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RESEARCH PAPER

# The effect of female secondary education on fertility and the timing of birth: regression discontinuity evidence from Ghana

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**Abstract**
The objective of this paper is to investigate the causal effect of education on fertility. The study adopts an education reform in 1987 that shortened the years of completing secondary school education in Ghana as a natural experiment. The data used for the analysis come from 10% of the 2021 Ghana Population and Housing Census. Women exposed to the reform experienced an increase in secondary school enrolment, which resulted in an overall reduction in fertility. The results obtained in this study indicate that the rise in secondary school education due to the 1987 reform extended the age at first birth. The study found knowledge acquisition, incarceration effect, opportunity cost, and autonomy as possible pathways through which secondary education affects fertility. The study broadens the scope of exploration of existing studies by identifying several mechanisms through which education affects fertility in Ghana.

**Keywords** Fertility · Incarceration effect · Autonomy · Opportunity cost · Regression · Discontinuity · Ghana · J13

**JEL Classification** J13

## Introduction

For a long time, issues concerning the dynamics of female education and fertility have been a central matter in development economics. This is because female education is considered one of the essential policies that facilitate the demographic transition, which accelerates economic growth and development (Cohen 2008; Burchi 2006; Portes 2006). In recent

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years, studies about the effect of female education on fertility in the SSA subregion have increased because of the projections by the United Nations—that the world population will move from its present 7.7 billion to 10.9 billion people by 2100, with SSA contributing to more than half of the increase (United Nations 2019). Educating women will empower them in all aspects of their lives, which would enable them to have more input into their timing of marriage and the total number of births (see, inter alia, Becker 1993; James and Vujic 2019; DeCicca and Krashinsky 2020).

UPE is the major policy intervention that has been used to study the causal effect of education on fertility in SSA. While UPE policy affects all women at the school-going age, the policy often benefits women only up to around the age of 16 years since the majority of these girls are likely to finish primary school around this age. Given the above, UPE is likely to manipulate the fertility of women at a much younger age. However, using reforms that affect students in secondary schools is likely to manipulate the education of women who are older than the age cohorts that UPE manipulates. Against these considerations, the paper seeks to investigate the impact of secondary education on fertility by adopting an educational reform in 1987 that aims to improve secondary school enrolment as a natural experiment. The reform reduced secondary school completion from 5 or 7 years to 3 years. The reduction in the years of secondary education caused a surge in secondary school enrolment and it is upon this basis that the empirical design for the study is determined.

The main contribution of this paper is that the identification strategy used in this study affects the total schooling years of women who have at least completed basic education.[1] Thus, the paper reports how educational policies that seem to manipulate the education of older women may impact fertility. Hence, the findings of this study are quite different from several quasi-experimental designs in developing countries that adopt UPE which manipulates the fertility of women at a much younger age. Second, unlike the several studies in SSA that adopt UPE which is a recent policy, the policy used in this study was implemented several years and therefore fertility of women who are at the tail end of their fertility transition can be studied. Third, the few studies that have examined the effect of secondary school education on fertility in SSA study the fertility of women between the ages of 15 and 25. However, this study examines the fertility of women older than 40 years, and therefore analysis in this study is closer to the impact of education on completed fertility. Finally, the study broadens the scope of exploration of existing studies by identifying several possible mechanisms through which education affects fertility.

The rest of the paper is organized as follows: Section "Literature review" briefly describes the literature on the topic. In Section "Policy background", we provide information on the 1987 educational policy. Section "Data source, sample, and definition of variables" describes the source of data. In Section "Empirical framework, polynomial specification, and internal validity checks", we discuss the empirical framework and identification strategy. Section "Results" reports the estimation results of the main findings. Section "Conclusion" concludes.

[1] Basic education in Ghana before the 1987 reform was 10 years but reduced to 9 years after the 1987 educational reform.

## Literature review

The observed negative correlation between education and fertility and education and the timing of birth in SSA is not different from that reported in other studies conducted outside the subregion. All studies report a strong correlation between female education and the timing of birth (see, inter alia, Cochrane 1979; Strauss et al. 1995; Grossman 2006; and Ganguli et al. 2014). The timing of birth and fertility is a major concern, given the strong evidence of negative consequences associated with early childbirth and large family size.

Education can delay fertility via the following mechanisms. First, education increases the individual's knowledge; therefore, an increase in female education could likely enhance women's ability to use contraception effectively and efficiently (Rosenzweig and Schultz 1989). Second, child care is more time-intensive, and therefore as the value of a woman's time increases, she would prefer to demand fewer children to spend less time on childcare-related activities to allow her to participate in the labour market (see, inter alia, Schultz 1981). Third, educated women are more likely to contribute to household decision-making, which includes the ideal number of children for the household. Fourth, keeping women in school reduces the probability that they will engage in activities that could lead to unplanned births (see, inter alia, DeCicca and Krashinsky, 2020; Black et al. 2008). Finally, the marriage market operates in a way where educated women have a higher likelihood of being matched to an educated man who will also prefer fewer children (see, inter alia, Lavy and Zablotsky 2015; Tequame and Tirivayi 2015).

Using the actual date of birth and a compulsory law change in education to conduct a regression discontinuity design, Kan and Lee (2018) find no causal effect of education on fertility in Taiwan. A similar design and policy are also used by McCrary and Royer (2011) for USA data, and their findings corroborate those of Kan and Lee (2018). On the contrary, several studies have rather found that the gains in education resulting from compulsory schooling laws lead to a decrease in fertility (see, inter alia, DeCicca and Krashinsky 2020, Black et al. 2008). Using UPE as an instrument for education, several studies have found an increase in education attainment to cause a decline in fertility (see, inter alia, Osili and Long 2008; Keats 2018; Boahen and Yamauchi 2018). Ferré (2009) and Ali and Gurmu (2018) used a change in the length of primary schooling as an instrument of education and found a negative causal relationship between education and fertility.

