statistics Division. (n.d.). Methodology [Accessed: 2023-8-29]. https://unstats.un.org/unsd/methodology/m49/

Uwakwe, C., Falaye, A. O., Emunemu, B. O., & Adelore, O. (2008). Impact of decentralization and privatization on the quality of education in sub-Saharan Africa: The Nigerian experience. European Journal of social sciences, 7(1), 160–170.

Wills, G. (2023). Early grade repetition in south Africa.

Wood, S. N. (2017). Generalized additive models: An introduction with r. Chapman; Hall/CRC. https://doi.org/10.1201/9781315370279

Appendix A

We present the countries and the survey years used in the analysis in Table A1.

Table A1: Countries and year of survey included in the study.

Country	Survey Year
Angola	2011, 2016
Benin	1996, 2001, 2006, 2012, 2018
Burkina Faso	1992, 1998, 2003, 2010
Burundi	1987, 2010, 2016
Cameroon	1991, 1998, 2018, 2004, 2011
Central African Republic	1994
Chad	1996, 2004, 2014
Comoros	1996, 2012
Congo	2005, 2012
Cote D'Ivoire	1994, 1998, 2012
Democratic Republic of Congo	2007, 2013
Eswatini	2006
Ethiopia	1992, 1997, 2003, 2008, 2011
Gabon	2000, 2012
Gambia	2013, 2019
Ghana	1988, 1993, 1999, 2003, 2008, 2014
Guinea	1999, 2005, 2012, 2018
Kenya	1988, 1993, 1998, 2003, 2009, 2014
Lesotho	2004, 2009, 2014
Liberia	1986, 2007, 2009, 2013, 2019
Madagascar	1992, 1997, 2004, 2008
Malawi	1992, 2000, 2004, 2010, 2015
Mali	1987, 1995, 2001, 2006, 2013, 2018
Mozambique	1997, 2003, 2011
Namibia	1992, 2000, 2006, 2013
Niger	1992, 1998, 2006, 2012
Nigeria	1990, 2003, 2008, 2010, 2013, 2018
Rwanda	1992, 2000, 2005, 2011, 2014, 2019
Sao Tome and Principe	2008
Senegal	1986, 1993, 1997, 2005, 2008, 2013, 2014, 2015, 2017, 2018
Sierra Leone	2008, 2013, 2019
South Africa	1998, 2016
Sudan	1989
Tanzania	1992, 1996, 1999, 2010, 2015
Togo	1988, 1998, 2014
Uganda	1988, 1995, 2001, 2006, 2011, 2016
Zambia	1992, 1996, 2002, 2007, 2014, 2018
Zimbabwe	1989, 1994, 2005, 2011, 2015

Tables A2 and A3 show the total number of category cells in the final dataset for age at first birth and number of children, respectively, together with their weighted means and medians.

Table A2: Descriptive statistics of sample for age at first birth

Education and Literacy	Total category cells	Weighted mean	Weighted median
No Education and Illiterate	24,933	18.834	18.725
No Education and Semi-literate	2,172	19.031	18.786
No Education and Literate	1,252	19.980	20.988
Primary Education and Illiterate	10,854	18.725	18.662
Primary Education and Semi-literate	9,114	18.880	18.764
Primary Education and Literate	11,368	19.112	18.829
Secondary Education	14,102	20.242	20.211
Higher Education	4,485	22.808	22.731

Table A3: Descriptive statistics of sample for number of children

Education and Literacy	Total category cells	Weighted mean	Weighted median
No Education and Illiterate	18,454	6.792	6.814
No Education and Semi-literate	2,171	6.388	6.509
No Education and Literate	1,223	6.023	6.139
Primary Education and Illiterate	9,546	6.476	6.504
Primary Education and Semi-literate	8,328	6.090	6.054
Primary Education and Literate	9,998	5.892	5.862
Secondary Education	10,636	4.397	4.372
Higher Education	3,453	3.263	3.204

Appendix B

In Figure B1, we compare the fitted values of a Poisson regression against a GAM and the survey mean age at first birth. To check how well the GAM explains mean age at first birth from the data, we test the predictive power of both a Poisson and a GAM without any covariates. We calculate the mean of the age at first birth by country, year of birth, level of education and literacy for women aged 40 to 50 at the time of the survey and then apply our model.

The GAM is defined as;

$$E\left(\text{Mean age at first birth}\right) = \beta_0 + \sum_p \beta_p \left(s\left(\text{Year of birth}\right)_{\text{country}}\right).$$

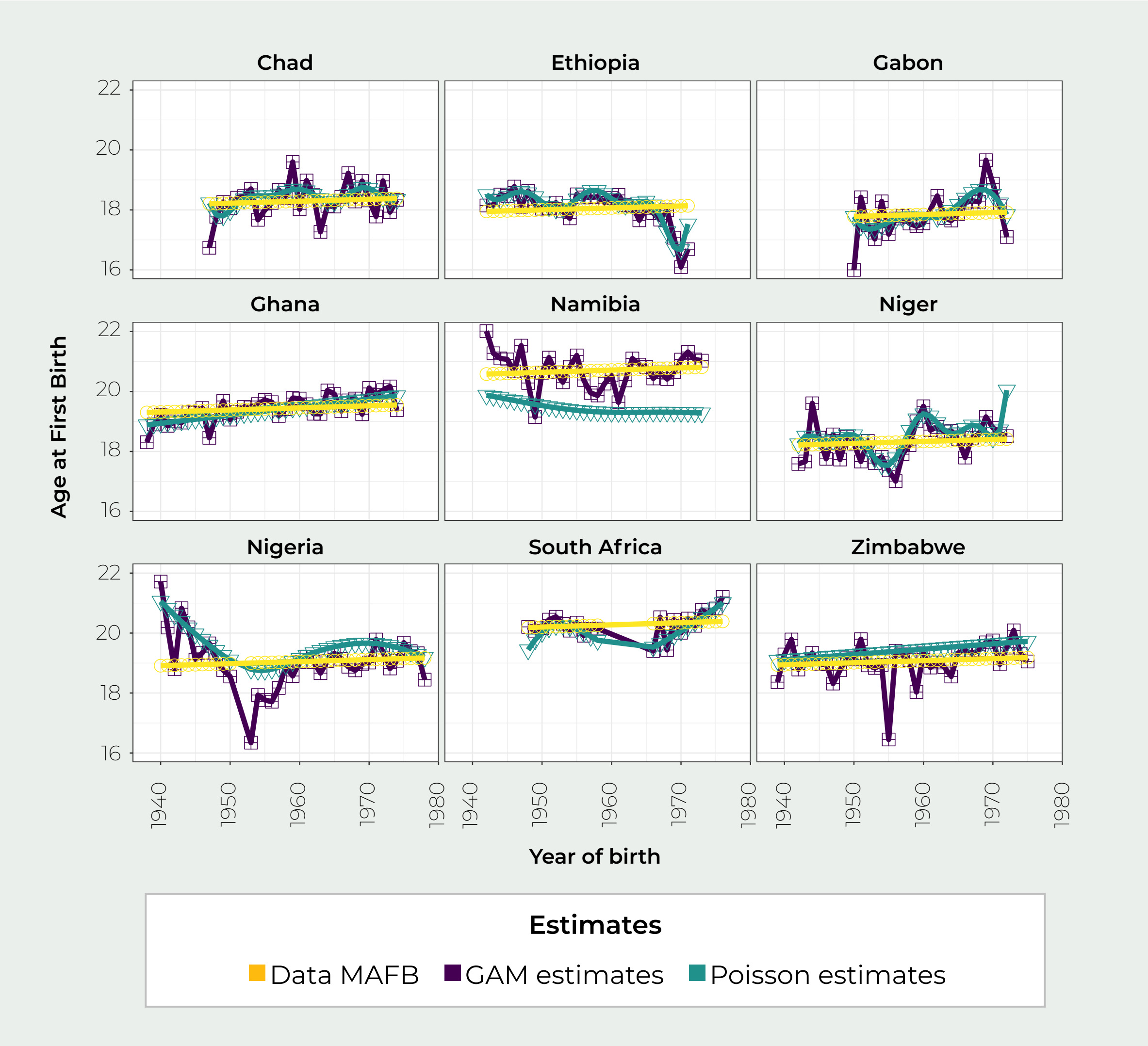
We estimate the expectation of the mean age at first birth in the GAM by adding the intercept to a smoothing term of year of birth by each country. Likewise, we estimate the log of the expectation of mean age at first birth as the sum of the intercept, year of birth, and country estimates.

