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Asian Immigrant Advancement in Canada

Barry Edmonston

Abstract

This paper analyses the advancement of Asian immigrants in Canada, using census data from 1986 to 2016. We analyse four Asian immigrant groups - Chinese, Filipinos, South Asians, and all other Asians – in the context of six outcome statuses that are important measures of immigrant advancement. The paper presents a new method for summarising the pace of advancement of immigrants in Canada. Measuring the pace of immigrant advancement requires methodological improvements that deal with potential biases stemming from variations in the composition of immigrants groups by age, age at arrival, and duration of residence since arrival. The new summary period measure of immigrant advancement proposed in this paper provides useful information for comparisons of time periods, age at arrival, and immigrant groups. It offers a more comprehensive picture of the pace of immigrant advancement than other current measures.

Introduction

Consider four broad areas of inquiry for immigration research: 1) why some people decide to leave their country of origin; 2) why emigrants select a destination country for new settlement: 3) immigration policies in destination countries that affect selection of new immigrants; and 4) how immigrants adjust and succeed in their destination countries. This paper deals with the fourth area of research and focusses on the pace of advancement of Asian immigrants after their arrival in Canada. Although there is a wide body of detailed studies about the adjustment of immigrants, we lack adequate specific empirical knowledge about a fundamental question: how are immigrants themselves doing (Smith and Edmonston, 1997)? The answer to this question requires research on the pace of advancement, how it varies for immigrant groups of different ethnicity or country-of-origin, and how advancement rates differ over time. There are basic methodological problems that challenge the measurement of immigrant advancement, including biases that occur due to variations in the composition of immigrant groups by age, age at arrival, and duration of residence since arrival. To take these compositional differences into account, this paper makes use of a measure of immigration advancement originally proposed by Pitkin and Myers (2011). Because we have not found empirical analysis using this measure, we explicate the new measure and present examples of its use by studying advancement of Asian immigrants in Canada. There are two likely reasons that this new measure has received relatively little attention for empirical analysis earlier. First, it may be difficult for researchers to compute the new measure, which requires several detailed steps. Second, calculations are quite intensive. We have used this new measure to study of the advancement of several groups of Asian immigrants in Canada and to compare temporal changes in the advancement for three periods: 1986 to 1996; 1996 to 2006; and 2006 to 2016. The analysis is based on Canadian census microdata samples for 1986, 1996, 2006, and 2016. We examine the three ethnic groups – Chinese, Filipinos, and South Asians – that constitute the largest Asian immigrant groups in Canada and, in addition, the general group of all other Asian immigrants.

The new measure that we use in the present paper provides an index of expected lifetime advancement based on decennial changes over the past 30 years. We calculate the cohort advancement between two censuses as the difference in observed status attainment, which shows the ten-year advancement between the first and the second census for birth and arrival cohorts. We combine observed changes in attainment for different cohorts into a synthetic estimate of the expected advancement to a specific older age. The observed change in attainment per person is calculated as a hazard rate for the number of persons advancing relative to the risk population (that is, the number who have not attained the status). The total advancement to a specific older age is the cumulative hazard of advancing to that age, which is the expected lifetime attainment for the outcome measure.

The summary period measure of migration advancement used in this paper has several benefits compared to other measures. It distinguishes the initial attainments of immigrants at the time of arrival from subsequent advancements, which is an important aspect of separating immigrant selection effects from immigrant lifetime advancements (Chiswick, 2000). Moreover, it standardises age composition and duration of residence of immigrant groups, which are persistent methodological problems because attainments of immigrants differ markedly by age and duration of residence. Finally, it offers a consistent temporal measure based on the pace of change during ten-year periods – similar to the total fertility rate, a summary period measure for expected lifetime fertility – that is expressed as expected lifetime advancement.

The primary purpose of this paper is to present the new measure of immigrant advancement and to give examples of its use. While other studies have focused on explanations for variations among groups or explanations for variations in socioeconomic achievements, this paper has three more limited research purposes: 1) to consider variations in current age and age at arrival with a new summary measure of lifetime advancement; 2) to compare lifetime attainment measures; and 3) to calculate initial attainment and lifetime advancement rates for four groups of Asian immigrants on six outcome measures. Although the main aim of the paper is to describe a new method for immigration research, the paper also cites selected studies that offer analysis to explain variations in outcomes measures for groups.

Immigration in Canada

Since 1851, immigration flows to Canada have averaged around 120 thousand arrivals per year, with considerable variation from peaks during the 1900s, 1910s, and 1950s to troughs of the 1890s, late 1910s, 1930s, and early 1940s (Figure 1). From 1880 to 1930 there was prolonged large-scale immigration from Europe to Canada when immigration exceeded 10 immigrants per 1,000 population, with comparatively much higher rates in the late 1880s and from 1900 to 1914 (Edmonston, 2016). The five-year period of 1909 to 1913 witnessed the largest volume of immigrants to Canada, in both absolute and relative terms, with the arrival of 1.3 million immigrants, or more than 250 thousand annually. By 1913, more than one-sixth of the Canadian population had arrived in the preceding five years. Immigration levels declined during the World War I and increased in the early 1920s. As economic conditions worsened in Europe in the 1920s, migration to Canada increased after 1918, averaging about 100 thousand immigrants annually in the early 1920s and almost 150 thousand immigrants annually in the late 1920s. In contrast, number of immigrants decreased during the 1890s, World War I, and the 1930 to 1945 period of the Great Depression and the World War II. There were only about 15 thousand immigrants per year on average in the 1930s, and the numbers decreased even further during the World War II, to a low of 7.5 thousand immigrants in 1942.

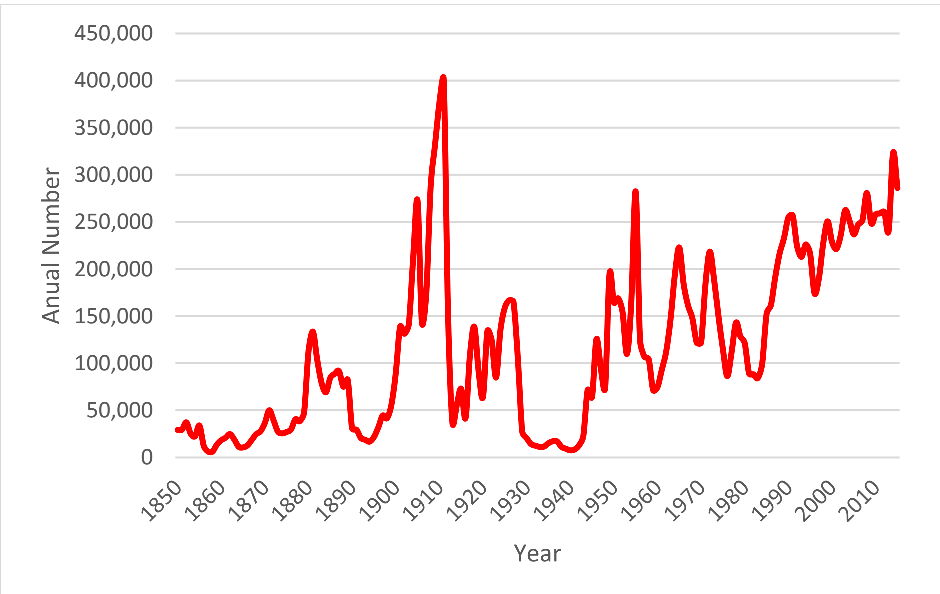

Figure 1: Number of immigrants arriving annually in Canada
Source: From 1852 to 1979: Statistics Canada (2016). From 1980 to 2017: Immigration, Refugees and Citizenship Canada (2017).

After the World War II, immigration in Canada increased steadily as the country enjoyed a high degree of political freedom and economic prosperity, compared with Europe and many other parts of the world. Availability of employment in the expanding manufacturing, resource, and construction sectors of the Canadian economy gave ample opportunities for a new wave of immigrants. The 1967 changes in immigration law, especially the elimination of national preference policies that had favoured immigration from European countries, prompted further increase in immigration as Canada began to receive new immigrants from Asia and Latin America. After 1967, equal preference was given to applications from any country. In recent years, annual immigration numbers have varied between 250-300 thousand with an annual average of 270 thousand.

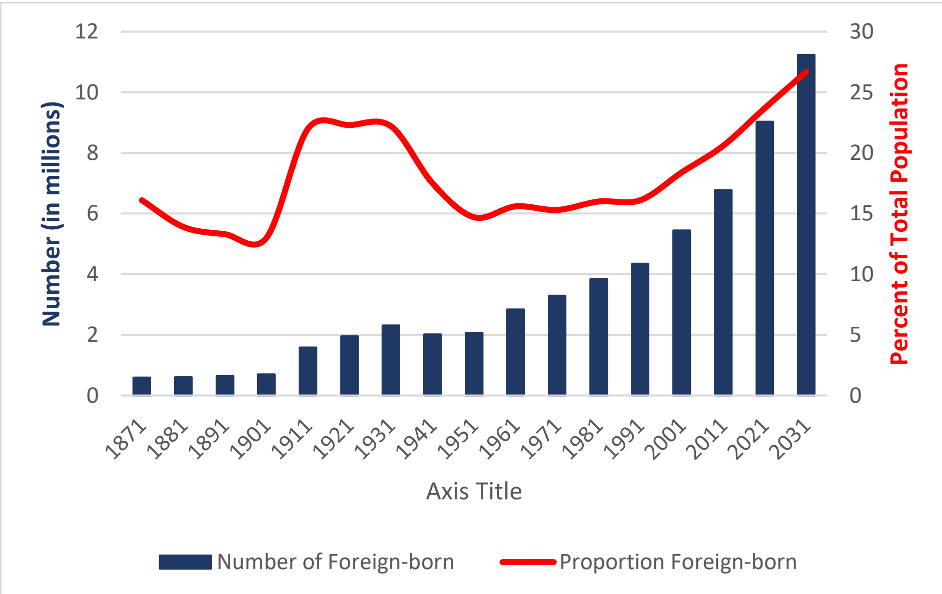

Figure 2: Number and Proportion of Foreign-born Population in Canada, 1871 to 2031
Remarks: For 1871 to 2016, enumerated population. For 2021 and 2031, projected population.
Source: Statistics Canada, Census of Population, 1871 to 2006, 2016; National Household Survey, 2011; Immigration and Diversity: Population Projections for Canada and its Regions, 2011 to 2036 (reference scenario).

In addition to immigration statistics, it is useful to examine data on the foreign-born population in Canada because some immigrants decide to leave Canada, others may move back and forth between their country of origin and Canada, and some may have died. Periodic population censuses provide a direct measure of the effect of immigration on the population growth in Canada by counting the number of foreign-born people living in the country at a specific point in time (Figure 2). The 1871 Census enumerated approximately half a million foreign-born people, representing 16 percent of the Canadian population. The foreign-born population continued to rise at the end of the 1800s, but at a slower pace than the population born in Canada. The 1901 Census recorded the lowest proportion of foreign-born population (13 per cent). After the considerable rise in immigration at the beginning of the 1900s, the 1931 Census counted nearly 2.3 million of foreign-born people, representing 22 per cent of the population of Canada. This influx of immigrants was followed by a significant drop to approximately 2.0 million in 1941 as a result of the Great Depression and World War II and also due to high out-migration from Canada. By contrast, since the 1950s, the foreign-born population in Canada has been steadily increasing. The 2016 population census enumerated the foreign-born population of 7,540,830 or 22 per cent of the total population enumerated. This was the largest proportion since the 1931 population census. By 2031, the foreign-born population in Canada is projected to increase to 11.4 million, or 27 per cent of the total population of the country.

The birthplace of newly arrived immigrants has also shifted in recent decades. The proportion of immigrants from Europe and the United States has decreased from 27 per cent in 1991 to 16 per cent in 2016. Immigrants born in the United Kingdom comprise about one-fourth of recent immigrants from Europe and the United States. The proportion of recently arrived immigrants from South Asia has steadily increased from 9 per cent in 1991 to 17 per cent in 2016. Immigrants from Asia make up the largest share of the recently arrived immigrants, with South Asians comprising 20 per cent of the recent Asian immigrants and 38 per cent of all Asian immigrants in Canada in 2016. Immigrants from the Philippines are the second largest group of recent Asian immigrants comprising 15 per cent of recent arrivals and 16 per cent of all Asian immigrants. Chinese immigrants comprise of 11 per cent of all recently arrived immigrants in 2016 and are the second largest group of Asian immigrants in Canada, comprising 34 per cent of Asian residents. Smaller proportions of Asian immigrants have arrived in recent years from Korea, Vietnam, Japan, and other countries.

Chinese Immigrants. Chinese immigrants have been arriving in Canada since the late 1870s. Until recent decades, the largest number of arrivals occurred from about 1870 to 1920, when Chinese labourers arrived for building most of British Columbia's portion of the trans-Canada railway. Independent Chinese immigration in Canada resumed after Canada eliminated ethnic-origin and the "place of origin" rules from its immigration policy in 1967. From 1947 to the early 1970s, Chinese immigrants to Canada came mostly from Hong Kong, Taiwan, and Southeast Asia. There was an increase in Chinese immigration from Hong Kong from 1991 to 1996, with about 30 thousand Hong Kong residents migrating annually to Canada, comprising over one-half of all Hong Kong emigrants and about 20 per cent of the total number of immigrants to Canada. The great majority of these people settled in the Toronto and Vancouver areas, where there were well-established Chinese communities.

In recent decades, mainland China has overtaken Hong Kong as the largest source of Chinese immigrants. A great number of immigrants in the past have been Cantonese speakers and a disproportionate representation of Cantonese compared to other Chinese-speakers is prevalent in many Chinese communities in Canada. According to the 2016 population census, 1.4 million Chinese reside in Canada. Chinese are Canada's largest Asian ethnic group. Chinese immigrants have provided the third largest number of Canadian immigrants since 2010, averaging 30,600 immigrants per year, or 11.3 per cent of all immigrants to Canada (Immigration, Refugees, and Citizenship Canada, 2017).

South Asian Immigrants. South Asian troops from Hong Kong and the Malay States visited British Columba in 1897 on their return from London after celebrations of Queen Victoria's Diamond Jubilee in London. It is believed that they told stories to others at home about conditions in British Columbia that may have stimulated South Asian migration to Canada. By 1904, arrivals of South Asians to Vancouver began, with the first few hundred South Asian immigrants arriving from Hong Kong and other British Far Eastern settlements. From 1904 to 1908 – before Canada's immigration ban on South Asian immigration in 1908 – about 5 thousand South Asians settled in British Columbia. The majority of them were Sikh. In 1908, the federal government enacted immigration regulations that specified that immigrants had to travel to Canada with continuous-passage arrangements from their country of origin, which was not possible between India and Canada. This travel restriction ended, in practice, the immigration of South Asians to Canada in 1908. After a long period of ban on South Asian immigration to Canada after 1908, the federal government removed, partially, the continuous-passage regulation in 1951, because of the independence of India and the government perception that there should not be a total ban on South Asian immigration. The government instituted a quota system for South Asian immigration in 1951, with a modest quota of a few hundred each year. Subsequently, the Immigration Act of 1967 removed most of the racial and national restrictions from the federal immigration regulations and established a new point system for determining the eligibility for immigration. As racial and national restrictions were removed, South Asian immigration to Canada increased again and, at the same time, became much more culturally diverse. A large proportion of immigrants during the 1950s were Sikh relatives of earlier South Asian settlers, while the 1960s also saw sharp increase in immigration from other parts of India and from Pakistan. By the early 1970s, two-third of South Asian immigrant men were professionals — teachers, doctors, university professors and scientists. Canadian preference for highly skilled immigrants during the 1960s broadened the ethnic range of South Asian immigrants and decreased the proportion of Sikhs.

South Asian countries – mainly India, Pakistan, Bangladesh, and Sri Lanka – have supplied an annual average of more than 54 thousand immigrants in Canada since 2010, or around 20.1 per cent of all annual average Canadian immigrants. The migrants from the South Asian countries are the largest group of recent immigrants in Canada. In 2016, there were 1,097,000 South Asians living in Canada which is the second largest group of Asian immigrants next to China (Immigration, Refugees, and Citizenship Canada, 2017).

Filipino Immigrants. During the 1960s, Canada began to receive workers from the Philippines who were nurses or doctors, technicians, and office workers. In the late 1960s, more Filipinos came to work in the garment industry of Canada. During the 1970s, a greater proportion of Filipinos came to work in clerical, sales, and manufacturing fields. By the late 1970s, an increasing proportion of Filipinos arrived in Canada to join their relatives under the family reunification programme. Economic and political difficulties (especially following the declaration of martial law in 1972) initiated increased emigration starting in the 1970s. During the 1980s, Canada saw an influx of Filipino contract workers, many of them found work as live-in caregivers. Many of these contract workers later became landed immigrants under the conditions of Canada's Live-In Caregiver Programme. From 1990 onward, there has been a steady flow of Filipinos entering Canada as families and independents instead of being sponsored by family or being recruited as contract workers. By 1995, more than 220 thousand Filipinos had entered Canada as landed immigrants seeking better economic opportunities for their families. The majority were young adult women, relatively well educated and proficient in English. Their intended occupations were in health, manufacturing, sales, teaching and service categories. Since the 1990s, Filipinos have consistently ranked first in the "independent immigrants" category, a group based on skills and ability to contribute quickly to Canadian society and economy. According to 2016 population census, there were 652 thousand Filipinos living in Canada, and the number has been increasing rapidly in recent years. Since 2010, the Philippines has been the second largest source of immigrants to Canada (Immigration, Refugees, and Citizenship Canada, 2017).

Other Asian Immigrants. Other Asian immigrants constitutes a diverse group of immigrants from East and Southeast Asia. The main other Asian immigrants are Korean, Vietnamese, Japanese, and Thai. Koreans make up one of the largest Asian ethnic groups in Canada. Almost all Korean immigration to Canada is from the Republic of Korea (South Korea). There are less than 10 arrivals each year from People's Democratic Republic of Korea (North Korea). It was only after 1967 that the number of Koreans arriving in Canada annually numbered in the hundreds and, after 1970, in thousands. Most Korean-Canadians, including immigrants and their children, are skilled workers or professionals – doctors, professors, or engineers – or are engaged in retail businesses such as food stores, gasoline stations, restaurants, printing shops, and real-estate and insurance agencies. Most Koreans have settled in urban centres, particularly in Toronto, Vancouver, Edmonton, and Calgary. More recently, some are moving to smaller centres as economic opportunities change. Canada also receives many Korean tourists and university students. According to the 2016 population census, the population of Korean origin in Canada was 241 thousand. The population of Korean origin is concentrated in Ontario (49 per cent) and British Columbia (35 per cent), with the majority living in Toronto and Vancouver. An annual average arrival of Koreans in Canada since 2010 has been around 4,600 per year or around 1.7 per cent of all immigrants to Canadian according to official sources (Immigration, Refugees, and Citizenship Canada, 2017).

On the other hand, settlement of Vietnamese in Canada is relatively recent. It resulted from two waves of immigration in the aftermath of the Vietnam War. The first wave consisted mostly of middle-class Vietnamese who arrived in Canada after the fall of Saigon in 1975. Most of these immigrants spoke French. The second wave of immigration consisted of refugees from the former South Vietnam, seeking to escape the harsh living conditions and deteriorating human-rights situation following the reunification of North and South Vietnam after 1975. These refugees were widely referred to in the media as the "boat people." Moved by the desperate plight of the hundreds of thousands who took to high seas in makeshift boats to flee Vietnam, the Government of Canada accepted 50,000 refugees from Indochina (Vietnam, Cambodia, and Laos), and later raised the figure to 60,000. According to 2016 population census, there were 241 thousand persons of Vietnamese origin in Canada. Vietnamese-Canadians live primarily in the metropolitan areas of Toronto, Montréal, Vancouver, and Calgary and the majority are first-generation Canadians (born in Vietnam or other countries of Asia). An annual average of 2,200 Vietnamese arrived in Canada per year since 2010, or 0.8 percent of all Canadian immigrants (Immigration, Refugees, and Citizenship Canada, 2017).