Even though there are mixed findings in the literature concerning the causal relationship between education and fertility, the mixed results can only be seen in studies that used developed countries data. However, evidence from developing countries consistently shows a causal effect of education on fertility. Despite the rich literature about the effect of education on fertility in developing countries, there are only a few studies that examine the effect of secondary school education on fertility (Duflo et al. 2022; Ozier 2018).

**Table 1** Phase-in of the post-reform educational structure. *Source* Authors' adaptation from World Bank (2004) (Color table online)

| | | 86/87 | 87/88 | 88/89 | 89/90 | 90/91 | 91/92 | 92/93 | 93/94 | 94/95 | 95/96 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Basic education | Old system: Middle School | Last cohort started | | | Last cohort finished | Middle Schools ended | | | | | |
| | New system: JSS | JSS not yet started | First cohort started | | First cohort finished | | | | | | |
| Secondary Education | Old system: O- & A-levels | | | | Last cohort started Form 1 | | | | Last cohort finished Form 5 | | Last cohort finished Form 7 |
| | New system: SSS | SSS not yet started | | | | First cohort started | | First cohort finished | | | |

## Policy background

### The 1987 policy

In 1987, the New Educational Reform Programme (NERP) was introduced with the focus of a total restructuring of the entire pretertiary educational system.[2] NERP reduced JSS (formally called Middle School) from 4 to 3 years and secondary school from 7 or 5 years to 3 years. However, primary school education was maintained at 6 years. This means that the existing 17 or 15 years of pretertiary education was replaced with 12 years.

Two significant changes in the NERP were

- the introduction of a mandatory 9 years of presecondary education applicable to all primary schools. Even though most Ghanaians welcomed the idea the small elite group in the society was against this policy (Akyeampong et al. 2007).
- A reduction of the years of secondary schooling from 5 years to three for those who wished to attend other tertiary education apart from university and then from 7 to 3 for those who wanted to attend university. This means that 3 years of secondary education became the basic requirement to enter any tertiary institution in the country.

The reduction in years of pretertiary education from 6–4–5–2/6–4–7–2 to 6–3–3 in the 1987 reform forms the basis of the empirical strategy of this study. Table 1 provides a summary of the NERP.

### Why NERP might affect fertility?

Considering that NERP reduced the years of preuniversity education from 17 to 12, the human capital of the policy-unaffected cohort is likely to be higher, thereby resulting in better wages than the policy-affected cohort. Higher wages are likely to motivate the policy-unaffected group to reduce their fertility so that they can participate in the labour market (see, inter alia, Becker 1993; Ozier 2018; Abekah-Nkrumah et al. 2019; Boahen et al.

[2] The previous educational structure was criticized for being selective favouring the rich in society to have their children spending fewer years to get access to secondary school compared to children from poor homes.

2020). However, requiring 12 years in pretertiary education instead of 15 or 17 years is likely to cause a higher enrolment for both secondary and tertiary education. This means that the policy-affected group would be able to provide a better signal to employers about their productivity than those in the policy-unaffected cohort (see, inter alia, Spence 1973; Stiglitz 1975). If this is the case, the policy-affected cohort is more likely to earn higher wages than the unaffected cohort and therefore more likely to substitute time for childcare with work— meaning demand for fewer children (Boahen et al. 2020). Whether the former (quality effect) or the latter (quantity effect) dominates is a matter of empirical question.

Similarly, NERP reduced the years of education of the policy-affected cohort, and therefore, the incarceration effect is likely to happen in a way opposite to the manner observed in the fertility literature. However, if the quantity effect in accessing secondary school education due to NERP is stronger to overturn the long years of schooling, the policy-unaffected cohort would rather become free for mating at early ages than the policy-affected cohort since secondary school completion after NERP takes 12 years. Whether the incarceration effect is stronger in the pre-NERP era or post-NERP era is also a matter of empirical study. The reform affected men as well; therefore, it is likely that the husbands of those in the policy-unaffected cohort experience more years of schooling than those cohorts that are affected by the policy. On the other hand, the husbands of women in the policy-affected cohort are more likely to attend secondary school. Thus, assortative matching and household bargaining are possible pathways through which NERP can affect fertility.

## Data source, sample, and definition of variables

The data analysed here come from the 2021 Ghana Population and Housing Census (GPHC).[3] Information on the years of education,[4] the highest level of education completed, ethnicity, religion, fertility, literacy, radio and television ownership, and age at first birth, which form the main variables for the study, are taken from the GPHC. The 1987 policy that is been used as an instrument for education is quite recent. Because of that, the study can only rely on women who are 41 years or older instead of 50 years older which by them all of them would be at their menopausal age.

The total sample size obtained from the 10% 2021 GPHC for women who are 41 years or older is 327,340. By choosing the year of birth to represent a bandwidth, only 7 bandwidths are observed at the right side of the cut-off point, and this group forms the policy-affected cohort, and the remaining cohort on the left side of the cut-off forms the policy-unaffected cohort. The total observation for the policy-affected cohort is 99,917, and the unaffected cohort is 227,423.

Tables 2 and 3 give descriptive statistics for the sampled observations. The main outcome variable total fertility is defined as the total live births of the woman at the time of the survey, and it is computed by directly summing the four fertility variables in the dataset, namely (1) the number of male children alive, (2) the number of female children alive, (3) the number of live birth male children that have died and (4) the number of live birth female children that have died.

[3] The study uses the 10% publicly available 2021 population and housing census for Ghana.

[4] Years of education refer to the highest grade completed. Since there is no information on repetition in the dataset, we consider the highest grade completed as total years of education or total schooling years.