The Poisson regression model is defined as;

$$\log\left(E\left(\text{Mean age at first birth}\right)\right) = \beta_0 + \beta_p\left(\text{Year of birth}\right) + \sum_q \beta_q\,(\text{country}).$$

We show the predicted estimates of both models for some selected countries in Figure B1. In countries like Gabon and Chad, the GAM captures and smooths out the fluctuations in reported mean age at first birth (MAFB), whereas the Poisson fails.

Figure B1: Comparison of mean age at first birth for selected Sub-Saharan African countries.



Appendix C

We present the full results of the model presented in the main text in Table 1. We show the full model estimates of estimated mean age at first birth and completed fertility in Table C1. For all the tables containing the full results, including Appendix D, the standard errors are presented in brackets. The figures presented are the estimates and the standard errors in brackets for the parameters. In the smoothed terms, the figures provided are effective degrees of freedom (edfs) and reference degrees of freedom (Ref.df) in brackets.

Table C1: Coefficients and standard errors from selected GAM for estimated mean age at first birth and completed fertility

Parameter	Mean age at first birth (Equation 1)		Mean number of children (Equation 2)	
No Education and Illiterate	−0.17	[−0.24;−0.11]*	0.67	[0.62;0.72]
No Education and Semi-literate	−0.22	[−0.41;−0.03]*	0.30	[0.16;0.44]
No Education and Literate	0.11	[−0.13;0.34]	0.01	[−0.16;0.18]
Primary Education and Illiterate	−0.06	[−0.15;0.02]	0.39	[0.33;0.45]
Primary Education and Semi-literate	0.00	[−0.09;0.10]	0.05	[−0.01;0.12]
Primary Education and Literate	RC		RC	
Secondary Education	1.41	[1.33;1.50]*	−1.33	[−1.39;−1.28]
Higher Education	4.01	[3.85;4.17]*	−2.57	[−2.65;−2.48]
Angola	RC		RC	
Benin	−3.76	[−11.27;3.74]	−0.16	[−0.50;0.17]
Burkina Faso	−3.69	[−11.21;3.83]	0.29	[−0.13;0.71]
Burundi	−0.89	[−8.55;6.76]	−0.51	[−1.57;0.54]
Cameroon	−4.62	[−12.12;2.89]	−0.11	[−0.43;0.21]
Central African Republic	6.34	[−84.33;97.00]	−0.86	[−1.58;−0.13]
Chad	−4.80	[−12.38;2.77]	0.56	[0.14;0.97]
Comoros	−3.27	[−10.79;4.26]	−0.41	[−0.84;0.03]
Congo	−5.61	[−13.17;1.95]	0.18	[−1.10;1.46]
Cote D'Ivoire	−4.35	[−11.86;3.15]	−0.45	[−0.85;−0.05]
Democratic Republic of Congo	−13.27	[−30.44;3.91]	0.94	[−1.57;3.45]
Eswatini	−15.72	[−46.87;15.43]	−0.13	[−0.53;0.27]
Ethiopia	−5.32	[−12.83;2.19]	0.29	[−0.15;0.74]
Gabon	−6.36	[−14.24;1.52]	−0.02	[−0.46;0.42]
Gambia	−5.13	[−13.12;2.87]	−0.38	[−1.91;1.15]
Ghana	−3.90	[−11.40;3.61]	−0.50	[−0.82;−0.18]
Guinea	−4.19	[−11.71;3.33]	−0.18	[−0.75;0.39]
Kenya	−4.42	[−11.92;3.08]	0.05	[−0.27;0.37]
Lesotho	−3.12	[−10.99;4.74]	−1.20	[−2.41;0.00]
Liberia	−5.37	[−12.90;2.16]	−0.09	[−0.56;0.37]

Madagascar	−4.01	[−11.61;3.59]	−0.75	[−1.74;0.23]
Malawi	−4.27	[−11.77;3.23]	0.19	[−0.13;0.51]
Mali	−3.89	[−11.39;3.62]	0.31	[−0.01;0.63]
Mozambique	−2.46	[−10.61;5.68]	−0.17	[−2.38;2.05]
Namibia	−3.17	[−10.69;4.35]	−1.02	[−1.35;−0.69]
Niger	−5.35	[−12.88;2.17]	1.01	[0.65;1.37]
Nigeria	−4.34	[−11.84;3.16]	0.29	[−0.03;0.60]
Rwanda	−1.88	[−9.38;5.62]	0.11	[−0.21;0.42]
Sao Tome and Principe	−5.48	[−14.78;3.81]	1.30	[−3.84;6.45]
Senegal	−3.56	[−11.07;3.94]	−0.20	[−0.51;0.11]
Sierra Leone	−5.37	[−14.04;3.30]	−0.74	[−2.06;0.57]
South Africa	−3.79	[−11.30;3.73]	−1.86	[−2.25;−1.47]
Sudan	12.81	[−94.27;119.89]	−5.50	[−64.78;53.78]
Tanzania	−4.37	[−11.88;3.13]	−0.05	[−0.37;0.27]
Togo	−3.43	[−10.94;4.08]	−0.55	[−0.90;−0.21]
Uganda	−4.90	[−12.40;2.61]	0.90	[0.58;1.22]
Zambia	−5.09	[−12.60;2.41]	0.78	[0.46;1.10]
Zimbabwe	−4.34	[−11.84;3.17]	−0.58	[−0.90;−0.25]
s(Year of birth): Angola	4.01	[−11.67;19.69]	0.93	[−14.75;16.61]
s(Year of birth): Benin	7.03	[−10.61;24.67]	6.32	[−11.32;23.96]
s(Year of birth): Burkina Faso	6.62	[−11.02;24.26]	5.84	[−11.80;23.48]
s(Year of birth): Burundi	8.79	[−8.85;26.43]	7.61	[−10.03;25.25]
s(Year of birth): Cameroon	7.47	[−10.17;25.11]	4.83	[−12.81;22.46]
s(Year of birth): Central African Republic	3.86	[−11.82;19.54]	0.53	[−13.19;14.25]
s(Year of birth): Chad	7.68	[−9.96;25.31]	5.80	[−11.83;23.44]
s(Year of birth): Comoros	4.90	[−12.73;22.54]	3.65	[−13.99;21.29]
s(Year of birth): Congo	2.38	[−13.29;18.06]	3.34	[−12.34;19.02]
s(Year of birth): Cote D'Ivoire	4.89	[−12.75;22.53]	5.52	[−12.12;23.16]
s(Year of birth): Democratic Republic of Congo	5.72	[−11.92;23.36]	4.15	[−13.49;21.79]
s(Year of birth): Eswatini	3.95	[−11.73;19.63]	0.96	[−12.76;14.68]
s(Year of birth): Ethiopia	6.85	[−10.79;24.49]	7.18	[−10.46;24.82]
s(Year of birth): Gabon	5.51	[−12.13;23.15]	2.56	[−15.07;20.20]
s(Year of birth): Gambia	2.92	[−12.76;18.60]	2.61	[−13.06;18.29]
s(Year of birth): Ghana	5.45	[−12.18;23.09]	6.45	[−11.19;24.09]
s(Year of birth): Guinea	6.10	[−11.54;23.74]	6.34	[−11.30;23.98]
s(Year of birth): Kenya	6.27	[−11.37;23.91]	7.59	[−10.05;25.23]
s(Year of birth): Lesotho	4.45	[−13.19;22.09]	4.18	[−13.46;21.82]
s(Year of birth): Liberia	8.75	[−8.89;26.39]	7.40	[−10.24;25.04]