The recent wave of Japanese immigration to Canada began in 1967, when immigration laws were amended, and a point system of deciding the eligibility for immigration was instituted in Canada. Many Japanese that have migrated to Canada work in business and service sectors and are skilled traders. According to the 2016 population census of Canada, there were 121 thousand Japanese-Canadians. Almost one third of the Japanese immigrants in Canada are first generation immigrants; around one-third are second generation while another one-third are third or greater generation immigrants. An average of 1,100 Japanese arrived in Canada every year since 2010, or 0.4 per cent of all Canadian immigrants (Immigration, Refugees, and Citizenship Canada, 2017).

Immigration from Thailand to Canada has continued at a slow pace since the 1950s, with a brief period of increase after the 1997 financial crisis in Thailand, which resulted in more Thais looking for work and educational opportunities overseas. In contrast to the 1960s, when only about 100 immigrants from Thailand arrived annually, Canada now receives about 500 Thai immigrants every year on average, or around 0.2 per cent of all Canadian immigrants (Immigration, Refugees, and Citizenship Canada, 2017). The majority of Thai-Canadians are well-educated professionals who have migrated to Canada for the purpose of either education or business, or marriage. Educational links between Thailand and Canada are strong, and many young Thais travel to Canada for post-secondary education and return back to Thailand after completing their studies. Those immigrants who stay permanently in Canada, generally work in professional fields such as banking, medicine, engineering, and business. Some Thai immigrants also work in the restaurant industry because Thai cuisine has become popular in Canada, particularly in the urban areas. According to the 2016 population census of Canada, more than 19 thousand people in Canada were reported to be Thai origin (Immigration, Refugees, and Citizenship Canada, 2017).

Table 1: Socioeconomic status of Asian Immigrants in Canada, 2016.

Group	Percent with University Degree or More	Mean Individual Income	Percent Professional or Managerial Occupation
Canadian-born adults	15.4	$51,100	26.6
Foreign-born Adults	30.0	$44,300	29.6
Chinese	37.4	$40,300	37.5
Filipino	32.5	$37,900	11.8
South Asian	35.9	$40,000	28.3
All Other Asian	31.4	$34,000	27.2

Source: Author's analysis based on 2016 population census data.

Table 2: Asian immigrants arriving in Canada, by age at arrival, 2006-2016.

Age at arrival (years)	Asian Immigrants					All Immigrants
	Chinese	Filipino	South Asian	Other Asian	All	
0-4	7.3	4.8	8.8	6.9	7.1	8.2
5-9	4.8	8.1	6.9	6.8	6.7	7.9
10-14	5.9	10.2	5.5	8.2	7.2	7.1
15-19	7.0	8.0	4.7	8.3	6.6	6.4
20-24	7.7	5.1	10.9	6.9	8.1	8.2
25-29	16.6	9.7	18.7	11.7	14.9	14.7
30-34	11.2	14.8	15.0	14.3	13.9	14.8
35-39	9.7	13.5	8.8	11.0	10.6	11.2
40-44	10.4	9.4	4.7	9.1	7.9	7.6
45-49	6.5	6.7	3.4	5.1	5.3	4.9
50-54	3.2	3.0	3.4	2.7	3.2	2.8
55-59	2.4	1.4	3.6	2.2	2.5	2.1
60-64	2.8	2.9	3.0	2.6	2.9	1.8
65-69	2.5	1.5	1.5	2.3	1.8	1.3
70-74	2.1	1.0	1.0	2.0	1.4	1.0
All Ages	100.0	100.0	100.0	100.0	100.0	100.0
Median	31.1	30.9	28.5	27.7	29.8	29.2

Source: Author's analysis based on 2016 population census data.

Asian immigrants differ from other Canadian residents in terms of socioeconomic status. Table 2 shows educational attainment, individual income, and occupation of Canadian-born adults compared to foreign-born adults - Chinese, Filipino, South Asian, and other Asian. Compared to Canadian-born adults, Asian immigrants have almost twice as many adults with a university degree or more and are more likely to be employed in a professional or managerial occupation. On the other hand, Asian immigrants report slightly lower individual incomes than native Canadians. The reason is that Canada's point-based preference system for immigration is biased towards better educated adults as far as immigration to Canada is concerned. The educational advantages of Asian immigrants, however, are not reflected in their individual income. Asian immigrants report slightly lower individual income than all immigrants in Canada. The income of Asian immigrants is also lower than the income of native Canadian. Picot and others (2007) have analysed reasons for relatively lower individual income of Asian immigrants in Canada. Looking at the proportion of adults with professional or managerial occupations, only Chinese immigrants in Canada report higher levels of individual income as compared to all foreign-born and Canada-born adults. Filipino immigrants in Canada report relatively lower proportion of adults with professional or managerial occupations. However, Asian immigrants are relatively well-educated and reasonably represented in professional and managerial occupations but have lower individual income than other foreign-born or Canada-born adults.

Methods

The paper focusses on the pace of advancement, how it varies for different immigrant groups, and how rates of advancement differ over time. There are four basic methodological problems that challenge the measurement of immigrant advancement, including biases that occur due to variations in: 1) initial level of attainment at the time of arrival; 2) composition of immigrant cohorts observed at different times; 3) composition of immigrant groups by age; and 4) composition of immigrant groups by age at arrival. We next describe each of these four biases.

One of the most common problems in comparing immigrant advancement is that the status attainments observed after arrival are heavily influenced by the initial level of attainment. Immigrants arrive with different skills and social capital. Immigrants who arrive as refugees are often poorly educated and have minimal occupational skills. Immigrants who arrive based on occupational skills frequently have professional degrees and several years employment experience. If immigrants are asked about their education, occupation, or income several years after arrival, refugees and skilled immigrants will differ greatly because of their initial attainment, and not primarily because of their advancement after arrival.

Consider four groups of immigrants: Group A: high initial attainment and high advancement after arrival; Group B: high initial attainment and low advancement after arrival; Group C: low initial attainment and high advancement after arrival; and Group D: low initial attainment and low advancement after arrival. If these four groups are observed several decades after arrival, group A would have very high observed attainment, groups B and C might have similar attainment, and group D would have low attainment. For Group A, we may infer substantial advancement and for Group D, we may suspect little advancement. For groups B and C, we may not be able to infer whether either or both have experienced similar advancement after arrival without evidence about their initial attainment. To make comparison about expected lifetime achievement of immigrants as the outcome variable, a summary period measure is needs to compare initial attainment and subsequent advancement over the lifetime of the immigrants.

A second problem of bias relates to the variations in the composition of immigrant cohorts observed at different times. The error of using cross-sectional data for a single period to infer lifetime advancement has long been recognised by immigration researchers (Borjas, 1985). The problem is that cross-sectional observations by age cannot be linked together as if they represent a longitudinal path of attainment. In cross-sectional observations, older immigrants may have had different attainments when they were young than younger immigrants. To observe changes in immigrant cohorts – a group of immigrants who arrived in the same time period – it is necessary to have observations at least two points in time.

Comparison of immigrant groups are affected by the age composition of the groups which is third type of bias. Differences in the age composition of immigrant groups are obvious and most multivariate analyses include immigrant age in order to take age differences into account. For a summary measure, it is equally important to adjust for age differences. The summary period measure used in this analysis is constructed in such a manner that differences in age composition do not influence the summary period measure.

Fourth, comparison of immigrants is also influenced by the variation in the age composition at the time of arrival. This leads to different durations of residence for immigrants of the same age (Lee and Edmonston, 2011). The duration effect on status attainment means that immigrant groups with longer residence have more time to advance than immigrant groups that have arrived only recently. The summary measure used in this analysis is based on standardised age composition at arrival so that it is not influenced by differences in the age composition at arrival.

Appendix A presents formal definitions and derivations of the summary period measure of lifetime advancement used in the present analysis. The measure proposed is similar to the total fertility rate, a summary period measure commonly used in demography. Appendix B describes the data and calculation of the summary period measure in detail, illustrating the calculation of summary period measure for Chinese immigrants arriving in Canada between 2006 and 2016. The key steps are as follows:

- Tabulate number of Chinese immigrants by age and age at arrival who are and who are not Canadian citizens for two successive censuses. Next, calculate the proportion who have or do not have Canadian citizenship for each census by age and age at arrival.
- For the time period between the two censuses, calculate the hazard rate of attaining Canadian citizenship for each age and age at arrival. The hazard rate is defined as the proportion of immigrants – by age and age at arrival – attaining Canadian citizenship during the period between the two censuses. The hazard rate is calculated by dividing the number who attained Canadian

citizenship during the period by the number who were not Canadian citizens in the beginning census.

- Based on the hazard rates, calculate the expected lifetime advancement for each age at arrival group. This is done by calculating the proportion of Canadian citizens observed in the first census for each age at arrival group. For immigrants arriving at age 25 to 29 years, for example, they would be 30-34 years old when observed in the first census. For this reason, a small proportion of some immigrants might already have Canadian citizenship when observed in the first census, even though new immigrants would not have Canadian citizenship at the time of initial arrival. We refer to data for the first year of observation in the census as "initial attainment". Based on the hazard rates for each age group for the age of arrival group, we calculate the advancement of attaining Canadian citizenship until an older age, which is taken to be age 75 years. The proportion attaining Canadian citizenship – for each age at arrival group – is termed "lifetime attainment". The difference between initial attainment and lifetime attainment is referred to as "lifetime advancement".
- To calculate an overall period measure, we standardise the measure using a standard age at arrival distribution. The standardisation is done by weighting the age at arrival distribution for each immigrant group for each period by the age at arrival distribution of all Asian immigrants arriving in Canada during 2006 to 2016. This means that differences in the lifetime advancement for different immigrant groups or different time periods are **not** the result in differences in the observed age or age at arrival distributions.

The standardised summary measure for immigrants complements such other methods as longitudinal studies of immigrant's achievements over time or multivariate analysis of immigrants from successive censuses or surveys. The summary period measure used in this analysis describes the experiences of a particular population over a specific period of time. It has three important advantages. First, it considers variation in age, age at arrival, and duration of residence which can distort comparison of immigrant status achievement. Second, it is calculated for specific time periods which reflect the changing social and economic conditions that immigrants experience. Third, it distinguishes separate effects of initial status attainments from subsequent advancements.

As illustrated in the analysis below, the expected lifetime achievement may vary for different time periods because the measure summarises achievements for different birth and arrival cohorts for a particular period. The social and economic conditions for immigrants may vary for different time periods, and advancement during a given period will affect the expected lifetime advancement.

There are some limitations to the summary period measure used in this analysis. First, the measure is influenced by the distribution of age at arrival. If comparison is made for periods with greatly different age at arrival distributions, it is useful to standardise the comparison with a representative distribution. For this reason, in the analysis below, comparisons are standardised for each immigrant group for each period on the age at arrival distribution for all Asian immigrants arriving during 2006-2016.

A second limitation is that the measure considers only possible positive advances in achievement. The measure is not affected by negative or reversible changes, such as decline in homeownership or income for a birth or arrival cohort from one census to the next. If negative or reversible changes need to be considered, the lifetime measure would need to be altered.

Third, the period summary measure is designed for studying initial immigrants and considers the age at arrival and duration of residence since arrival. Analysis of second-generation immigrants - sons, and daughters of immigrants, is a topic of considerable interest. The second-generation, however, has important differences from their parents. They are Canadian citizens at birth and proficient in English, French, or both. The measure proposed here can be calculated for second-generation immigrants by treating them as a single cohort arriving at birth, all with the same category of duration of residence. It is not clear, however, that this would be a useful summary measure for research on second-generation immigrant or for possible comparison to expected lifetime achievements of immigrants.

Data

We consider three broad topics for the measurement of immigrant advancement: acquisition of human capital, socioeconomic achievement, and social integration. We consider six outcome measures. For the acquisition of human capital, we include (1) knowledge of Canada's two official language, English, French, or both and (2) completion of a university degree. For socioeconomic achievements, we include (3) professional or managerial occupation, (4) above median family income; and (5) home ownership. For social integration, we include (6) Canadian citizenship.

Table 3: Details of microdata files of different population census used in the analysis.

Census Year	Total Population	Sampling Fraction	Sample Size
1986	26,100,587	2.0	500,434
1996	28,846,761	2.7	792,448
2006	31,612,897	2.7	844,476
2016	35,151,728	2.7	930,421

We analyse census microdata files of four recent Canadian censuses which are samples of individuals (Table 3). The Canadian census microdata excludes some residents, including persons living in institutional collective dwellings such as nursing homes and prisons; and persons living in non-institutional collective dwellings such as student dormitories, hotels and motels, and work camps.

The analysis is limited to foreign-born residents only who identify themselves as Chinese, Filipino, South Asian, or other Asian ethnic origins. For each of the four groups, we tabulate the number below and above the threshold level (described below) by age and duration of residence for the six outcome measures. Foreign-born residents were asked about the year in which they first obtained landed or permanent resident status. We use year of immigration to calculate the duration of residence. We calculate age at immigration, based on the person's year of birth and year of immigrant arrival.

We examine six outcome measures for the advancement of immigrant groups. The outcome measures are:

- Knowledge of official languages means whether the person can converse in English, French, or both. We code the outcome variable as either above the status threshold (the person can converse in English, French, or both) or below the threshold (the person cannot converse in either English or French).
- University degree means whether a person aged at least 15 years has completed a university (bachelor's) degree. Persons aged less than 15 years are assumed to have not completed a university degree.
- Professional or managerial occupation means a person at least 15 years of age is employed in a professional or managerial occupation. Persons below 15 years of age are assumed to be not employed in a professional or managerial occupation. Like most national statistical agencies, Statistics Canada periodically revises its occupational classifications. We code professional or managerial occupations to be as similar as possible over time, but there may be some lack of correspondence between censuses.
- Median individual income means all income received by an individual at least 15 years of age before taxes and deductions. Persons below 15 years of age are assumed to be below the median income level. We code individuals as either above or below the median income thresholds for each census year. The median individual income threshold in the current Canadian dollars is $10, 972 in 1986, $16,672 in 1996, $24,000 in 2006, and $34,000 in 2016.
- House ownership means the person owns a private dwelling if a member of the household to which the person belongs owns a dwelling even if it is not fully paid for. It does not make sense, however, to assume that all household members, including children, are homeowners if one household member (or an adult couple) is the owner. We classify a person as owning a house if the lives in a household that owns a house, and the person forms either an adult couple or is a lone parent or living alone. Otherwise, we classify the person as not owning a house. This operational definition means that all children in a household, regardless of their age, are classified as not owning a house.
- Canadian citizenship means that the person has acquired Canadian citizenship by naturalisation. Canadian citizens can have more than one citizenship, and we code immigrants (persons who were not Canadian citizens at birth) as either having or not having Canadian citizenship by naturalisation.

The Canadian census asks respondents about their ethnic origin, which refers to the ethnic or cultural origin of person's ancestors (Lee, 2011). We limit attention to persons who report a single ethnic origin. Chinese includes persons who report Chinese as their only ethnic origin. Filipino includes persons who report Filipino as their only ethnic origin. South Asian includes persons who report one of several possible single ethnic origins, including Bangladeshi, East Indian, Gujarati, Pakistani, Punjabi, Sri Lankan, Tamil, or South Asian. We include all other single origin Asian immigrants in the analysis as a comparison group.

Canada ethnic origin data are not based on birthplace. Indeed, there is considerable variation in birthplace for Asian ethnic groups. Respondents identifying themselves as Chinese in the 2016 census report their birthplace as: mainland China (68 per cent), Hong Kong (18 per cent), Taiwan (4 per cent), Southeast Asia (3 per cent), and other places (7 per cent). Filipinos are predominantly born in the Philippines (99 per cent), with only a small number born in other places. South Asians include immigrants born in many places, including India (56 per cent), Pakistan (15 per cent) Sri Lanka (10 per cent) Bangladesh (5 per cent), Eastern Africa (3 per cent), South America (3 per cent), Middle East (2 per cent), Oceania (2 per cent), Caribbean (1 per cent), United Kingdom (1 per cent), and other places (2 per cent). Finally, all other Asian immigrants are diverse in their ethnicity and country of origin with more than 90 per cent of recent arrivals from six countries (Immigration, Refugees and Citizenship Canada, 2017), including Korea (36 per cent of all other Asian Immigrants), Vietnam (32 per cent), Japan (13 per cent), Thailand (5 per cent), Indonesia (2 per cent), and Cambodia (2 per cent). Some immigrants from these countries identify themselves as Chinese, Filipino, or South Asian. They are reported in their ethnic origin categories and not as "other Asian immigrants."

Since the 1981 population census, respondents have been allowed to report more than one ethnic origin. Over time, with ethnic intermarriages, an increasing proportion of Canadians have reported multiple ethnic origins. It is difficult to interpret data for immigrants with multiple ethnic origins. We, therefore, restrict attention to single ethnic origins. This is, however, not an important restriction as most Asian immigrants report single ethnic origin. In 2016, the proportion of Asian immigrants reporting multiple origins was 2 per cent for Chinese, 3 per cent for South Asians, 4 per cent for Filipinos, and 4 per cent for Vietnamese.

There are three types of outcome variables used in the present analysis (Table 4). The first outcome variable type involves individual-level characteristics of immigrants. These characteristics are related to the early years of life. For example, an individual can report (or have reported by someone else) Canadian citizenship from the moment of birth. If a young child arrives in Canada at one year of age, for example, he may be reported in the initial census as lacking Canadian citizenship until, after several years, he possibly acquires Canadian citizenship. The second outcome variable type involve those individual characteristics which are not usually reported in the population census until early adult years. Most population census do not ask young persons about their educational attainment or occupation because they are enrolled in school and have not entered the labour force. In Canadian population census, data on educational attainment and occupation are not collected for persons below 15 years of age. For the present analysis, we impute status attainment for persons below 15 years of age as follows: 1) tabulate the study population by age and age at arrival in Canada and report all persons as below status attainment; and 2) impute the proportion of persons with above status attainment as zero. After reaching age 15 years, birth cohorts advance from an age group (10-14 years) with all persons below status to an age group (15-19 years) with status attainment based on the reported census data.

Table 4: Outcome variables used in the analysis.

Outcome variable type	Example	Variable coding	
		Aged 0 to 14 Years	Aged 15 or More Years
1. Individual level with information at birth	Citizenship	As reported for the individual	As reported for the individual
2. Individual level with no information for children or youth	Occupation	Impute below-attainment status for all individuals	As reported for the individual
3. Family-level	House ownership	Impute below-attainment status for all individuals	As reported for family if respondent is family head, partner, or living alone

Source: Author

The third outcome variable type is more complicated because some variables are based on family characteristics. One common family-based measure is house ownership. Because house ownership is measured at the family-level, all persons of the family share the same value of this measure. Having the same family-level characteristics, however, poses a problem for interpreting individual advancement over the lifetime. A lifetime variable based on family-level data, for example, may record owning a house as an infant, not owning a house as a young adult, owning a house as an older adult, and finally not owning a house as an elderly adult living with offspring. For a summary period measure of individual advancement over the lifetime, it is, therefore, necessary to recode family-level measures. For the present analysis, we recode family-based measures to below attainment for all children and youth aged 0 to 14 years. After age 15 years, we code family-based measures as observed if the respondent is the family head or partner. In other words, we adopt a coding procedure for family-based data that presumes that individuals have the family attainment characteristics only if they are the family's primary maintainer or partner of primary maintainer.

