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YSSP Report
Young Scientists Summer Program

Educational differentials in the completed cohort and total fertility in major regions of India: A study of cohorts born in 1945-1974 and periods 1992-2015

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Approved by

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Abstract

Women's educational attainment is essential for fertility decline in any region. Rising female educational attainment in the country is not always proportionally related to fertility decline. With economic development and urbanization, women's education increased over the decades in India. This analysis aims to explain the pattern of fertility differentials by the level of education and the contribution of the changes in women's educational attainment in relation to fertility decline during the fertility transition in India. The data for this study were drawn from the four rounds of the National Family Health Survey (NFHS) survey, a nationally representative cross-sectional survey which was collected in India from 1992-93 to 2015-16. In this study, it was found that women's educational improvements contributed less than one-fifth of the completed cohort fertility (CCF) decline across the region of India between 1945-49 and 1970-74 birth cohorts. If we look at the recent Total Fertility Rates (TFR) between the period 1992-93 and 2015-16, the improvements in women's education contributed 39% to the reduction in TFR. The educational differentials in fertility are narrowing in India over the decades because most of the decline in fertility rates comes from the no educated women and no educated women are the drivers of the fertility declined in India. Although, improvements in women's educational attainment had a very small contribution to CCF decline across the region. Nevertheless, the advancement of women in education is playing a significant role in the decline of TFR. Investments in female education would benefit the future fertility decline in the currently high fertility regions of India.

Acknowledgments

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I believe that I have improved my research abilities during this three-month YSSP program with the assistance of my supervisors.
In between, we have discussed a range of aspects, including the quantum and tempo of fertility, the proximate determinates of fertility and childlessness; the postponement and recuperation of fertility rates, the reconstruction of long term fertility trends, and different methods for estimating fertility such as Poisson regression and exposure methods. I am grateful to them for their time, patience, and strength in advising me. Thank you to the world population team, notably Dr. Samir KC, Dr. Raya Muttarak, and Dr. Tomas Sobotka for their useful comments and suggestions.
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1. Introduction

A wide range of studies has established a strong negative association between women's education and fertility in both developed and developing countries (Bongaarts, 2010; Kravdal, 2001; Samir et al., 2010; Zang, 2019). However, the causal pathways through which educational changes affect fertility in developing countries might be different from those hypothesized, based on observations made in developed nations. For example, in Australia, fertility rates among uneducated women have been declining, and the fertility among university-educated women which has remained constant (Peter McDonald and Helen Moyle, 2019). In Brazil, on the other hand, education has a negative effect on fertility over the first eight years of schooling (Lam & Duryea, 1999).

Furthermore, even within developed countries, the association varies all the way down to the regional level (Nisén et al., 2014), and gains in the female educational attainment have; not been linked to the declining fertility equally across all educational sub-groups. Increasing women's education also had an impact on the desired family sizes and the achievement of childbearing goals. There is also a negative relationship between female schooling and realized fertility all over the world (Schultz, 1993). Women's increased schooling has a positive impact on child outcomes such as health and school enrollment. In addition, we cannot assume that the education-fertility link has remained the same over time as the social function of education changes in the development process. Over time, increased awareness of social development approaches such as public health, elementary education, and social security as well as improved living conditions, may alter the link between education and fertility (Drèze & Murthi, 2001). Hence, if the political goal is to bring down fertility in high fertility countries, investing in the education of women certainly warrants more attention as a strategy (Wolfgang Lutz & Skirbekk, 2013). However, we need to come to a better understanding of what supports this potentially important policy link between education and fertility.

To seek more answers to this question, there is probably no better place than India. Characterized by marked spatial variation in its fertility regimes (Samir et al., 2018), India experienced rapid fertility decline during the last quarter of the twentieth century. While India's total fertility rate fell rapidly from between 5-6.5 children per woman in the 1950s to a near replacement level of 2.2 children per woman in 2015-16 (MAHOFW, 2017). Although, this national average, however, masks large regional differences. Between the 1990s and the 2000s, the fertility rates in Indian's southern region states fell below the replacement level; in contrast, the fertility rate in the country's large northern region states has remained above the replacement level, thus leaping India to the world's second-most populous country, and, in the coming decades, the most populous country(Nations, 2019). During the period of declining fertility, there has been a significant improvement in women's education across the Indian subcontinent (Jeffery & Basu, 1996). Women's educational attainment is closely linked to contraceptive use (Stephenson et al., 2007), including changes in ideal and intended family size (Bongaarts, 2020) and infant mortality (Jain, 1985), therefore, it is important to investigate the nexus between education and fertility over time.

We investigate trends in the education fertility link over time at the subnational level to explore how increasing educational attainment among women of childbearing age has contributed to declining fertility in India. The data comes from four rounds of National Family Health Surveys (NFHS) 1992-93 to 2015-16 from India. The analysis is divided into two parts: the first part looks at changing cohort and total fertility rates by education and in the next part we investigate the contribution of educational expansion in fertility decline using decomposition (Kitagawa, 1955). NFHS data allows us to study fertility decline from both cohort and period perspectives. Cohort fertility analysis is useful for shedding light on the historical changes in education-specific fertility, while total fertility rates take into account the most recent decline in fertility rates. Our main hypothesis is that: whether the expansion of women's education is a major factor that contributed to the rapid transition from high to low fertility rates in

India. The main research question that we address is whether changes in the completed cohort and total fertility vary by changes in educational level or changes within education groups?
The report is structured in the following sections. Section 2, we discuss different theories of education-fertility differences, and we present an overview of the relationships in different parts of the world. Section 2.1 examines the Indian fertility transition. In section 2.2 traces the educational differentials in fertility in India. Section 2.3 summarizes the existing knowledge on the educational gradient of fertility at the subnational level in India. Section 3 describes the data and methods. Section 4, first examines trends in educational differentials in fertility at the regional level among women born between 1945 and 1974, and then the association between changes in reproduction and the changes in women's educational attainment of cohorts and periods is examined using the decomposition analysis.

2. Background

In an attempt to formalize (Cleland, 2002) the most popular model for changes in fertility rates associated with women's education, (Bongaarts, 2003) proposes two models of how women's education is related to fertility transition in developing countries: 1) the "leader-follower" model and 2) the "permanent difference" model. According to the "leader-follower model" fertility decline begins with educated women, and less educated women follow in the footsteps of more educated strata. Thus, at the beginning of the transition, a wide gap in fertility rates develops between the highly educated and less educated strata. According to this hypothesis, educational differences in fertility are a temporary phenomenon. In contrast, the "permanent-difference" model contends that fertility differences persist at all stages of the fertility transition and, thus changes in the educational composition of women of reproductive age will affect the overall total fertility rate.
Demographers have long recognized the relationship between education and fertility within the larger framework of social and behavioral determinants of fertility in order to link them to fertility reduction policies. According to the literature, social welfare programs play an important role in the allocation of resources within families with the trade-off in quality and quantity of children (Becker, 1992; Becker & Lewis, 1973). Furthermore, socioeconomic change is a major driving force in increasing educational attainment, which leads to lower fertility. (Lerch & Spoorenberg, 2020) found that limiting family size and prolonging the birth intervals were the primary mechanisms of fertility decline in developing countries.
Fertility changes began in developing countries when the majority of the population had no formal education, and very few women had access to secondary school education (Jain, 1981)). The fertility gap between women with no formal education and women with high educational achievements is the most pronounced at the beginning of the transition and begins to close once fertility rates of less-educated women begin to decline (KC & Potančoková, 2013). According to (McNay et al., 2003), in India, fertility declined first among well-educated women and then among women with little or no formal education as a result of the diffusion process. In the next stage of the fertility transition, less educated women emulate the reproductive behavior of highly educated women, allowing uneducated women to reduce their fertility while well-educated women serve as role models for uneducated women. In the final stage of the fertility transition, the difference between fertility and education virtually fades away and is converged.
(Caldwell, 1980) made a significant contribution to understanding the routes to mass education and fertility reduction in developing countries. Furthermore, studies have shown that education is intimately linked to changes in reproductive processes such as childbirth and birth control at the individual level (Bongaarts et al., 2017; Cleland, 2002; Kebede et al., 2021). Scholars appear to agree that more educated women have fewer children because they can achieve their desired family size and have a less unmet need for contraception (Lutz et al., 2014). According to (Kravdal & Rindfuss, 2008) educational differences in fertility essentially work through four different links such as balancing roles

in households, affording children, acquiring knowledge, and finding a partner. However, studies have shown that fertility among educated women has been steadily declining while the rate of decline in fertility has been faster among no-education women than among well-educated women (Arokiasamy, 2009; Axinn & Barber, 2001). Using data from the Demographic and Health Survey (DHS), (Liu & Raftery, 2020) found that fertility among secondary educated women declined faster than that of with higher levels of education.

In addition, studies also found that community-level education and contraceptive use create a negative gradient between education and fertility (Colleran & Snopkowski, 2018; Kravdal, 2001). Parental investments for the education of the child enhancing the value of the child, which might make the difference between education and fertility.

Thus, the association between education and fertility becomes a transient phenomenon during the transition process. (Cleland, 2002) noted that educational differentials in fertility in developing countries are in the process of divergence and convergence. (Arokiasamy & Goli, 2012) .

2.1 The fertility transition in India

The fertility transition in India is coming to an end as the total fertility rate is nearing replacement level and reached 2.22 in 2015-16. Since the 1970s India's total fertility rate began to decline from a total fertility rate of 5.6 children per woman (Drèze & Murthi, 2001; Registrar General of India 1961). Fertility rates declined in all states due to efforts to implementation of family planning programs (Maharatna, 2002). Between 1961-1971 the rate of population growth was peaked at around 2.5 percent, and the government began to promote sterilization as a serious policy intervention to control population growth. In addition, women in India got the right to abortion in 1972.

In states where family planning programs have been successful, ASFR has shifted to higher reproductive ages (Matthews et al., 2009). Fertility rates in southern states such as Kerala, Tamil Nadu, Andhra Pradesh, Telangana total fertility rates reached the below replacement level in the mid of the 1990s with the remarkable development of women's education. The northern state like Uttar Pradesh and eastern state Bihar will have to wait for a few decades to achieve replacement level fertility (Dyson, 2002).

There is convincing evidence of a decline in total fertility at the national levels due to changes in quantum of fertility as national levels of fertility fell, regional level variations started to increase (Matthews et al., 2009). However, at the national level, the total fertility rates (TFR) have declined by 35% from 3.4 to 2.2 births per woman over the 23 years' period between 1992-93 and 2015-16. Many policies, approaches, and strategies interventions such as family planning programs, maternal and child health programs, and emphasis on girl's education in recent country first National Population Policy (NPP) in 2000 led to a radical reduction in TFR in India.

2.2 Educational differentials in fertility over the course of fertility transition in India

During the early stages of the fertility transition, the policy primarily embraced universal family planning programs as means of development (Drèze & Murthi, 2001). Female education remained a secondary concern in India's early stages of population policy because literacy levels were exceptionally low. As a result, during the early stages of fertility decline, the government's expenditure on women's education was low. The expenditure on education in India began to rise in the 1970s, following the formulation of national education policy in the 1968s., Most women did not have access to primary school education, during the early stages of the fertility transition and the link between women's education and

childbearing was tenuous. The effect of education in reducing fertility via contraceptive acceptance, age at first marriage, and birth interval increases (Reddy, 2003).

In 1992-93, the fertility rate among women with no education was 4.0 children born per woman, and this rate was reduced to 3.1 children born per woman in 2015-16 (IIPS 1995; IIPS, 2017). Between 1992-1993 and 1998-1999 in India, fertility declined by 65.3% due to uneducated women and 20.8% due to educated women. (Bhat, 2002). The educational differential in fertility was very high during this period because the proportion of uneducated women was very high, resulting in a large number of unwanted birth (Bhat & Zavier, 2003). Inequality of economic development and the lack of the standard quality of education systems in the states, with a growing share of educated women do not translate into fertility declined.

If we look at the fertility decline among women with higher education, it was 2.4 births per woman in 1992-93 and plummeted to 1.9 births per woman in 2015-16. Noteworthy, the fertility rates among well-educated women not declined during this period as policymakers expected because better-educated women earn more and may raise their children effectively.

2.3 Education expansion and fertility transition in India and its regions

Fertility analysis in a region and place of residence is an important pathway in understanding the spatial concentration of a population and the reproductive transition in a country. The education-fertility relationship varies due to the intervening effects of relevant aspects such as urbanization, social organization, level of development, educational structure, and family planning programs of different regions in countries such as India. In the 1951 census, 8.86 percent of the women in India, were literate; by 2011, that figure had risen to 65.46 percent. Most of the pronounced fertility decline occurs in the southern region states such as Kerala, where the share of women with no education has decreased from 10.6 percent in 1992-93 to 0.9 percent in 2015-16. In the northern states, particularly Uttar Pradesh, the proportion of women, without a high school education fell from 67 percent in 1992-93 to 34.7 percent in 2015-16. Well-educated women, on the other hand, experienced a slow decline in fertility in some regions. In recent decades, there has been a significant increase in women's age at marriage and educational levels, which has resulted in a decline in age-specific fertility rates.