s(Year of birth): Madagascar	6.25	[−11.39;23.89]	6.37	[−11.27;24.01]
s(Year of birth): Malawi	7.54	[−10.10;25.18]	5.92	[−11.72;23.56]
s(Year of birth): Mali	8.41	[−9.23;26.05]	7.71	[−9.93;25.35]
s(Year of birth): Mozambique	7.45	[−10.19;25.09]	7.47	[−10.17;25.11]
s(Year of birth): Namibia	7.62	[−10.02;25.26]	4.43	[−13.21;22.07]
s(Year of birth): Niger	7.89	[−9.75;25.53]	6.25	[−11.39;23.89]
s(Year of birth): Nigeria	8.65	[−8.98;26.29]	7.89	[−9.75;25.53]
s(Year of birth): Rwanda	7.49	[−10.15;25.13]	7.05	[−10.59;24.69]
s(Year of birth): Sao Tome and Principe	2.23	[−13.45;17.91]	2.46	[−13.22;18.14]
s(Year of birth): Senegal	6.96	[−10.68;24.60]	7.82	[−9.82;25.46]
s(Year of birth): Sierra Leone	4.75	[−12.89;22.39]	3.96	[−11.72;19.64]
s(Year of birth): South Africa	4.18	[−13.46;21.82]	4.68	[−12.96;22.32]
s(Year of birth): Sudan	3.75	[−11.93;19.43]	3.53	[−12.15;19.21]
s(Year of birth): Tanzania	7.77	[−9.87;25.41]	6.61	[−11.03;24.25]
s(Year of birth): Togo	7.57	[−10.07;25.21]	6.48	[−11.16;24.12]
s(Year of birth): Uganda	7.93	[−9.71;25.57]	8.19	[−9.45;25.83]
s(Year of birth): Zambia	7.58	[−10.06;25.22]	7.32	[−10.32;24.95]
s(Year of birth): Zimbabwe	2.24	[−15.40;19.88]	5.44	[−12.20;23.08]
AIC	42304.01		34256.42	
BIC	44316.06		36077.10	
Log Likelihood	−20874.26		−16877.14	
Deviance	1437709.93		120040.18	
Deviance explained	0.54		0.74	
Dispersion	139.35		11.55	
R2	0.52		0.73	
GCV score	402793.12		275873.03	
Num. obs.	10345		10422	
Num. smooth terms	38		38	

*Null hypothesis value outside the confidence interval.

Similar to Table C1, we show the results of the model for only education level separately for countries where literacy is "widespread" and "limited" (as described in the method section of the main text Equations 3 and 4 in Tables C2 and C3).

Table C2: Coefficients and standard errors of GAM for mean age at first birth by education level, grouped by literacy prevalence at primary education

Parameter	Widespread		Limited	
Intercept	21.99	[20.62;23.35]	22.83	[15.48;30.19]
No Education and Illiterate	−0.57	[−0.67;−0.47]	−0.01	[−0.10;0.08]
No Education and Semi-literate	−0.15	[−0.43;0.13]	−0.22	[−0.46;0.03]
No Education and Literate	0.19	[−0.08;0.45]	−0.21	[−0.60;0.18]
Primary Education and Illiterate	−0.40	[−0.56;−0.23]	0.08	[−0.03;0.18]
Primary Education and Semi-literate	−0.22	[−0.37;−0.08]	0.15	[0.03;0.27]
Primary and Literate	RC		RC	
Secondary Education	1.57	[1.43;1.70]	1.46	[1.35;1.57]
Higher Education	4.36	[4.05;4.67]	4.03	[3.84;4.23]
Burundi	RC			
Eswatini	−13.17	[−40.26;13.92]		
Lesotho	−2.07	[−5.00;0.85]		
Madagascar	−2.86	[−4.67;−1.04]		
Namibia	−2.01	[−3.41;−0.61]		
Rwanda	−0.65	[−2.02;0.72]		
South Africa	−2.81	[−4.24;−1.37]		
Tanzania	−3.14	[−4.51;−1.77]		
Zimbabwe	−3.21	[−4.58;−1.84]		
Angola			RC	
Benin			−3.71	[−11.06;3.65]
Burkina Faso			−3.66	[−11.04;3.71]
Cameroon			−4.53	[−11.88;2.82]
Central African Republic			6.47	[−82.98;95.92]
Chad			−4.74	[−12.17;2.70]
Comoros			−3.21	[−10.59;4.17]
Congo			−5.50	[−12.91;1.92]
Cote D'Ivoire			−4.30	[−11.66;3.06]
Democratic Republic of Congo			−12.86	[−29.64;3.92]
Ethiopia			−5.29	[−12.66;2.07]
Gabon			−6.24	[−13.97;1.50]
Gambia			−5.07	[−12.90;2.77]
Ghana			−3.82	[−11.17;3.54]