The period summary measure of expected attainment (see equation 5 in Appendix A) is weighted by the number of immigrants that arrive at each age. To consider differences in the age composition at arrival for different immigrant groups and different time periods, we standardise comparison by using the same age composition at arrival for all calculations of expected lifetime attainment.

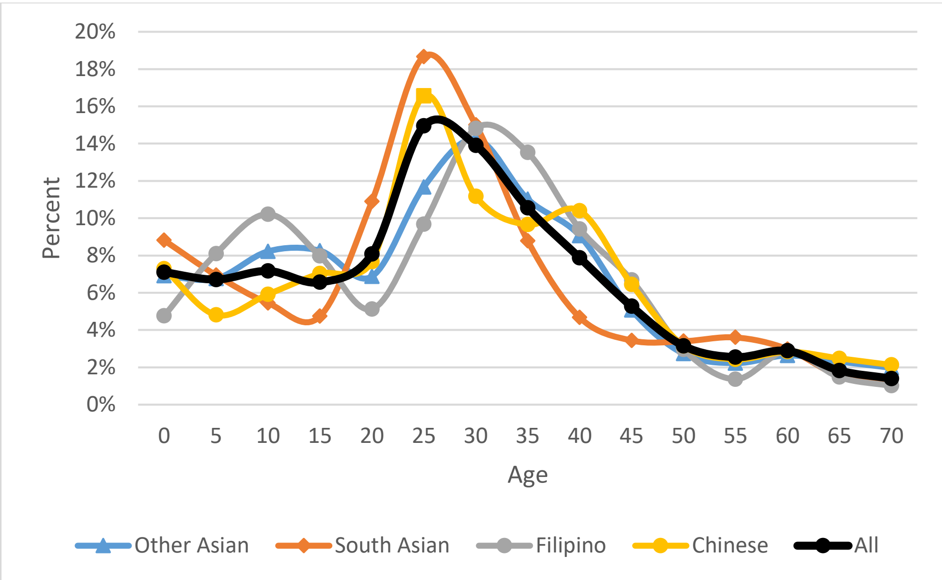

Figure 3: Age at Arrival in Canada for Asian Immigrant Groups, 2006-2016.
Source: Author

Figure 3 illustrates the age composition at arrival for four Asian immigrant groups as well as all Asian immigrants. Chinese immigrants arrive at slightly older ages and display a bimodal distribution, with peak arrivals at about age 25 years and age 40 years. Filipinos, on the other hand, have the second oldest age at arrival, with a higher proportion of adults arriving with teen-age children. South Asians have the third oldest age at arrival, with a noticeable peak for adults in their late 20s and a higher proportion arriving with relatively young children. Other Asian immigrants have the youngest age at arrival with a higher proportion of adults arriving with children and youth. The black line in Figure 3 shows the age composition for all Asian immigrants at arrival which is used for standardising the summary period outcome measures.

Results

Age at arrival effects. Figure 4 displays the lifetime advancement by age at arrival. There is striking contrast between the results for South Asians who arrived at 0-19 years of age and those who arrived at age at least 50 years. South Asian immigrants who arrived before 20 years of age have relatively high rates of initial attainment of knowing one or both official languages, with 74 per cent reporting that they knew English, French, or both at their first census, compared to 54 per cent for immigrants arriving at age 50 years or older. Initial attainment levels are based on attainment rates reported in the first census after arrival. For immigrants arriving in the five years prior to the census, they are about 2.5 years prior to first census. For immigrants arriving 5-10 years prior to the census, they are about 7.5 years prior to the first census.

Figure 4: Lifetime attainments and age at arrival.
Source: Author

Immigrants arriving at age less than 20 years generally do not have a university degree; they are not in the labour force and do not have income. They also do not own a house. Therefore, the expected lifetime initial attainment for these immigrants is mainly dependent upon lifetime advancement. This contrasts to immigrants who arrive at age 50 years or older. They have higher initial attainment on education, occupation, income, and house ownership. Based on higher rates of lifetime advancement, South Asian immigrants who arrived in their youth have higher expected lifetime attainment rates for every outcome measure, compared to immigrants who arrived at age 50 years or older. Although South Asian immigrants arriving at age 50 or older experience some advancement for citizenship and professional/managerial occupation, yet they make little advancement in house ownership, individual income, university degree, or knowledge of official language after arrival in Canada.

South Asian immigrants who arrived at age 20-49 years have higher initial attainment levels but lower rates of advancement, compared to immigrants arriving at younger ages. Overall, South Asian immigrants arriving at younger ages have modestly higher rates of expected lifetime attainment of citizenship but lower rates of expected lifetime attainment in terms of house ownership, compared to immigrants arriving at 20-49 years of age. However, the two groups are similar for other outcome measures.

Time Period Effects. Figure 5 shows the expected advancement for Chinese immigrants for three time periods, 1986-1996, 1996-2006, and 2006-2016 in terms of knowledge of official languages, university degree, and above median income. Almost 87 per cent Chinese immigrants in 1986-1996 arrived in Canada with the knowledge of either English or French or both compared to 74 per cent in the recent period. This difference is mainly a result of the place of origin of Chinese immigrants. Immigrants who arrived before the 1990s included a higher proportion from Hong Kong, where familiarity with English is more common. In all time periods, about 9 to 11 per cent Chinese immigrants advanced their lifetime knowledge of official languages. Most of the difference in expected lifetime attainment of official languages for the three time periods results from the knowledge that they reported upon their arrival in Canada.

There has been a substantial increase in the lifetime attainment of achieving a university degree for Chinese immigrants over time, with a gain from 41 per cent in 1986-1996 to 62 per cent in 1996-2006 and 68 per cent in 2006-2016. This gain occurred due to the increase in initial attainment as well as expected lifetime advancement. In 1986-1996, 25 per cent of Chinese immigrants had an initial attainment of a university degree, which increased to 34 per cent in 1996-2006 and 35 per cent in 2006-2106. The expected lifetime advancement to a university degree also increased, from a lifetime advancement of 16 per cent in 1986-1996 to 28 per cent in 1996-2006 and 2006-2016. This means that Chinese immigrants have arrived with better education. One reason is Canada's immigration point system which gives preference for educated immigrants. At the same time, the population census data suggest that Chinese immigrants in Canada appear to have increasingly pursued a university education after arrival.

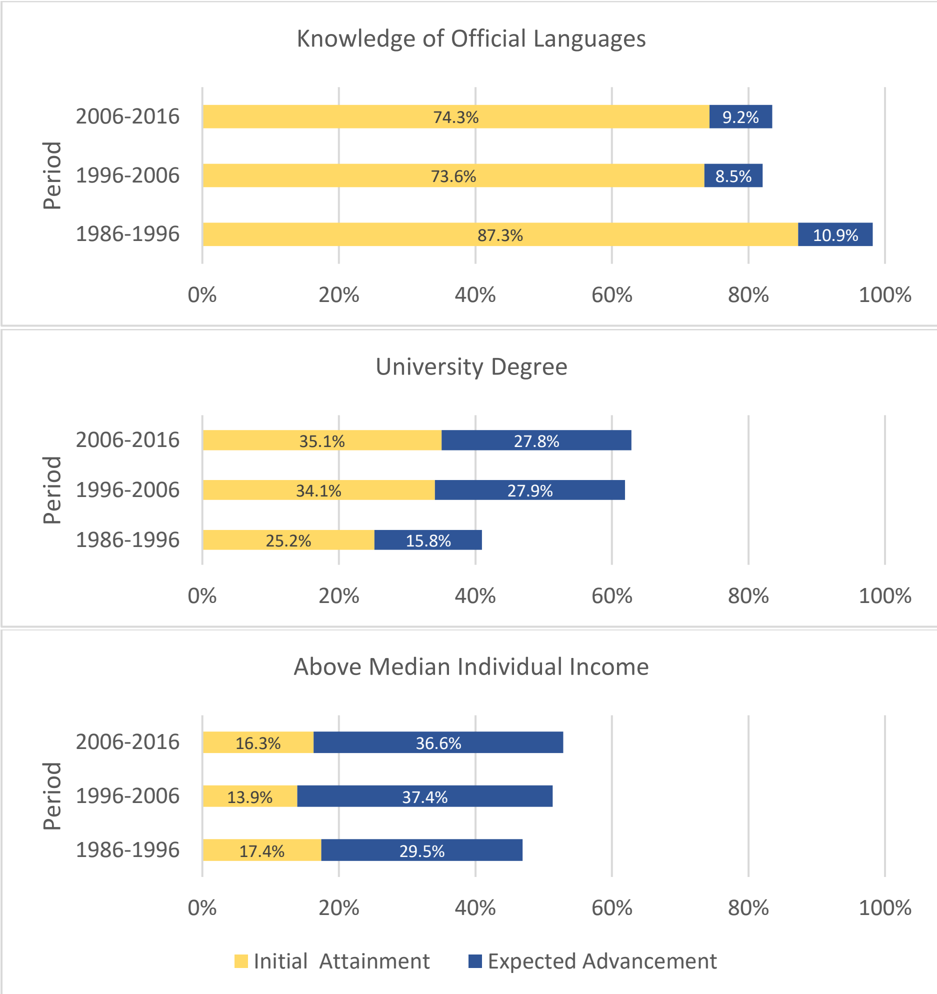

Figure 5: Period changes for expected advancement for Chinese immigrants 1986-2016
Source: Author

Chinese immigrants in recent time periods have also experienced improvement in attaining above median individual income. About 17 per cent Chinese immigrants in 1986-1996 reported an initial attainment of above median individual income, compared to 14 per cent in 1996-2006 and 16 per cent in 2006-2016. The main difference is that the two recent time periods have witnessed gains in the proportion of Chinese immigrants advancing to above median individual income, with an increase of 30 per cent in 1986-1996 and 37 per cent in both 1996-2006 and 2006-2016. As a result, more than one-half of Chinese immigrants in recent time periods have expected lifetime attainments that are above the median individual income.

Variation in Outcome Measures for Immigrant Groups. In this section, we review evidence about the expected lifetime advancement of four Asian immigrant groups for the six outcome measures. We take age at arrival into account by standardising all outcome measures for all time periods. This means that variation in outcome measures across Asian immigrant groups: 1) is not due to variation in the age composition at arrival and 2) is not due to variation in age composition at arrival in different time periods. Variation in outcome measures reflects differences in initial attainment or lifetime advancement for a particular ethnic group in a particular time period.

Figure 6 shows that the expected lifetime attainment of official languages varies across the four Asian immigrant groups. Most of the difference in lifetime attainment of official language is due to the initial attainment as 74 per cent Chinese; 83 per cent Other Asians; 87 per cent South Asians; and 93 per cent Filipinos immigrants had knowledge of official languages at initial attainment. Moreover, the expected lifetime advancement is similar and modest for all four Asian immigrant groups. All the four groups have made gains in their knowledge of official languages, but lower initial attainment of Chinese immigrants leads to expected lower lifetime attainment – given that all groups experience similar lifetime advancement.

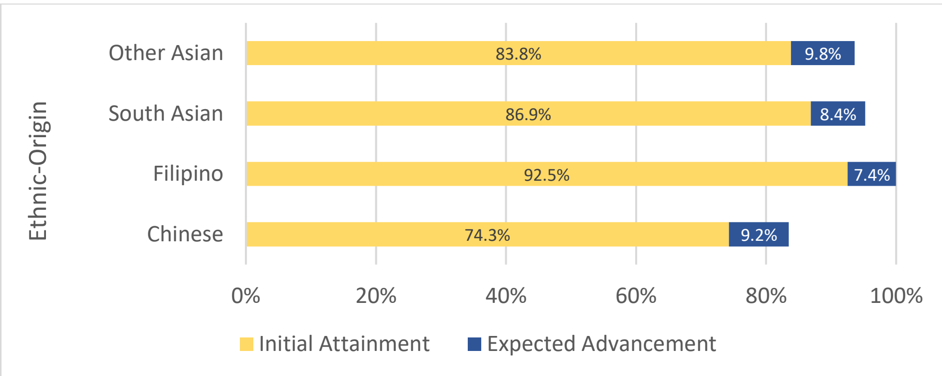

Figure 6: Initial attainment and expected lifetime advancement in knowledge of official language

Source: Author

Figure 7 shows initial attainment and expected lifetime advancement in achieving a university degree. Filipinos have lower expected lifetime attainment of a university degree compared to Chinese, Other Asians, and South Asians. The lower lifetime attainment level for Filipinos largely results from relatively low expected lifetime advancement. These are interesting differences that deserve further analysis. It would be interesting to explore further whether these differences are related to the occupations that different groups of Asian immigrants pursue. It would also be interesting to explore the differences in the educational advancement for immigrants who arrived as children compared to those who arrived as adult.

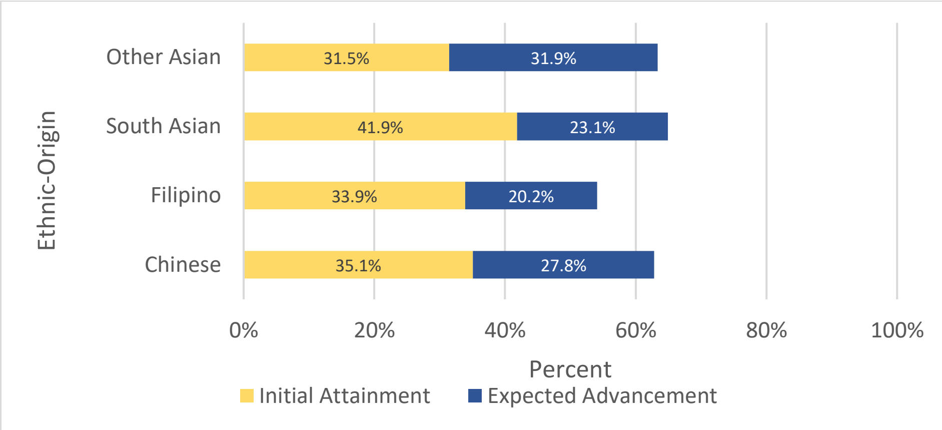

Figure 7: Initial attainment and expected lifetime advancement in achieving university degree among Asian immigrants, 2006-2016
Source: Author

Expected lifetime attainment of professional or managerial occupations has greater variation than any of the other outcome measures (Figure 8). This variation is mainly due to differences in initial attainment, but also partially influenced by differences in lifetime advancement. The lower lifetime attainment of professional or managerial occupation for Filipinos reflect the lower initial attainment and relatively low expected advancement. South Asians have relatively high lifetime advancement which helps them achieve about 20 percentage-points higher lifetime attainment than Filipinos. Chinese immigrants benefit from both higher initial attainment and high expected lifetime advancement.

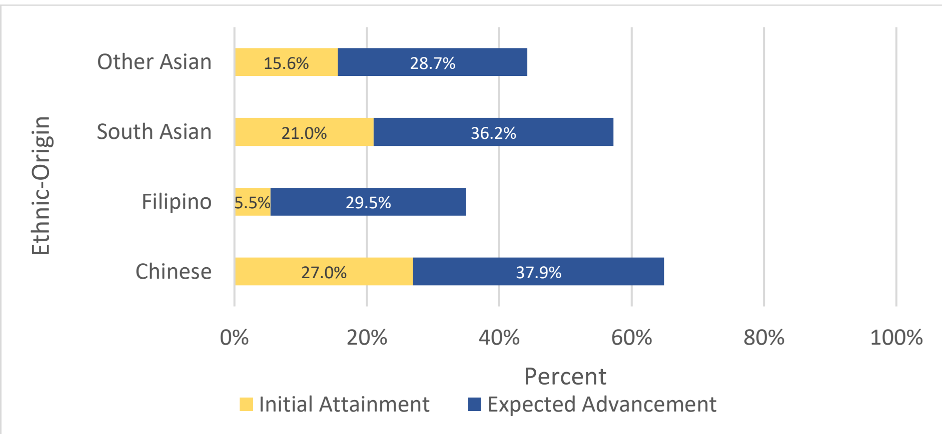

Figure 8: Initial attainment and expected lifetime advancement in achieving university degree among Asian immigrants, 2006-2016
Source: Author

Filipinos have the highest rates of expected lifetime attainment of above median individual income (Figure 9), with an expected attainment of 80 per cent above the median individual income. These results for Filipinos stem from relatively high initial attainment coupled with comparatively high expected lifetime advancement. Both initial attainment and lifetime advancement in Filipinos are much higher than for the other three Asian immigrant groups.

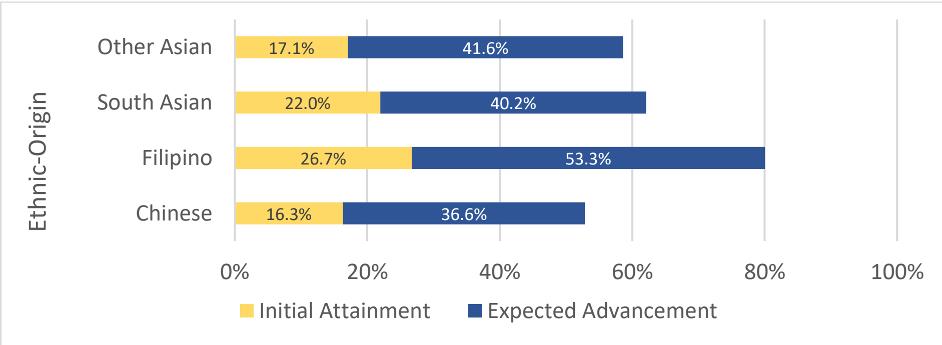

Figure 9: Initial attainment and expected lifetime advancement in median individual income among Asian immigrants, 2006-2016
Source: Author

The exceptionally high expected lifetime house ownership attainment in Chinese immigrants is primarily due to extraordinary high rates of initial attainment (Figure 10). About 55 per cent Chinese immigrants report house ownership at the first census after arrival. This suggests that many Chinese immigrants have a strong desire to buy a house, have some familiarity with the Canadian housing market, and have sufficient financial resources to purchase a house. Other Asian immigrant groups report lower initial levels of house ownership. All Asian immigrant groups have made major lifetime advancement in house ownership. Filipinos have the lowest expected lifetime attainment in house ownership.

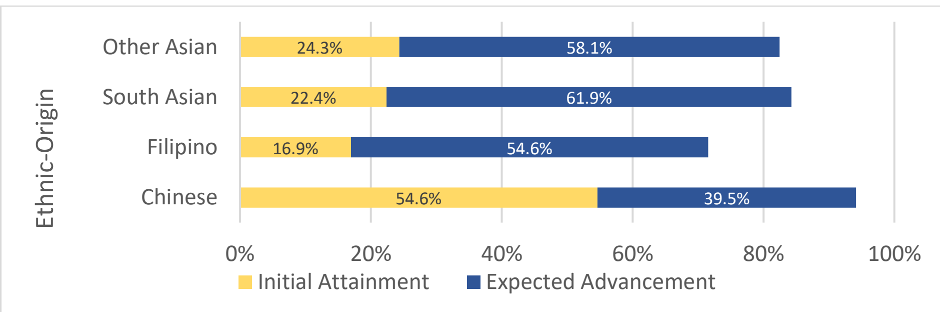

Figure 10: Initial attainment and expected lifetime advancement in house ownership among Asian immigrants, 2006-2016
Source: Author

Figure 11 shows differences in the expected lifetime attainment of citizenship. All the four Asian immigrant groups report similar initial attainment level of citizenship. Three groups (Filipinos, South Asians, and Other Asians) have expected lifetime advancement rate ranging from 87-91 per cent, resulting in lifetime attainment level of 94-98 per cent. Chinese immigrants have somewhat lower expected lifetime advancement which results in an expected lifetime attainment of 90 per cent.