**Table 2** Descriptive statistics of covariates. *Source* Authors' calculations based on the 2021 GPHC

| | Unaffected Cohort | | | Affected Cohort | | | Full Sample | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | N | Mean | S.D. | N | Mean | S.D. | N |
| *Age* | 62.59 | 11.3 | 227,423 | 44.2 | 2.3 | 99,917 | 56.3 | 12.7 | 327,340 |
| *Education* | | | | | | | | | |
| Years of education | 4.42 | 5.59 | 227,423 | 5.38 | 5.47 | 99,917 | 4.61 | 5.58 | 327,340 |
| 1 if no education | 0.54 | 0.50 | 227,423 | 0.43 | 0.50 | 99,917 | 0.52 | 0.50 | 327,340 |
| 1 if primary | 0.09 | 0.29 | 227,423 | 0.12 | 0.32 | 99,917 | 0.10 | 0.29 | 327,340 |
| 1 if JSS/Middle | 0.25 | 0.44 | 227,423 | 0.25 | 0.44 | 99,917 | 0.25 | 0.44 | 327,340 |
| 1 if secondary | 0.04 | 0.21 | 227,423 | 0.12 | 0.32 | 99,917 | 0.06 | 0.24 | 327,340 |
| 1 if tertiary | 0.03 | 0.18 | 227,423 | 0.05 | 0.21 | 99,917 | 0.04 | 0.18 | 327,340 |
| *Ethnicity* | | | | | | | | | |
| 1 if Akan | 0.50 | 0.50 | 227,423 | 0.49 | 0.50 | 99,917 | 0.50 | 0.50 | 327,340 |
| 1 if Ewe | 0.14 | 0.35 | 227,423 | 0.14 | 0.35 | 99,917 | 0.14 | 0.35 | 327,340 |
| 1 if Mole Dagbani | 0.14 | 0.35 | 227,423 | 0.15 | 0.35 | 99,917 | 0.14 | 0.35 | 327,340 |
| 1 if Ga-Dangbe | 0.08 | 0.28 | 227,423 | 0.08 | 0.28 | 99,917 | 0.08 | 0.27 | 327,340 |
| 1 if Other Ethnicity | 0.12 | 0.33 | 227,423 | 0.13 | 0.34 | 99,917 | 0.12 | 0.33 | 327,340 |
| *Religion* | | | | | | | | | |
| 1 if Christian | 0.76 | 0.43 | 227,423 | 0.76 | 0.43 | 99,917 | 0.76 | 0.43 | 327,340 |
| 1 if Islamic | 0.14 | 0.35 | 227,423 | 0.15 | 0.36 | 99,917 | 0.14 | 0.35 | 327,340 |
| 1 if Other Religion | 0.10 | 0.30 | 227,423 | 0.09 | 0.28 | 99,917 | 0.10 | 0.30 | 327,340 |
| *Literacy* | | | | | | | | | |
| 1 if can read and write | 0.41 | 0.49 | 227,423 | 0.51 | 0.50 | 99,917 | 0.43 | 0.50 | 327,340 |
| *Labour market* | | | | | | | | | |
| 1 if in labour force | 0.52 | 0.49 | 227,423 | 0.76 | 0.43 | 99,917 | 0.57 | 0.50 | 327,340 |
| 1 if employee | 0.47 | 0.50 | 227,423 | 0.71 | 0.45 | 99,917 | 0.52 | 0.50 | 327,340 |
| *Knowledge mediums* | | | | | | | | | |
| 1 if owned radio | 0.50 | 0.50 | 227,423 | 0.52 | 0.50 | 99,917 | 0.51 | 0.50 | 327,340 |
| 1 if owned television | 0.57 | 0.50 | 227,423 | 0.64 | 0.50 | 99,917 | 0.58 | 0.49 | 327,340 |

S.D. represents the standard deviation, and N represents the sample size

**Table 3** Descriptive statistics of the outcome variable. *Source* Authors' calculations based on the 2021 GPHC

| Fertility | Unaffected Cohort | | Affected Cohort | | | Test of mean differences | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | N | Mean | S.D. | N | Difference | S.E. |
| Total Fertility | 5.56 | 3.84 | 226,604 | 4.19 | 2.84 | 99,525 | 1.37*** | 0.014 |
| Age at first birth | 23.18 | 5.76 | 226,604 | 23.20 | 5.74 | 99,525 | − 0.02 | 0.023 |

S.D. represents the standard deviation, S.E represents a standard error, and N represents sample size

Table 2 summarizes the mean, standard deviation, and sample size for education, ethnicity, religion, literacy, labour market variables, and variables to measure knowledge mediums. The table suggests that the policy-affected cohort has more favourable education outcomes. For example, while the average years of education for the policy-affected cohort is 5.38, it is only 4.4 for the unaffected cohort, and approximately 17% of the policy-affected cohort have at least secondary education, while the unaffected cohort is only 7%. Similarly, the policy-affected cohorts are more likely to be able to read and write, participate in the labour market, and own a radio or television than their counterparts that were not affected by the policy. Table 3 shows descriptive statistics for the main outcome variables by testing the mean difference between the policy-affected cohort and unaffected cohort of these two main outcome variables. It can be seen from the table that the policy-affected cohort has lower fertility than the unaffected cohort, and the test of mean difference is statistically significant. However, in terms of age at first birth, there was no statistically significant difference between the policy-affected cohort and the unaffected cohort.

## Empirical framework, polynomial specification, and internal validity checks

### Empirical framework

The exogenous implementation of the 1987 reform fits a regression discontinuity design for the identification of the causal effect of secondary education on fertility and the timing of birth. The study depends on the year of birth of females in the dataset to determine the cohorts that were affected by the reform.[5]

Since the year of birth rather than the year of first entry into secondary school is used as the running variable and given the possibility of late or early entry into primary school, the treatment status is therefore not a deterministic function of the running variable. A fuzzy regression discontinuity framework is therefore used to determine the causal effect. In a fuzzy regression discontinuity framework, the estimand is expressed as

$$\tau = \frac{\lim_{x\downarrow c}\mathbb{E}[Y|x] - lim_{x\uparrow c}\mathbb{E}[Y|x]}{\lim_{x\downarrow c}\mathbb{E}[educ|x] - lim_{x\uparrow c}\mathbb{E}[educ|x]}$$

where $x$ is the running variable (i.e. the year of birth), $c$ is the cut-off point, *educ* is a dichotomous variable for at least secondary school education and $Y$ represents the outcome variables.