The spatial concentration of the population has increased rapidly over the past decades, with currently 31.16 % population living in an urban area (Chandramouli & General, 2011). In 1951 the 25% population lived in the urban areas in Kerala whereas in the northern states like Bihar and up this percentage was only 10 percentage points.

Can you add the % of the urban population in the regions? Rural to urban migration accelerates urban population growth, which plays an important role in reducing overall fertility rates by increasing new reproductive behavior through structural changes (Lerch, 2019). In 2011, the literacy rate among rural women was about 58.8% compared to 79.9% among urban women in India (Chandramouli & General, 2011). Despite significant per capita economic growth and rapid decline in fertility, India's achievement in women's education has only been modest.

3 Data and Methods

3.1 Data

The data for this study comes from four rounds of the National Family Health Survey (NFHS) in India, which were conducted between 1992-93 and 2015-16. NFHS is a nationally representative sample survey that collected data on a range of socioeconomic, demographic, and maternal and child health variables, as well as data, on the whole, birth history of respondents in the reproductive age groups

(15-49) women, were collected in all the rounds of the NFHS survey. The datasets are available for free download upon request at https://dhsprogram.com.

The first NFHS (NFHS-1) was held between April 1992 and September 1993 in 25 states except for Sikkim. At the national level, 89777 ever-married women aged 13-49 were interviewed, and 275172 births information were recorded (IIPS, 1995). NFHS-2 collected data in 26 states between November 1998 and December 1999. At the national level, 89,199 ever-married women aged 15-49 were interviewed, with a 95.5% individual response rate. The birth dates of the children collected in the birth history were completed in 94.6% of the cases. The total number of births in NFHS-2 was 268,879 (IIPS, ORC Macro, 2000).

The third round of NFHS (NFHS-3) was conducted between November 2005 and August 2006. NFHS-1 and NFHS-2 only collected data on ever-married women, whereas NFHS-3 collected data on all women. The individual responses rate was 94.5% among 124385 women aged 15-49 who were interviewed. And of the 256,782 children born to these women, 1.23% had a missing month of birth and 0.17% had a missing month and year of birth (IIPS, 2007). NFHS-4, like NFHS-3, collected sample of all women, around 699,686 women sample interviews in 2015-16. From 20 January 2015 to 4 December 2016, the NFHS-4 fieldwork was carried out in two phases. The NFHS-4 had a female responses rate of 97%. The total number of births recorded by the NFHS-4 was 1,315,617 (IIPS, 2017).

For this study, we pooled birth history data from four rounds of the NFHS for women born between 1945 and 1974. Women who gave birth in all four rounds of the survey were included in the cohort formation, with some cohorts coming from only one round of the survey, others from two rounds of the survey, and three rounds of a survey, and some of the fourth rounds of the survey. Table1 shows, information on birth histories from different rounds of NFHS contributing to the cohorts in our study various ages and duration of time. Most of the cohort's birth histories records are found at the completed age of 40 years.

We, therefore, took all women above the age of 40 and all their children to estimate the completed cohort fertility rate (CCF). Women between the age of 40 and 49 had exceptionally low fertility rates because 90 percent of women completed their fertility by the age of 40 years in India. Births before age of 10 and after the age of 40 were excluded from the analysis, because we have considered the women at the age of 40, and which birth history data is available at all the women cohorts. We harmonized educational categories from all four rounds into five groups as: "*no education", "1-5 years", "6-9 years", "10-11 years" and "12 or more years of education*". Due to sample size constraints, we divided women-years of education into four categories ("*no education", "1-5 years", "6-9 years", "10 or more years of education*") based on residence (Urban and Rural). The study also found that if the education categories were redefined with narrower boundaries, educated women's fertility would be further reduced (Jain, 1981).

We used macro-regions instead of state-level analysis because the sample size was insufficient to estimate trends in educational differentials in fertility at the state level. Due to sample size limitations, we have created three broad regions to estimate educational differences in completed cohort fertility in India.

The regions in which the states fall are as follows:

North and Central Jammu and Kashmir, Himachal Pradesh, Haryana, Punjab, Delhi, Rajasthan, Madhya Pradesh, Chhattisgarh, Utter Pradesh, Uttarakhand.

East and Northeast Bihar, Jharkhand, West Bengal, Odisha, Assam, Sikkim, Arunachal Pradesh, Meghalaya, Manipur, Tripura, Nagaland, Mizoram

South and West Gujrat, Maharashtra, Goa, Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Telangana.

The analysis included 201,809 women and 715,937 children in the final sample. To examine the education-fertility relationship at the regional level, we divided the sample into five-year birth cohorts: 1945-1949, …,1970-1974. NFHS-1 and NFHS-2 only collected birth histories for ever-married women, however, the proportion of non-marital births and never-married women between the ages 15 and 49

in India is very low in these cohorts. Thus working with all women poses no limitations in the analysis of completed cohort fertility.

Table 1: Formation of birth cohorts in India from NFHS-1, NFHS-2, NFHS-3 & NFHS-4 surveys

Cohort Birth Year	The ages of the women at the Interview				Total number of women	Total number of births
	NFHS-1 (1992-93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)		
1945-49	42-46	49			9216	45914
1950-54	37-41	44-48			15102	70289
1955-59	36-32	39-43	46-49		15316	65963
1960-64	27-31	34-38	41-45		11770	47504
1965-69	22-26	29-33	36-40	45-49	57523	194670
1970-74	17-21	24-28	31-35	40-44	75985	243684

3.2 Methods

We examine educational differences in the cohort and total fertility rate (TFR) in India. We include birth cohorts of women who reached the end of their reproductive periods truncated at age 40. In addition, we looked at recent fertility trends using NFHS period data. Cohorts were created based on women's "years of birth". To estimate the completed cohort fertility rate, the total number of births of a woman aged 40 years and the total number of women in birth cohorts of five years were calculated. We used the total number of women in the denominator and their total births in the numerator to calculate the completed cohort fertility (CCF). All women factors and appropriate sample weight were used to estimate the completed cohort fertility rates. In contrast, total fertility rate (TFR) was estimated in Stata version 14.2 using Shoemaker's (2013) tfr2 command. Total fertility rates (TFR) for women aged 15–49 years were estimated for the three years preceding each survey. As a result, total fertility rates span a wider age range than the cohort fertility rates presented.

3.2.1 Decomposition analysis

We used the decomposition method of the change in rate and composition effect for change in fertility rate, proposed by (Kitagawa, 1955) and modified by (Bhat, 2002), to quantify the contribution of women's education in reducing fertility. This decomposition method allows for rate and composition changes without any residual. The following mathematical formula is used:

$$
\begin{aligned}
F_b - F_a &= \sum_{i=1}^{k} F_{b,i}\, C_{b,i} - \sum_{i=1}^{k} F_{a,i} C_{a,i} \\
&= (F_{b,1} - F_{a,1})\,(C_{b,1} + C_{a,1})/2 \\
&\quad + \sum_{i=2}^{k} (F_{b,i} - F_{a,i})\,(C_{b,i} + C_{a,i})/2 \\
&\quad + \sum_{i=1}^{k} (C_{b,i} - C_{a,i})\,(F_{b,i} + F_{a,i})/2
\end{aligned}
$$

Where $C_{a,i}$ and $C_{b,i}$denote the proportion of women in educational class *i* at the times *a* and time *b,* respectively. The three additive terms on the right-hand side of the equation represent the contributions of the three above-mentioned components to the overall change in total fertility (with *i=1* denoting the

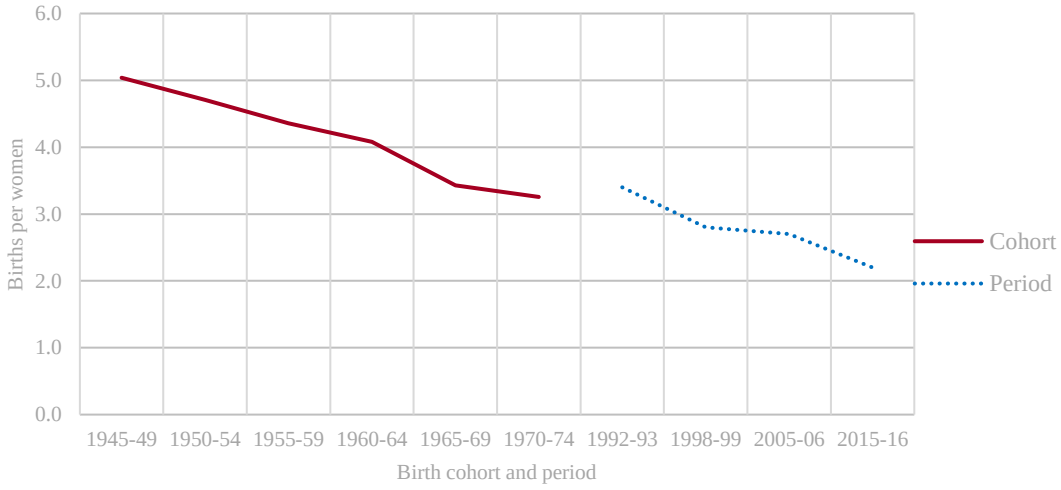
category of uneducated women). It is worth noting that by applying the average values of the two points in time as weights to the category-specific differences, the overall change is divided into three components, without leaving anything for the residual category of "interaction effects".

4 Results

4.1 Completed cohort and total fertility rates and educational fertility differentials

Figure 1 presents the completed cohort fertility rate (CCF) from 1945 to 1974 and total fertility rate (TFR) three years before the survey from 1992-93 to 2015-16. The quantum of fertility has steadily declined over the cohort at age 40 and total fertility rate three years before the survey. CCF began to decline from 5.0 children from 1945-49 birth cohort to 3.3 children in 1970-1974 birth cohort. On the other hand, TFR fell dramatically from 3.4 children in 1992-93 to 2.2 children in 2015-16, indicating a rapid decline

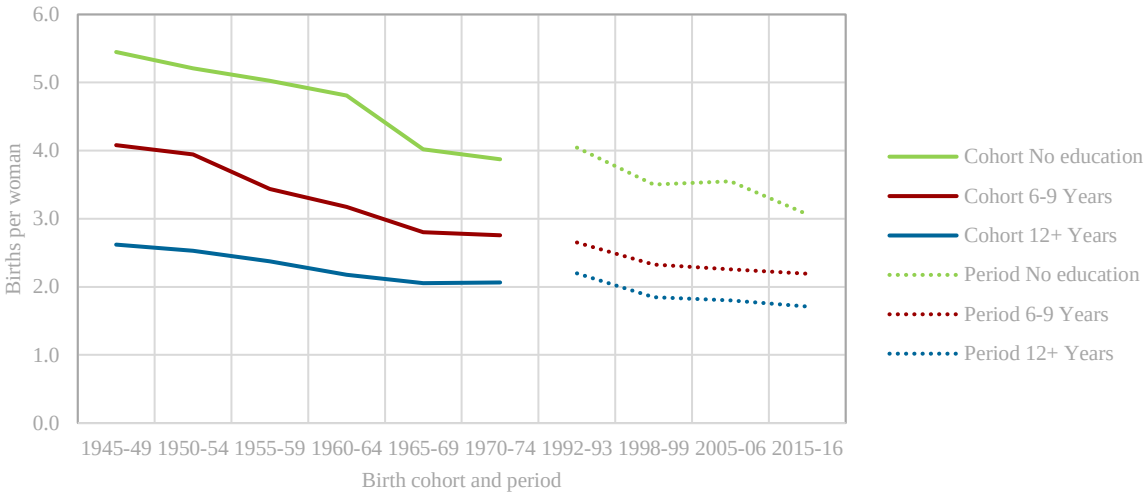
Figure 1: Completed cohort fertility rates for birth cohorts, 1945-49 and 1970-74 and total fertility rates during the 3 years preceding the survey, 1992-2015, India



Source: Own calculation based on all the rounds of NFHS,1992-2015; data weighted by the sample weight and awfactt.