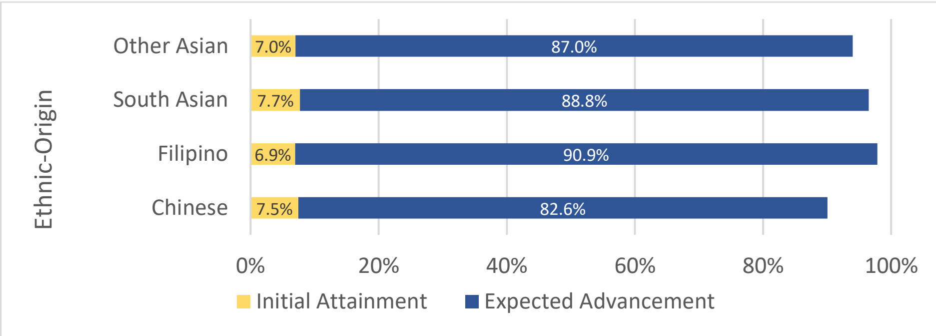

Figure 11: Initial attainment and expected lifetime advancement in house ownership among Asian immigrants, 2006-2016
Source: Author

Table 5 presents the overall summary of the analysis carried out in the present paper. The table shows the increase, decrease and no change in the expected lifetime advancement in different outcome measures considered in the present analysis. A "0" indicates the average advancement in the expected lifetime advancement; a "+" indicates the more than average advancement whereas a "-" indicates less than average advancement. The expected lifetime advancement has been average in all the six outcome measures in the South Asia immigrant group whereas volatility in the expected lifetime advancement has been the maximum in Filipino immigrants. In Chinese immigrants, expected lifetime advancement has been below average in case of the knowledge of official languages.

Table 5: Summary of expected lifetime advancement levels for Asian immigrant groups, 2006-2016

Outcome Measure	Immigrant group			
	Chinese	Filipino	South Asian	Other Asian
Know Official Languages	-	+	0	0
University Degree	0	-	0	+
Professional/Managerial Occupation	+	-	0	-
Above Median Individual Income	0	+	0	0
House ownership	+	-	0	0
Canadian citizenship	0	0	0	0

Source: Author

Discussions and Conclusions

This paper has argued that measuring the pace of immigrant advancement requires methodological improvements that deal with potential biases stemming from variation in the composition of immigrants groups by age, age at arrival, and duration of residence since arrival. We described a new summary period measure of advancement that provides useful information for comparisons of time periods, age at arrival, and immigrant groups. The new measure offers a more comprehensive indicator of the pace of immigrant advancement than other measures. Our analysis reveals that initial attainment accounts for some differences in expected lifetime attainment, especially for knowledge of official languages for all immigrant groups; house ownership for Chinese immigrants; and for professional or managerial occupations and above median individual income for Filipino immigrants. The contribution of expected lifetime advancement to lifetime attainment – the focus of the present analysis shows interesting variation for Asian immigrant groups for the six outcome measures:

- Chinese immigrants do well on entering managerial or professional occupations and house ownership but have lower advancement for learning official languages.
- Filipino immigrants are noteworthy for higher advancement for knowing official languages and above median individual income, but they have lower advancement in attaining university degree, professional or managerial occupation, and house ownership.
- South Asian immigrants have average advancement levels, compared to other Asian immigrants, on all outcome measures.
- Other Asian immigrants are noticeable for higher advancement in achieving university degree, but they have lower advancement for professional or managerial occupations.

This paper makes two theoretical contributions to previous research on immigrant advancement. First, it demonstrates the important distinction between initial attainment and lifetime advancement for several outcome measures of immigrant achievements. Previous work by Chiswick (2000) and others have emphasised the significance of immigrant selection effects, at the time of arrival, from the advances made by immigrants after arrival. Borjas (2014) has emphasised that interpreting changes in the initial attainment of immigrant-arrival cohorts is challenging. Changes in initial attainment, such as entry wages, may be due to differences in immigrant characteristics, labour force demands, or immigration selection policy. It is difficult in empirical research to measure links between types of immigration policies and the resulting skill composition of immigrants. Lifetime advancement needs to track a particular cohort across censuses or surveys, observing relative changes as the cohort ages over time and considering labour market conditions.

An alternative approach for measuring initial attainment and lifetime advancement is a double-cohort method, which nests immigrant cohorts within birth cohorts (Edmonston and Lee, 2013). The double-cohort method includes both immigrants and native population for the same time period for two or more censuses or surveys. All persons have the same period changes, so differences can be interpreted as net of period effects, with the initial attainment of immigrants on arrival compared to Canadian-born residents of the same age. Changes in the native population represent lifetime advancement and provide a reference group for comparison of changes over time for immigrants. Differences between natives and immigrants of the same birth cohort, therefore, represent changes for immigrants due to duration of residence, net of period and age effects.

Longitudinal data offers a third approach for the study of immigrant arrivals and lifetime advancement. Several types of longitudinal data are potentially useful for immigration research (Edmonston, 1996). Retrospective data can be used, either by selecting respondents and asking about changes in the past or by studying synthetic cohorts in successive censuses or surveys. Prospective data requires new data collection in which respondents are surveyed and followed regularly over time. Such surveys have been conducted in several countries, including Canada and the United States. These surveys, however, have a heavy respondent burden, are expensive, take a long time to collect data, and require several new surveys over time to have comparative immigrant arrival cohorts.

The second theoretical contribution of this paper is to confirm the importance of considering variation in age, age at arrival, and duration of residence. A fundamental problem for analysis of immigrant advancement is that groups of immigrants observed at a single point vary in their age distribution, age at arrival, and duration of residence. Because age, age and arrival, and duration of residence are potentially related to initial attainment and lifetime advancement, empirical analysis needs to take all three demographic factors into account and make assumption to permit estimation of their separate effects.

There are other statistical methods to estimate changes over time for a particular response variable, such a house ownership or wages, where we need to deal with the identification problem that there are no separately identifiable age, cohort, and time effects. For multivariate analysis, one restriction that deals with the perfect collinearity built into the age-cohort-time relationship is that period effects are the same for immigrants and natives Borjas (2014). This restriction, stated differently, is the assumption that economic or social conditions affect immigrants and natives by the same proportionate amount. The double-cohort method makes a similar assumption (Edmonston and Lee, 2013).

This paper suggests four policy implications. First, the initial attainment levels for Asian immigrants indicate that Canada’s point-based admission system has been relatively successful in selecting immigrants with higher levels of education and labour market skills. Second, although Asian immigrants with relatively high levels of educations are likely to have higher levels of professional or managerial occupations in their lifetime attainment, their individual income is not correspondingly high. This suggests that education and labour market experience by Asian immigrants may be undervalued in the Canadian context, which accords with previous studies (Lewin-Epstein, et al., 2003; Picot, et al., 2007; Wu, et al., 2018).

Third, Asian immigrants display relatively large gains in lifetime advancement for occupational status, individual income, house ownership, and citizenship. Although it is noteworthy that Asian immigrants report high levels of English or French language skills upon arrival in Canada, there is relatively small improvement in official language skills, particularly for Chinese immigrants, after arrival. Lack of official language skills hinder social integration and stymies socioeconomic advancement and is worth further study in search of possible improvements. Finally, older Asian immigrants do well in improving their occupational skills and in acquiring Canadian citizenship with the passage of time. Older arrivals, however, do not advance their educational attainment but display two indicators of policy concern: 1) little improvement in official language skills after arrival; and 2) lower than median income.

Although this paper primarily offers descriptive analysis, the findings raise questions about explanation for differences seen for the four Asian immigrant groups. First, the differences in expected lifetime attainment of knowledge of official languages is mostly due to initial attainment. Previous useful analysis of language acquisition by Canadian immigrants using 1991 census data (Chiswick and Miller, 2001) suggests that there is greater knowledge of English or French for immigrants who arrive at younger ages, who have resided longer in Canada, have higher educational attainment, are from countries closer to Canada, have mother tongue that is linguistically closer to English or French, and from a former British, French, or American colony. This suggests that it may be useful to replicate the previous Chiswick and Miller study with more recent data to examine knowledge of English or French at the time of arrival for Asian immigrant groups. Second, analysis of the initial attainment and expected lifetime advancement for a university degree reveals interested differences that need further analysis, especially in the context of how much of the overall gains for Other Asians and Chinese are possibly due to higher advancement rate of immigrants who arrived as children and youth. Third, analysis of attainment of professional or managerial occupation and attainment of median individual income reveals a peculiar situation for Filipinos that needs to be investigated further in terms of the relationship between occupation and other labour force characteristics for Filipino immigrants, compared to other Asian immigrants. Fourth, analysis of above median individual income shows that Filipino immigrants have both a relatively high initial attainment and a comparatively high expected lifetime advancement. There is a need to undercover reasons for these variations in individual income for Asian immigrants, with a focus of uncovering possible explanations for the higher levels of Filipino immigrants. Wang and Lo (2005) provide analysis for Chinese immigrants in Canada. Wu and others (2018) present a related study of income of Chinese immigrants in Canada and the United States). Fifth, although Asian immigrants are expected to achieve relatively high lifetime levels of house ownership, this paper does not analyse how Asian immigrants responded to fluctuations in housing markets in recent decades. Edmonston and Lee (2013) present a related study of homeownership trends for immigrants in Canada. An unusually high proportion of Asian immigrants live in Canada's two most expensive metropolitan areas – Toronto and Vancouver. Finally, the analysis of citizenship acquisition revealed variations for Asian immigrant groups that warrant further study. The eligibility for acquiring Canadian citizenship has changed in recent decades, and these changes may have affected the timing of acquisition of Canadian citizenship. Several conditions affect the acquisition of citizenship, including individual characteristics as well as factors at the country of origin and country of destination. Individual differences in language competence, years of residence, age, and education have been found to be important predictors (Dronkers and Vink, 2012). Factors at the country of origin affect naturalization rates. In addition, some origin countries may prohibit dual citizenship and the loss of citizenship may prohibit land ownership or restrict inheritance of property. Factors at the destination country also influence naturalization. Destination countries often institute rules for citizenship, including several years of residence; exhibiting knowledge of the official language(s); demonstrating knowledge of social, political, and economic institutions; be willing to do military service; or renouncing citizenship in other countries. Research on explanations of naturalization rates in Canada should not only consider institutional conditions but also other destination and origin country factors and individual characteristics of immigrants. Further study is needed to examine the factors affecting citizenship acquisition.

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Appendix A

A Summary Period Measure of Lifetime Advancement

This appendix describes the definition and derivation of a summary period measure that is applied to the calculation of lifetime advancement of status attainment variables for immigrants. The calculation of the new summary period measure is described below, based on the original formulation of Pitkin and Myers (2011).

For an outcome measure for attainment in a census year, we write:

$$x_{age,duration}^{year}$$

where age is a five-year age group and duration is a five-year group since arrival in Canada. If the outcome measure is Canadian citizenship, for example, then the tabulation is the number who do not have citizenship and the number that have citizenship, with both tabulations by age and duration of residence. If two censuses are 10 years apart, then the 10-year change for the outcome measure is defined for any birth-arrival cohort as:

$$\Delta age = age2 - age1$$

where *age1* is the age group in the first census and *age2* (10 years older than *age1*) is the age group in second census, and:

$$\Delta duration = duration2 - duration1$$

where, again, *duration2* is 10 years more than *duration1*.

We also define 5-year age at arrival groups for 0-4 to 70-74 years of age for analysis, *arrival*, where *arrival1* are immigrants who arrived at age 0-4 years, *arrival2* are immigrants who arrived at age 5-9 years, and incremented to *arrival15* for age 70-74 years.

We describe the cohort advancement between two censuses, *year1* and *year2*, as the difference, *change*, in the observed status attainment as:

$$change_{age1+\Delta age,duration1+\Delta duration}^{year2} = x_{age1+\Delta age,duration1+\Delta duration}^{year2} - x_{age1,duration\ 1}^{year1} \quad (1)$$

which shows the ten-year advancement of the outcome measures between *year1* and *year2* for birth and arrival cohorts in *year2* in which *age1*>0 or *duration1*>0.

We combine observed changes in attainment for different cohorts into a synthetic estimate of the expected advancement to a particular older age, called *AGE*. Such a synthetic measure – similar to the demographic calculation of the total fertility rate from an observed set of age-specific fertility rates – uses observed changes for cohorts at each age, *agei*, and observed changes by duration of residence, *durationi*, during the census period *year1* to *year2*. The observed change in attainment per person is calculated as a hazard rate for the number of persons advancing, *change*, relative to the risk population (that is, the number who have not attained the status), or

$$hazard^{year2}_{age1+\Delta age,duration1+\Delta duration} = \frac{change^{year2}_{age1+\Delta age,duration1+\Delta duration}}{1-x^{year1}_{age1,duration1}} \qquad (2)$$

Then, the total advancing to an older age, $l^{year2}_{agei\to AGE}$, is the cumulative hazard of advancing, or:

$$l^{year2}_{agei\to AGE} = 1 - \left[\left(1 - x^{year1}_{agei,0}\right) * \prod_{k=1\ to\ \frac{(AGE-agei)}{\Delta age}} \left(1 - hazard^{year2}_{agei+k\Delta age,k\Delta age}\right)\right] \quad (3)$$

for each age at arrival group, *arrivalj*. Because of smaller numbers of older immigrants and immigrants who arrived many years ago, it is reasonable to calculate a cumulative hazard up to age 75 years and to assume that the longest duration of residence is 30 years. The effect of ignoring advancement after age 75 years or after 30 years of residence is negligible.

Because some measures of advancement reach a peak before maximum age 75 years, and then decline, we define the peak advancement for each age at arrival group as L^{year2}_{agei}, at age *agei* as:

$$L^{year2}_{arrivalj} = \max(l^{year2}_{arrivlaj\to arrivalj+\Delta arrival}, \dots, l^{year2}_{arrivalj\to 75}) \qquad (4)$$

Equation (4) shows the lifetime expected advancements selected for the maximum lifetime value for each age at arrival. All ages at arrival can be combined in a summary expected value as an average weighted by the number of immigrants that arrive at each age for year *yearT*, or $n^{yearT}_{arrivalj}$:

$$\overline{L}^{yearT} = \frac{\sum_{arrivalj=0\ to\ 74} L^{year2}_{arrivalj} * n^{yearT}_{arrivalj}}{\sum_{arrivalj=0\ to\ 74} n^{yearT}_{arrivalj}} \qquad (5)$$

which offers a synthetic lifetime measure of changes for the outcome measure. In order to consider possible differences in the age at arrival composition of different periods or different immigrant groups, it is preferable to standardize comparisons by using a common age at arrival distribution. For this paper's analysis, we standardize comparisons by using the age at arrival distribution for Asian immigrants arriving in Canada during 2006 to 2016 as common distribution for all immigrant groups and time periods.

This measure combines all age groups, however, and includes immigrants who arrive at younger ages and have different experiences over their lifetimes compared to immigrants arriving at older ages (Lee and Edmonston, 2011). Immigrants arriving at ages 0 to 4 years, for example, receive all their schooling in Canada and have higher language fluency in English, French, or both than immigrants arriving at older ages. It is useful to compute expected lifetime advances for three general age groups: immigrants arriving before age 20 years, immigrants arriving as adults at ages 20 to 49 years, and immigrants arriving at ages 50 to 74 years. Other age groups could also be defined. For immigrants arriving before age 20 years, we compute:

$$\overline{L}_{<20}^{year2} = \frac{\sum_{arrivalj=0\ to\ 19} L_{arrivalj}^{year2} * n_{arrivalj}^{yearT}}{\sum_{arrivalj=0\ to\ 19} n_{arrivalj}^{yearT}} \tag{6}$$

For immigrants arriving between ages 20 to 49 years, we have:

$$\overline{L}_{20-49}^{year2} = \frac{\sum_{arrivalj=20\ to\ 49} L_{arrivalj}^{year2} * n_{arrivalj}^{yearT}}{\sum_{arrivalj=20\ to\ 49} n_{arrivalj}^{yearT}} \tag{7}$$

And for immigrants arriving between ages 50 and 74 years, we compute:

$$\overline{L}_{50-74}^{year2} = \frac{\sum_{arrivalj=50\ to\ 74} L_{arrivalj}^{year2} * n_{arrivalj}^{yearT}}{\sum_{arrivalj=50\ to\ 74} n_{arrivalj}^{yearT}} \tag{8}$$

Appendix B

Calculation of Lifetime Advancement

This appendix describes the tabulation of census data on attainment thresholds and the calculation of lifetime advancement and attainment. Tabulations and calculations are illustrated for Chinese-origin immigrants for Canadian citizenship attainment between the censuses of 2006 and 2016. The appendix includes three tables. Table B.1 displays the share of the Chinese immigrants at or above the attainment threshold – meaning that they have become Canadian citizens – by age and time of entry to Canada for 2006 and 2016. Table B.2 organizes the tabulations to show the proportion of immigrant cohorts, by age at the end of decade and age at arrival, that have attained Canadian citizenship at the beginning and end of the 2006-2016 decade. Finally, Table B.3 presents (a) the calculation of hazard rates for changes in the attainment of Canadian citizenship for arrival cohorts by age; (b) shows the initial attainment, expected lifetime attainment, and expected lifetime advancement for arrival cohorts; (c) notes the standard distribution of immigrants arrivals by age based on 2006 to 2016 data on age at arrivals for all Asian immigrants to Canada; and (d) shows summary results for initial attainment, expected lifetime attainment, and expected lifetime advancement for all ages and for three selected age at arrival groups.

The data required for the calculation of initial attainment, expected lifetime attainment, and expected lifetime advancement are tabulations of an immigrant group at the beginning and end of a decade. For Chinese immigrants advancing to Canadian citizenship during 2006 to 2016, we tabulate foreign-born Chinese, by age and time of entry, using Canadian microdata census samples for 2006 and 2016. Two tabulations by age and time of entry are required for 2006 and another two for 2016: one for individuals who do not have Canadian citizenship and another for individuals who report having Canadian citizenship. Population censuses vary in the type of questions asked of foreign-born residents. If a census does not ask "when did you arrive", the census may ask "how long have you lived here since arriving as an immigrant" or "how old were you when you arrived" that can be used to calculate the time of entry.

The first calculation made from the tabulated data are the shares of the immigrant group that are at or above the attainment threshold for the two censuses. In this case, we calculate the proportion who are report that they are Canadian citizens by age and time of entry for 2006 and 2016 (see Table B.1). As expected, immigrants report lower levels of Canadian citizenship soon after arrival and higher levels of Canadian citizenship with longer residence in Canada.

An intermediate step is needed to calculate the number of immigrants who have attained Canadian citizenship by age and age at arrival, based on their age at the end of the decade (see Table B.2). There is a peculiar feature in the top panel of Table B.2 for 2006: individuals aged 0 to 9 years at the end of the decade were not yet born at the beginning of the decade. Children less than 10 years of age, however, do arrive during the decade and are observed in the 2016 census.