Guinea		−4.15 [−11.52;3.22]
Kenya		−4.31 [−11.66;3.04]
Liberia		−5.30 [−12.68;2.08]
Malawi		−4.19 [−11.55;3.16]
Mali		−3.84 [−11.19;3.51]
Mozambique		−2.41 [−10.51;5.69]
Niger		−5.37 [−12.75;2.01]
Nigeria		−4.28 [−11.63;3.07]
Sao Tome and Principe		−5.38 [−14.48;3.73]
Senegal		−3.50 [−10.85;3.85]
Sierra Leone		−5.29 [−13.78;3.21]
Sudan		12.32 [−93.72;118.36]
Togo		−3.38 [−10.73;3.98]
Uganda		−4.81 [−12.16;2.54]
Zambia		−4.99 [−12.34;2.36]
s(Year of birth): Burundi	8.81 [−8.83;26.45]	
s(Year of birth): Eswatini	3.99 [−11.69;19.67]	
s(Year of birth): Lesotho	4.76 [−10.92;20.44]	
s(Year of birth): Madagascar	6.81 [−10.82;24.45]	
s(Year of birth): Namibia	7.72 [−9.92;25.36]	
s(Year of birth): Rwanda	7.68 [−9.96;25.32]	
s(Year of birth): South Africa	4.95 [−12.69;22.59]	
s(Year of birth): Tanzania	7.81 [−9.83;25.45]	
s(Year of birth): Zimbabwe	7.03 [−10.61;24.67]	
s(Year of birth): Angola		3.98 [−11.70;19.66]
s(Year of birth): Benin		6.96 [−10.68;24.60]
s(Year of birth): Burkina Faso		6.59 [−11.05;24.23]
s(Year of birth): Cameroon		7.43 [−10.20;25.07]
s(Year of birth): Central African Republic		3.83 [−11.85;19.51]
s(Year of birth): Chad		7.65 [−9.99;25.29]
s(Year of birth): Comoros		4.85 [−12.79;22.48]
s(Year of birth): Congo		2.36 [−13.32;18.04]
s(Year of birth): Cote D'Ivoire		4.67 [−12.97;22.31]
s(Year of birth): Democratic Republic of Congo		5.69 [−11.95;23.33]
s(Year of birth): Ethiopia		6.82 [−10.82;24.46]
s(Year of birth): Gabon		5.46 [−12.18;23.10]
s(Year of birth): Gambia		2.88 [−12.80;18.56]
s(Year of birth): Ghana		4.72 [−12.92;22.36]
s(Year of birth): Guinea		6.06 [−11.58;23.70]

s(Year of birth): Kenya		6.21	[−11.43;23.85]
s(Year of birth): Liberia		8.74	[−8.90;26.38]
s(Year of birth): Malawi		7.49	[−10.14;25.13]
s(Year of birth): Mali		8.37	[−9.27;26.01]
s(Year of birth): Mozambique		7.43	[−10.21;25.07]
s(Year of birth): Niger		7.88	[−9.76;25.52]
s(Year of birth): Nigeria		8.64	[−9.00;26.28]
s(Year of birth): Sao Tome and Principe		2.19	[−13.49;17.87]
s(Year of birth): Senegal		6.87	[−10.77;24.51]
s(Year of birth): Sierra Leone		4.73	[−12.91;22.37]
s(Year of birth): Sudan		3.72	[−11.96;19.40]
s(Year of birth): Togo		7.54	[−10.10;25.18]
s(Year of birth): Uganda		7.92	[−9.72;25.56]
s(Year of birth): Zambia		7.54	[−10.09;25.18]
AIC	9315.26	32776.84	
BIC	9763.91	34266.41	
Log Likelihood	−4580.56	−16174.66	
Deviance	253978.41	1168405.25	
Deviance explained	0.67	0.43	
Dispersion	102.15	149.22	
R2	0.66	0.41	
GCV score	93251.01	308368.43	
Num. obs.	2494	7851	
Num. smooth terms	9	29	

*Null hypothesis value outside the confidence interval.

Table C3: Coefficients and 95% confidence intervals for completed fertility by education level, grouped by literacy prevalence at primary education

Parameter	Widespread		Limited	
Intercept	5.68	[4.69;6.68]	6.05	[5.74;6.36]
No Education and Illiterate	0.44	[0.36;0.51]	0.76	[0.70;0.83]
No Education and Semi-literate	0.22	[0.02;0.43]	0.36	[0.19;0.54]
No Education and Literate	−0.01	[−0.21;0.18]	−0.06	[−0.33;0.22]
Primary Education and Illiterate	0.25	[0.13;0.38]	0.47	[0.40;0.54]
Primary Education and Semi-literate	0.11	[0.01;0.22]	0.07	[−0.01;0.15]
Primary and Literate	RC		RC	
Secondary Education	−1.39	[−1.48;−1.30]	−1.26	[−1.33;−1.19]
Higher Education	−2.37	[−2.53;−2.22]	−2.57	[−2.68;−2.46]
Burundi	RC			
Eswatini	0.38	[−0.65;1.40]		
Lesotho	−0.78	[−2.41;0.86]		
Madagascar	−0.40	[−1.80;0.99]		
Namibia	−0.51	[−1.51;0.49]		
Rwanda	0.70	[−0.29;1.70]		
South Africa	−1.40	[−2.42;−0.37]		
Tanzania	0.51	[−0.49;1.51]		
Zimbabwe	−0.07	[−1.07;0.93]		
Angola			RC	
Benin			−0.20	[−0.54;0.14]
Burkina Faso			0.25	[−0.19;0.68]
Cameroon			−0.12	[−0.44;0.20]
Central African Republic			−0.84	[−1.59;−0.10]
Chad			0.53	[0.11;0.95]
Comoros			−0.44	[−0.88;−0.00]
Congo			0.17	[−1.07;1.41]
Cote D'Ivoire			−0.49	[−0.90;−0.07]
Democratic Republic of Congo			0.90	[−1.55;3.35]
Ethiopia			0.28	[−0.19;0.74]
Gabon			−0.03	[−0.47;0.42]
Gambia			−0.41	[−1.87;1.06]
Ghana			−0.53	[−0.85;−0.20]
Guinea			−0.24	[−0.80;0.31]
Kenya			0.05	[−0.27;0.37]

Liberia			−0.14	[−0.60;0.32]
Malawi			0.18	[−0.14;0.50]
Mali			0.27	[−0.05;0.59]
Mozambique			−0.23	[−2.59;2.14]
Niger			1.00	[0.64;1.37]
Nigeria			0.27	[−0.05;0.59]
Sao Tome and Principe			1.30	[−3.79;6.40]
Senegal			−0.24	[−0.55;0.08]
Sierra Leone			−0.78	[−2.06;0.50]
Sudan			−5.96	[−67.64;55.73]
Togo			−0.58	[−0.93;−0.24]
Uganda			0.90	[0.57;1.22]
Zambia			0.78	[0.46;1.10]
s(Year of birth): Burundi	7.70	[−9.94;25.34]		
s(Year of birth): Eswatini	0.97	[−12.75;14.69]		
s(Year of birth): Lesotho	4.46	[−11.22;20.14]		
s(Year of birth): Madagascar	7.03	[−10.61;24.67]		
s(Year of birth): Namibia	4.82	[−12.82;22.46]		
s(Year of birth): Rwanda	7.31	[−10.33;24.94]		
s(Year of birth): South Africa	5.09	[−12.55;22.73]		
s(Year of birth): Tanzania	6.80	[−10.84;24.44]		
s(Year of birth): Zimbabwe	5.92	[−11.72;23.56]		
s(Year of birth): Angola			0.93	[−14.75;16.61]
s(Year of birth): Benin			6.28	[−11.36;23.92]
s(Year of birth): Burkina Faso			5.80	[−11.84;23.44]
s(Year of birth): Cameroon			4.77	[−12.87;22.41]
s(Year of birth): Central African Republic			0.54	[−13.18;14.26]
s(Year of birth): Chad			5.78	[−11.86;23.42]
s(Year of birth): Comoros			3.59	[−14.05;21.23]
s(Year of birth): Congo			3.28	[−12.40;18.96]
s(Year of birth): Cote D'Ivoire			5.47	[−12.17;23.11]
s(Year of birth): Democratic Republic of Congo			4.12	[−13.52;21.76]
s(Year of birth): Ethiopia			7.15	[−10.49;24.79]
s(Year of birth): Gabon			2.56	[−15.08;20.20]
s(Year of birth): Gambia			2.55	[−13.13;18.23]
s(Year of birth): Ghana			6.37	[−11.27;24.01]
s(Year of birth): Guinea			6.29	[−11.35;23.93]
s(Year of birth): Kenya			7.55	[−10.09;25.19]
s(Year of birth): Liberia			7.33	[−10.31;24.97]