Using the dummy indicator $D$=1[year of birth $\geq$ c], the estimand of the fuzzy regression discontinuity is equivalent to the 2SLS[6] estimator $\beta_1$ (Hahn et al. 2001), given by

$$educ = \alpha_o + \alpha_1 D + f_1(year\ of\ birth - c) + \alpha_2 Z + \varepsilon_1 \tag{1}$$

$$Y = \beta_o + \beta_1 \widehat{educ} + f_2(year\ of\ birth - c) + \beta_2 Z + \varepsilon_2 \tag{2}$$

where $f_1$ and $f_2$ are polynomial functions and Eqs. (1) and (2) are the 1st stage and 2nd stage regression, respectively. $Z$ is a vector of observed pretreatment covariates. The pretreatment covariates used in the regression analysis are religion and ethnicity. The other

[5] For an extensive survey in the literature on regression discontinuity design, see Lee and Lemieux (2010).

[6] The estimation approach is equivalent to local linear regression with uniform corner.

pre-covariates (1 if ever attended school and 1 if at least completed primary school) used in Fig. 2 are only for checking smoothness around the discontinuity.

### Identification and internal validity checks

The potential concern here is that other government policies are likely to be related to NERP at the specified cut-off. If this were to happen, the estimated results would identify the combined causal effect of NERP and other policies. To the best of our knowledge, there are no other government programmes that created a discontinuity in education in the specified cut-off. One may argue that the late 1980s and the early 1990s were periods of reforms and these reforms are likely to improve education and labour market outcomes which may also reduce fertility. Since the two cohorts were graduating secondary school students from 1993 to 1996 after which the old educational system ended, any policy change that benefited the policy-affected cohort close to the cut-off is likely to as well benefit the policy-unaffected cohort close to the cut-off. Hence, any discontinuity around the threshold is likely to be a result of NERP rather than a combined effect of NERP and some other policies.

Another potential concern is the existence of international schools that offer privileges to children from richer households and the existence of experimental junior secondary schools (JSS) in the pre-NERP time. These schools demanded fewer years of education than the normal system. The number of experimental JSS was 2% of the total number of Middle Schools, and the total number of international schools accounted for only 1% of primary schools in the country before the reform. These percentages are very small and unlikely to change the estimation results significantly.

Since Birthyear was determined many years before the reform, the running variable is unlikely to be manipulated (Elsayed and Marie 2015).

Finally, it is argued that the substantial reduction of the duration of secondary school education from 7 to 3 years may cause the curriculum of post-reform students to be of lower quality than their counterparts in post-reform period (Agyeman et al. 2000). Also, if the compressed curricula overburdened students, then their personality development may be affected (Thiel et al. 2014; Thomsen 2015), and this may likely affect their fertility outcomes. Since a priory expectation of the effect of curricula changes and reduction in duration has the opposite effect on fertility, the total effect of the reform can only be determined empirically.

One of the identification procedures in regression discontinuity analysis is a graphical representation of the discontinuity at the cut-off point. Although children in Ghana are officially supposed to begin primary 1 at the age of 6, the mean age of entering primary 1 is 7.5 years due to late entry (Akyeampong et al. 2007). Thus, similar to Boahen et al. (2020) the study assigns a mean age of entry into primary 1 to be 8. By assuming no grade repetition, a child would be in the first year of junior secondary school by age 14 if she began primary school at age 8. Since the reform affected children who were in their first year of junior secondary school (JSS) when it was first implemented in 1987, the discontinuity in education therefore affected individuals born in 1973 or later.

Figure 1 shows secondary school enrolment centring on the year of birth at the cut-off point. The validity of the results rests on the assumption that women who are born close to the cut-off have similar predetermined characteristics. Discontinuities in predetermined characteristics would imply some form of self-selection around the cut-off point. Because of limited information on predetermined characteristics in the population

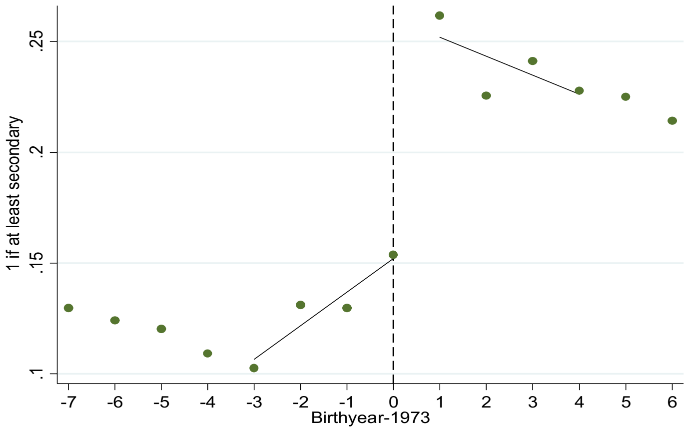


**Fig. 1** Regression discontinuity plot on 1987 educational policy. *Note* The scatter plot shows the mean education of every birth year. *Source* 2021 population census

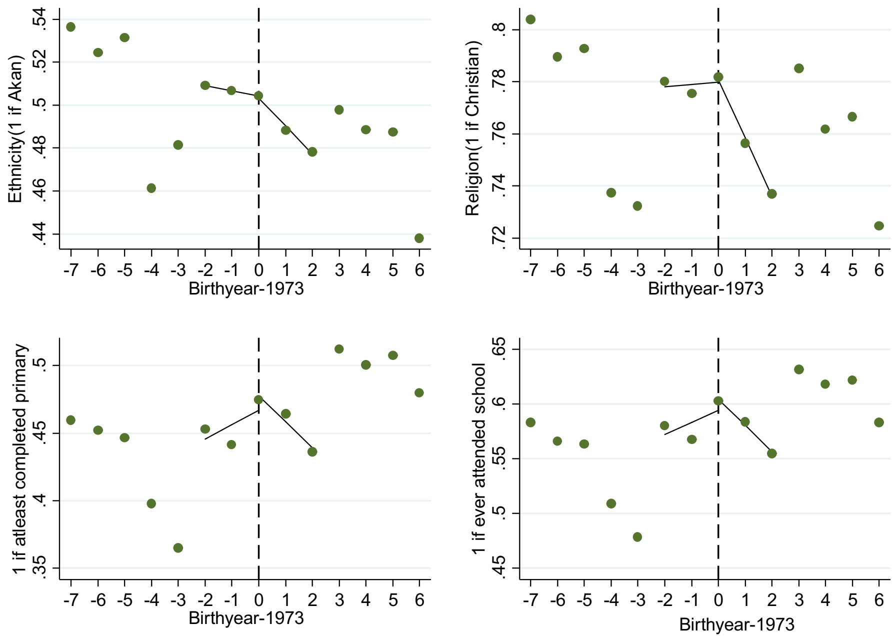


**Fig. 2** Regression discontinuity plot for pretreatment covariates. *Note* The scatter plot shows the mean education of every birth year. *Source* 2021 population census