For status attainment during a decade, a distinction needs to be made for whether individuals arrived in the first half or second half of the decade. Immigrants who arrived in the first half of the decade (years ending in 6, 7, 8, 9, or 0 for these census data) are observed for more than 5 years after arrival. Immigrants who arrived in the second half of the decade (years ending in 1, 2, 3, 4, 5), on the other hand are observed for no more than 5 years. To make comparable estimates for the "first-half" and "second-half" immigrant arrivals, five-year advances for the first-half arrivals need to be estimated. Following Pitkin and Myers (2011: footnote 25), a synthesized estimate of the five-year advance for the first-half arrivals can be made from the difference between the end-of-decade attainment at the first observed age and the mid-decade attainment at the reported age at arrival.

Based on Table B.1 and B.2, we can calculate the summary period measures in several steps shown in Table B.3. In panel A of Table B.3, we calculate the proportional decrease in the hazard of non-attainment for the 10-year advance between 2006 and 2016, underlining cohorts who arrived in the first half of the decade so that we make separate calculations for the first half and second-half cohorts. Next, in panel B of Table B.3, we calculate the expected lifetime attainment at age 75 years based on the cumulative proportional decreases in the hazard of non-attainment, separately for the first half, and second half cohorts. The two estimates are combined into a single mean estimate for lifetime attainment to age 75 years.

Panel C of Table B.3 displays the initial attainment and expected lifetime attainment for age-at-arrival cohorts. Estimates of expected lifetime advancement are calculated as the difference between expected lifetime attainment and initial attainment.

In order to obtain comparable weighted estimates for different immigrant groups and different time periods, the observed age-at-arrival data are weighted by the age-at-arrival distribution for Asian immigrants arriving in Canada during 2006 to 2016, shown in panel D of Table B.3.

Panel E of Table B.3 shows weighted estimates for initial attainment, expected lifetime advancement, and expected lifetime attainment for all ages as well as ages less than 20 years, 20 to 49 years, and 50 years and older.

Table B1: Share of the Chinese immigrants at or above the attainment threshold for Canadian citizenship, by age and year of entry in Canada, 2006 and 2016.

Age (Years)	Time of entry in Canada							
	Less than 5 years ago	5 to 9 years ago	10 to 14 years ago	15 to 19 years ago	20 to 24 years ago	25 to 29 years ago	30 to 39 years ago	40 or more years ago
	2006							
<5	0.0859							
5-9	0.1498	0.7782						
10-14	0.0569	0.7968	0.9253					
15-19	0.0873	0.8062	0.9303	0.9459				
20-24	0.0727	0.8173	0.9595	0.9751	0.9999			
25-29	0.0640	0.7979	0.9605	0.9781	0.9900	0.9999		
30-34	0.0991	0.7523	0.9262	0.9780	0.9836	0.9843	0.9999	
35-39	0.0626	0.7995	0.9394	0.9727	0.9781	0.9774	0.9999	
40-44	0.0690	0.7401	0.9439	0.9454	0.9774	0.9747	0.9762	0.9999
45-49	0.0733	0.7371	0.9091	0.9442	0.9635	0.9891	0.9868	0.9999
50-54	0.1284	0.7341	0.9178	0.9734	0.9717	0.9875	0.9715	0.9048
55-59	0.1324	0.6194	0.9045	0.9650	0.9632	0.9803	0.9789	0.9999
60-64	0.0541	0.7108	0.8919	0.9481	0.9481	0.9929	0.9856	0.9999
65-69	0.0633	0.7711	0.9358	0.9921	0.9846	0.9888	0.9827	0.9999
70-74	0.0635	0.6447	0.9187	0.9612	0.9886	0.9899	0.9918	0.9999

Age (Years)	Time of entry in Canada									
	Less than 5 years ago	5 to 9 years ago	10 to 14 years ago	15 to 19 years ago	20 to 24 years ago	25 to 29 years ago	30 to 39 years ago	40 or more years ago		
	2016									
<5	0.0435									
5-9	0.1881	0.7440								
10-14	0.0979	0.6652	0.8982							
15-19	0.0921	0.6103	0.8667	0.9552						
20-24	0.0872	0.7178	0.8472	0.9760	0.9655					
25-29	0.0481	0.6599	0.9083	0.9668	0.9548	0.9605				
30-34	0.0643	0.5726	0.8690	0.9462	0.9917	0.9893	0.9999			
35-39	0.0872	0.5301	0.8115	0.9221	0.9786	0.9781	0.9999	0.8261		
40-44	0.0784	0.5025	0.8246	0.9333	0.9424	0.9660	0.9999	0.9885	0.9999	
45-49	0.0714	0.4686	0.7717	0.9504	0.9317	0.9528	0.9779	0.9900	0.9518	
50-54	0.0428	0.3278	0.6998	0.9124	0.9531	0.9763	0.9507	0.9912	0.9911	0.9999
55-59	0.0704	0.3333	0.6447	0.9036	0.9575	0.9564	0.9781	0.9679	0.9718	0.8889
60-64	0.0331	0.4639	0.6944	0.9327	0.9544	0.9688	0.9821	0.9956	0.9680	0.9999
65-69	0.0049	0.5079	0.6860	0.9180	0.9431	0.9554	0.9809	0.9749	0.9837	0.9821
70-74	0.0054	0.2239	0.5303	0.8286	0.9388	0.9680	0.9487	0.9740	0.9792	0.9667

Table B2: Proportion of Chinese immigrant cohorts, by age at the end of the decade (2016) and age at arrival who have attained Canadian citizenship at the beginning (2006) and at the end (2016)

Age in 2016 (Years)	Age at arrival (Years)												
	<5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
							2006						
<5													
5-9													
10-14	0.0859												
15-19	0.7782	0.1498											
20-24	0.9253	0.7968	0.0569										
25-29	0.9459	0.9303	0.8062	0.0873									
30-34	0.9999	0.9751	0.9595	0.8173	0.0727								
35-39	0.9999	0.9900	0.9781	0.9605	0.7979	0.0640							
40-44	0.9999	0.9843	0.9836	0.9780	0.9262	0.7523	0.0991						
45-49	0.9999	0.9999	0.9774	0.9781	0.9727	0.9394	0.7995	0.0626					
50-54	0.9999	0.9762	0.9762	0.9747	0.9774	0.9454	0.9439	0.7401	0.0690				
55-59	0.9999	0.9999	0.9868	0.9868	0.9891	0.9635	0.9442	0.9091	0.7371	0.0733			
60-64	0.9048	0.9048	0.9048	0.9715	0.9715	0.9875	0.9717	0.9734	0.9178	0.7341	0.1284		
65-69	0.9999	0.9999	0.9999	0.9999	0.9789	0.9789	0.9803	0.9632	0.9650	0.9045	0.6194	0.1324	
70-74	0.9999	0.9999	0.9999	0.9999	0.9999	0.9856	0.9856	0.9929	0.9481	0.9481	0.8919	0.7108	0.0541

Age in 2016 (Years)	Age at arrival (Years)												
	<5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
							2016						
<5													
5-9	0.7440	0.1881											
10-14	0.8982	0.6652	0.0979										
15-19	0.9552	0.8667	0.6103	0.0921									
20-24	0.9655	0.9760	0.8472	0.7178	0.0872								
25-29	0.9605	0.9548	0.9668	0.9083	0.6599	0.0481							
30-34	0.9999	0.9893	0.9917	0.9462	0.8690	0.5726	0.0643						
35-39	0.8261	0.9999	0.9781	0.9786	0.9221	0.8115	0.5301	0.0872					
40-44	0.9999	0.9885	0.9999	0.9660	0.9424	0.9333	0.8246	0.5025	0.0784				
45-49	0.9518	0.9518	0.9900	0.9779	0.9528	0.9317	0.9504	0.7717	0.4686	0.0714			
50-54	0.9999	0.9911	0.9911	0.9912	0.9507	0.9763	0.9531	0.9124	0.6998	0.3278	0.0428		
55-59	0.8889	0.8889	0.9718	0.9718	0.9679	0.9781	0.9564	0.9575	0.9036	0.6447	0.3333	0.0704	
60-64	0.9999	0.9999	0.9999	0.9680	0.9680	0.9956	0.9821	0.9688	0.9544	0.9327	0.6944	0.4639	0.0331
65-69	0.9821	0.9821	0.9821	0.9821	0.9837	0.9837	0.9749	0.9809	0.9554	0.9431	0.9180	0.6860	0.5079
70-74	0.9667	0.9667	0.9667	0.9667	0.9667	0.9792	0.9792	0.9740	0.9487	0.9680	0.9388	0.8286	0.5303

Table B3: Increase in synthetic immigrant cohort in the share of attainment of Canadian citizenship up to age 75 years for 2006-2016. (Cohorts arriving in the first half of the decade are underlined. Separate calculations are made for the first half and the second half of the decade as described in the text)

Age in 2006 (Years)	Age at arrival (in years)												
	<5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
	A. Proportional decrease in the hazard of non-attainment for the 10 years advance between 2006 and 2016												
10-14	0.8982												
15-19	0.7981	0.8432											
20-24	0.5385	0.8820	0.8380										
25-29	0.2697	0.3508	0.8286	0.8995									
30-34	0.0000	0.5704	0.7951	0.7054	0.8588								
35-39	0.0000	0.9900	0.0033	0.4592	0.6144	0.7986							
40-44	0.0000	0.2701	0.9939	0.0000	0.2193	0.7308	0.8054						
45-49	0.0000	0.0000	0.5567	0.0000	0.0000	0.0000	0.7528	0.7565					
50-54	0.0000	0.6250	0.6250	0.6496	0.0000	0.5654	0.1643	0.6629	0.6776				
55-59	0.0000	0.0000	0.0000	0.0000	0.0000	0.4000	0.2189	0.5329	0.6333	0.6166			
60-64	0.9990	0.9990	0.9990	0.0000	0.0000	0.6507	0.3662	0.0000	0.4458	0.7470	0.6494		
65-69	0.0000	0.0000	0.0000	0.0000	0.2288	0.2288	0.0000	0.4803	0.0000	0.4039	0.7846	0.6382	
70-74	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0128	0.3840	0.4337	0.4071	0.5035

Age at arrival (in years)												
<5	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64
B. Advancement to age 75 years based on cumulative proportional decrease in hazard of non-attainment												
Maximum in the 1st half of the decade												
1.0000	0.9990	1.0000	0.9456	0.8898	0.9068	0.8969	0.9409	0.8236	0.8153	0.8015	0.7118	0.5035
Maximum in the 2nd half of the decade												
0.9648	1.0000	0.9646	0.9616	0.8751	0.9802	0.8935	0.8070	0.7795	0.8840	0.8731	0.6221	
Mean of the maximum of the two halves of the decade												
0.9824	0.9995	0.9823	0.9536	0.8824	0.9435	0.8952	0.8739	0.8016	0.8497	0.8373	0.6669	0.5035
C. Initial attainment and expected lifetime attainment, as proportion of immigrant cohort, at age of arrival observed in 2006												
Initial attainment												
0.0000	0.1881	0.0979	0.0921	0.0872	0.0481	0.0643	0.0872	0.0784	0.0714	0.0428	0.0704	0.0331
Expected lifetime attainment												
0.9824	0.9996	0.9840	0.9579	0.8927	0.9462	0.9019	0.8849	0.8171	0.8604	0.8442	0.6904	0.5199
Exp. Lifetime Advancement												
0.9824	0.8115	0.8861	0.8658	0.8055	0.8981	0.8377	0.7977	0.7388	0.7890	0.8015	0.6200	0.4868
D. Standard distribution of age (proportion) at arrival (Asian immigrants arriving in Canada during 2006 to 2016)												
0.0727	0.0686	0.0734	0.0677	0.0825	0.1531	0.1419	0.1081	0.0805	0.0636	0.0318	0.0260	0.0301

E. Summary results (Panel C weighted by Panel D)

Age at Arrival (in years)			
All Ages	Arrive less than Age 20	Arrive at Age 20 to 49	Arrive at Age 50 or older
Initial attainment			
0.0745	0.0933	0.0698	0.0476
Expected lifetime advancement			
0.8262	0.8879	0.8243	0.6406
Expected lifetime attainment			
0.9007	0.9811	0.8941	0.6882

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A Non-parametric Approach to Small Area Estimation with Application to Madhya Pradesh, India

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Abstract

This paper proposes a simple approach to extrapolate demographic indicators at the local level to a recent date for which estimate of the demographic indicator is available at the aggregate level through the application of data mining technique. The approach has been applied to estimate the probability of death in the first five years of life in the districts of Madhya Pradesh, India for the year 2017 corresponding to the estimate of under-five mortality rate for Madhya Pradesh for the year 2017 available through India's official sample registration system.

Introduction

There is a long-standing demand for district level estimates of key demographic indicators to facilitate decentralised district development planning in India. There is, however, little progress in this direction. Estimates of key demographic indicators in India are not available below the district level on a regular basis. The registration of births and deaths in India is compulsory under the Registration of Birth and Death Act of 1969 (Government of India, 1969), but birth and death registration in the country is not satisfactory to provide reliable estimates of key demographic indicators at the district level. To improve the civil registration system, the sample registration system was launched in 1965-65 and introduced throughout the country in 1969-70 (Padmanabha, 1982). However, the system hardly contributed to improving the civil registration data and remained confined to providing estimates of selected demographic indicators at national and state levels only. There has been little attempt to extend and expand the system so that it can provide estimates of selected demographic indicators at the district level. It continues to remain a stand-alone system with little linkages with the civil registration system.

In 1992, the Government of India launched the National Family Health Survey Programme to obtain information on selected aspects of health and family welfare situation in the country. The first three rounds of the National Family Health Survey, carried out in 1992-93; 1998-99; and 2005-06, provided only national and state level information about the health and family welfare situation including estimates of some demographic indicators. Since the fourth round (2015-16), the survey has provided information related to health and family welfare situation at the district level also (Government of India, 2017). However, estimation of key demographic indicators at the district level could not be possible because of the small size of the sample of households surveyed at the district level, although there have been attempts to estimate demographic indicators at the district level from the data available through the survey.

The Government of India had also launched the district level rapid household survey under the Reproductive and Child Health Programme (Government of India, 2010). This survey could also not provide district level estimates of demographic indicators because of the very small size of the sample at the district level. This survey has now been discontinued. Another initiative taken by the Government of India to generate estimates of demographic indicators at the district level was the Annual Health Survey which was launched in 2010. This survey, however, was confined to selected states only, known as the Empowered Action Group (EAG) states, and was discontinued in 2013 (Rathi et al, 2018).

Given the weakness of the civil registration system and the limitations of the sample registration system and the National Family Health Survey, the only source for estimating demographic indicators below the state level in India is the decennial population census. The summary birth history data (SBH) collected during the decennial population census have been used to estimate selected indicators of fertility and mortality at the district level using indirect techniques of demographic estimation (Ahuja, no date; Bhat, 1996; Guilmoto and Rajan, 2001; 2002; 2013; Government of India, 1988; Government of India, 1989; Government of India, 1997; Kumar and Sathyanarayana, 2012; Rajan and Mohanchandran, 1998; Sharma and Choudhury, 2014). However, a major limitation in the use of census data in estimating demographic indicators at the district level is that these estimates are available at an interval of 10 years only.

The problem of estimating demographic indicators at the district level in India may be viewed as a problem of small area estimation. Small area estimation is related to estimating parameters of a sub-group of the population – a district is a sub-group of the state or the country. Different approaches have been suggested for small area estimation. These approaches can be divided into three categories: 1) direct survey-based estimation approach; 2) small area estimation using auxiliary information; and 3) small area estimation using regression-based models (Asian Development Bank, 2020). The direct survey-based estimation requires selecting a in each sub-population which is large enough to provide statistically reliable estimate of demographic indicators. The sample size requirement, in this approach, increases parabolically when estimates need to be disaggregated by gender, residence, social class, and other characteristics of the population. The small area estimation using auxiliary information, on the other hand, includes broad area ratio estimation and synthetic estimation. Broad area ratio estimation is one of the simplest and most straightforward method of small area estimation. This approach uses direct estimate of the variable of interest for the population and the proportionate distribution of the population across sub-group which can be obtained from the population census (Australian Bureau of Statistics, 2006). Synthetic estimation procedure uses estimate of the variable of interest at some higher level of aggregation and the variable of interest for different sub-groups of the population and then scales these estimates in proportion to the variation across sub-groups within the sub-population of interest. These estimates are not obtained directly from survey and hence are referred to as synthetic estimates (Purcell and Kish, 1979). Finally, regression-based models, include regression-synthetic, empirical best linear unbiased prediction (EBLUP), empirical Bayes, and the hierarchical Bayes techniques and approach suggested by Elbers et al (2003). This approach includes an error structure component that allows measurement of local variation among small areas. This approach can generate efficient estimates. The regression-based approach has become popular because it can handle complex cases such as cross-sectional and time-series data. Moreover, unlike synthetic and composite methods, estimates obtained through regression-based approach measures variability.

In this paper, we propose a non-parametric approach to estimate district level demographic indicators and apply the approach to estimate the probability of death in the first five-years of life in districts of Madhya Pradesh, India. The approach is based on the district level estimates of the probability of death in the first five years of life estimated from the summary birth history data from the decennial population census and the latest estimate of the probability of death in the first five years of life for Madhya Pradesh obtained from the official sample registration system of India. The approach is based on the assumption that the variation in demographic indicators across different mutually exclusive yet exhaustive population subgroups either at the aggregate level or at the lower level remains largely unchanged in the immediate future so that any change in the demographic indicator at the aggregate (state) level leads to corresponding change in the demographic indicator at the local (district) level. The approach, essentially, establishes the pattern of variation in the demographic indicator across districts within the state and across different population sub-groups within the district and assumes that this pattern remains largely unchanged during the inter-census period.

The paper is organised as follows. The next section of the paper describes the proposed method. The third section of the paper presents estimates of the probability of death in the first five years of life (${}_5q_0$) for 12 mutually exclusive yet exhaustive population sub-groups in each district of Madhya Pradesh, India as derived from the data on children ever born and children surviving available through the 2011 population census using the indirect technique of child mortality estimation. These estimates have been used to establish the pattern of variation in ${}_5q_0$ across districts in the state and across 12 mutually exclusive yet exhaustive population sub-groups within each district. The fourth section of the paper uses the pattern of variation in ${}_5q_0$ so established to estimate ${}_5q_0$ for the districts of the state for the year 2018 corresponding to the estimate of ${}_5q_0$ for Madhya Pradesh available through the sample registration system. The last section of the paper discusses the usefulness of the method proposed for estimating demographic indicators at the local level based on the estimate of the indicator available at the aggregate level.

The Method

Suppose that the population of an administrative area (state in the present case), is divided into r sub-administrative areas (district in the present case) and the population in each district is divided into c mutually exclusive, yet exhaustive population sub-groups so that the entire population of the administrative area is divided into $k=r*c$ mutually exclusive and exhaustive population sub-groups. Suppose also that the estimate of a given demographic indicator of interest, d, is available for each of the k mutually exclusive and exhaustive population sub-groups which can be organised in a matrix or a two-way table comprising of r rows (districts) and c columns so that d_{ij} represents the estimate of the indicator for the j^{th} population sub-group of district i. This matrix or two-way table reflects the pattern of variation in the demographic indicator of interest across mutually exclusive and exhaustive population sub-groups.