Figure 2 further displays the CCF and TFR with the selected women's education groups. Fertility rates have been decreased over periods and across cohorts as women's educational level has increased. Furthermore, among women with no education, fertility rates fell the fastest, from 5.4 children born in the 1945-49 birth cohort to 3.9 children born in 1970-74 birth cohort. The TFR among women with no education fell from 4.0 children in 1992-93 to 3.1 children in 2015-16. Fertility rates among women with higher education decreased as well from 2.6 children from 1945-49 to 2.1 children in the 1970-74 birth cohort

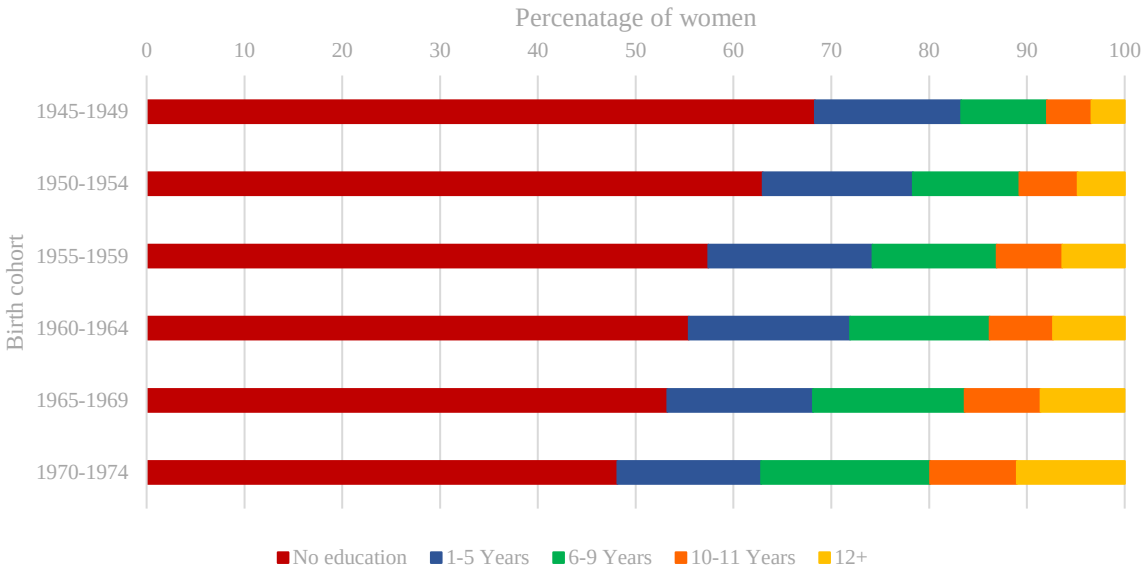
Figure 2: Completed cohort fertility rates for birth cohorts 1945-49 and 1970-74 and total fertility rates during the 3 years preceding the survey,1992-2015 by selected education groups in India



Source: Own calculation based on all-round of NFHS,1992-2015, cohort CCF calculated based on birth history data and TFR calculated using STATA package tfr2.

Figure 3 illustrates the gradual improvement in the educational attainment of women aged 40 years and above between 1945 and 1974 birth cohorts. Women with no education dropped from 68% in the 1945-49 cohort to 48% in the 1970-74 cohort. Further, women's educational attainment up to the secondary level increased from 9% in 1945-49 to 17% in the 1970-74 cohort. Similarly, those with 12 or more years of education increased from 3% to 11% between the 1945-49 and 1970-74 birth cohorts.

Figure 3: Percentage of women by years of education in India, birth cohorts 1945-74



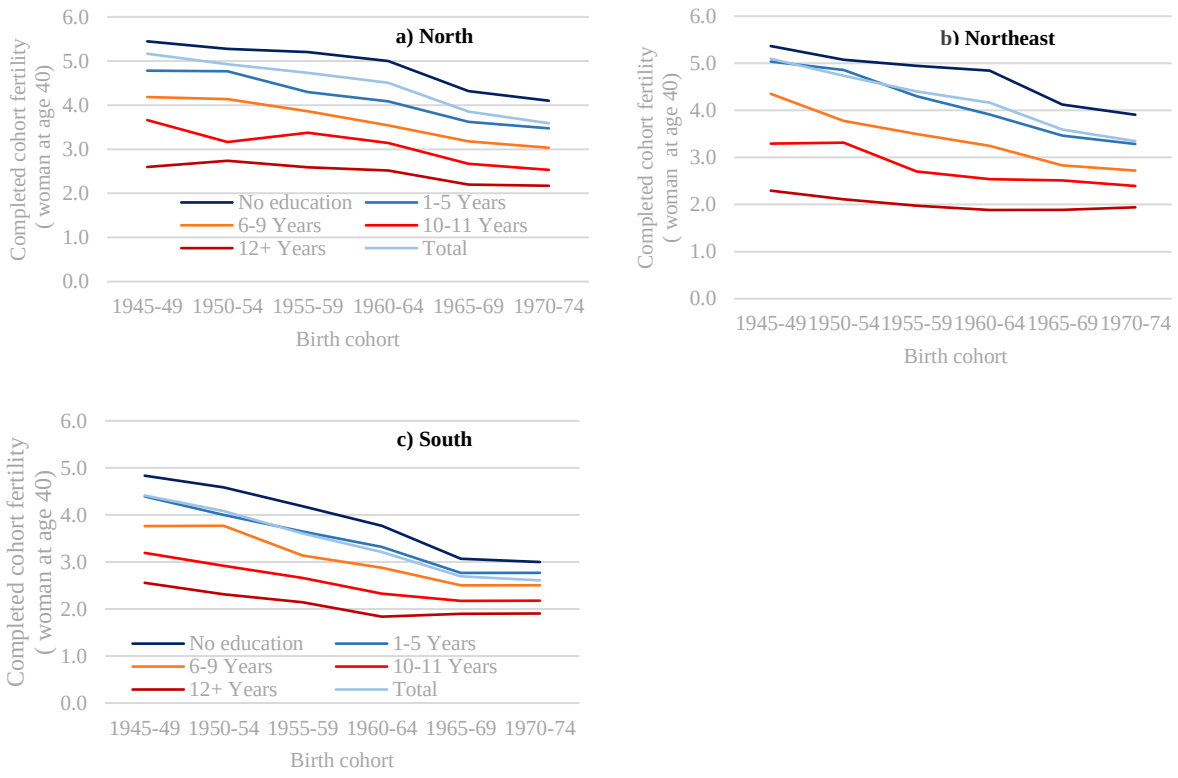
Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

4.2 Regional variations in education gradients of fertility

Looking at the fertility rate by educational attainment in Figures 4 and 5 reveals two significant findings. Fertility among women with no education started to decline in the northern region 8.13% decline between 1945-49 and 1960-64 birth cohort and 18.06% decline between 1960-64 and 1970-74 birth cohort. The CCF has been steadily declined by women's education levels in the southern region and the CCF has stalled in the most recent cohort. However, there is a convergence of fertility by women's educational levels in recent cohorts of women in the southern region. CCF among women with 12 or more years of education is stalling in all regions.

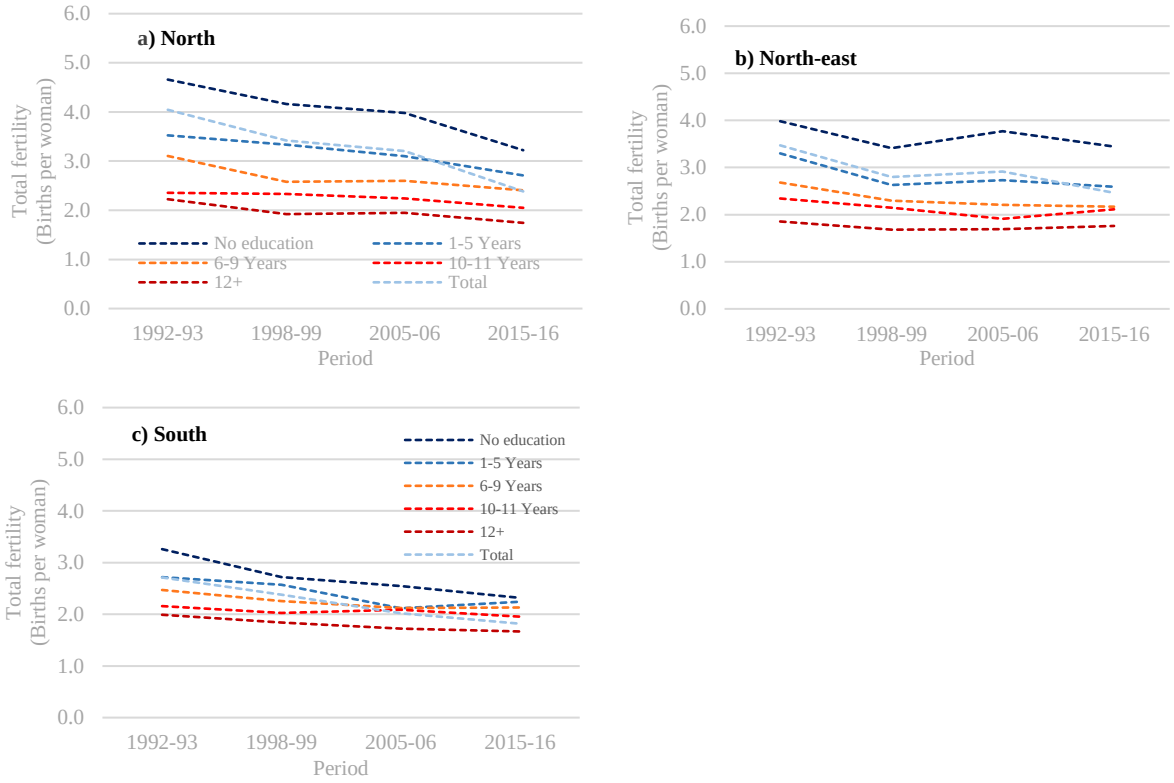
Figure 5 also shows that TFR gradually declines between 1992-93 and 2015-16, and there is clear evidence of a negative educational gradient in fertility. There is also a large difference in fertility rates based on women's educational levels in northern and northeastern regions. Fertility rates in the southern region, have converged in recent periods by women's educational levels. The northeastern region, on the other hand, exhibits a zigzag pattern due to the small sample sizes. Most of the fertility rates by educational level are rapidly fall in the southern region of India by cohorts and periods. Since 1998-99, fertility among highly-educated women in the southern region has been low. TFR among women with 12 or more years of education in the northern region decreased from 2.2 children in 1992-93 to 1.7 children in 2015-16. The most rapid decline in fertility occurred among women with no education from the southern region, where it was 3.3 children in 1992-93 and 2.3 children in 2015-16.

Figure 4: Completed cohort fertility rates by years of education in major regions of India, birth cohorts 1945-74



Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Figure 5: Total fertility rates by years of education in major regions of India, 1992-2015