census dataset, we used information on religion and ethnicity, 1(if ever attended school) and 1(if completed primary school). The graphs presented in Fig. 2 show no jumps in these predetermined variables.

**Table 4** Impact of NERP on Secondary School Education. *Source* Author's estimation based on the 2021 population and housing census

| At least secondary | (1) Bandwidth 7 | (2) Bandwidth 7 | (3) Bandwidth 4 | (4) Bandwidth 4 |
|---|---|---|---|---|
| 1[Birthyear ≥ 1973] | 0.0956*** | 0.0891*** | 0.0621*** | 0.0701*** |
| | (0.0041) | (0.0041) | (0.0052) | (0.0049) |
| Observations | 174,629 | 174,629 | 113,313 | 113,313 |
| Covariates | No | Yes | No | Yes |
| Fixed effects | No | Yes | No | Yes |
| R-squared | 0.0177 | 0.0927 | 0.0201 | 0.0944 |

Robust standard errors clustered at the district level (270 clusters) are in parentheses. Predetermined covariates included in the regression are religion and ethnicity. All estimations with control variables (religion and ethnicity) also include regional fixed effects. Years of birth have been recentered at the discontinuity (1973)

*Denotes significance at the 10% level

**At the 5% level

***At the 1% level

## Results

### First-stage regression

Our estimation uses an ad hoc bandwidth selection. Given that only 7 birthyear cohorts can be found on the right side of the cut-off, the study first presents results of bandwidth of 7 at both sides of the cut-off. In addition, the study presents a bandwidth of 4 at both sides of the cut-off. The choice of the bandwidth of 4 is influenced by how well the linear curve fits the 4-year cohorts at both sides of the cut-off point, which is shown in Fig. 1. Secondly, analysis from the 2022 demographic and health survey dataset indicates that approximately 88% of the sampled women who were 49 years old had not given birth in the past 5 years. This suggests that roughly 88% of women might have stopped childbearing by age 44 years (i.e. (49–5 = 44) years). Appendix Table 9 reveals that the few who give birth even after age 44 are most likely to give birth to only one child. Further analysis of the dataset reveals that among the women who were 49 years old, only 2.2% of their births occurred at age 44 years or older. Thus, the results that would be obtained from using a bandwidth of 4 are likely to be similar to the results that would be obtained when complete fertility is used.

The first-stage estimations in Table 4 give an estimate of the jump in enrolling in secondary school at the threshold. Columns (1) and (2) show the results for a bandwidth of 7 and columns (3) and (4) for a bandwidth of 4. By the use of a bandwidth of 7, the study compares the fertility of cohorts that were born in 1966–1972 with cohorts born in 1973–1979. Similarly, the bandwidth of 4 compares the fertility of cohorts born in 1969–1972 with cohorts born in 1973–1976. While columns (2) and (4) present regression estimates that control for pretreatment covariates, columns (1) and (3) do not control for pretreatment covariates. The standard errors of all the regression estimates reported in this study are clustered at the district level.[7]

[7] The results are still robust for all the regression estimations when clustering is done on year of birth.

**Table 5** Impact of secondary school education on fertility. *Source* Author's estimation based on the 2021 population and housing census

| Outcomes | (1) Bandwidth 7 | (2) | (3) Bandwidth 4 | (4) |
|---|---|---|---|---|
| Fertility | − 1.1842*** | − 0.7691** | − 0.6581* | − 0.6277* |
| | (0.3341) | (0.3256) | (0.4233) | (0.4159) |
| Observations | 173,926 | 173,926 | 112,840 | 112,840 |
| Covariates | No | Yes | No | Yes |
| Fixed effects | No | Yes | No | Yes |
| R-squared | 0.0507 | 0.0804 | 0.07 | 0.0740 |

Robust standard errors clustered at the district level (270 clusters) are in parentheses. Predetermined covariates included in the regression are religion and ethnicity. All estimations with control variables (religion and ethnicity) also include regional fixed effects. Years of birth have been recentered at the discontinuity (1973)

*Denotes significance at the 10% level

**At the 5% level

***At the 1% level

In all four different estimations presented in Table 4, the discontinuity in secondary school enrolment varies from 6.21 percentage points to 9.56 percentage points. Given that approximately 12% of the population in the policy-unaffected cohort has at least secondary school education, we can say that the reform increased secondary school enrolment by 50%(0.06/0.12)–80%(0.1/0.12). In the case of Table 10 and 11 in Appendix, we provided a falsification test by shifting the threshold to 3 years to the left and 3 years to the right and there is no evidence of an increase in secondary school enrolment at those thresholds. The results from the falsification test suggest that the discontinuity in secondary school enrolment presented in Table 1 is a result of NERP.

Two important deductions can be made for this large impact of NERP on secondary school enrolment. The first is that the reduction of years of secondary education from 7 to 3 automatically freed up several other classrooms that could be used to enrol more students. Second, the reduction in the duration of secondary school reduced both the direct and indirect costs of secondary school education, and as such, some households that could not afford secondary school education before NERP may be able to do so after NERP.