s(Year of birth): Malawi			5.47	[−12.17;23.11]
s(Year of birth): Mali			8.47	[−9.17;26.11]
s(Year of birth): Mozambique			7.46	[−10.18;25.10]
s(Year of birth): Niger			6.20	[−11.44;23.84]
s(Year of birth): Nigeria			7.89	[−9.75;25.53]
s(Year of birth): Sao Tome and Principe			2.45	[−13.23;18.13]
s(Year of birth): Senegal			7.81	[−9.83;25.45]
s(Year of birth): Sierra Leone			3.92	[−11.76;19.60]
s(Year of birth): Sudan	3.53	[−12.15;19.21]	3.92	[−11.76;19.60]
s(Year of birth): Togo			6.41	[−11.23;24.05]
s(Year of birth): Uganda			8.06	[−9.57;25.70]
s(Year of birth): Zambia			7.25	[−10.39;24.89]
AIC	7443.62		26702.20	
BIC	7837.53		28051.69	
Log Likelihood	−3654.22		−13157.66	
Deviance	23324.74		95956.60	
Deviance explained	0.80		0.70	
Dispersion	9.32		12.16	
R2	0.79		0.68	
GCV score	63752.86		211478.58	
Num. obs.	2510		7912	
Num. smooth terms	9		29	

*Null hypothesis value outside the confidence interval.

Table C4 shows the full results of the model for primary educated women with a focus on surveys after 2000 (Models 5 and 6) and without controlling for years of schooling.

Table C4: Coefficients and 95% confidence intervals for completed fertility and age at first birth only for primary education.

Parameter	Mean age at first birth (Equation 5)		Mean age at first birth		Completed fertility (Equation 6)		Completed fertility	
Intercept	21.38	[19.03;23.74]	21.41	[19.12;23.70]	6.35	[5.42;7.28]	6.27	[5.28;7.26]
Primary Education and Illiterate	0.21	[0.11;0.30]	−0.06	[−0.14;0.02]	0.19	[0.12;0.27]	0.47	[0.41;0.54]
Primary Education and Semi-literate	0.18	[0.09;0.28]	0.05	[−0.04;0.14]	−0.05	[−0.12;0.02]	0.08	[0.01;0.15]
Primary Education and Literate	RC		RC		RC		RC	
Years of schooling: 0	−0.21	[−0.50;0.07]			0.11	[−0.11;0.32]		
Years of schooling: 1	−0.31	[−0.47;−0.14]			0.34	[0.22;0.47]		
Years of schooling: 2	−0.25	[−0.39;−0.11]			0.26	[0.15;0.37]		
Years of schooling: 3	−0.20	[−0.32;−0.07]			0.25	[0.15;0.34]		
Years of schooling: 4	−0.18	[−0.30;−0.05]			0.13	[0.04;0.23]		
Years of schooling: 5	RC				RC			
Years of schooling: 6	0.04	[−0.08;0.15]			−0.13	[−0.22;−0.05]		
Years of schooling: 7	0.47	[0.33;0.61]			−0.43	[−0.53;−0.33]		
Years of schooling: 8	0.93	[0.73;1.14]			−0.76	[−0.90;−0.61]		
Years of schooling: 9	1.62	[0.27;2.97]			−1.34	[−2.24;−0.44]		
Years of schooling: 10+	3.39	[1.26;5.53]			−2.22	[−3.41;−1.02]		
Angola	RC		RC		RC		RC	
Benin	−1.65	[−4.02;0.71]	−1.65	[−3.96;0.65]	−1.23	[−2.17;−0.29]	−1.20	[−2.21;−0.20]
Burkina Faso	−2.54	[−5.08;0.01]	−2.51	[−5.00;−0.02]	−1.33	[−3.10;0.44]	−1.30	[−3.06;0.45]
Burundi	−0.26	[−2.65;2.13]	−0.33	[−2.66;2.00]	0.41	[−1.01;1.83]	0.47	[−0.92;1.86]
Cameroon	−2.96	[−5.32;−0.60]	−2.91	[−5.21;−0.61]	−0.45	[−1.39;0.48]	−0.49	[−1.49;0.51]
Chad	−3.02	[−5.39;−0.65]	−3.01	[−5.33;−0.70]	1.16	[0.19;2.13]	1.18	[0.15;2.22]
Comoros	−2.53	[−5.29;0.24]	−2.52	[−5.31;0.26]	−3.19	[−13.57;7.18]	−3.33	[−13.18;6.52]
Congo	−3.22	[−5.71;−0.72]	−3.16	[−5.60;−0.72]	−1.56	[−3.61;0.48]	−1.59	[−3.66;0.49]
Cote D'Ivoire	−2.99	[−5.39;−0.60]	−2.96	[−5.29;−0.62]	−1.01	[−2.01;−0.02]	−1.03	[−2.09;0.02]
Democratic Republic of Congo	−2.95	[−5.41;−0.49]	−2.93	[−5.33;−0.53]	0.33	[−0.71;1.37]	0.35	[−0.74;1.44]
Eswatini	−4.01	[−6.49;−1.53]	−3.94	[−6.35;−1.54]	−0.41	[−2.19;1.37]	−0.53	[−2.12;1.07]
Ethiopia	−3.45	[−7.72;0.81]	−3.52	[−7.63;0.58]	−0.09	[−1.45;1.27]	−0.10	[−1.39;1.18]
Gabon	−3.61	[−6.83;−0.39]	−3.62	[−6.80;−0.44]	2.47	[−11.42;16.36]	2.50	[−12.00;17.01]
Gambia	−2.74	[−5.24;−0.24]	−2.59	[−5.03;−0.14]	−1.30	[−5.36;2.76]	−1.48	[−5.69;2.73]
Ghana	−2.72	[−5.09;−0.35]	−2.61	[−4.93;−0.30]	−1.25	[−2.28;−0.23]	−1.30	[−2.38;−0.22]
Guinea	−2.92	[−5.33;−0.52]	−2.84	[−5.19;−0.50]	−0.62	[−1.62;0.37]	−0.67	[−1.72;0.39]
Kenya	−3.39	[−5.75;−1.04]	−3.05	[−5.35;−0.75]	−0.14	[−1.07;0.80]	−0.41	[−1.41;0.59]
Lesotho	−2.06	[−4.43;0.31]	−1.86	[−4.17;0.45]	−1.49	[−2.45;−0.54]	−1.63	[−2.65;−0.61]
Liberia	−3.51	[−5.89;−1.14]	−3.46	[−5.78;−1.15]	−0.15	[−1.12;0.83]	−0.15	[−1.19;0.88]