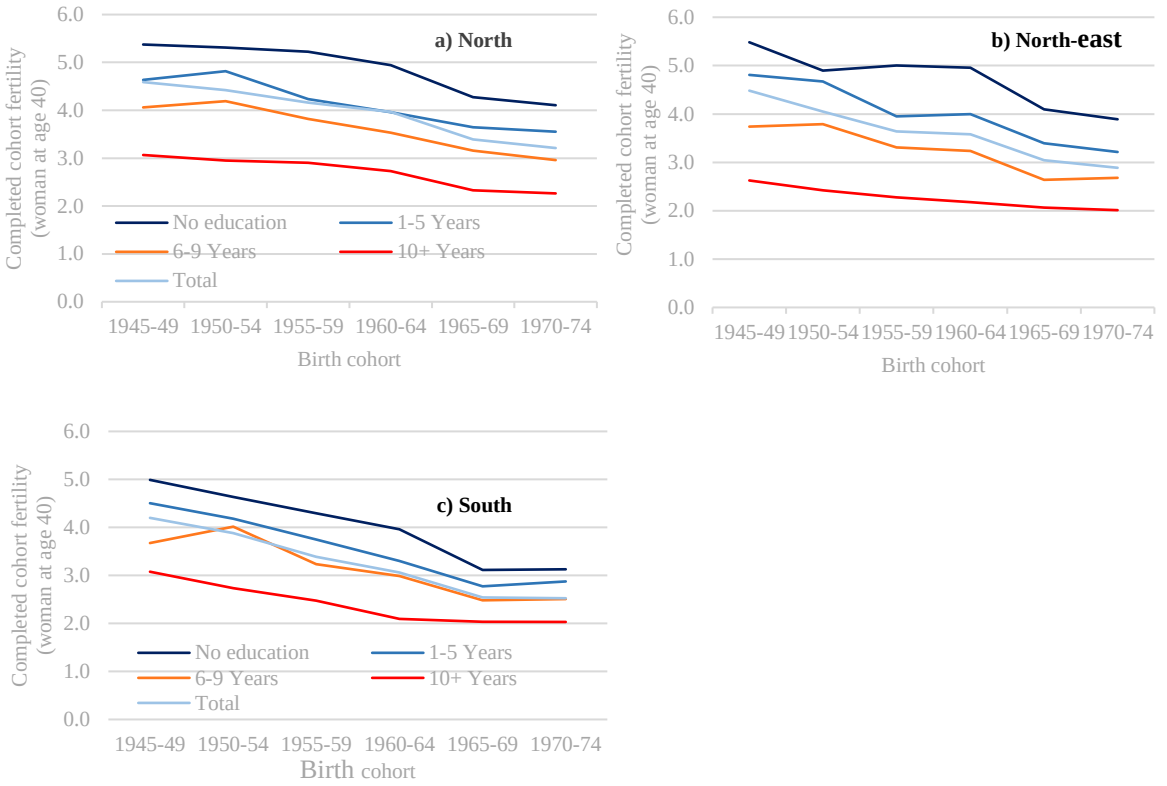


Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

4.3 Urban and rural gradient of educational differentials in fertility

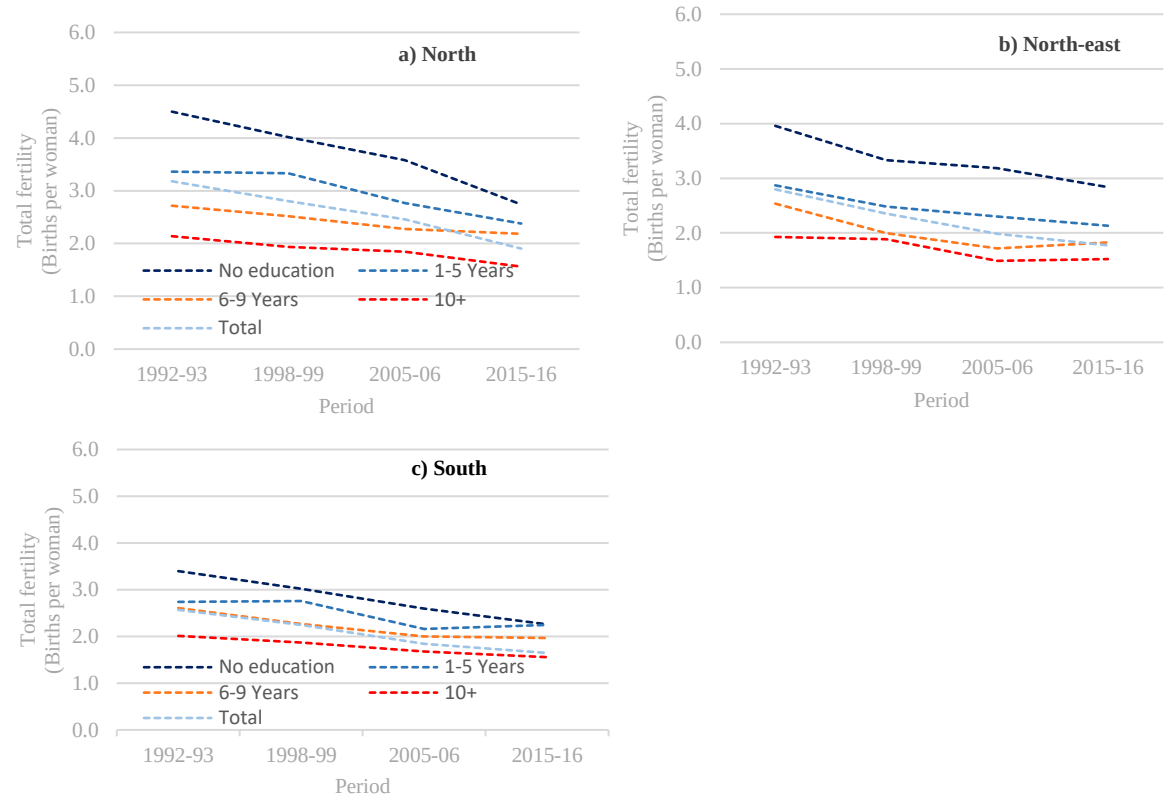
The trend of educational differences in fertility in urban India shows an interesting pattern (Figure 6 and 7). However, there is a significant gap between the fertility rate and the level of education of women in urban areas of India. The cohort fertility rate among women with no education in urban areas was rapidly declining in South India. Between 1945-49 and 1970-74, the fertility rate among women with no education in the southern region fell from 5.0 children to 3.1 children. Fertility rates among women with no education in the northern region fell from 5.4 children in 1945-49 to 4.1 children in the 1970-74 cohort. Cohort fertility rates among women with 10 or more years of education declined from 3.1 children to 2.0 children per woman in the southern region between the 1945-49 and 1970-74 cohorts. In 2015-16, TFR among 10+ educated women fell below the replacement level in all regions, as depicted in figure7. In every region of urban India, women with no education have lower fertility rates. While the difference in fertility rates by women's educational attainment was greater in northern and northeastern region urban areas. Fertility rates among women with no education have fallen from 4.5 children in 1992-93 to 2.7 children in 2015-16. Furthermore, fertility rates among women with 10 or more years of schooling have remained stable in the northeast region since 2005-06. However, in the northern and southern regions, the fertility rate among women with 10 or more years of schooling fell 36.9% and 29.26%, respectively between 1992-93 to 2015-16.

Figure 6: Completed cohort fertility rates by years of education in major regions of urban India, 1945-74



Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Figure 7: Total fertility rate by years of education in major regions of urban India, 1992-2015

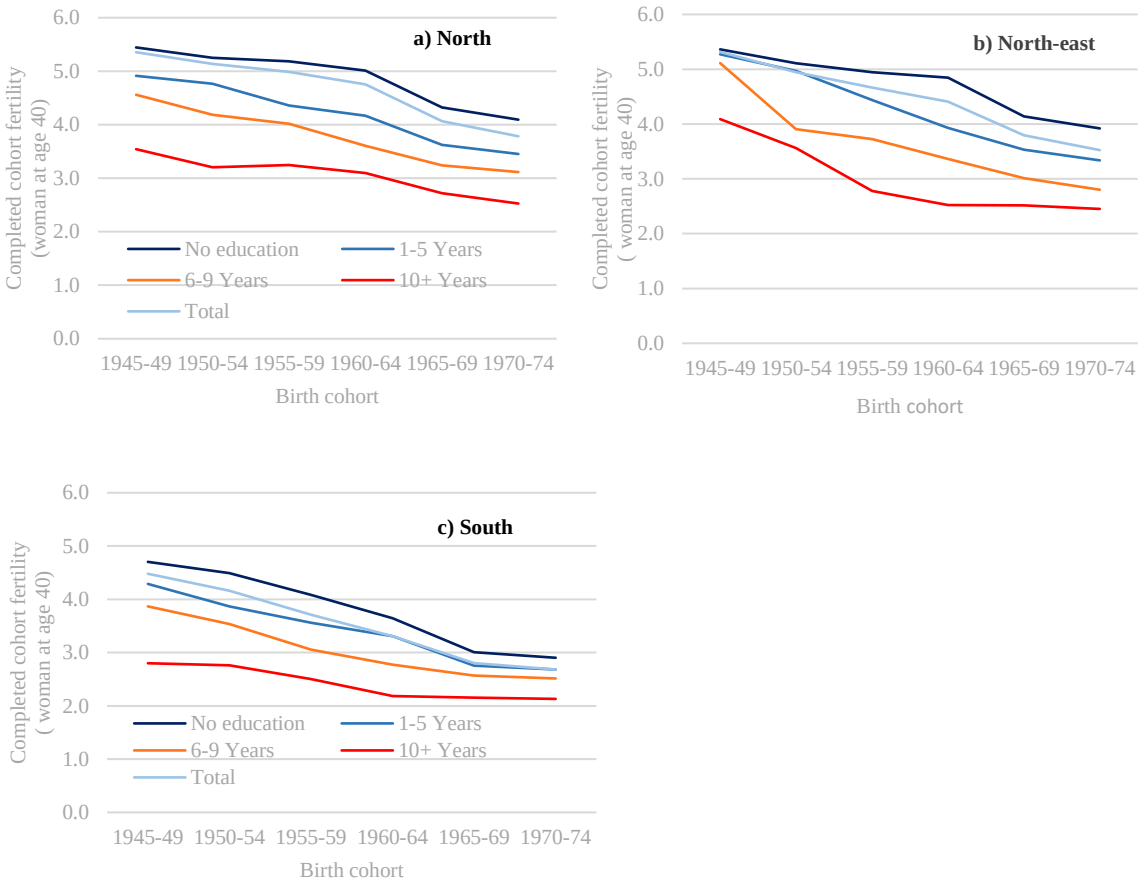


Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

4.4 Regional differentials of rural fertility

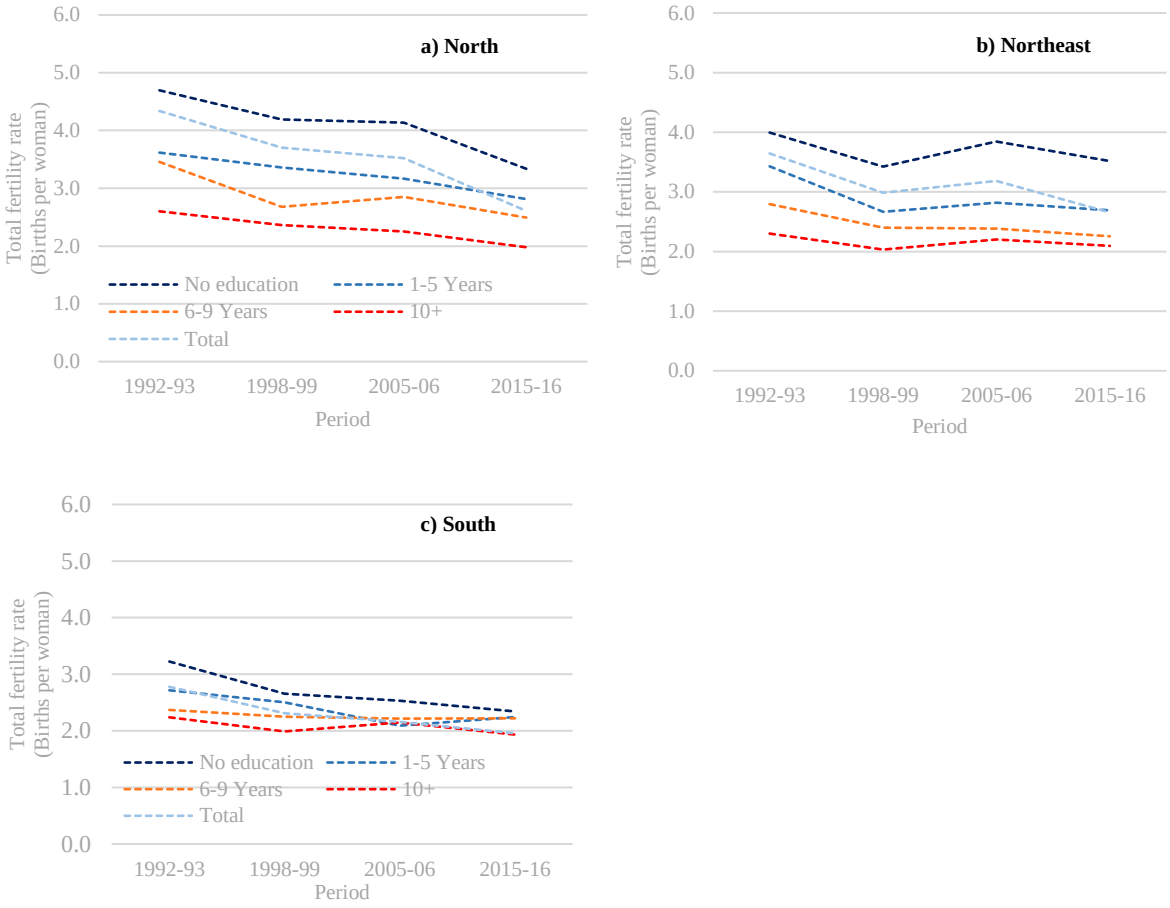
Figures 8 and 9 show the extraordinary fertility decline in rural Indian regions. In the rural areas, completed cohort fertility has gradually declined in all regions. The CCF rate in northern India has decreased from 5.4 children per woman in the 1945-49 cohort to 3.8 children per woman in the 1970-74 cohort. In the northern and northeastern regions of India, completed cohort fertility rates by women's education levels were far away from the replacement level of fertility. Nonetheless, in the rural areas of the southern region, the cohort fertility rate of women with 10 or more years' schooling reached the replacement level in the recent cohorts. Furthermore, it was also observed that the CCF in Indian's southern region has remained unchanged in recent cohorts. The cohort fertility rate among women with 10 or more years' education in the north region fell from 3.5 children in 1945-49 to 2.5 children in the 1970-74 cohort. The CCF in the southern and northeastern regions, declined by 31.42% and 66.8% respectively, during the same periods. However, total fertility rates (figure 9) have decreased by women's educational levels in all regions. Nonetheless, fertility rates by women's educational levels converged in the southern region of rural India. Rural TFR has reduced among women with no education, with 40.7% in the north, 13.5% in the south, and 37.7% in the northeast.

Figure 8: Completed cohort fertility rates by years of education in major regions of rural India, 1945-74



Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Figure 9: Total fertility rates by years of education in major regions of rural India, 1992-2015

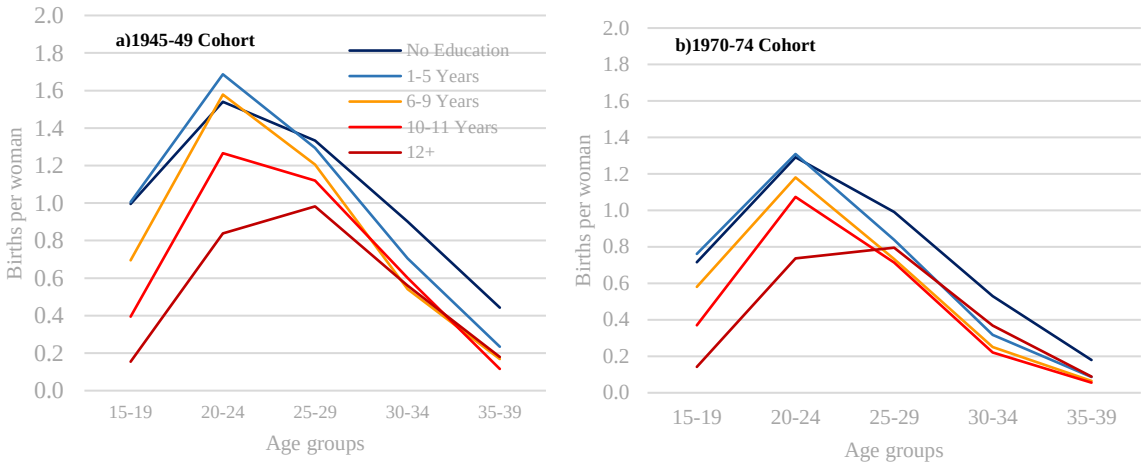


Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

4.5 Cohort and period age-specific fertility rates (ASFRs)

Figure 10 shows remarkable features of the fertility pattern. Fertility within age groups by education level was lower in the cohorts 1945-49 than in the previous year's education levels, except for no educated women. No educated women bearing had a larger number of children than the other education levels in 30-34 and 35-39 age groups. In the 1945-49 cohorts, women with 1-5 years of education had more children in the age groups 20-24 than women with no education levels. In the case of no educated women, the family size was very high in the 30-34 and 35-39 age groups. The ASFR pattern in the 1970-74 cohort of 12+ educated women is completely different from that of the 1945-49 cohorts. Fertility rates in the 15-19 age groups were very low among the 12+ educated women, but there were a larger number of women bearing children in the 30-34 and 35-39 age groups, which was higher than the other education groups. Appendix figure A1 shows that cohort ASFR in the 15-39 age groups has decreased across all cohorts, and childbearing age among the 12+ educated women has gradually shifted from 20-24 to the 25-29 age groups.