The two-way table so constructed can be decomposed in absolute terms (additive decomposition) or in relative terms (multiplicative decomposition). In absolute terms, the value of the demographic indicator in sub-group j of the district i may be decomposed as

$$d_{ij} = \mu + x_i + y_j + r_{ij} \text{ for all } i \text{ and } j. \quad (1)$$

where x_i denotes the row or district effect, y_j denotes the column or population sub-group effect, r_{ij} is the residual term and μ is the mean of d_{ij} over all i and j.

On the other hand, in relative terms, d_{ij} can be decomposed as

$$d_{ij} = \eta * \alpha_i * \beta_j * \nu_{ij} \text{ for all } i \text{ and } j. \quad (2)$$

where α_i is the row or district multiplier, β_j is the column or population subgroup multiplier, ν_{ij} is the residuals multiplier and η is the geometric mean of d_{ij} over all i and j.

It may be noticed that multiplicative decomposition can be transformed into the additive decomposition through logarithmic transformation

$$\ln(d_{ij}) = \ln(\eta)+\ln(\alpha_i) +\ln(\beta_j) +\ln(\nu_{ij}) \text{ for all } i \text{ and } j. \quad (3)$$

The additive decomposition can be carried out through data mining techniques such as mean polish (Selvin, 2004) or median polish (Tukey, 1977) for examining the contribution of different factors in a multifactor model. The advantage of mean or median polish technique is that these techniques make no assumption about the underlying distribution of the data. The technique remains effective even when the data are rates or counts or any other data classified in a two-way table. Since the interest in the present paper is in finding the sub-administrative area (district) and population sub-group effects of the variation in the demographic indicator, the arithmetic mean is preferred over the median for polishing as arithmetic mean is based on all values in the distribution whereas median is based on the middle values of the distribution only. Moreover, since the population composition is not the same across the sub-administrative areas (districts) and across different population sub-groups within the same sub-administrative area, weighted mean should be used in place of simple mean to establish the underlying patterns of variation in the demographic indicator so that estimates of the demographic indicator for different population sub-groups add up to the estimate of the demographic indicator for the whole population (Chaurasia, 2013).

If it is assumed that the row effect, column effect and the residual effect of the decomposition remain unchanged over time, then a change in the grand mean μ or the aggregate (state) level value of the demographic indicator leads to a new value of d_{ij} for all values of i and j. In other words, if the aggregate level estimate of the demographic indicator changes from μ_1 to μ_2 over time, then the new estimate of the demographic indicator, d_{ij2}, for population sub-group j of district i may be obtained as

$$d_{ij2} = \mu_2 + x_i + y_j + r_{ij} \text{ for all } i \text{ and } j \tag{4}$$

if the decomposition is additive, or

$$\ln(d_{ij2}) = \ln(\eta_2) + \ln(\alpha_i) + \ln(\beta_j) + \ln(\nu_{ij}) \text{ for all } i \text{ and } j \tag{5}$$

if the decomposition is multiplicative. Once estimates of the demographic indicator for different population sub-groups are obtained corresponding to the aggregate (state) level estimate, the estimate of the demographic indicator of interest for the district i at the recent date, d_{i2}, may be obtained as the weighted average of the estimates of the demographic indicator of interest for mutually exclusive population sub-groups within each district. In other words

$$d_{i2} = \sum_{j=1}^{c} w_{ij} * d_{ij2} \tag{6}$$

if the additive decomposition is used or

$$\ln(d_{i2}) = \sum_{j=1}^{c} w_{ij} * \ln(d_{ij2}) \tag{7}$$

if the multiplicative decomposition is used for establishing the pattern of variation in the demographic indicator across mutually exclusive yet exhaustive population sub-groups. Here, w_{ij} is the weight assigned for the population sub-group j in district i. In case of the estimation of demographic indicators, the multiplicative decomposition is preferred over the additive decomposition because the change in demographic indicators is not linear. The pace of decrease in demographic indicators slows down with the improvement in demographic indicators as all demographic indicators have an upper limit.

Under-five Mortality in Madhya Pradesh, India

We have applied the above approach to obtain estimates of the probability of death in the first five years of life ($_5q_o$) for the districts (local level) of Madhya Pradesh, India for the year 2017 which correspond to the latest estimate of $_5q_o$ for Madhya Pradesh (aggregate level) available through India's official sample registration system. According to sample registration system, $_5q_o$ in Madhya Pradesh is the highest amongst states and Union Territories of the country (Government of India, 2020). We first estimate $_5q_o$ for 12 mutually exclusive and exhaustive population subgroups as classified in table 1 for 50 districts of the state from the summary birth history data available from the 2011 population census and using the indirect technique of child mortality estimation (Moultrie et al, 2014). These estimates are presented in table 2. The table also presents district level estimates of $_5q_0$ obtained as the weighted average of $_5q_0$ for the 12 mutually exclusive population subgroups in each district. The proportionate distribution of the live births across the 12 mutually exclusive population sub-groups in each district obtained from the 2011 population census has been used as weight for calculating the district estimate of $_5q_0$. The weighted average of the district level $5q_0$, then, gives the estimate of $_5q_0$ for the whole state. According to this exercise, $_5q_0$ for Madhya Pradesh is estimated to be 0.097 around the year 2005. On the other hand, $_5q_o$ for Madhya Pradesh in 2005-06 is estimated to be 94 under five deaths for every 1000 live births based on the National Family Health Survey 2005-06 (Government of India, 2017). This shows that estimate of $_5q_0$ obtained from the summary birth history data of 2011 population census is a close approximation of the estimate of $_5q_o$ obtained from the full birth history data collected during the National Family Health Survey 2005-06.

Table 1
Mutually exclusive population sub-groups in a district

Social class	Rural		Urban	
	Male	Female	Male	Female
Scheduled Castes	*SCRM*	*SCRF*	*SCUM*	*SCUF*
Scheduled Tribes	*STRM*	*STRF*	*STUM*	*STUF*
Other Castes	*OCRM*	*OCRF*	*OCUM*	*OCUF*

Table 3 presents results of the multiplicative decomposition analysis of the variation in $_5q_0$ across 600 mutually exclusive and exhaustive population sub-groups in Madhya Pradesh (50 districts x 12 sub-groups). The table provides estimates of overall or grand mean or common multiplier, row or district multiplier, column or population sub-group multiplier and residual multiplier for each of the 600 mutually exclusive population sub-groups. Based on table 3, $_5q_0$ in any mutually exclusive population sub-group of the any district can be obtained by multiplying the grand mean or common multiplier by the row or district multiplier, column or population sub-group multiplier and the residual multiplier specific to the mutually exclusive population sub-group and the district. For example, $_5q_0$ in male Scheduled Castes children living in the rural areas of district Alirajpur of the state can be estimated as

$0.114 = (\eta = 0.097)^{*}(\alpha_i = 0.969)^{*}(\beta_j = 1.110)^{*}(\nu_{ij} = 1.091)$.

In other words, the difference in ${}_5q_0$ between district Alirajpur and Madhya Pradesh can be explained in terms of district effect or row multiplier, sub-group effect or column multiplier and the residual effect that is specific to the district and the sub-group of the population. In the same manner, the difference between the district ${}_5q_0$ and the state ${}_5q_0$ can be explained.

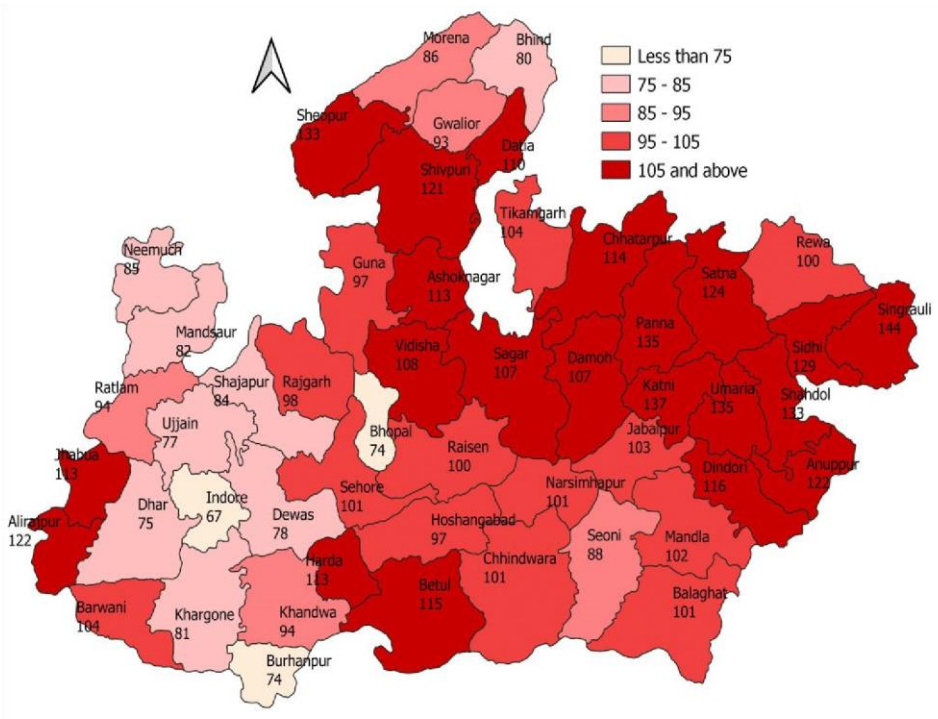

Figure 1: Estimates of 5qo for districts of Madhya Pradesh, based on SBH data from 2011 population census (Circa 2005).
Source: Author

Table 3 can be used for estimating ${}_5q_0$ for different mutually exclusive and exhaustive population sub-groups in each district at a recent date if the estimate of the grand mean or common multiplier for the recent date is known and if it is assumed that the district or row multiplier, sub-group or column multiplier and the residual multiplier remain unchanged. It may be noticed that the grand mean or the common multiplier is a close approximation of ${}_5q_0$ for the state as a whole. According to the official sample registration system of the country, ${}_5q_o$ in Madhya Pradesh was around 0.056 in the year 2017 (Government of India, *no date*). Using the ratio between the grand mean or common multiplier of table 3 and ${}_5q_0$ for Madhya Pradesh obtained from the 2011 population census, a ${}_5q_0$ of 0.056 in the state in the year 2017 is equivalent to a grand mean or common multiplier of 0.054. Replacing the grand mean or common multiplier of table 3 by 0.54 and making necessary calculations yield estimates of ${}_5q_0$ for each of the 600 mutually exclusive yet exhaustive population sub-groups in the state (12 mutually exclusive population sub-groups in each district and 50 districts in the state). These estimates are presented in table 4. These estimates are based on the assumption that the variation in ${}_5q_0$ across the 600 mutually exclusive population sub-groups in the state as revealed through the 2011 population census remains largely the same. Finally, the weighted average of ${}_5q_0$ in different mutually exclusive and exhaustive population sub-groups in a district gives the estimate of ${}_5q_0$ for the district at the recent date which correspond to the estimated of ${}_5q_0$ for the state as a whole as obtained from the sample registration system. The district level estimates of ${}_5q_0$ for the year 2017, so obtained are presented in figure 2. The ${}_5q_0$ in the state varies from 0.038 in district Indore to 0.081 in district Singrauli of the state. In 7 districts of the state, ${}_5q_0$ is estimated to be more than 0.070.

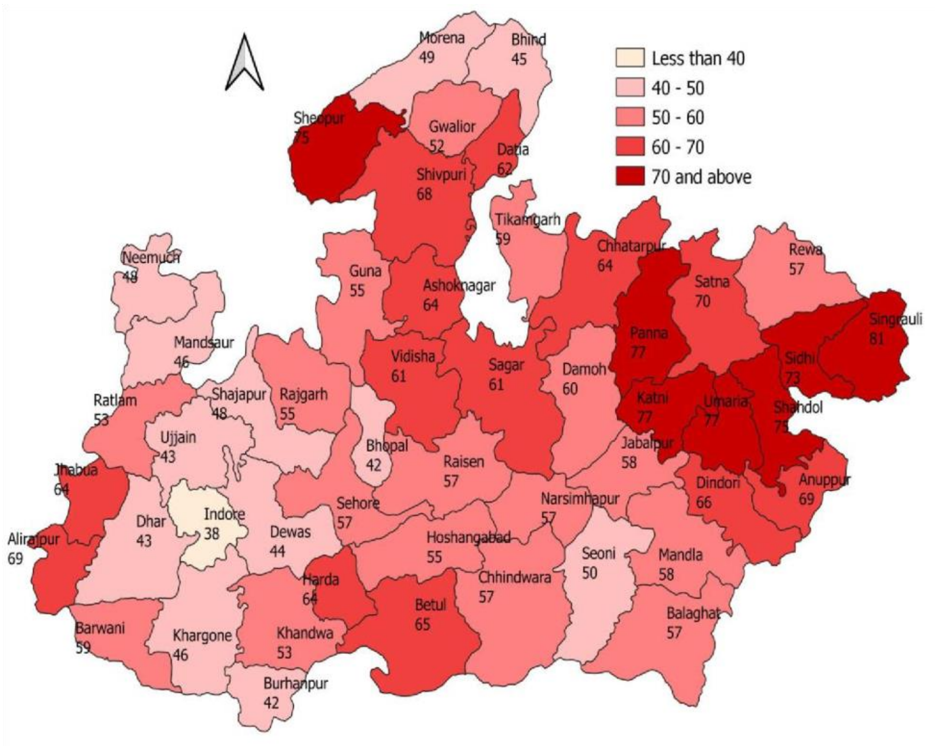

Figure 2: Estimates of 5qo in districts of Madhya Pradesh, circa 2017.
Source: Author

Table 2: Estimates of ${}_5q_0$ in different mutually exclusive and exhaustive population sub-groups in districts of Madhya Pradesh based on 2011 population census.

District	Rural						Urban					
	Scheduled Castes		Scheduled Tribes		Other Castes		Scheduled Castes		Scheduled Tribes		Other Castes	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Madhya Pradesh	0.112	0.119	0.130	0.124	0.093	0.094	0.089	0.087	0.099	0.095	0.075	0.070
Alirajpur	0.114	0.108	0.135	0.122	0.081	0.086	0.046	0.053	0.075	0.058	0.034	0.055
Anuppur	0.136	0.133	0.139	0.125	0.128	0.107	0.116	0.110	0.132	0.104	0.093	0.082
Ashoknagar	0.131	0.133	0.168	0.182	0.095	0.104	0.109	0.097	0.103	0.132	0.079	0.083
Balaghat	0.119	0.101	0.127	0.112	0.107	0.089	0.086	0.078	0.086	0.061	0.086	0.066
Barwani	0.099	0.099	0.118	0.105	0.092	0.083	0.070	0.076	0.083	0.072	0.064	0.053
Betul	0.117	0.105	0.144	0.133	0.101	0.088	0.091	0.077	0.109	0.114	0.087	0.075
Bhind	0.080	0.098	0.115	0.139	0.068	0.087	0.079	0.101	0.043	0.092	0.069	0.086
Bhopal	0.109	0.126	0.119	0.117	0.092	0.085	0.075	0.066	0.066	0.070	0.066	0.067
Burhanpur	0.065	0.054	0.099	0.096	0.059	0.074	0.062	0.055	0.079	0.055	0.054	0.059
Chhatarpur	0.132	0.140	0.158	0.179	0.104	0.113	0.107	0.108	0.120	0.134	0.089	0.090
Chhindwara	0.103	0.097	0.133	0.119	0.097	0.085	0.080	0.065	0.085	0.083	0.065	0.062
Damoh	0.120	0.134	0.130	0.128	0.096	0.108	0.090	0.097	0.092	0.131	0.077	0.072
Datia	0.121	0.128	0.145	0.172	0.101	0.105	0.122	0.129	0.131	0.088	0.108	0.097
Dewas	0.091	0.096	0.099	0.110	0.067	0.070	0.067	0.071	0.077	0.080	0.059	0.056
Dhar	0.078	0.073	0.085	0.086	0.060	0.061	0.064	0.059	0.062	0.066	0.055	0.059
Dindori	0.157	0.144	0.123	0.112	0.109	0.106	0.171	0.049	0.151	0.103	0.092	0.077
Guna	0.098	0.118	0.129	0.140	0.084	0.095	0.071	0.094	0.110	0.131	0.074	0.070
Gwalior	0.102	0.112	0.158	0.168	0.077	0.097	0.099	0.090	0.108	0.146	0.091	0.080
Harda	0.104	0.122	0.142	0.155	0.096	0.099	0.069	0.071	0.122	0.086	0.079	0.065
Hoshangabad	0.119	0.128	0.143	0.126	0.086	0.086	0.090	0.114	0.075	0.072	0.074	0.063

District	Rural						Urban					
	Scheduled Castes		Scheduled Tribes		Other Castes		Scheduled Castes		Scheduled Tribes		Other Castes	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Indore	0.073	0.067	0.080	0.078	0.060	0.058	0.073	0.066	0.078	0.073	0.072	0.063
Jabalpur	0.130	0.120	0.147	0.133	0.107	0.093	0.110	0.099	0.129	0.131	0.094	0.077
Jhabua	0.064	0.072	0.121	0.117	0.079	0.076	0.094	0.050	0.071	0.065	0.077	0.055
Katni	0.141	0.133	0.178	0.170	0.130	0.120	0.116	0.120	0.165	0.129	0.100	0.077
Khandwa	0.088	0.096	0.116	0.120	0.081	0.082	0.072	0.069	0.083	0.069	0.063	0.054
Khargone	0.088	0.085	0.094	0.088	0.075	0.072	0.076	0.049	0.076	0.071	0.057	0.052
Mandla	0.094	0.090	0.114	0.100	0.114	0.096	0.079	0.046	0.101	0.055	0.071	0.056
Mandsaur	0.106	0.102	0.118	0.102	0.084	0.077	0.068	0.075	0.078	0.046	0.056	0.055
Morena	0.082	0.119	0.131	0.142	0.072	0.097	0.084	0.101	0.042	0.099	0.067	0.081
Narsimhapur	0.113	0.110	0.133	0.123	0.105	0.091	0.089	0.085	0.110	0.075	0.075	0.069
Neemuch	0.105	0.094	0.148	0.128	0.082	0.079	0.080	0.071	0.100	0.111	0.068	0.057
Panna	0.147	0.162	0.178	0.174	0.120	0.118	0.118	0.132	0.125	0.169	0.077	0.064
Raisen	0.121	0.119	0.136	0.132	0.090	0.091	0.100	0.093	0.102	0.116	0.077	0.070
Rajgarh	0.115	0.121	0.119	0.103	0.095	0.097	0.090	0.090	0.084	0.077	0.079	0.077
Ratlam	0.114	0.109	0.117	0.117	0.088	0.080	0.071	0.083	0.085	0.103	0.068	0.057
Rewa	0.112	0.124	0.144	0.150	0.084	0.082	0.110	0.101	0.139	0.151	0.072	0.078
Sagar	0.130	0.137	0.149	0.140	0.095	0.096	0.105	0.107	0.136	0.184	0.091	0.088
Satna	0.135	0.142	0.178	0.180	0.109	0.115	0.125	0.106	0.168	0.150	0.074	0.076
Sehore	0.127	0.121	0.131	0.129	0.092	0.086	0.111	0.101	0.093	0.075	0.081	0.080
Seoni	0.095	0.093	0.096	0.088	0.090	0.084	0.092	0.060	0.097	0.063	0.076	0.060
Shahdol	0.137	0.135	0.163	0.146	0.129	0.122	0.097	0.076	0.109	0.116	0.069	0.067
Shajapur	0.099	0.108	0.093	0.098	0.081	0.081	0.093	0.086	0.065	0.056	0.062	0.066
Sheopur	0.111	0.145	0.192	0.194	0.104	0.107	0.117	0.118	0.131	0.165	0.077	0.096