Madagascar	−1.60	[−4.06;0.86]	−1.51	[−4.14;1.12]	−1.46	[−9.46;6.55]	−1.28	[−9.24;6.67]
Malawi	−3.12	[−5.48;−0.77]	−3.01	[−5.30;−0.71]	0.31	[−0.64;1.26]	0.26	[−0.76;1.27]
Mali	−2.48	[−4.86;−0.11]	−2.44	[−4.76;−0.13]	−0.13	[−1.09;0.83]	−0.14	[−1.17;0.88]
Mozambique	−4.45	[−9.25;0.36]	−4.53	[−9.36;0.31]	−0.98	[−2.42;0.45]	−0.92	[−2.40;0.57]
Namibia	−1.92	[−4.31;0.47]	−1.90	[−4.24;0.44]	−1.23	[−2.18;−0.29]	−1.15	[−2.27;−0.02]
Niger	−0.71	[−4.82;3.40]	−0.75	[−4.78;3.28]	−1.56	[−5.06;1.93]	−1.39	[−4.81;2.03]
Nigeria	−2.63	[−4.99;−0.28]	−2.51	[−4.81;−0.21]	0.13	[−0.81;1.06]	−0.01	[−1.01;0.99]
Rwanda	0.07	[−2.29;2.42]	0.14	[−2.15;2.44]	−0.41	[−1.34;0.52]	−0.43	[−1.43;0.56]
Sao Tome and Principe	−2.79	[−5.25;−0.33]	−2.85	[−5.26;−0.44]	−0.17	[−2.11;1.76]	−0.13	[−2.08;1.82]
Senegal	−1.15	[−3.51;1.21]	−1.13	[−3.43;1.17]	−1.32	[−2.26;−0.39]	−1.31	[−2.31;−0.31]
Sierra Leone	−2.88	[−5.50;−0.26]	−2.80	[−5.35;−0.24]	−0.42	[−1.67;0.83]	−1.46	[−3.62;0.70]
South Africa	−2.60	[−5.81;0.61]	−2.44	[−5.60;0.72]	−2.26	[−3.86;−0.67]	−2.37	[−3.95;−0.78]
Tanzania	−3.04	[−5.55;−0.53]	−2.69	[−5.17;−0.22]	−0.30	[−1.30;0.71]	−0.58	[−1.63;0.48]
Togo	4.32	[−12.64;21.29]	4.31	[−12.05;20.68]	−2.22	[−5.72;1.29]	−2.22	[−5.65;1.20]
Uganda	−3.36	[−5.71;−1.00]	−3.30	[−5.60;−1.00]	0.78	[−0.15;1.72]	0.76	[−0.24;1.75]
Zambia	−3.64	[−6.00;−1.28]	−3.44	[−5.74;−1.15]	0.64	[−0.29;1.57]	0.48	[−0.52;1.48]
Zimbabwe	−3.15	[−5.51;−0.78]	−2.97	[−5.28;−0.66]	−0.87	[−1.81;0.08]	−1.02	[−2.02;−0.01]
s(Year of birth): Angola	5.57	[−12.07;23.21]	5.52	[−12.12;23.16]	4.61	[−13.03;22.25]	4.69	[−12.95;22.33]
s(Year of birth): Benin	7.26	[−10.38;24.90]	7.25	[−10.39;24.89]	7.40	[−10.24;25.04]	7.72	[−9.92;25.36]
s(Year of birth): Burkina Faso	2.92	[−14.72;20.56]	2.86	[−14.78;20.50]	4.85	[−12.79;22.49]	4.73	[−12.91;22.37]
s(Year of birth): Burundi	1.78	[−15.86;19.42]	1.66	[−15.98;19.30]	4.86	[−12.77;22.50]	4.67	[−12.97;22.31]
s(Year of birth): Cameroon	6.64	[−11.00;24.28]	6.60	[−11.04;24.24]	5.83	[−11.81;23.47]	5.83	[−11.81;23.47]
s(Year of birth): Chad	3.13	[−14.51;20.77]	3.11	[−14.52;20.75]	5.13	[−12.51;22.77]	4.99	[−12.65;22.63]
s(Year of birth): Comoros	0.78	[−14.90;16.46]	0.86	[−14.82;16.54]	3.50	[−12.18;19.18]	3.43	[−12.25;19.11]
s(Year of birth): Congo	4.23	[−13.41;21.87]	4.20	[−13.44;21.84]	6.17	[−11.47;23.81]	6.15	[−11.49;23.79]
s(Year of birth): Cote D'Ivoire	0.00	[−15.68;15.68]	0.01	[−15.67;15.69]	0.77	[−14.91;16.45]	0.79	[−14.89;16.47]
s(Year of birth): Democratic Republic of Congo	6.14	[−11.50;23.78]	6.10	[−11.54;23.74]	5.77	[−11.87;23.41]	5.66	[−11.98;23.30]
s(Year of birth): Eswatini	0.72	[−14.96;16.40]	0.61	[−15.07;16.29]	1.83	[−13.85;17.51]	1.57	[−14.11;17.25]
s(Year of birth): Ethiopia	7.27	[−10.37;24.91]	7.20	[−10.44;24.84]	6.03	[−11.61;23.67]	5.72	[−11.92;23.36]
s(Year of birth): Gabon	3.08	[−12.60;18.76]	3.07	[−12.61;18.75]	5.34	[−10.34;21.02]	5.38	[−10.30;21.06]
s(Year of birth): Gambia	0.86	[−16.78;18.50]	0.87	[−16.77;18.51]	5.21	[−12.43;22.85]	5.24	[−12.40;22.88]
s(Year of birth): Ghana	0.90	[−16.74;18.54]	0.87	[−16.77;18.51]	7.59	[−10.05;25.23]	7.49	[−10.15;25.13]
s(Year of birth): Guinea	6.56	[−11.08;24.20]	6.58	[−11.06;24.22]	5.28	[−12.36;22.92]	5.32	[−12.32;22.96]
s(Year of birth): Kenya	4.37	[−13.27;22.01]	5.09	[−12.54;22.73]	6.57	[−11.07;24.21]	6.87	[−10.77;24.51]
s(Year of birth): Lesotho	5.14	[−12.50;22.78]	5.04	[−12.60;22.68]	6.35	[−11.29;23.99]	6.52	[−11.12;24.16]
s(Year of birth): Liberia	4.56	[−13.08;22.20]	4.29	[−13.35;21.93]	6.17	[−11.47;23.81]	5.97	[−11.67;23.61]
s(Year of birth): Madagascar	3.19	[−14.45;20.83]	4.19	[−13.45;21.83]	6.61	[−11.03;24.25]	6.60	[−11.04;24.24]
s(Year of birth): Malawi	5.84	[−11.80;23.48]	5.91	[−11.73;23.55]	7.88	[−9.76;25.52]	7.89	[−9.75;25.53]
s(Year of birth): Mali	2.29	[−15.35;19.93]	2.27	[−15.37;19.91]	7.26	[−10.38;24.90]	7.25	[−10.39;24.89]