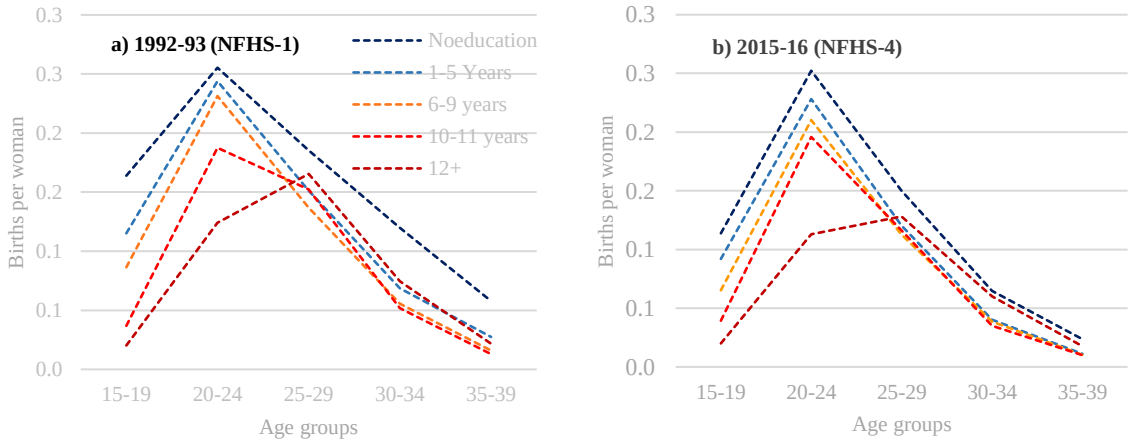
Figure 10: Cohort age-specific fertility rates (ASFRs) by years of education in India, birth cohorts, 1945-49 and 1970-74



Source: Own calculation based on NFHS, 1992-93 and 2015-16; data weighted by sample weight, and awfacte.

Figure 11 shows that all education groups' period age-specific fertility rates have declined. In 1992-93 the ASFR of no educated women was higher than that of other education groups. The 10-11 years and 12+ educated women bearing children in the age groups 20-24 and 25-29 but the other educated women mostly bearing children in the age groups 20-24. Fertility rates among no educated women are higher in the 35-39 age groups than in the other education groups. In 2015-16, age-specific fertility rates have declined but most of the women bearing children in the age groups 20-24 which was similar to the 1992-93 period except for women with 12+ education. In our analysis, we found that large family size has among 12+ educated women in the 25-29 and 30-34 age groups than other education levels women, whereas age-specific fertility rates gradually converged in the 35-39 age groups. Figure A2 in the appendix shows that age-specific fertility rates have declined throughout the period by the women's educational attainment. The 12+ educated women fertility rates have much lower in the 20-24 age groups but most of the women bearing children in 20-24 age groups.

Figure 11: Period age-specific fertility rates (ASFRs) by years of education in India, 1992-93 and 2015-16



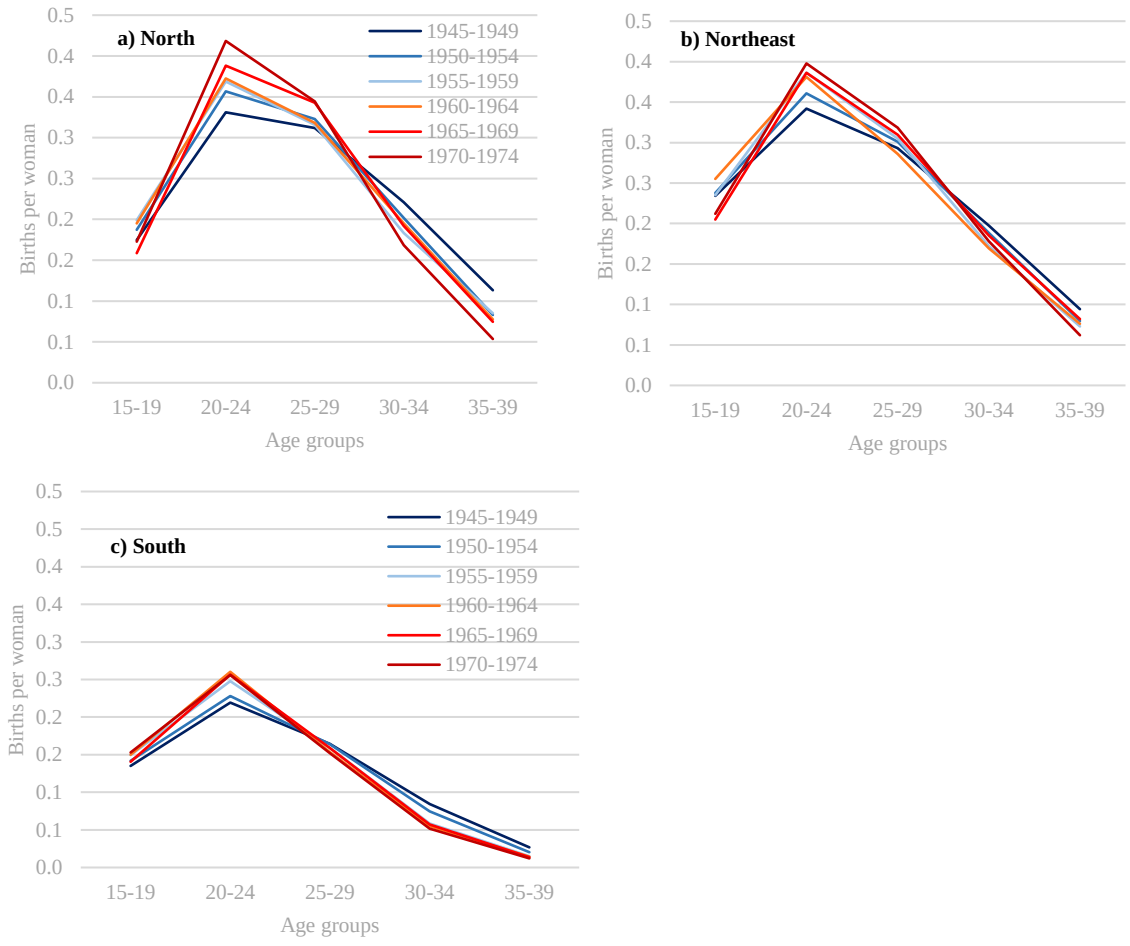
Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Figures 12 and 13 show the ASFR fertility rates by period and cohort across the regions of India. The cohort ASFR has declined in the recent cohorts than in previous cohorts.

As fertility rates fell, cohort ASFR in 20-24 age groups increased in all the regions. The cohort ASFR has largely declined in the higher reproductive age groups than previous cohorts. The 15-19 age group ASFR was higher in the northeast than in other regions. Outstandingly, in the southern regions cohort, ASFR has slowly declined compares to other regions. The shape of the ASFR in the northern and northeast regions has an inverted "U" shape.

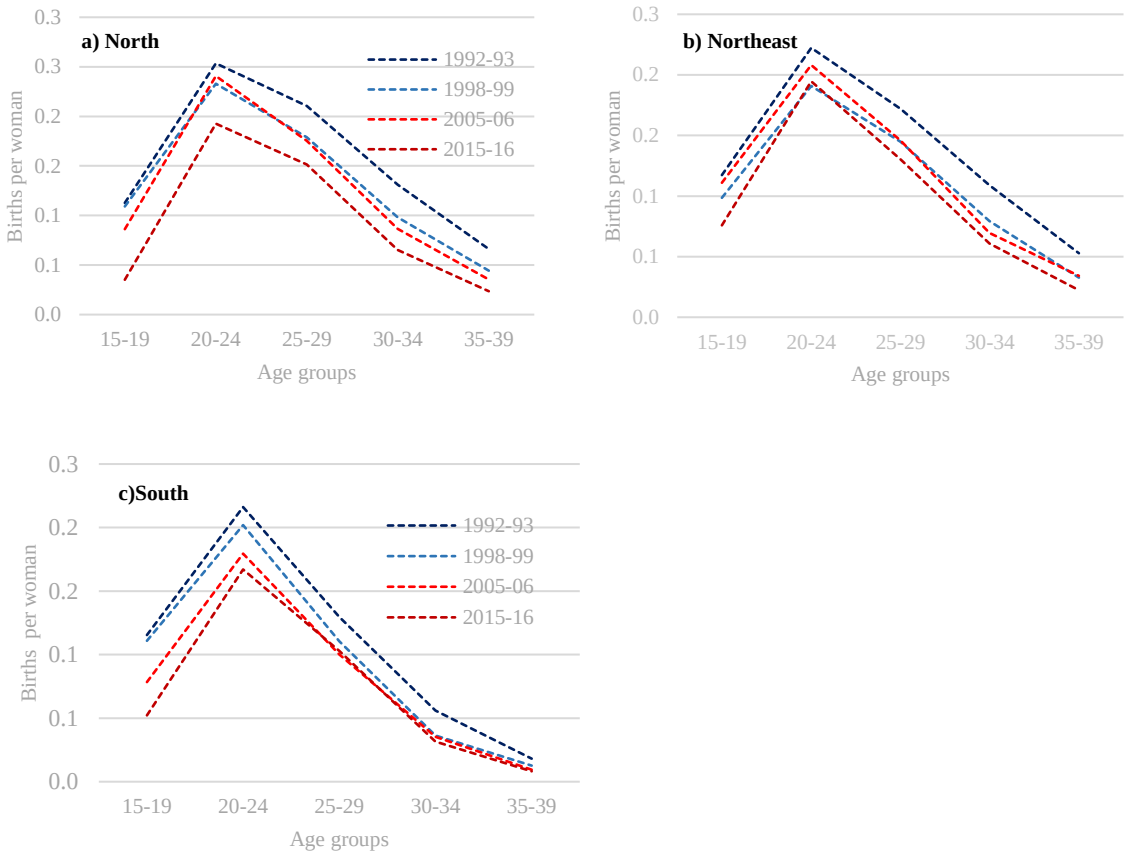
In figure 13, the period ASFRs rates in all age groups in the regions are steadily declining. ASFR has been declining in lower reproductive age groups in all regions. As the total fertility rate in the south region falls, the period ASFR in higher reproductive age groups is gradually declining. However, the fertility rate in the northeastern and northern regions is relatively high. In all the regions, the 20-24 age group has the highest ASFR. Fertility rates in the lower reproductive age groups remain high in all regions. However, family sizes have reduced in older age groups.

Figure 12: Cohort age-specific fertility rates (ASFRs) by major regions in India, birth cohorts 1945-1974



Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Figure 13: Period age-specific fertility rates (ASFRs) by major regions in India, 1992-2015



Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

4.6 Decomposition results

We used the standard demographic decomposition technique to examine whether changes in women's education or changes in educational composition have had a significant impact on fertility decline in India. We took the 1945-49 and the 1970-74 birth cohorts for the decomposition analysis (spanning a period of 29 years). To illustrate more recent trends which cannot be captured by cohort fertility because the women are still in childbearing age, we also decompose the change in TFR between 1992-93 and 2015-16. We can link the two although TFRs are not pure quantum measures, but we have shown that no indication of changes in fertility tempo in total fertility and in education-specific fertility rates. It is important to look into more recent trends as educational expansion continues. Total fertility rates capture the childbearing behavior of younger cohorts of women among whom we find higher shares of those with higher educational attainments (Table 5). This decomposition gives the rate and composition effects of women's education for changes in CCF and total fertility rates. The "rate effect" changes in fertility are due to changes in women's reproductive behavior, contraceptive use being a prominent factor. On the other hand, the "composition effect" quantifies how much of the change in the overall fertility rate is due to an increase in the levels of women's education between the (synthetic) cohorts under study.

Table 2 shows the changes in completed cohort fertility and its decomposition in the five-year birth cohort in India. The CCF declined from 5.0 births in the 1945-1949 cohort to 3.3 births in the 1970-1974 cohort, or 1.8 births per woman in 29 years. During this cohort, women's education has changed unprecedentedly, with uneducated women declining from 68% to 48% and those with at least 6-9 years of education growing up from 9% to 17%. Decomposition analysis results show that changes in women's educational composition explained not more than one-fifth (20%) of the change in completed cohort fertility (-1.8 births per woman) between 1945-49 to 1970-74 birth cohorts. The rate effect, on the other hand, accounted for four-fifths (80%) of the total change in the completed cohort fertility rate. Despite steadily improving women's education over time, only one-fifth of the change in fertility rate has been observed. This is not to say that women changing educational levels cannot accurately reflect a decline in women's fertility. Improving women's education has both direct and indirect effects, and the indirect effects may outweigh the direct effect on fertility reduction.