District	Rural						Urban					
	Scheduled Castes		Scheduled Tribes		Other Castes		Scheduled Castes		Scheduled Tribes		Other Castes	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Shivpuri	0.120	0.131	0.189	0.201	0.101	0.111	0.089	0.113	0.136	0.165	0.067	0.078
Sidhi	0.136	0.136	0.168	0.171	0.105	0.109	0.125	0.138	0.139	0.111	0.075	0.076
Singrauli	0.155	0.142	0.170	0.168	0.130	0.130	0.141	0.131	0.161	0.141	0.099	0.080
Tikamgarh	0.102	0.122	0.138	0.160	0.098	0.107	0.072	0.103	0.104	0.065	0.087	0.081
Ujjain	0.095	0.102	0.091	0.087	0.077	0.076	0.073	0.067	0.093	0.050	0.058	0.062
Umaria	0.128	0.130	0.163	0.154	0.115	0.116	0.122	0.101	0.122	0.142	0.081	0.088
Vidisha	0.131	0.138	0.183	0.176	0.098	0.104	0.099	0.108	0.119	0.161	0.076	0.074

Source: Author's calculations

Table 3: Results of the decomposition of inter-district and intra-district variation in ${}_5q_0$

Grand mean (η)	0.097	Population sub-group effect (β_j)											
		SCRM	SCRF	STRM	STRF	OCRM	OCRF	SCUM		SCUSTUM	STUF	OCUM	OCUF
District effect (α_i)		1.110	1.176	1.350	1.291	0.917	0.934	0.916		0.1.010	0.959	0.782	0.737
		Residual (ν_{ij})											
Alirajpur	0.969	*1.091*	*0.973*	*1.058*	*1.005*	*0.932*	*0.982*	*0.533*	*0.631*	*0.791*	*0.641*	*0.467*	*0.786*
Anuppur	1.144	*1.099*	*1.019*	*0.928*	*0.873*	*1.254*	*1.027*	*1.140*	*1.109*	*1.178*	*0.977*	*1.070*	*1.005*
Ashoknagar	1.149	*1.060*	*1.014*	*1.116*	*1.262*	*0.926*	*0.993*	*1.064*	*0.978*	*0.912*	*1.230*	*0.907*	*1.009*
Balaghat	1.029	*1.069*	*0.858*	*0.942*	*0.869*	*1.165*	*0.954*	*0.938*	*0.875*	*0.847*	*0.635*	*1.093*	*0.893*
Barwani	0.874	*1.054*	*0.994*	*1.032*	*0.954*	*1.177*	*1.040*	*0.897*	*1.007*	*0.969*	*0.879*	*0.969*	*0.838*
Betul	1.065	*1.018*	*0.864*	*1.029*	*0.997*	*1.068*	*0.912*	*0.963*	*0.839*	*1.041*	*1.153*	*1.072*	*0.978*
Bhind	0.873	*0.846*	*0.981*	*1.001*	*1.268*	*0.872*	*1.096*	*1.016*	*1.335*	*0.506*	*1.129*	*1.036*	*1.382*
Bhopal	0.906	*1.115*	*1.217*	*1.003*	*1.026*	*1.140*	*1.034*	*0.925*	*0.838*	*0.736*	*0.825*	*0.963*	*1.027*
Burhanpur	0.733	*0.823*	*0.649*	*1.025*	*1.038*	*0.909*	*1.114*	*0.947*	*0.869*	*1.094*	*0.798*	*0.962*	*1.120*
Chhatarpur	1.213	*1.006*	*1.007*	*0.990*	*1.179*	*0.961*	*1.025*	*0.989*	*1.031*	*1.007*	*1.186*	*0.969*	*1.030*
Chhindwara	0.960	*0.992*	*0.884*	*1.058*	*0.986*	*1.128*	*0.974*	*0.935*	*0.786*	*0.905*	*0.932*	*0.891*	*0.904*
Damoh	1.095	*1.018*	*1.069*	*0.902*	*0.934*	*0.987*	*1.083*	*0.919*	*1.025*	*0.860*	*1.282*	*0.924*	*0.919*
Datia	1.187	*0.947*	*0.940*	*0.930*	*1.156*	*0.958*	*0.973*	*1.158*	*1.258*	*1.126*	*0.799*	*1.200*	*1.138*
Dewas	0.790	*1.071*	*1.066*	*0.957*	*1.106*	*0.956*	*0.980*	*0.957*	*1.040*	*0.989*	*1.086*	*0.979*	*0.995*
Dhar	0.680	*1.065*	*0.942*	*0.951*	*1.007*	*0.992*	*0.992*	*1.055*	*1.009*	*0.928*	*1.048*	*1.071*	*1.208*
Dindori	1.016	*1.434*	*1.242*	*0.926*	*0.882*	*1.201*	*1.145*	*1.893*	*0.560*	*1.511*	*1.083*	*1.193*	*1.053*
Guna	0.994	*0.912*	*1.042*	*0.992*	*1.121*	*0.953*	*1.049*	*0.807*	*1.091*	*1.132*	*1.411*	*0.977*	*0.985*
Gwalior	1.070	*0.885*	*0.915*	*1.128*	*1.248*	*0.811*	*0.996*	*1.014*	*0.974*	*1.024*	*1.467*	*1.125*	*1.046*
Harda	1.075	*0.900*	*0.993*	*1.006*	*1.150*	*1.004*	*1.017*	*0.723*	*0.759*	*1.154*	*0.856*	*0.972*	*0.850*
Hoshangabad	0.990	*1.116*	*1.129*	*1.101*	*1.012*	*0.972*	*0.959*	*1.019*	*1.327*	*0.771*	*0.783*	*0.985*	*0.884*
Indore	0.806	*0.844*	*0.724*	*0.759*	*0.769*	*0.839*	*0.793*	*1.013*	*0.938*	*0.979*	*0.966*	*1.170*	*1.091*

Grand mean (η)	0.097	Population sub-group effect (β_j)											
		SCRM	SCRF	STRM	STRF	OCRM	OCRF	SCUM		SCUSTUM	STUF	OCUM	OCUF
District effect (α_i)		1.110	1.176	1.350	1.291	0.917	0.934	0.916		0.1.010	0.959	0.782	0.737
		Residual (ν_{ij})											
Jabalpur	1.142	*1.052*	*0.915*	*0.980*	*0.930*	*1.048*	*0.897*	*1.083*	*0.997*	*1.155*	*1.227*	*1.086*	*0.944*
Jhabua	0.913	*0.653*	*0.688*	*1.014*	*1.018*	*0.974*	*0.923*	*1.155*	*0.630*	*0.796*	*0.758*	*1.107*	*0.844*
Katni	1.344	*0.970*	*0.868*	*1.011*	*1.009*	*1.089*	*0.984*	*0.972*	*1.032*	*1.250*	*1.029*	*0.978*	*0.797*
Khandwa	0.884	*0.922*	*0.945*	*1.002*	*1.082*	*1.029*	*1.018*	*0.911*	*0.903*	*0.956*	*0.840*	*0.944*	*0.849*
Khargone	0.751	*1.081*	*0.984*	*0.950*	*0.933*	*1.124*	*1.051*	*1.133*	*0.752*	*1.030*	*1.011*	*0.990*	*0.963*
Mandla	0.915	*0.957*	*0.864*	*0.948*	*0.872*	*1.401*	*1.152*	*0.969*	*0.574*	*1.124*	*0.645*	*1.014*	*0.856*
Mandsaur	0.879	*1.120*	*1.014*	*1.027*	*0.924*	*1.078*	*0.963*	*0.871*	*0.983*	*0.906*	*0.562*	*0.842*	*0.877*
Morena	0.929	*0.820*	*1.117*	*1.075*	*1.218*	*0.868*	*1.149*	*1.014*	*1.255*	*0.455*	*1.148*	*0.942*	*1.213*
Narsimhapur	1.048	*0.999*	*0.914*	*0.966*	*0.937*	*1.128*	*0.960*	*0.955*	*0.935*	*1.070*	*0.767*	*0.946*	*0.918*
Neemuch	0.902	*1.082*	*0.912*	*1.248*	*1.135*	*1.018*	*0.964*	*0.998*	*0.902*	*1.132*	*1.325*	*0.995*	*0.879*
Panna	1.320	*1.035*	*1.073*	*1.026*	*1.051*	*1.016*	*0.983*	*1.007*	*1.151*	*0.961*	*1.371*	*0.763*	*0.680*
Raisen	1.025	*1.095*	*1.016*	*1.014*	*1.022*	*0.981*	*0.975*	*1.093*	*1.052*	*1.014*	*1.212*	*0.990*	*0.956*
Rajgarh	1.056	*1.009*	*1.004*	*0.858*	*0.781*	*1.013*	*1.011*	*0.961*	*0.982*	*0.814*	*0.786*	*0.990*	*1.017*
Ratlam	0.915	*1.152*	*1.040*	*0.977*	*1.020*	*1.085*	*0.968*	*0.869*	*1.042*	*0.946*	*1.205*	*0.976*	*0.873*
Rewa	1.000	*1.035*	*1.083*	*1.099*	*1.198*	*0.938*	*0.906*	*1.231*	*1.166*	*1.415*	*1.622*	*0.945*	*1.086*
Sagar	1.131	*1.063*	*1.061*	*1.001*	*0.985*	*0.939*	*0.937*	*1.038*	*1.089*	*1.229*	*1.745*	*1.060*	*1.086*
Satna	1.243	*1.009*	*1.002*	*1.094*	*1.154*	*0.981*	*1.017*	*1.126*	*0.986*	*1.373*	*1.296*	*0.786*	*0.855*
Sehore	1.034	*1.136*	*1.027*	*0.964*	*0.995*	*0.995*	*0.912*	*1.207*	*1.129*	*0.916*	*0.775*	*1.028*	*1.086*
Seoni	0.851	*1.039*	*0.959*	*0.860*	*0.828*	*1.189*	*1.087*	*1.218*	*0.814*	*1.165*	*0.794*	*1.175*	*0.982*
Shahdol	1.221	*1.041*	*0.966*	*1.017*	*0.952*	*1.185*	*1.099*	*0.895*	*0.718*	*0.909*	*1.021*	*0.738*	*0.768*
Shajapur	0.902	*1.017*	*1.050*	*0.787*	*0.870*	*1.011*	*0.989*	*1.163*	*1.099*	*0.734*	*0.668*	*0.907*	*1.017*

Grand mean (η)	0.097	Population sub-group effect (β_j)											
		SCRM	SCRF	STRM	STRF	OCRM	OCRF	SCUM		SCUSTUM	STUF	OCUM	OCUF
District effect (α_i)		1.110	1.176	1.350	1.291	0.917	0.934	0.916		0.1.010	0.959	0.782	0.737
		Residual (ν_{ij})											
Sheopur	1.262	*0.816*	*1.007*	*1.158*	*1.226*	*0.928*	*0.937*	*1.037*	*1.083*	*1.057*	*1.405*	*0.807*	*1.066*
Shivpuri	1.198	*0.927*	*0.958*	*1.204*	*1.336*	*0.950*	*1.023*	*0.834*	*1.084*	*1.153*	*1.480*	*0.739*	*0.906*
Sidhi	1.227	*1.026*	*0.967*	*1.044*	*1.109*	*0.964*	*0.976*	*1.149*	*1.301*	*1.158*	*0.971*	*0.807*	*0.860*
Singrauli	1.366	*1.050*	*0.907*	*0.948*	*0.982*	*1.069*	*1.046*	*1.158*	*1.105*	*1.203*	*1.104*	*0.949*	*0.813*
Tikamgarh	1.098	*0.865*	*0.968*	*0.959*	*1.164*	*0.999*	*1.076*	*0.737*	*1.078*	*0.961*	*0.639*	*1.038*	*1.025*
Ujjain	0.839	*1.049*	*1.059*	*0.823*	*0.824*	*1.030*	*0.997*	*0.977*	*0.923*	*1.127*	*0.638*	*0.915*	*1.025*
Umaria	1.243	*0.953*	*0.912*	*1.001*	*0.990*	*1.034*	*1.025*	*1.100*	*0.940*	*1.004*	*1.226*	*0.856*	*0.991*
Vidisha	1.139	*1.068*	*1.060*	*1.222*	*1.230*	*0.963*	*1.009*	*0.973*	*1.093*	*1.064*	*1.513*	*0.881*	*0.902*

Source: Author’s calculations

Table 4: Estimates of $_5q_0$ in districts and population sub-group within district in Madhya Pradesh for the year 2017.

State/District	Population sub-groups											
	All	SCRM	SCRF	STRM	STRF	OCRM	OCRF	SCUM	SCUF	STUM	STUF	OCUM	OCUF
Madhya Pradesh	0.056	0.062	0.066	0.073	0.070	0.052	0.052	0.049	0.049	0.055	0.053	0.041	0.039
Alirajpur	0.068	0.063	0.060	0.075	0.068	0.045	0.048	0.026	0.029	0.042	0.032	0.019	0.030
Anuppur	0.068	0.075	0.074	0.077	0.070	0.071	0.059	0.065	0.061	0.074	0.058	0.052	0.046
Ashoknagar	0.063	0.073	0.074	0.093	0.101	0.053	0.058	0.060	0.054	0.057	0.073	0.044	0.046
Balaghat	0.056	0.066	0.056	0.071	0.062	0.059	0.050	0.048	0.043	0.048	0.034	0.048	0.037
Barwani	0.058	0.055	0.055	0.066	0.058	0.051	0.046	0.039	0.042	0.046	0.040	0.036	0.029
Betul	0.064	0.065	0.058	0.080	0.074	0.056	0.049	0.051	0.043	0.060	0.064	0.048	0.041
Bhind	0.044	0.044	0.054	0.064	0.077	0.038	0.048	0.044	0.056	0.024	0.051	0.038	0.048
Bhopal	0.041	0.061	0.070	0.066	0.065	0.051	0.047	0.041	0.037	0.036	0.039	0.037	0.037
Burhanpur	0.041	0.036	0.030	0.055	0.053	0.033	0.041	0.034	0.031	0.044	0.030	0.030	0.033
Chhatarpur	0.063	0.073	0.078	0.088	0.100	0.058	0.063	0.059	0.060	0.067	0.074	0.050	0.050
Chhindwara	0.056	0.057	0.054	0.074	0.066	0.054	0.047	0.044	0.036	0.047	0.046	0.036	0.035
Damoh	0.059	0.067	0.074	0.072	0.071	0.054	0.060	0.050	0.054	0.051	0.073	0.043	0.040
Datia	0.061	0.067	0.071	0.080	0.096	0.056	0.058	0.068	0.072	0.073	0.049	0.060	0.054
Dewas	0.043	0.051	0.054	0.055	0.061	0.037	0.039	0.037	0.040	0.043	0.044	0.033	0.031
Dhar	0.042	0.043	0.041	0.047	0.048	0.033	0.034	0.035	0.033	0.034	0.037	0.031	0.033
Dindori	0.064	0.087	0.080	0.069	0.062	0.060	0.059	0.095	0.027	0.084	0.057	0.051	0.043
Guna	0.054	0.054	0.066	0.072	0.078	0.047	0.053	0.040	0.052	0.061	0.073	0.041	0.039
Gwalior	0.052	0.057	0.062	0.088	0.093	0.043	0.054	0.055	0.050	0.060	0.081	0.051	0.045
Harda	0.063	0.058	0.068	0.079	0.086	0.053	0.055	0.038	0.039	0.068	0.048	0.044	0.036
Hoshangabad	0.054	0.066	0.071	0.079	0.070	0.048	0.048	0.050	0.063	0.042	0.040	0.041	0.035
Indore	0.038	0.041	0.037	0.045	0.043	0.034	0.032	0.040	0.036	0.043	0.040	0.040	0.035

State/District	Population sub-groups												
	All	SCRM	SCRF	STRM	STRF	OCRM	OCRF	SCUM	SCUF	STUM	STUF	OCUM	OCUF
Jabalpur	0.057	0.072	0.066	0.082	0.074	0.059	0.052	0.061	0.055	0.072	0.073	0.052	0.043
Jhabua	0.063	0.036	0.040	0.067	0.065	0.044	0.042	0.052	0.028	0.040	0.036	0.043	0.031
Katni	0.076	0.078	0.074	0.099	0.095	0.072	0.067	0.065	0.067	0.092	0.072	0.056	0.043
Khandwa	0.052	0.049	0.053	0.065	0.067	0.045	0.045	0.040	0.038	0.046	0.038	0.035	0.030
Khargone	0.045	0.049	0.047	0.052	0.049	0.042	0.040	0.042	0.027	0.042	0.039	0.031	0.029
Mandla	0.057	0.052	0.050	0.063	0.056	0.063	0.053	0.044	0.025	0.056	0.031	0.039	0.031
Mandsaur	0.046	0.059	0.057	0.066	0.057	0.047	0.043	0.038	0.042	0.043	0.026	0.031	0.031
Morena	0.048	0.046	0.066	0.073	0.079	0.040	0.054	0.047	0.056	0.023	0.055	0.037	0.045
Narsimhapur	0.056	0.063	0.061	0.074	0.068	0.059	0.051	0.049	0.047	0.061	0.042	0.042	0.038
Neemuch	0.047	0.058	0.052	0.082	0.071	0.045	0.044	0.045	0.039	0.056	0.062	0.038	0.032
Panna	0.075	0.082	0.090	0.099	0.097	0.066	0.065	0.066	0.073	0.069	0.094	0.043	0.036
Raisen	0.056	0.067	0.066	0.076	0.073	0.050	0.050	0.055	0.052	0.057	0.064	0.043	0.039
Rajgarh	0.054	0.064	0.067	0.066	0.057	0.053	0.054	0.050	0.050	0.047	0.043	0.044	0.043
Ratlam	0.052	0.063	0.060	0.065	0.065	0.049	0.045	0.039	0.046	0.047	0.057	0.038	0.032
Rewa	0.056	0.062	0.069	0.080	0.084	0.046	0.046	0.061	0.056	0.077	0.084	0.040	0.043
Sagar	0.059	0.072	0.076	0.083	0.078	0.053	0.053	0.058	0.059	0.076	0.102	0.051	0.049
Satna	0.069	0.075	0.079	0.099	0.100	0.060	0.064	0.069	0.059	0.093	0.083	0.041	0.042
Sehore	0.056	0.070	0.067	0.073	0.072	0.051	0.048	0.062	0.056	0.052	0.041	0.045	0.045
Seoni	0.049	0.053	0.052	0.053	0.049	0.050	0.047	0.051	0.033	0.054	0.035	0.042	0.033
Shahdol	0.074	0.076	0.075	0.091	0.081	0.072	0.068	0.054	0.042	0.061	0.065	0.038	0.037
Shajapur	0.047	0.055	0.060	0.052	0.055	0.045	0.045	0.052	0.048	0.036	0.031	0.035	0.037
Sheopur	0.074	0.062	0.081	0.107	0.108	0.058	0.060	0.065	0.066	0.073	0.092	0.043	0.054
Shivpuri	0.067	0.067	0.073	0.105	0.112	0.056	0.062	0.049	0.063	0.075	0.092	0.037	0.043
Sidhi	0.072	0.075	0.075	0.093	0.095	0.059	0.060	0.070	0.077	0.077	0.062	0.042	0.042