s(Year of birth): Mozambique	7.43	[−10.21;25.07]	7.43	[−10.20;25.07]	6.44	[−11.20;24.08]	6.44	[−11.20;24.08]
s(Year of birth): Namibia	3.50	[−14.14;21.14]	3.88	[−13.75;21.52]	0.95	[−16.69;18.59]	5.27	[−12.37;22.91]
s(Year of birth): Niger	6.22	[−11.42;23.86]	6.18	[−11.46;23.82]	6.66	[−10.98;24.30]	6.61	[−11.03;24.25]
s(Year of birth): Nigeria	6.77	[−10.87;24.41]	6.78	[−10.86;24.42]	6.30	[−11.34;23.94]	6.34	[−11.30;23.98]
s(Year of birth): Rwanda	6.40	[−11.24;24.04]	6.75	[−10.89;24.39]	6.98	[−10.66;24.62]	6.71	[−10.93;24.35]
s(Year of birth): Sao Tome and Principe	1.02	[−14.66;16.70]	1.04	[−14.64;16.72]	2.55	[−13.13;18.23]	2.52	[−13.16;18.20]
s(Year of birth): Senegal	6.60	[−11.04;24.23]	6.61	[−11.03;24.25]	7.75	[−9.89;25.39]	7.74	[−9.90;25.38]
s(Year of birth): Sierra Leone	6.50	[−11.14;24.14]	6.46	[−11.18;24.10]	6.42	[−11.22;24.06]	7.52	[−10.12;25.16]
s(Year of birth): South Africa	1.54	[−14.14;17.22]	1.52	[−14.16;17.20]	1.56	[−14.12;17.24]	1.49	[−14.19;17.17]
s(Year of birth): Tanzania	5.10	[−12.54;22.74]	5.20	[−12.44;22.84]	4.16	[−13.48;21.80]	4.06	[−13.58;21.70]
s(Year of birth): Togo	4.80	[−10.88;20.48]	4.77	[−10.91;20.45]	3.61	[−12.07;19.29]	3.56	[−12.12;19.24]
s(Year of birth): Uganda	7.68	[−9.96;25.32]	7.81	[−9.83;25.45]	6.15	[−11.49;23.79]	6.23	[−11.41;23.87]
s(Year of birth): Zambia	6.69	[−10.95;24.33]	6.60	[−11.04;24.24]	6.55	[−11.09;24.19]	6.56	[−11.08;24.20]
s(Year of birth): Zimbabwe	5.63	[−12.01;23.27]	5.80	[−11.84;23.44]	5.63	[−12.01;23.27]	5.80	[−11.84;23.44]
AIC	59533.27		59730.73		52192.96		52515.73	
BIC	61095.93		61236.77		54008.52		54295.54	
Log Likelihood	−29556.12		−29662.48		−25852.23		−26018.43	
Deviance	1153163.19		1173164.94		107106.16		109992.90	
Deviance explained	0.27		0.26		0.28		0.26	
Dispersion	93.38		94.99		8.59		8.82	
R2	0.26		0.25		0.27		0.25	
GCV score	456437.38		457506.09		312154.33		313829.91	
Num. obs.	12370		12370		12498		12498	
Num. smooth terms	36		36		36		36	

*Null hypothesis value outside the confidence interval. RC- Reference category.

Appendix D

We run the following interaction GAMs for age at first birth and number of children ever born respectively and present the results in Table D1.

$$\mathrm{E}\left(\text{age at first birth}\right) = \beta_0 + \beta_j \cdot \mathrm{Country}_j + \sum_p \beta_p \left(s\left(\text{Year of birth}\right)_{\text{country}} \right) + \beta_m \cdot \mathrm{Education}_m + \beta_n \cdot \mathrm{Literacy}_n + \beta_r \cdot \mathrm{Education} \times \mathrm{Literacy}_r. \quad (7)$$

$$\mathrm{E}\left(\text{number of children ever born}\right) = \beta_0 + \beta_j \cdot \mathrm{Country}_j + \sum_p \beta_p \left(s\left(\text{Year of birth}\right)_{\text{country}} \right) + \beta_m \cdot \mathrm{Education}_m + \beta_n \cdot \mathrm{Literacy}_n + \beta_r \cdot \mathrm{Education} \times \mathrm{Literacy}_r. \quad (8)$$

Table D1: Coefficients and standard errors of GAM for completed fertility and age at first birth with interaction

Parameter	Mean age at first birth (Equation 7)		Mean number of children (Equation 8)	
Intercept	23.03	[15.51;30.55]	6.00	[5.59;6.42]
No Education	−0.22	[−0.42;−0.02]	0.41	[0.10;0.72]
Primary Education	RC		RC	
Secondary Education	1.44	[1.15;1.73]	−1.07	[−1.30;−0.84]
Higher Education	4.02	[3.69;4.36]	−2.28	[−2.52;−2.03]
Illiterate	−0.64	[−1.09;−0.19]	0.51	[0.23;0.78]
Semi-literate	RC		RC	
Literate	−0.02	[−0.30;0.27]	−0.18	[−0.35;−0.01]
No Education:Illiterate	0.69	[0.20;1.17]	−0.13	[−0.44;0.18]
No Education:Semi-literate	0.00	[0.00;0.00]	0.00	[0.00;0.00]
No Education:Literate	0.34	[−0.07;0.75]	−0.11	[−0.38;0.16]
Primary Education:Illiterate	0.57	[0.11;1.03]	0.00	[0.00;0.00]
Primary Education:Semi-literate	0.00	[0.00;0.00]	0.16	[−0.13;0.45]
Primary Education:Literate	0.01	[−0.29;0.31]	0.28	[0.05;0.52]
Other	RC		RC	
Angola	RC		RC	
Benin	−3.76	[−11.28;3.76]	−0.17	[−0.51;0.17]
Burkina Faso	−3.69	[−11.23;3.85]	0.28	[−0.14;0.70]
Burundi	−0.89	[−8.57;6.78]	−0.52	[−1.57;0.53]
Cameroon	−4.59	[−12.11;2.93]	−0.12	[−0.44;0.20]
Central African Republic	6.33	[−84.36;97.03]	−0.86	[−1.60;−0.12]
Chad	−4.80	[−12.39;2.79]	0.55	[0.13;0.97]
Comoros	−3.26	[−10.81;4.28]	−0.41	[−0.84;0.02]
Congo	−5.61	[−13.19;1.97]	0.19	[−1.09;1.46]
Cote D'Ivoire	−4.35	[−11.88;3.17]	−0.45	[−0.85;−0.05]