Table 2: Decomposition of the changes in completed cohort fertility rates between the 1945-49 and 1970-74 birth cohorts by years of education in India

Birth Cohort (by years of education)	Observed change in CCF	Change in standardized CCF		Change attributable to			
				Composition effects		Rate effects	
C1945-49/C1970-74	-1.78	-1.78	(100%)	-0.36	(20%)	-1.43	(80%)
No education		-1.86	(104%)	-0.94	(53%)	-0.92	(51%)
1-5 Years		-0.24	(13%)	-0.01	(1%)	-0.17	(13%)
6-9 Years		0.12	(-7%)	0.29	(-16%)	-0.07	(10%)
10-11 Years		0.06	(-3%)	0.13	(-7%)	-0.04	(4%)
12+		0.14	(-8%)	0.18	(-10%)	-1.43	(2%)

Source: Own calculation based NFHS, 1992-93 and 2015-16; data weighted by sample weight, and awfacte.

We have further extended the decomposition analysis at the regional level. India is a very large heterogeneous country, and there are sizable spatial differences in fertility reduction across regions, education, place of residence. In addition, each geographical region of India represents different stages of fertility decline with varying socioeconomic spectrums. As shown in Tables 3 and 4, characteristics of women of reproductive age differ across regions and the pace of change of female education differs as well. Table 3 shows the percentage of urban women in India and its major regions by cohorts (1945-74). The percentage of women in these periods and cohorts increased in urban areas of India. On the other hand, the number of women living in urban areas of India increased from 28.7% in 1945-49 to 36.8% in the 1970-74 birth cohort. The highest spatial concentration of women living in urban areas is in the southern region as compared to other regions of India. In the southern region, the number of women residing in urban areas grew by 49.8 % in 1945-49 to 53.3% in 1970-74 birth cohort and 32.9% in 1992-93 to 49.4% in 2015-16.

Table 3: Percentage of women residing in urban areas at the survey, by birth cohorts 1945-49 and 1970-74 in major regions of India

Birth cohort	Percent of women residing in the urban areas			
	India	North	Northeast	South
1945-49	28.7	31.1	19.1	49.8
1950-54	30.2	32.4	17.0	50.6
1955-59	32.1	32.4	17.7	50.0
1960-64	34.3	31.2	19.0	49.8
1965-69	35.6	28.7	16.3	55.0
1970-74	36.8	30.7	16.0	53.3

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Regional development disparities contribute to more pronounced differences in fertility changes. To address this, we decompose cohort fertility decline between the two cohorts 1945-49 and 1970-74 for each geographical region (Table-4). CCF in northern decreased from 5.2 to 3.6 children between 1945-49 and 1970-74 cohorts. Further, the decline in CCF (-1.6 children) is attributable to 21 % of the change in composition effect and 79% of the change in rate effect in the northern region. CCF in the northeast region fell from 5.1 children per woman to 3.3 children per woman between the 1945-49 and 1970-74 birth cohorts. The decomposition results show a decline of (-1.7 children per woman), which is attributable to one-fifth (17%) of the change in the education composition of women. The rate effect, on the other hand, explains 83 % of the change in fertility rates in India's northeast region. If we look at the southern region, the CCF rate has declined from 4.4 to 2.6 at the same time. This declined is due to 16% due to education composition and 84% is due to the rate effect.

Table 4: Decomposition of the changes in completed cohort fertility rates between birth cohorts 1945-49 and 1970-74 birth cohorts by years of education in major regions of India

Birth Cohort (by years of education)	The observed change in CCF	Change in standardized CCF		Change attributable to			
				Composition effects		Rate effects	
A) North							
C1945-49/C1970-74	-1.58	-1.58	100%	-0.32	(21%)	-1.25	(79%)
No education		-1.92	(121.57%)	-0.99	(63%)	-0.92	(59%)
1-5 Years		0.00	(-0.04%)	0.15	(-10%)	-0.15	(10%)
6-9 Years		0.15	(-9.43%)	0.24	(-15%)	-0.09	(6%)
10-11 Years		0.06	(-3.76%)	0.11	(-7%)	-0.06	(4%)
12+		0.13	(-8.33%)	0.16	(-10%)	-0.03	(2%)
B) Northeast							
C1945-49/C1970-74	-1.75	-1.75	(100%)	-0.30	(17%)	-1.45	(83%)
No education		-1.76	(100.67)	-0.86	(49%)	-0.90	(51%)
1-5 Years		-0.26	(14.89)	0.01	(0%)	-0.27	(15%)
6-9 Years		0.12	(-6.63)	0.33	(-19%)	-0.22	(12%)
10-11 Years		0.06	(-3.49)	0.10	(-6%)	-0.04	(2%)
12 +		0.10	(-5.44)	0.11	(-6%)	-0.02	(1%)
C) South							
C1945-49/C1970-74	-1.80	-1.80	(100%)	-0.29	(16%)	-1.52	(84%)
No education		-1.65	(91.61%)	-0.79	(43%)	-0.87	(48%)
1-5 Years		-0.42	(23.63%)	-0.15	(8%)	-0.28	(16%)
6-9 Years		0.07	(-4.04%)	0.29	(-16%)	-0.22	(12%)
10-11 Years		0.04	(-2.35%)	0.14	(-8%)	-0.10	(5%)
12+		0.16	(-8.85%)	0.22	(-12%)	-0.06	(3%)

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Table 5 shows that the percentage of no educated women and women with 10 or more years of education in major regions of India. In India's urban areas the percentage of women with no education declined by 32.3% between the 1945-49 cohort and the 1970-74 cohort. Between the 1945-49 cohort and the 1970-74 cohort, the percentage of no educated women in urban areas declined by 27.37 % in the north, 27.8% in the northeast, and 37.3% in the south. In India, however, the percentage of 10 or more year schooling women has increased by 40.2% between 1945-49 cohort and 1970-74 cohort. Further, the number of women with 10 or more years' education women increased by 62.7% in the north, 82.6% in the northeast, 63.6% in the south between the 1945-49 cohort and the 1970-74 cohort. In addition, the number of no educated women decreased by 58.05% between 1992-93 to 2015-16. Moreover, between 1992-93 and 2015-16, the number of uneducated women decreased by 56.24% in the northern region, 55.69% in the northeast, and 61% in the southern region. The number of 10 or more years' education women increased by 26% between 1992-93 and 2015-16 in India. The number of women with 10 more years increased 80% in the north, 76.98% in the northeast, 106.89% in the south region.

Table 5: Percentage of no education and 10 or more years educated women by birth cohorts 1945-74 and 1970-74 in urban areas of major regions in India

Birth Cohorts	Women's highest attained education level							
	No education				10 or more years of education			
	India	North	Northeast	South	India	North	Northeast	South
1945-49	42.4	50.7	40.0	38.2	21.9	22.0	17.8	23.5
1950-54	37.1	45.0	38.2	31.6	26.9	27.7	22.0	28.0
1955-59	32.0	40.8	31.6	26.5	30.3	31.6	29.8	29.7
1960-64	33.6	44.2	32.6	27.3	29.5	31.1	31.2	27.9
1965-69	30.7	39.6	31.5	25.7	32.3	32.5	29.7	33.0
1970-74	28.7	36.8	28.9	24.0	36.6	35.7	32.5	38.4

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Table 6 shows the percentage of no educated women and those with 10 or more years' education in rural India for both period and cohort. The percentage of no educated women decreased by 24.70% between the 1945-49 cohort to 1970-74 cohort in rural India. During the same period, the rate of decline for no educated women in rural areas was 7% lower than in urban areas. In rural India, the proportion of no educated women declined by 22.61% in the north, 25.45% in the northeast, and 27.49% in the south, from the 1945-49 cohort to the 1970-74 cohort. During this period, the number of women with 10 or more years' education increased from 2.2 % in the 1945-49 cohort to 10.1% in the 1970-74 cohort in rural India. The proportion of well-educated women increased in all parts of India, with the north region having the highest growth rate of highly-educated women compared to other regions. The proportion of no educated women in India declined from 73.0% in 1992-93 to 33.9% in 2015-16. The regional pattern of no educated women decreased by 54.21% in the north, 49.92% in the northeast, and 57.5% in the south region from 1992-93 to 2015-16. The 10 or more years of educated women increased from 4.4% in 1992-93 to 27.3% in 2015-16. The rapid increase of the 10 or more years of schooling women observed in the northern region of India.

Table 6: Percentage of no education and 10 or more years of educated women by cohorts 1945-49 and 1970-74 in rural areas of major regions in India

Birth cohort	Women's highest attained education level							
	No education				10 or more years of education			
	India	North	Northeast	South	India	North	Northeast	South
1945-49	79.0	88.5	80	68.4	2.2	1.5	1.6	3.4
1950-54	74.5	85.6	74.8	63.8	3.5	1.7	2.5	5.9
1955-59	69.6	81.8	70.1	57.6	4.7	3.3	3.4	7.2
1960-64	66.9	78.5	66.0	54.6	5.6	4.2	4.4	8.3
1965-69	65.7	74.6	65.6	56.9	7.5	5.3	6.4	10.6
1970-74	59.5	68.5	59.6	49.6	10.1	8.1	8.5	13.8

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Table-3 shows that the proportion of women living in urban areas has increased significantly across India. The urban population's spatial concentration has an unprecedented effect on fertility reduction. The increasing proportion of women's education by period and cohort would have played a significant role in reducing regional fertility differences. We further extended the analysis in urban and rural areas in the geographical region of India. Table-7 shows that decomposition results in changes in the completed cohort fertility rate of the population between the 1945-49 cohort and the 1970-1974 cohort based on four categories of women education in urban areas of India.

We found that the CCF has declined by 1.4 children per woman between 1945-49 and 1970-74 cohorts, which is attributable to a 21% change in composition effect, and a 79% change in rates effect in urban areas of north India. Furthermore, 1.6 children per woman decreased in the northeastern region, which is attributable to the 23% composition effect and 77% of rate effects of India. In the southern region, the composition effect is attributable to the 15% and rate effects is 85%, which is contributed 1.7% declined of the CCF.

Table 7: Decomposition of the changes in completed cohort fertility rates between birth cohorts 1945-49 and 1970-74 by years of education in urban areas in major regions of India

Birth Cohort (by years of education)	Observed change in CCF	Change in standardized CCF		Change attributable to			
				Composition effects		Rate effects	
A) North							
C1945-49/C1970-74	-1.38	-1.38	(100%)	-0.29	(21%)	-1.08	(79%)
No education		-1.20	(87%)	-0.64	(47%)	-0.55	(40%)
1-5 Years		-0.24	(17%)	-0.09	(6%)	-0.15	(11%)
6-9 Years		-0.07	(5%)	0.08	(-6%)	-0.14	(10%)
10+		0.13	(-9%)	0.36	(-26%)	-0.23	(17%)
B) Northeast							
C1945-49/C1970-74	-1.60	-1.60	(100%)	-0.37	(23%)	-1.23	(77%)
No education		-1.06	(66%)	-0.51	(32%)	-0.55	(34%)
1-5 Years		-0.68	(43%)	-0.38	(24%)	-0.30	(19%)
6-9 Years		-0.04	(3%)	0.19	(-12%)	-0.23	(14%)
10+		0.18	(-11%)	0.34	(-21%)	-0.15	(10%)
C) South							
C1945-49/C1970-74	-1.67	-1.67	(100%)	-0.25	(15%)	-1.42	(85%)
No education		-1.14	(68%)	-0.57	(34%)	-0.58	(34%)
1-5 Years		-0.52	(31%)	0.24	(14%)	-0.28	(16%)
6-9 Years		-0.07	(4%)	0.18	(-11%)	-0.25	(15%)
10+		0.05	(-3%)	0.37	(-22%)	-0.32	(19%)

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Table 8 shows that the decomposition of the completed cohort fertility rates based on rural areas. The completed cohort fertility rates have declined in all rural areas of India. On the other hand, in rural areas of north Indian, where 1.6 children declined between the 1945-49 to 1970-74 cohort, which is attributable to the 14% composition effect and 86% rate effect. In the northeast region, 1.8 children per woman declined, which is due to the 10% composition effect and 90% of rate effect. Fertility declined by 1.8 births per woman declined in the southern region, which can be attributed to an 11% rate effect and 89% composition effect.