## Impact of secondary education on fertility

Using the treatment dummy for cohorts born on and after 1973 as an instrument for secondary education in our analysis, we present the results of the effect of secondary schooling on fertility in Table 5. Column (1) shows a reduction of 1.18 births, while the other three columns show fertility reduction close to 0.65 births. Given that the results for columns (2)–(4) are similar (confidence interval shows substantial overlap), we can say that an increase in secondary school enrolment reduces fertility by almost 0.65 births. Since the average fertility of the policy-unaffected cohort is 4.68 births, we can say that secondary school enrolment reduced fertility by 13.89% (0.65/4.68). This negative causal relationship between education and fertility and fertility timing is consistent with (see, inter alia, Keats 2018; Ferré 2009; Ozier 2018; Chicoine 2012; Duflo et al. 2022).

**Table 6** Impact of secondary school education on age at first birth. *Source* Author's estimation based on the 2021 population and housing census

| Outcomes | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Bandwidth 7 | | Bandwidth 4 | |
| Age at first birth | 1.5142** | 1.4002* | 2.3740* | 2.2928* |
| | (0.6987) | (0.7442) | (1.4421) | (1.2773) |
| Observations | 157,378 | 157,378 | 102,183 | 102,183 |
| Covariates | No | Yes | No | Yes |
| Fixed effects | No | Yes | No | Yes |
| R-squared | 0.0277 | 0.0291 | 0.0333 | 0.0355 |

Robust standard errors clustered at the district level (270 clusters) are in parentheses. Predetermined covariates included in the regression are religion and ethnicity. All estimations with control variables (religion and ethnicity) also include regional fixed effects. Years of birth have been recentered at the discontinuity (1973)

*Denotes significance at the 10% level

**At the 5% level

***At the 1% level

**Table 7** Impact of secondary education on age at first-time birth. *Source* Author's estimation based on the 2021 population and housing census

| Outcomes | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Bandwidth 7 | | Bandwidth 4 | |
| 1 if given birth by age 18 | − 0.0258 | − 0.0242 | − 0.1067 | − 0.1021 |
| | (0.0424) | (0.0444) | (0.0822) | (0.0731) |
| 1 if given birth by age 19 | − 0.1442*** | − 0.1433*** | − 0.2124*** | − 0.2089*** |
| | (0.0483) | (0.0505) | (0.0983) | (0.0869) |
| 1 if given birth by age 20 | − 0.2597*** | − 0.2548*** | − 0.2032** | − 0.2113** |
| | (0.0531) | (0.0558) | (0.1019) | (0.0968) |
| 1 if given birth by age 21 | − 0.2886*** | − 0.2818*** | − 0.0914 | − 0.1175 |
| | (0.0543) | (0.0573) | (0.1119) | (0.0994) |
| 1 if given birth by age 22 | − 0.2168*** | − 0.2086*** | − 0.1725* | − 0.1874** |
| | (0.0553) | (0.0584) | (0.0972) | (0.0953) |
| 1 if given birth by age 23 | − 0.1463*** | − 0.1326** | − 0.2458** | − 0.2580*** |
| | (0.0539) | (0.0569) | (0.1047) | (0.0936) |
| 1 if given birth by age 24 | − 0.0716 | − 0.0563 | − 0.2025* | − 0.1813* |
| | (0.0511) | (0.0538) | (0.1010) | (0.0904) |
| 1 if given birth by age 25 | − 0.0301 | − 0.0116 | − 0.0233 | − 0.0594 |
| | (0.0509) | (0.0534) | (0.1025) | (0.0910) |
| Covariates | No | Yes | No | Yes |
| Fixed effects | No | Yes | No | Yes |

Robust standard errors clustered at the district level (270 clusters) are in parentheses. Predetermined covariates included in the regression are religion and ethnicity. All estimations with control variables (religion and ethnicity) also include regional fixed effects. Years of birth have been recentered at the discontinuity (1973)

*Denotes significance at the 10% level

**At the 5% level

***At the 1% level

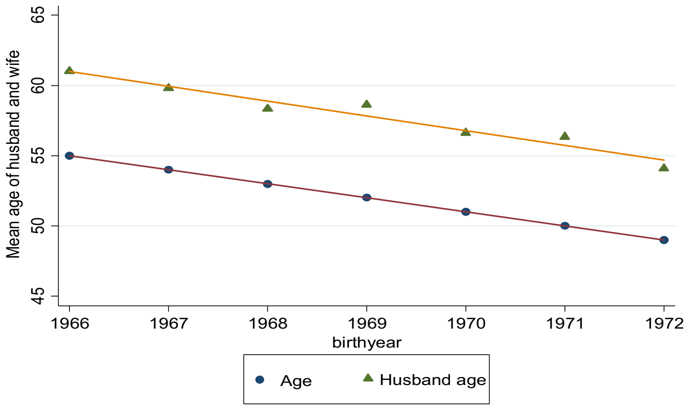


**Fig. 3** Average age of husbands and wives by birth year. *Source* 2021 population census

## Impact of secondary school education on age at first birth

This section examines the impact of secondary school education on fertility timing. The results are presented in Tables 6 and 7. The results in Table 6 indicate that enrolment in secondary school causes fertility timing to increase by an average of 1.5 years, as shown for the bandwidth of 7, or an average of 2.3 years, as shown by the bandwidth of 4. In Table 7, we provide results of the impact of secondary school on the timing of birth at ages whereby girls are most likely to have just completed basic school and are about to enter secondary school. These estimations help us to understand how schooling causes girls to delay childbirth. Given that the average age of beginning primary 1 is assumed to be 8 years and the duration of basic education for the policy-unaffected cohort is 10 years and 9 years for the policy-affected cohort, it can be assumed that by the age of 18 years, girls in basic school might have completed school. Since the older cohort used either 5 or 7 years for secondary school education, we provide estimates for age at first birth from age 18 years up to 25 years.

From Table 7, the effect of secondary school on ever giving birth by age 18 years is not significant, but it is significant for ages 19 to 23. The coefficient is also negative, showing that the probability of giving birth at those ages for girls who enrolled in secondary school is lower than their counterparts without secondary school education. In the case of ages 24 and 25, the results are not significant. This is probably because most Ghanaians who enrolled before NERP often ended their secondary school education at the O-level (i.e. 5 years of secondary education), only a few can continue to do A-level (i.e. 6th and 7th year of secondary school education).