Democratic Republic of Congo	−13.27	[−30.46;3.92]	0.93	[−1.57;3.43]
Eswatini	−15.70	[−46.82;15.43]	−0.13	[−0.53;0.27]
Ethiopia	−5.31	[−12.84;2.22]	0.29	[−0.16;0.74]
Gabon	−6.36	[−14.26;1.53]	−0.02	[−0.46;0.42]
Gambia	−5.12	[−13.13;2.88]	−0.38	[−1.78;1.01]
Ghana	−3.83	[−11.35;3.69]	−0.57	[−0.89;−0.25]
Guinea	−4.19	[−11.73;3.35]	−0.19	[−0.76;0.38]
Kenya	−4.42	[−11.94;3.10]	0.05	[−0.27;0.37]
Lesotho	−3.12	[−11.01;4.76]	−1.20	[−2.41;0.01]
Liberia	−5.36	[−12.91;2.18]	−0.10	[−0.56;0.37]
Madagascar	−4.01	[−11.63;3.61]	−0.76	[−1.75;0.23]
Malawi	−4.27	[−11.79;3.25]	0.18	[−0.14;0.50]
Mali	−3.88	[−11.40;3.64]	0.30	[−0.01;0.62]
Mozambique	−2.45	[−10.61;5.70]	−0.18	[−2.39;2.04]
Namibia	−3.17	[−10.71;4.36]	−1.02	[−1.35;−0.69]
Niger	−5.35	[−12.89;2.19]	1.00	[0.64;1.37]
Nigeria	−4.34	[−11.86;3.18]	0.28	[−0.04;0.60]
Rwanda	−1.88	[−9.40;5.65]	0.10	[−0.22;0.42]
Sao Tome and Principe	−5.48	[−14.81;3.84]	1.30	[−3.85;6.45]
Senegal	−3.56	[−11.08;3.96]	−0.20	[−0.52;0.11]
Sierra Leone	−5.37	[−14.06;3.32]	−0.75	[−2.07;0.58]
South Africa	−3.79	[−11.32;3.74]	−1.86	[−2.25;−1.47]
Sudan	12.86	[−94.40;120.12]	−5.58	[−65.02;53.85]
Tanzania	−4.37	[−11.89;3.15]	−0.06	[−0.38;0.26]
Togo	−3.43	[−10.95;4.10]	−0.56	[−0.90;−0.21]
Uganda	−4.89	[−12.42;2.63]	0.89	[0.57;1.21]
Zambia	−5.09	[−12.61;2.43]	0.78	[0.46;1.10]
Zimbabwe	−4.34	[−11.86;3.18]	−0.57	[−0.90;−0.25]
s(Year of birth): Angola	4.02	[−11.66;19.70]	0.93	[−14.75;16.61]
s(Year of birth): Benin	7.03	[−10.61;24.67]	6.31	[−11.33;23.95]
s(Year of birth): Burkina Faso	6.62	[−11.01;24.26]	5.85	[−11.79;23.48]
s(Year of birth): Burundi	8.79	[−8.85;26.43]	7.61	[−10.03;25.25]
s(Year of birth): Cameroon	7.96	[−9.68;25.60]	4.84	[−12.80;22.48]
s(Year of birth): Central African Republic	3.86	[−11.82;19.54]	0.54	[−13.18;14.26]
s(Year of birth): Chad	7.68	[−9.96;25.32]	5.81	[−11.83;23.45]
s(Year of birth): Comoros	4.91	[−12.73;22.55]	3.66	[−13.98;21.30]
s(Year of birth): Congo	2.38	[−13.30;18.06]	3.34	[−12.34;19.02]
s(Year of birth): Cote D'Ivoire	4.90	[−12.74;22.54]	5.53	[−12.11;23.17]
s(Year of birth): Democratic Republic of Congo	5.72	[−11.92;23.36]	4.15	[−13.49;21.79]

s(Year of birth): Eswatini	3.95	[−11.73;19.63]	0.96	[−12.76;14.68]
s(Year of birth): Ethiopia	6.85	[−10.79;24.49]	7.19	[−10.45;24.83]
s(Year of birth): Gabon	5.51	[−12.13;23.15]	2.57	[−15.07;20.21]
s(Year of birth): Gambia	2.91	[−12.77;18.59]	2.50	[−13.18;18.18]
s(Year of birth): Ghana	4.68	[−12.96;22.32]	6.49	[−11.15;24.13]
s(Year of birth): Guinea	6.10	[−11.54;23.74]	6.34	[−11.30;23.98]
s(Year of birth): Kenya	6.27	[−11.36;23.91]	7.59	[−10.05;25.23]
s(Year of birth): Lesotho	4.45	[−13.19;22.09]	4.19	[−13.45;21.83]
s(Year of birth): Liberia	8.75	[−8.89;26.39]	7.42	[−10.22;25.06]
s(Year of birth): Madagascar	6.25	[−11.39;23.89]	6.39	[−11.25;24.03]
s(Year of birth): Malawi	7.55	[−10.09;25.18]	5.92	[−11.72;23.56]
s(Year of birth): Mali	8.41	[−9.23;26.05]	7.71	[−9.93;25.35]
s(Year of birth): Mozambique	7.45	[−10.19;25.09]	7.47	[−10.17;25.11]
s(Year of birth): Namibia	7.62	[−10.02;25.26]	4.43	[−13.21;22.07]
s(Year of birth): Niger	7.89	[−9.75;25.53]	6.26	[−11.38;23.90]
s(Year of birth): Nigeria	8.65	[−8.99;26.29]	7.89	[−9.75;25.53]
s(Year of birth): Rwanda	7.49	[−10.14;25.13]	7.05	[−10.59;24.69]
s(Year of birth): Sao Tome and Principe	2.23	[−13.45;17.91]	2.47	[−13.21;18.15]
s(Year of birth): Senegal	6.97	[−10.67;24.61]	7.82	[−9.82;25.46]
s(Year of birth): Sierra Leone	4.75	[−12.89;22.39]	3.97	[−11.71;19.65]
s(Year of birth): South Africa	4.19	[−13.45;21.83]	4.71	[−12.93;22.35]
s(Year of birth): Sudan	3.75	[−11.93;19.43]	3.54	[−12.14;19.21]
s(Year of birth): Tanzania	7.77	[−9.87;25.41]	6.60	[−11.04;24.24]
s(Year of birth): Togo	7.57	[−10.07;25.21]	6.48	[−11.16;24.12]
s(Year of birth): Uganda	7.93	[−9.71;25.57]	7.32	[−10.32;24.96]
s(Year of birth): Zambia	7.59	[−10.05;25.23]	7.32	[−10.32;24.96]
s(Year of birth): Zimbabwe	2.27	[−15.37;19.91]	5.42	[−12.22;23.06]
AIC	42295.30		34222.84	
BIC	44322.71		36052.07	
Log Likelihood	−20867.79		−16859.17	
Deviance	1435911.86		119627.03	
Deviance explained	0.54		0.74	
Dispersion	139.17		11.51	
R2	0.52		0.73	
GCV score	402730.15		275690.43	
Num. obs.	10345		10422	
Num. smooth terms	38		38	

*Null hypothesis value outside the confidence interval. RC- Reference category.

The “Other” category is the secondary and higher education levels interaction effects with literacy levels as we do not necessarily include this category in the text