Table 8: Decomposition of the changes in completed cohort fertility rates between birth cohorts 1945-49 and 1970-74 by years of education in rural areas in major regions of India

Birth Cohort (by years of education)	Observed change in CCF	Change in standardized CCF		Change attributable to Composition effects		Rate effects	
A)North							
C1945-49/C1970-74	-1.57	-1.57	(100%)	-0.22	(14%)	-1.35	(86%)
No education		-2.01	(128%)	-0.95	(61%)	-1.06	(67%)
1-5 Years		0.08	(-5%)	0.24	(-15%)	-0.16	(10%)
6-9 Years		0.21	(-13%)	0.29	(-19%)	-0.09	(6%)
10+		0.15	(-10%)	0.20	(-13%)	-0.05	(3%)
B)Northeast							
C1945-49/C1970-74	-1.79	-1.79	(100%)	-0.17	(10%)	-1.62	(90%)
No education		-1.94	(108%)	-0.94	(52%)	-1.01	(56%)
1-5 Years		-0.15	(8%)	0.13	(-7%)	-0.28	(16%)
6-9 Years		0.16	(-9%)	0.41	(-23%)	-0.25	(14%)
10+		0.14	(-8%)	0.22	(-13%)	-0.08	(5%)
C) South							
C1945-49/C1970-74	-1.80	-1.80	(100%)	-0.19	(11%)	-1.60	(89%)
No education		-1.77	(98%)	-0.71	(39%)	-1.06	(59%)
1-5 Years		-0.36	(20%)	-0.07	(4%)	-0.29	(16%)
6-9 Years		0.13	(-7%)	0.33	(-18%)	-0.20	(11%)
10+		0.20	(-11%)	0.25	(-14%)	-0.06	(3%)

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

4.7 Recent trends in total fertility rates

Further, we have extended the decomposition analysis to quantify the contribution of women's education in the total fertility decline because the structure of women's education has changed significantly in recent times. We used the four rounds of NFHSs (1992-2015) to understand the education differentials fertility in major regions of India. We divided the decomposition results into two analytical sections; first, we checked between 1992-93 and 2005-06; and second, we selected the periods 2005-06 and 2015-16. The main reason for dividing the results of decomposition into two sections was that we first confirmed the results of the previous studies of India by (Bhat, 2002) then examined the recent fertility trends (2005-2015) in India.

Table 9 shows that the total fertility change between 1992-93 to 2015-16 in India. The results show TFR has declined 3.4 in 1992-93 to 2.18 in 2015-16 which is attributable to the 1.2 births declined per woman which are related with the 39% of the composition effects and 61% of the rate effects. To better investigate the possibly changing role of change in the educational attainment of women (composition effect) we investigate the change in the rate separately for two periods 1992/93 – 2006/05 and the most recent period 2005/06 -2015/16. We hypothesize that the composition effect will become more pronounced in the most recent period.

Table 9: Decomposition of the changes in total fertility rates by years of education between 1992-93 and 2015-16 in India

Birth Cohort by years of education	Observed change in TFR	Change in standardized TFR		Change attributable to			
				Composition effects		Rate effects	
1992-93/2015-16	**-1.20**	**-1.07**	**(100%)**	**-0.42**	**(39%)**	**-0.65**	**(61%)**
No education		-1.39	(130%)	-0.99	(92%)	-0.41	(38%)
1-5 Years		-0.11	(10%)	-0.03	(3%)	-0.08	(7%)
6-9 Years		0.11	(-10%)	0.20	(-19%)	-0.09	(9%)
10-11 Years		0.09	(-9%)	0.12	(-11%)	-0.03	(3%)
12+		0.23	(-22%)	0.28	(-26%)	-0.05	(4%)

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Table 10 shows the decomposition of the total fertility rate between 1992-93/2005-06 and 2005-06/2015-16 in India. The TFR fell from 3.38 births per woman to 2.67 birth per woman during the first period (-0.71) and the decline continued in the second period to 2.18 births per woman in 2005-2015 (-0.49 child in a decade). The decomposition reveals that the role of educational improvements of women is becoming more prominent. In the first period, 35% of the change in total fertility rate (is attributable to the compositional effect compared to 47% in the second period. In other words, improvements in the educational attainment of women of reproductive age depressed the TFR by about 0.23-0.20 children during both analyzed periods. The effect of behavioral change (the rate effect) explains 65% of the total fertility rate decline during 1992-93 and 2005-06. Between 2005-06 and 2015-16, the contribution of the rate effect declined to 53%.

Table 10: Decomposition of the changes in total fertility rates between 1992-93/2005-06 and 2005-06/2015-16 by years of education in India

Birth Cohort (by years of education)	Observed change in TFR	Change in standardized TFR		Change attributable to			
				Composition effects		Rate effects	
1992-93/2005-06	**-0.71**	**-0.65**	**(100%)**	**-0.23**	**(35%)**	**-0.42**	**(65%)**
No education		-0.80	(123%)	-0.56	(86%)	-0.24	(37%)
1-5 Years		-0.04	(6%)	0.03	(-4%)	-0.07	(10%)
6-9 Years		0.08	(-12%)	0.16	(-24%)	-0.08	(12%)
10-11 Years		0.03	(-4%)	0.04	(-6%)	-0.02	(2%)
12+		0.08	(-12%)	0.10	(-16%)	-0.02	(4%)
2005-06/2015-16	**-0.49**	**-0.42**	**(100%)**	**-0.20**	**(47%)**	**-0.22**	**(53%)**
No education		-0.60	(142%)	-0.43	(103%)	-0.17	(39%)
1-5 Years		-0.07	(17%)	-0.06	(13%)	-0.01	(3%)
6-9 Years		0.03	(-7%)	0.04	(-11%)	-0.01	(4%)
10-11 Years		0.07	(-16%)	0.08	(-19%)	-0.01	(3%)
12+		0.15	(-36%)	0.17	(-39%)	-0.01	(4%)

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Because of variation in the pace of fertility decline and of educational expansion across India, we have repeated the analysis for the three major regions. Table 11 shows that the total fertility rate in major regions between 1992-2005 and 2005-2015 in India. During the first period (1992-93 to 2005-06), the total fertility rates declined 0.84 births per woman in the North region and 33% of this declined is attributable to the composition effect (additional 67% of the rate effects in the northern region of India.

At the same time in the northeastern region, total fertility rates declined 0.56 births per woman which is attributable to the 39% composition effect and 61% rate effects. Further, in the southern region, the total fertility rates declined 0.69 births which is attributable to the 21% composition effects and 79% of the rate effects.

Table 11: Decomposition of the changes in total fertility rates by years of education between 1992-93 to 2005-06 in major regions of India

Birth Cohort (by years of education)	Observed change in TFR	Change in standardized TFR		Change attributable to			
				Composition effects		Rate effects	
A) North							
1992-93/2005-06	-0.84	-0.81	(100%)	-0.27	(33%)	-0.54	(67%)
No education		-1.08	(133%)	-0.70	(86%)	-0.39	(47%)
1-5 Years		0.04	(-5%)	0.09	(-11%)	-0.05	(6%)
6-9 Years		0.13	(-15%)	0.20	(-24%)	-0.07	(9%)
10-11 Years		0.03	(-3%)	0.04	(-4%)	-0.01	(1%)
12+		0.08	(-10%)	0.11	(-13%)	-0.03	(3%)
B) Northeast							
1992-93/2005-06	-0.56	-0.53	(100%)	-0.21	(39%)	-0.33	(61%)
No education		-0.63	(119%)	-0.52	(98%)	-0.11	(21%)
1-5 Years		-0.02	(5%)	0.06	(-12%)	-0.09	(16%)
6-9 Years		0.08	(-15%)	0.17	(-32%)	-0.09	(17%)
10-11 Years		0.01	(-2%)	0.04	(-8%)	-0.03	(6%)
12+		0.04	(-7%)	0.05	(-9%)	-0.01	(2%)
C) South							
1992-93/2005-06	-0.69	-0.61	(100%)	-0.13	(21%)	-0.48	(79%)
No education		-0.69	(114%)	-0.43	(71%)	-0.26	(43%)
1-5 Years		-0.12	(20%)	-0.03	(5%)	-0.09	(15%)
6-9 Years		0.05	(-9%)	0.14	(-22%)	-0.08	(14%)
10-11 Years		0.04	(-7%)	0.05	(-9%)	-0.01	(1%)
12+		0.11	(-18%)	0.14	(-23%)	-0.03	(5%)

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Table 12 illustrates that the decomposition of the total fertility rates in between 2005-06 and 2015-16. The total fertility rates have declined 0.82 births per woman, which is attributable to the 37% of composition effect and 63% of rate effects in the northern region. In the northeastern region, fertility rates have declined by 0.45 births per woman, attributable to the 36% rate effects and 64% composition effects. However, in the northeastern region, we found a dramatic increase in the composition effects between 2005-2015 than in 1992-2005. In the southern region, fertility declined 0.21 births per woman, attributable to 46% rate effects and 54% composition effects. Therefore, in the recent period composition effects have increased than the previous round, except in the northern regions.

Table 12: Decomposition of the changes in total fertility rates by years of education between 2005-06 and 2015-16 in major regions of India

Birth Cohort (by years of education)	Observed change in TFR	Change in standardized TFR		Change attributable to			
				Composition effects		Rate effects	
A)North							
2005-06/2015-16	**-0.82**	**-0.72**	**(100%)**	**-0.27**	**(37%)**	**-0.45**	**(63%)**
No education		-0.92	(128%)	-0.61	(85%)	-0.31	(43%)
1-5 Years		-0.07	(10%)	-0.02	(3%)	-0.05	(7%)
6-9 Years		0.08	(-11%)	0.12	(-16%)	-0.04	(5%)
10-11 Years		0.05	(-7%)	0.07	(-9%)	-0.02	(3%)
12+		0.15	(-21%)	0.18	(-26%)	-0.03	(5%)
B)Northeast							
2005-06/2015-16	-0.45	-0.37	(100%)	-0.23	(64%)	-0.13	(36%)
No education		-0.61	(166%)	-0.48	(131%)	-0.13	(35%)
1-5 Years		-0.08	(21%)	0.06	(15%)	-0.02	(6%)
6-9 Years		0.10	(-28%)	0.11	(-31%)	-0.01	(3%)
10-11 Years		0.11	(-30%)	0.09	(-24%)	0.02	(-6%)
12+		-0.37	(-30%)	0.10	(-28%)	0.01	(-2%)
C) South							
2005-06/2015-16	-0.21	-0.15	(100%)	-0.08	(54%)	-0.07	(46%)
No education		-0.28	(182%)	-0.22	(146%)	-0.06	(36%)
1-5 Years		-0.06	(42%)	-0.08	(53%)	0.02	(-11%)
6-9 Years		-0.06	(36%)	0.06	(38%)	0.00	(-1%)
10-11 Years		0.07	(-43%)	0.09	(-57%)	-0.02	(14%)
12+		0.18	(-118%)	0.19	(-126%)	-0.01	(8%)

Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

5. Discussion

The main goal of this analysis was to examine how educational differences in fertility changed over the decades and to examine the contribution of the changes in women's educational attainment on fertility decline in India and its regions. The analysis of cohort fertility rates confirmed previously established findings of rapid fertility decline without any major stalls. This decline has been especially pronounced among women with low education. In the early stages of fertility, transition education played a smaller role in fertility decline and most of the change was attributable to behavioral change. Although we do not study changes in contraception use and family planning in this analysis, we hypothesize that much of the behavioral change is attributable to the adoption of family planning and high contraceptive use. Existing studies confirm widespread use of family planning by low educated women (Arokiasamy, 2009). India's total fertility rate dropped to near replacement level in 2015-16 and we find that increasing female education starts playing a more important role in fertility decline at these later stages of fertility transitions. The decomposition of the change in TFR showed that educational improvements among women of reproductive age explain 47% of the decline and depressed the TFR by 0.24 children per woman during 2005-06 2015-16. Earlier Bhat's analysis found that only 20 % of the decline between 1992-93 and 1998-99 was attributable to education (Bhat, 2002). The compositional effect contributes more to the decline in TFR when larger share of women of reproductive age achieves higher educational attainments (at year 10 completed years of education).

The fertility rate of women in the regions of India has declined across all levels of women's education except for a few regions, fertility rates declined throughout India. Trends in both CCF and TFR indicate that regional economic development, progress in women's education, and the use of modern

contraception have resulted in regional differences in fertility rates. However, it still warrants the attention of policymakers that fertility rates are comparatively higher in the northern region of India. Despite this, the gap in fertility rates by women's education levels has been steadily narrowing, resulting in the convergence of fertility across women's educational categories in southern states of India. These findings are consistent with previous research by (Cleland, 2002), who suggested that the fertility gap between women of different educational levels would narrow at the end of the fertility transition (Cleland, 2002).

In all geographical regions, educational disparities in fertility are greater in rural areas than in urban areas. Cities' structural and ideational changes have resulted in a lower fertility rate According to structural and diffusions theories, the outline of fertility transition began in urban areas, which later encouraged reduced periphery and rural fertility (Lerch & Spoorenberg, 2020). In addition, fertility rates were the pace of fertility was faster in the more urbanized southern and eastern states. Due to the delayed onset of fertility transition in urban areas in some states, excess rural fertility may distort the path between rural and urban fertility decline. However, rapid urbanization and structural change in developing countries have made a huge gap in fertility rates between rural and urban areas. In fact, the geographical concentration of the population has played an important role in lowering fertility. Nevertheless, with urbanization, opportunity cost, Industries, and services, employment has increased. Thus, lower levels of urbanization in a geographic region results in less diffusion of contraceptives and new reproductive behaviors.