Moreover, those in the policy-affected cohort only used 3 years to complete secondary, and therefore, by age 23, they might have completed secondary. Results are not significant at age 18 because an additional 9 months would be needed to give birth even if girls became pregnant right after completing JSS. The findings from the study are consistent with Duflo et al. (2022) and Ozier (2018).

The results presented in Table 5 show that there is no fertility convergence and that as shown in Tables 6 and 7, secondary school delays the timing of birth and that these girls do not catch up by the close of their fertility transition. Thus, Tables 5, 6 and 7 show that women with secondary school education delay their first birth, and this partly translates

**Table 8** Mechanisms. *Source* Author's estimation based on the 2021 population and housing census

| Outcome | OLS | 2SLS | Comparison means |
|---|---|---|---|
| *Knowledge effect* | | | |
| 1 if able to read | 0.07*** | 0.06** | 0.28 |
| 1 if knows a source of male condoms | 0.04*** | 0.05* | 0.63 |
| 1 if knows any pregnancy preventive method | 0.003*** | – 0.01 | 0.97 |
| *Opportunity cost* | | | |
| 1 if working | – 0.001 | – 0.007 | 0.93 |
| 1 if work for someone and receive payment | 0.01*** | 0.02 | 0.13 |
| *Household bargaining power and Autonomy effect* | | | |
| 1 if taking part in the decision of large household purchases | 0.01*** | 0.16* | 0.64 |
| 1 if take part in the decision of what to cook everyday | 0.01** | – 0.88 | 0.79 |
| 1 if beating is justified when a wife goes out without telling her husband | – 0.01*** | – 0.02 | 0.27 |
| 1 if beating is justified when the wife neglects children | – 0.02*** | 0.02 | 0.32 |
| 1 if beating is justified when the wife refuses to have sex with husband | – 0.01 | 0.08 | 0.19 |
| *Incarceration effect* | | | |
| Ever given birth by the age of 17 years | – 0.02*** | – 0.07*** | 1.43 |
| If the first sexual intercourse occurred 17 years or below | – 0.02*** | – 0.29 | 0.47 |
| *Assortative matching and fertility preferences* | | | |
| Husband years of schooling | 0.58*** | 0.544 | 7.2 |
| Husband age | – 0.2*** | – 3.60** | 42.8 |
| 1 if the husband prefers the same or less number of children | 0.01*** | 0.11* | 0.74 |
| Fertility preference for wife | – 0.14*** | – 0.4** | 4.9 |

*Denotes significance at the 10% level, **at the 5% level, and ***at the 1% level. Years of birth have been recentered at the discontinuity (1973). NERP is used as an instrument for education. The total observations are from the 1998, 2003, 2008, and 2014 DHS datasets. Estimates are based on the bandwidth of 4 years. The following variables are not in the 1998 wave(male source of condoms known, able to read, work for someone and receive payment, part of the household decision in large purchases, beating justified if the wife goes out without informing husband, beating justified if wife neglects children and beating justified if the wife refuses to have sexual intercourse with husband). All specifications allow the RD slopes to differ across the threshold.

into the lower births seen at the end of their fertility transition. While this finding is inconsistent with Monstad et al. (2008), it is consistent with Duflo et al., (2022), Keats (2018) and Lavy and Zablotsky (2018).

### Does the observed fertility decline partly be explained by male education?

The reform affected the years of education of men as well. This, therefore, suggests that if the age difference between husbands and wives in Ghana were close to zero, then the reform might have affected the fertility and the timing of birth by changing the education of husbands as well as wives. However, Fig. 3 indicates that husbands in Ghana are 6 to 7 years older than their wives. Our estimation used bandwidths of 4 and 7 years, which means that on average, the women in the estimated bandwidth are unlikely to have their husbands' secondary education manipulated by NERP. Thus, it is unlikely to have a marriage market equilibrium effect on fertility through the policy impact on men.

## Mechanisms

From the review of the literature, five main channels are identified through which education might affect fertility: knowledge effect, opportunity cost, household bargaining and autonomy, incarceration effect, and assortative matching. The study uses various outcomes likely to reflect four of the possible pathways through which education affects fertility and the timing of birth.

The results in Table 8 show that secondary school education increases the probability of being able to read and write. The high likelihood of reading and writing suggests the possibility of following the procedures for self-administration of family planning medication correctly thereby preventing unplanned pregnancies. More so, the results show that those enrolled in secondary school are more likely to own television and radio. To the extent that family planning education is often done through these two mediums, access to these mediums is likely to increase the stock of knowledge of women on family planning issues. This finding is consistent with Duflo et al. (2022).

Second, female education may increase the opportunity cost of childbearing and rearing. The results presented in Table 8 show insignificance for labour force participation but significance for the probability of working in paid employment.[8] The insignificance of labour force participation is not surprising since most Ghanaian women prefer to enter self-employment, rather than to stay out of the labour force. To the extent that secondary school enrolment increases the probability of engaging in paid employment shows that opportunity cost is one of the possible pathways through which enrolment in secondary school affects fertility. This is because there is less flexibility in working in paid employment than in self-employment. This finding is consistent with a study conducted in Uganda by Keats (2018) and Ghana by Duflo et al. (2022).

Third, the table suggests that women with secondary school education are 8 to 13 percentage points more likely to be heads of household than their counterparts who do not have secondary school education. This suggests some evidence of the autonomy effect as a possible pathway through which enrolment in secondary school affects fertility.

Finally, the results shown in Tables 6 and 7 indicate that secondary school education altered the age at first birth of women, implying that women in school are most likely restrained from engaging in sexual activities that can lead to unplanned pregnancies.[9] This finding is consistent with the incarceration effect principle in the literature (see Black et al. 2008; Keats 2018).

[8] Paid employment as used here includes people who are in wage employment and those casual workers who receive payment for their services rendered.