In the northern and northeastern region of India, where age-specific fertility rates are very high, mothers are still giving birth in the higher reproductive age group, resulting in higher total and completed fertility rates in these regions than in southern region states. There are several reasons for this. First, there is a low level of contraceptive use in social groups and the limitations of modern contraceptive use and the benefits of abortion care (Matthews et al., 2009). Second, a high proportion of uneducated women living in this region compared to other regions. On the other hand, age-specific fertility rates are rapidly declining even in the higher reproductive age group in the southern region because of the low desired and ideal family sizes among mothers.

We found that changes in the educational composition in rural areas contribute to less than 15% reduction in cohort fertility for birth cohorts 1945-49 and 1970-74 in all regions. Cohort fertility has declined in rural India, but the decline has been slow due to low socio-economic development and slower women's literacy (Bhat, 2002; Drèze & Murthi, 2001). Further, our analysis found that between 1945-49 and 1970-74 birth cohorts, the educational composition contributed around less than 23% of the decline in fertility in urban areas of India. We also found that women with 10 or more years of education were 2% in the 1945-49 cohort and 10% in 1970-74 cohorts in rural areas of India. Further, in urban areas, women with 10 or more years of education increased from 22% in the 1945-49 cohort to 37% in the 1970-74 cohort. The rate of diffusion and the rate of social interaction may further reduce educational differentials in fertility across (Lutz & Skirbekk, 2004) suggested that to further decline of fertility in India, there is a need to increase the education level of women. (Dasgupta, 1995) mentioned that improving women's education is the only way to control fertility, particularly population growth.

However, (James, 1999; Padmadas et al., 2004) argues that, despite significant improvements in women's education, fertility rates have fallen dramatically in states such as Telangana and Andhra Pradesh, where sterilization of women playing a major role in the low fertility. Therefore, it is not unusual for different regions of India to be at different stages of fertility transition. The southern states of India have already completed their fertility transition and total fertility rates are at/below replacement level, while the northern states of India are still far from completing the fertility transition (Dyson, 2009).

The Indian pattern of fertility differences by women's education confirms the leader-follower model rather than the permanent difference model demonstrating that the diffusion process is the root cause of the decline in fertility. Indeed, we cannot ignore the role of family planning programs in reducing fertility. Period measures of fertility are a short-term measure of fertility change as they are distorted

by changes in fertility tempo. On the other hand, cohort measures of fertility are qualitative measures of fertility. When one considers the cohort fertility rate, one may wonder whether if Indian fertility rates are really below the replacement level. In the case of India, most fertility has declined in the long run, the cohort measure of fertility rate has been appropriate for understanding India's fertility decline. The analysis presented in this study indicates that improving women's educational attainment is critical to further reducing total fertility in India. Our analysis shows that although initially behavioral factors, most likely adoption of family planning, were driving fertility decline during the last decades of the 20th century, significant proportions of recent fertility decline is driven by changes in educational composition. The effect of education thus becomes more pronounced as younger cohorts of women who completed at least 10 years of education enter reproductive age. This finding also confirms previous research, which states that education provides a solid foundation for fertility reduction, both directly and indirectly, and that the indirect effects of education on fertility are greater than the direct effects. There are also some limitations to this study. First, we didn't have a sufficient sample size to measure the education differentials fertility at the more granular regional level, so we created three geographical regions instead of six. Second, due to the sample size of college-educated women, we were able to assess their fertility rate, so we limited women's education to 12 or more years of education.

Despite these limitations, this study provides a comprehensive assessment of educational differences in fertility in major geographical regions of India. The completed cohort fertility rate remains above the replacement level, while total fertility has fallen below the replacement level. Thus, it raises the question of whether Indian fertility rates have reached the replacement level. Researchers and policymakers should pay closer attention to the spread of women's literacy levels and women's employment, as these will be useful in advancing fertility decline and lowering high parity births. Significant improvements in women's educational attainment have not resulted in a decline in fertility in India's regions. However, the relationship between education and fertility has shifted in the geographical areas of India. More detailed research with larger sample sizes by women's education is required to understand this relationship.

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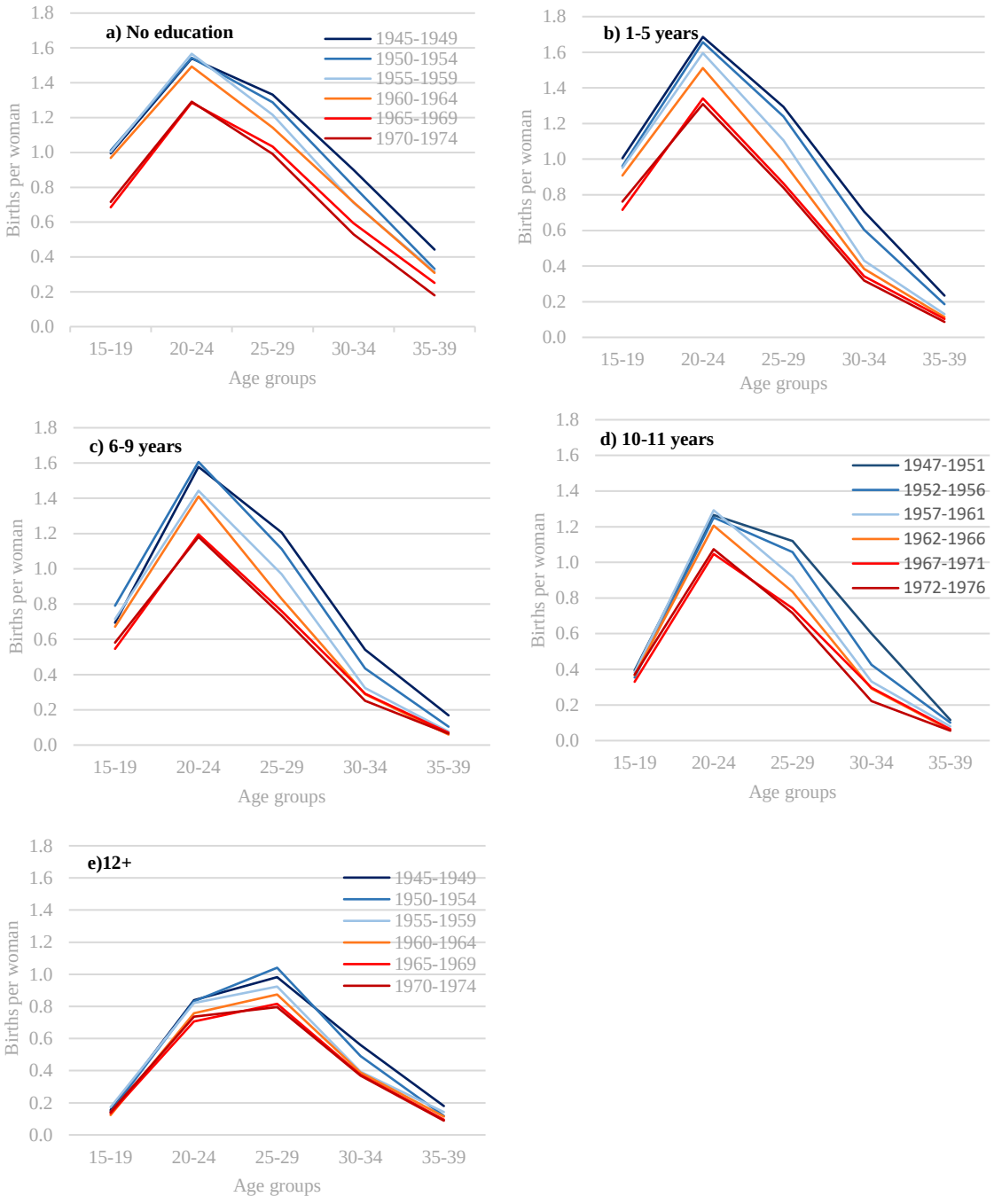
7. Appendix

Table A1 Formation of birth cohorts in India from NFHS-1, NFHS-2, NFHS-3 & NFHS-4 surveys

Birth Cohort	The ages of the women at the Interview				Total number of women	Total number of births
	NFHS-1 (1992-93)	NFHS-2 (1998-99)	NFHS-3 (2005-06)	NFHS-4 (2015-16)		
1945	46				1471	7653
1946	45				1575	8092
1947	44				2104	10232
1948	43				1608	7964
1949	42	49			2458	11973
1950	41	48			3582	17023
1951	40	47			3387	15973
1952	39	46			3875	17792
1953	38	45			2462	11406
1954	37	44			1796	8095
1955	36	43			1823	8318
1956	35	42	49		3064	13482
1957	34	41	48		3677	15929
1958	33	40	47		4373	18564
1959	32	39	46		2379	9670
1960	31	38	45		2758	11382
1961	30	37	44		2172	8837
1962	29	36	43		2095	8563
1963	28	35	42		2379	9534
1964	27	34	41		2366	9188
1965	26	33	40	49	6536	23243
1966	25	32	39	48	11213	37766
1967	24	31	38	47	12966	44073
1968	23	30	37	46	11812	39100
1969	22	29	36	45	14996	50488
1970	21	28	35	44	20547	68221
1971	20	27	34	43	12088	39334
1972	19	26	33	42	13394	42283
1973	18	25	32	41	13749	43388
1974	17	24	31	40	16207	50458

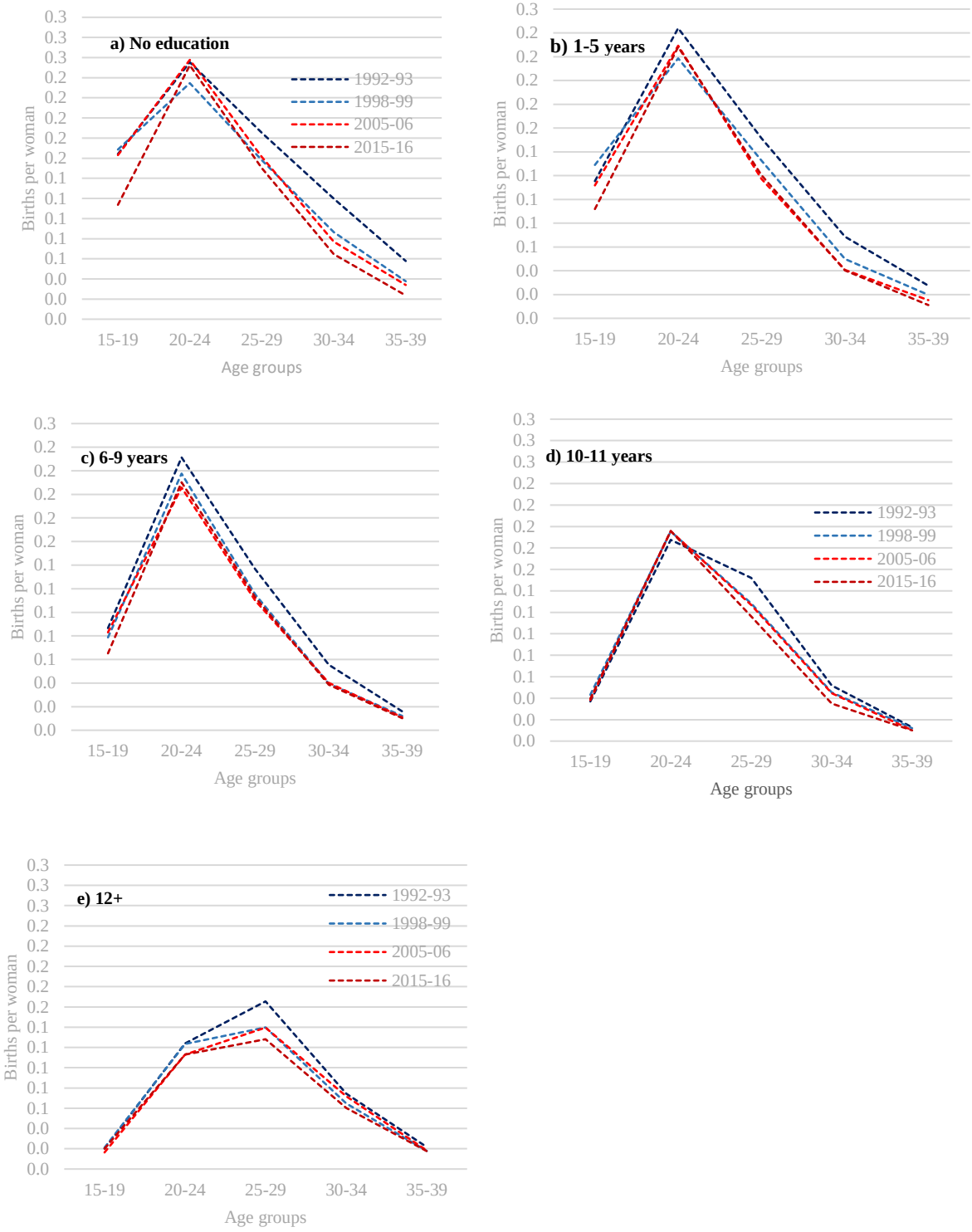
Source: Own calculation based on all NFHS, 1992-2015.

Figure A1: Cohort age-specific fertility rates (ASFRs) by years of education in India, between the 1945-49 and 1970-74



Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.

Figure A2: Period age-specific fertility rates (ASFRs) by years of education in India, 1992-2015



Source: Own calculation based on all NFHS, 1992-2015; data weighted by sample weight, and awfacte.