[9] The discussion would have been more interesting if data on age at first sexual intercourse was available but the population census data we used for our analysis does not capture that.

## Conclusion

This study investigates the causal link between secondary school education and reproductive outcomes by adopting educational reform in Ghana as a natural experiment. The findings from the study are consistent with other empirical studies in developing countries that posit a negative causal relationship between secondary education and fertility. It is found that the 6–10 percentage point increase in secondary school enrolment due to the 1987 reform reduced total fertility by 13.8%. The study further reveals that the increase in secondary school enrolment due to the reform caused an extension in the age at first birth by 1.5–2.3 years. Findings from the study suggest that secondary school education delays fertility and educated women do not catch up. In addition, we show that education affects fertility through the knowledge effect, incarceration effect, opportunity cost, and autonomy.

For the past three decades, there has been a sharp increase in the completion of basic education in the country because the cost of education at that level is virtually free. However, only a few JSS graduates can enter Senior Secondary Schools due to the high fees charged in Senior Secondary Schools.[10] The government of Ghana introduced free senior secondary school education in 2017. Before this policy, the majority of Ghanaians who completed basic education while they were still in their mid-teens were unable to continue their education due to the high fees charged in senior secondary schools but the majority are now able to do so because of the free SHS policy. This study provides evidence to show that the free SHS policy has the possibility of delaying the timing of birth of women in the country and thereby reducing overall fertility. As established in the literature, early childbirth and high fertility have negative consequences on the health of women.

There are a few limitations of the study. First, although the study found that secondary school enrolment delayed fertility and reduced overall fertility, information in the dataset we used is not enough to ascertain whether the reduction in overall fertility can only be attributed to the delay in first-time birth or a combination of birth spacing and delay in first-time birth. Future studies can explore this issue. Second, the youngest in the policy-affected cohort is 41 years, and some women might still be active in reproduction at that age indicating that the fertility of those women is censored. For a more robust result, future studies should consider using only women who have reached menopause for their analysis.

## Appendix

Tables 9, 10, 11.

[10] In recent years, late entry to primary 1 has significantly reduced in Ghana, and due to this, many children complete Junior Secondary School by the age of 15 years and of Senior Secondary School by the age of 18 years.

**Table 9** Total births in last 5 year across age groups. *Source* Authors own calculation from the 2022 Ghana Demographic and Health Survey

| Births in the last five years | Age Groups | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 25–29 | | 30–34 | | 35–39 | | 40–44 | | 45–48 | | 49 | |
| | No | % | No | % | No | % | No | % | No | % | No | % |
| None | 387 | 9.5 | 1021 | 15.7 | 2119 | 26.6 | 3921 | 51.4 | 3685 | 73.6 | 974 | 88.3 |
| One child | 1866 | 46 | 2931 | 45 | 3707 | 46.6 | 2780 | 36.4 | 1080 | 21.6 | 100 | 9.1 |
| Two children | 1567 | 38.6 | 2238 | 34.3 | 1825 | 22.9 | 855 | 11.2 | 215 | 4.3 | 28 | 2.5 |
| Three children | 221 | 5.5 | 303 | 4.7 | 310 | 3.9 | 72 | 0.9 | 24 | 0.5 | – | – |
| Four children | 16 | 0.4 | 26 | 0.4 | – | – | 4 | 0.05 | – | – | – | – |
| Total observation | 4057 | 100 | 6519 | 100 | 7961 | 100 | 7632 | 100 | 5004 | 100 | 1102 | 100 |

**Table 10** Impact of NERP on secondary school when by shifting discontinuity to 1970. *Source* Author's estimation based on the 2021 population and housing census

| At least secondary | (1)<br>Bandwidth 7 | (2)<br>Bandwidth 7 | (3)<br>Bandwidth 4 | (4)<br>Bandwidth 4 |
|---|---|---|---|---|
| 1[Birthyear ≥ 1970] | 0.0008 | 0.0006 | − 0.0101* | − 0.0113* |
| | (0.0033) | (0.0033) | (0.0058) | (0.0061) |
| Observations | 166,713 | 166,713 | 99,135 | 99,135 |
| Covariates | No | Yes | No | Yes |
| Fixed effects | No | Yes | No | Yes |
| R-squared | 0.0186 | 0.0907 | 0.0161 | 0.0866 |

Robust standard errors clustered at the district level (270 clusters) are in parentheses. Predetermined covariates included in the regression are religion and ethnicity. All estimations with control variables (religion and ethnicity) also include regional fixed effects. Years of birth has been recentered at the discontinuity (1970)

*Denotes significance at the 10% level

**At the 5% level

***At the 1% level

**Table 11** Impact of NERP on secondary school when by shifting discontinuity to 1976. *Source* Author's estimation based on the 2021 population and housing census

| At least secondary | (1)<br>Bandwidth 7 | (2)<br>Bandwidth 7 | (3)<br>Bandwidth 4 | (4)<br>Bandwidth 4 |
|---|---|---|---|---|
| 1[Birthyear ≥ 1970] | 0.0048 | 0.0056 | − 0.0166 | − 0.0179* |
| | (0.0042) | (0.0039) | (0.0098) | (0.0099) |
| Observations | 157,669 | 157,669 | 122,389 | 122,389 |
| Covariates | No | Yes | No | Yes |
| Fixed effects | No | Yes | No | Yes |
| R-squared | 0.0166 | 0.0927 | 0.0097 | 0.0889 |

Robust standard errors clustered at the district level (270 clusters) are in parentheses. Predetermined covariates included in the regression are religion and ethnicity. All estimations with control variables (religion and ethnicity) also include regional fixed effects. Years of birth has been recentered at the discontinuity (1976)

*Denotes significance at the 10% level

**At the 5% level

***At the 1% level

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**Data availability** The datasets analysed during the current study are available on the website https://www2.statsghana.gov.gh/nada/index.php/catalog/110.

## Declarations

**Conflict of interest** The corresponding author declares that there is no conflict of interest for his contribution to the study.

**Ethical approval** This article does not contain any studies with human participants performed by any of the authors.

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