State/District	Population sub-groups												
	All	SCRM	SCRF	STRM	STRF	OCRM	OCRF	SCUM	SCUF	STUM	STUF	OCUM	OCUF
Singrauli	0.080	0.086	0.079	0.094	0.094	0.072	0.072	0.078	0.073	0.090	0.078	0.055	0.044
Tikamgarh	0.058	0.057	0.068	0.077	0.089	0.054	0.060	0.040	0.057	0.058	0.036	0.048	0.045
Ujjain	0.043	0.053	0.056	0.050	0.048	0.043	0.042	0.041	0.037	0.052	0.028	0.032	0.034
Umaria	0.075	0.071	0.072	0.091	0.086	0.064	0.064	0.068	0.056	0.068	0.079	0.045	0.049
Vidisha	0.060	0.073	0.077	0.101	0.098	0.054	0.058	0.055	0.060	0.066	0.089	0.042	0.041

Source: Author's calculations

State/District	All	Rural						Urban					
		SC		ST		OT		SC		ST		OT	
		M	F	M	F	M	F	M	F	M	F	M	F
MP	0.056	0.061	0.065	0.074	0.071	0.050	0.051	0.050	0.049	0.056	0.053	0.043	0.041
Alirajpur	0.069	0.065	0.061	0.076	0.069	0.046	0.049	0.026	0.030	0.043	0.033	0.019	0.031
Anuppur	0.069	0.077	0.075	0.079	0.071	0.072	0.060	0.066	0.062	0.075	0.059	0.053	0.047
Ashoknagar	0.064	0.074	0.075	0.095	0.103	0.054	0.059	0.062	0.055	0.058	0.074	0.045	0.047
Balaghat	0.057	0.067	0.057	0.072	0.064	0.060	0.050	0.049	0.044	0.048	0.034	0.048	0.037
Barwani	0.059	0.056	0.056	0.067	0.059	0.052	0.047	0.040	0.043	0.047	0.041	0.036	0.030
Betul	0.065	0.066	0.059	0.081	0.075	0.057	0.050	0.052	0.044	0.062	0.065	0.049	0.042
Bhind	0.045	0.045	0.055	0.065	0.079	0.038	0.049	0.045	0.057	0.025	0.052	0.039	0.049
Bhopal	0.042	0.062	0.071	0.067	0.066	0.052	0.048	0.042	0.037	0.037	0.039	0.038	0.038
Burhanpur	0.042	0.037	0.031	0.056	0.054	0.034	0.042	0.035	0.031	0.045	0.031	0.030	0.033
Chhatarpur	0.064	0.074	0.079	0.089	0.101	0.059	0.064	0.060	0.061	0.068	0.076	0.051	0.051
Chhindwara	0.057	0.058	0.055	0.075	0.067	0.055	0.048	0.045	0.037	0.048	0.047	0.037	0.035
Damoh	0.060	0.068	0.076	0.073	0.073	0.055	0.061	0.051	0.055	0.052	0.074	0.044	0.041
Datia	0.062	0.069	0.072	0.082	0.097	0.057	0.059	0.069	0.073	0.074	0.050	0.061	0.055
Dewas	0.044	0.052	0.055	0.056	0.062	0.038	0.040	0.038	0.040	0.043	0.045	0.033	0.032
Dhar	0.043	0.044	0.041	0.048	0.049	0.034	0.035	0.036	0.034	0.035	0.038	0.031	0.033
Dindori	0.066	0.089	0.082	0.070	0.064	0.062	0.060	0.097	0.028	0.085	0.058	0.052	0.043
Guna	0.055	0.055	0.067	0.073	0.079	0.048	0.054	0.040	0.053	0.062	0.074	0.042	0.040
Gwalior	0.052	0.058	0.063	0.090	0.095	0.044	0.055	0.056	0.051	0.061	0.083	0.052	0.045
Harda	0.064	0.059	0.069	0.080	0.088	0.054	0.056	0.039	0.040	0.069	0.049	0.045	0.037
Hoshangabad	0.055	0.067	0.072	0.081	0.071	0.049	0.049	0.051	0.064	0.042	0.041	0.042	0.035
Indore	0.038	0.042	0.038	0.045	0.044	0.034	0.033	0.041	0.037	0.044	0.041	0.041	0.036

State/District	All	Rural						Urban					
		SC		ST		OT		SC		ST		OT	
		M	F	M	F	M	F	M	F	M	F	M	F
Jabalpur	0.058	0.073	0.068	0.083	0.075	0.060	0.053	0.062	0.056	0.073	0.074	0.053	0.044
Jhabua	0.064	0.036	0.041	0.069	0.066	0.045	0.043	0.053	0.028	0.040	0.037	0.043	0.031
Katni	0.077	0.080	0.075	0.101	0.096	0.074	0.068	0.066	0.068	0.093	0.073	0.057	0.043
Khandwa	0.053	0.050	0.054	0.066	0.068	0.046	0.046	0.041	0.039	0.047	0.039	0.036	0.030
Khargone	0.046	0.050	0.048	0.053	0.050	0.043	0.041	0.043	0.028	0.043	0.040	0.032	0.029
Mandla	0.058	0.053	0.051	0.064	0.057	0.065	0.054	0.045	0.026	0.057	0.031	0.040	0.032
Mandsaur	0.046	0.060	0.058	0.067	0.058	0.048	0.043	0.039	0.042	0.044	0.026	0.032	0.031
Morena	0.049	0.047	0.067	0.074	0.080	0.041	0.055	0.047	0.057	0.023	0.056	0.038	0.046
Narsimhapur	0.057	0.064	0.062	0.075	0.070	0.060	0.052	0.050	0.048	0.062	0.042	0.043	0.039
Neemuch	0.048	0.060	0.053	0.084	0.073	0.046	0.045	0.045	0.040	0.057	0.063	0.039	0.032
Panna	0.077	0.083	0.092	0.101	0.099	0.068	0.067	0.067	0.074	0.070	0.095	0.043	0.036
Raisen	0.057	0.069	0.067	0.077	0.074	0.051	0.051	0.056	0.053	0.058	0.066	0.044	0.040
Rajgarh	0.055	0.065	0.069	0.067	0.059	0.054	0.055	0.051	0.051	0.048	0.044	0.045	0.044
Ratlam	0.053	0.064	0.062	0.066	0.066	0.050	0.045	0.040	0.047	0.048	0.058	0.038	0.032
Rewa	0.057	0.063	0.070	0.082	0.085	0.047	0.047	0.062	0.057	0.079	0.086	0.041	0.044
Sagar	0.061	0.073	0.078	0.084	0.079	0.054	0.054	0.059	0.060	0.077	0.104	0.052	0.050
Satna	0.070	0.077	0.081	0.101	0.102	0.061	0.065	0.070	0.060	0.095	0.085	0.042	0.043
Sehore	0.057	0.072	0.069	0.074	0.073	0.052	0.048	0.063	0.057	0.053	0.042	0.046	0.046
Seoni	0.050	0.054	0.053	0.054	0.050	0.051	0.048	0.052	0.034	0.055	0.036	0.043	0.034
Shahdol	0.075	0.078	0.076	0.092	0.083	0.073	0.069	0.055	0.043	0.062	0.066	0.039	0.038
Shajapur	0.048	0.056	0.061	0.053	0.056	0.046	0.046	0.053	0.049	0.037	0.032	0.035	0.037
Sheopur	0.075	0.063	0.082	0.109	0.110	0.059	0.061	0.066	0.067	0.074	0.094	0.044	0.055

State/District	All	Rural						Urban					
		SC		ST		OT		SC		ST		OT	
		M	F	M	F	M	F	M	F	M	F	M	F
Shivpuri	0.068	0.068	0.074	0.107	0.114	0.057	0.063	0.050	0.064	0.077	0.094	0.038	0.044
Sidhi	0.073	0.077	0.077	0.095	0.097	0.060	0.061	0.071	0.078	0.079	0.063	0.043	0.043
Singrauli	0.081	0.088	0.080	0.096	0.095	0.074	0.073	0.080	0.074	0.091	0.080	0.056	0.045
Tikamgarh	0.059	0.058	0.069	0.078	0.091	0.055	0.061	0.041	0.058	0.059	0.037	0.049	0.046
Ujjain	0.043	0.054	0.058	0.051	0.049	0.044	0.043	0.041	0.038	0.053	0.028	0.033	0.035
Umaria	0.077	0.072	0.073	0.092	0.087	0.065	0.065	0.069	0.057	0.069	0.080	0.046	0.050
Vidisha	0.061	0.074	0.078	0.103	0.100	0.055	0.059	0.056	0.061	0.067	0.091	0.043	0.042

Figure 3: Heatmap of ${}_5q_0$ in Madhya Pradesh, 2017

Source: Author

The estimates of $_5q_0$ presented in table 4 reveal very strong variation across the 600 mutually exclusive yet exhaustive population sub-groups of Madhya Pradesh. These variations are depicted more explicitly in the heat-map (Figure 3). These variations suggest that a decentralised district-based approach is required to address the challenge of exceptionally high risk of death in the first five years of life in Madhya Pradesh.

Conclusions

In this paper, we have proposed a simple non-parametric data mining approach for estimating a demographic indicator at the local level on a recent date based on the past estimate of the demographic indicator at the local level usually available through the population census and the recent estimate of the indicator at higher administrative level available from some alternative source such as a survey. The approach has been used to estimate the most recent estimates of $_5q_0$ in districts of Madhya Pradesh based on the district level estimates derived from the 2011 population census and the most recent estimate of $_5q_0$ for Madhya Pradesh available through India's official sample registration system. The underlying assumption of the approach is that the pattern of variation in the $_5q_0$ across districts and across different population sub-groups within the district remain largely unchanged.

The approach proposed here is particularly suited in situations where estimates of the demographic indicator of interest is available on a regular basis at the aggregate level only but estimates of the demographic indicator below the aggregate - local - level are available only at one or two points in time either through a population census using indirect techniques of demographic estimation or from some other source. The usefulness of the approach lies in its simplicity and the fact that most of the data required for the application of the approach can be readily generated from the existing sources which makes the approach time and cost effective. An advantage of the approach is that it is entirely data driven. It makes no assumption about the underlying structure of the data and, therefore, can easily handle skewed data or the data having outliers. This is important as the assumption of the normality in the variation in the demographic indicators is deviated frequently at the local level because of the influence of the local level factors in deciding the level of demographic indicators.

An advantage of the method proposed is that it provides recent estimates of the demographic indicator for different mutually exclusive sub-groups within the sub-population (district). An important limitation of both sample registration system and the National Family Health Survey is that information available from these sources contribute little to within district diversity or inequality in the demographic situation. Assessment of the demographic diversity within the sub-population (district) is important from the perspective of development planning and programming and for monitoring and evaluating the impact of development efforts. The sample registration system and the National Family Health Survey are not designed to provide information that reflects the demographic diversity within the sub-population (district).

The proposed method can constitute the basis for establishing a system of estimating demographic indicators at the sub-administrative area (district) level on a regular basis in India to meet the long-standing demand of annual estimates of district level demographic indicators for the most recent date for the purpose of decentralised population and development planning and programming at the local (district) level. At present, district level planning and programming for population and development activities in India largely remains either anecdotal or analogical because local level estimates of key population and development indicators are either not available or, if available, are outdated.

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A Model Based Statistical Investigation of Female Age at Marriage

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Abstract

Age at marriage is a significant event in the life of every individual. In the Indian society, sexual activity outside the institution of marriage is a social taboo and is not accepted. Therefore, age at marriage is of an importance event due to its direct relationship with the sexual activity, family building or the level of fertility. In the present paper, a probability model has been developed to describe the distribution of the age at marriage of females in India. The model has been validated by comparing it with the actual data on female age at marriage from the National Family Health Survey. The model explains the variability in the age at marriage satisfactorily.

Introduction

The sexual activity and family building strategy in traditional societies is a very sensitive issue and discussing about sexual matters openly is almost restricted and considered as a social taboo. During past few decades, due to the increase in the level of education, common awareness and modernisation of the society, there has been an attitudinal shift in the perception about sex, especially, among the young generation. The knowledge of sex and reproductive health is also limited among both educated and uneducated females as very few rural young females could describe how body change is related to sexual intercourse and reproduction (Vlassof, 1987).

In societies where childbearing outside the institution of marriage is not socially acceptable, delay in marriage contributes significantly towards reduction in fertility by shortening the reproductive span. On the other hand, marriage at a young age is typically associated with a lower education and with lower social status also. The age at marriage varies by various socio-demographic factors such as religion/caste, geographical location, place of residence, type of family and level of income. In, India, marriage signals the beginning of the family building process. Age at marriage is also an important indicator of women's status because of its role in determining fertility level and improving health of women and children.

There are many studies on the differentials and determinants of age at marriage in India (Agarwal, 1962; Talwar, 1967; Krishnan, 1971; Malaker, 1987). In addition, probability models have been used to describe the distribution of females according to their age at marriage. Nydell (1924) has used the lognormal distribution to explain the age at marriage. Hyrenius and others (1967) have proposed logistic curve to graduate the number of females at different age at marriage. Coale (1971) has shown that the risk of first marriage for the standard population is very closely fitted by a double exponential function while Coale and McNeil (1972) have shown that the distribution of females by the age at marriage can be approximated very closely by the limiting distribution of the convolution of an infinite number of (normalised) exponentially distributed components, and that an equally good fit is obtained by the convolution of a finite number of the exponential components plus an additional Normal distribution. Malaker (1985) has observed that Coale and McNeil model failed to describe the Indian data. Hernes (1972) has fitted the Gompertz curve for US female age at marriage. According to Henry (1972), mates are not selected from country level marriage market, however, there exists a smaller circle of mates with homogeneous characteristics. McFarland (1972, 1975) has given "Iterative Adjustment Model" for marriage formation. Both Henry (1972) and McFarland (1972) have offered numerical procedures to be applied on the matrix of marriage data, but they have not given any algebraic form. Hill (1977) has used a simple polynomial to describe the marriage data. Rodriquez and Trussell (1980) have used a linear function of logarithm of standard Gamma function. Islam (1984) suggests modified exponential curve to describe the age pattern of proportion of never married females. Singh and others (1986) have refined the model proposed by Mishra (1979) and applied the refined model to describe the marriage data of Varanasi females. Diekman (1989) has used two-parameter log-logistic distribution for describing the US and German data. Mitter (1989) has used a convolution of normal and exponential distributions to understand the pattern of age at marriage. Nath and Talukdar (1992) have used Type-I extreme value distribution to describe the female age at marriage data from Assam.

Most of the models of describing the distribution of females by age at marriage discussed above are complex and contain many parameters. They have also not been found to be universally applicable. Verma and Pathak (2001) used a model for age at marriage, which was used for estimating the adolescent sterility among married females by Pathak and Prashad (1978). The model gives poor fit particularly for higher age at marriage due to the age heaping in the data. The age misreporting and digit preference complicate the model for describing the distribution of the age at marriage. To problem has been resolved to some extent by combining two consecutive age groups. Singh and others (2004) have proposed a discrete probability model (displaced negative binomial distribution) and have found that the model is suitable for describing the distribution of the age at marriage of females. Singh and others (2015) have discussed an alternative procedure to estimate the parameters of the above model. Alho (2016), on the other hand, has proposed a model in the stochastic form that has been defined in terms of rates and continuous time. On the other hand, the models proposed by Matthews and Garenne (2013a; 2013b) are deterministic, described in terms of counts and discrete time.

This paper has two objectives. The first objective is to analyse the pattern of female age at marriage in India. The second objective of the paper is to develop a suitable probability model that describes the distribution of the females by their age at marriage. The probability model so developed has been fitted using the data on female age at marriage available through the National Family Health Survey to examine the validity of the model.

Probability Distribution of the Age at Marriage

The female age at marriage is a continuous variable and it occurs after a certain age after the birth of the female. We assume that the age at marriage of a female is an independent and identically distributed (iid) random variable which follows an exponential distribution with a lower and an upper bound. There is very small probability of females marrying below a certain age. Similarly, there is very small probability of females marrying after a certain age so that these very small probabilities can be neglected. It is also well-known that the proportion of females marrying after a certain age decreases very rapidly after a certain age. Given these assumptions and considerations, the probability distribution of the female age at marriage may be modelled as

$$F(x) = 1 - exp\left[\frac{-\lambda(x-\theta_1)}{(\theta_2-x)}\right]; \theta_1 \leq x \leq \theta_2; \lambda > 0 \tag{1}$$

Where ϑ_1 is the lower bound and ϑ_2 is the upper bound of the female age at marriage.

The hazard rate function of model (1) is given by

$$h(x) = \frac{d}{dx}\{-ln[1-F(x)]\} \text{ therefore } h(x) = \frac{\lambda(\theta_2-\theta_1)}{(\theta_2-x)^2} \tag{2}$$

The hazard rate is an increasing function of x during the interval, $\vartheta_1 \leq x \leq \vartheta_2$ which means that the proportion of females getting married at higher ages is small. The probability density function of the model (1) is given by

$$f(x) = \frac{\lambda(\theta_2-\theta_1)}{(\theta_2-x)^2}\left[\exp\left\{\frac{-\lambda(x-\theta_1)}{(\theta_2-x)}\right\}\right]; \theta_1 \leq x \leq \theta_2; \lambda > 0 \tag{3}$$

The r^{th} moment of the distribution (1) is given by

$$E[X^r] = \int_{\theta_1}^{\theta_2} x^r \frac{\lambda(\theta_2-\theta_1)}{(\theta_2-x)^2} e^{\frac{-\lambda(x-\theta_1)}{(\theta_2-x)}} dx \tag{4}$$

Let

$$\frac{\lambda(x-\theta_1)}{(\theta_2-x)} = z \Rightarrow \frac{\lambda(\theta_2-\theta_1)}{(\theta_2-x)^2}dx = dz$$

It is obvious that if $x \epsilon (\vartheta_1, \vartheta_2)$ then $z \epsilon (0,\infty)$.

Also, we have

$\frac{x-\theta_1}{\theta_2-x} = \frac{z}{\lambda} \Rightarrow x = \frac{z\theta_2+\lambda\theta_1}{z+\lambda}$, therefore,

$$E[X^r] = \int_0^\infty \left(\frac{z\theta_2+\lambda\theta_1}{z+\lambda}\right)^r \frac{\lambda(\theta_2-\theta_1)}{(\theta_2-x)^2} e^{\frac{-\lambda(x-\theta_1)}{(\theta_2-x)}} dx \tag{5}$$

$$\Rightarrow \int_0^\infty \left(\frac{z\theta_2+\lambda\theta_1}{z+\lambda}\right)^r e^{-z}\,dz = \int_0^\infty \left(\theta_2 + \frac{\lambda(\theta_1-\theta_2)}{z+\lambda}\right)^r e^{-z}\,dz$$

$$\Rightarrow \int_0^\infty \sum_{k=0}^r \binom{r}{k} \theta_2^{r-k} \left(\frac{\lambda(\theta_1-\theta_2)}{z+\lambda}\right)^k e^{-z}\,dz = \sum_{k=0}^r \binom{r}{k} \theta_2^{r-k} [\lambda(\theta_1-\theta_2)]^k \int_0^\infty \frac{e^{-z}}{(z+\lambda)^k} dz \tag{6}$$

Let $z+\lambda=l$ so that $z=l-\lambda$ and $dz=dl$. Now

$$\int_0^\infty \frac{e^{-z}}{(z+\lambda)^k} = \int_\lambda^\infty \frac{e^{-(l-\lambda)}}{l^k} dl = e^\lambda \int_\lambda^\infty \frac{e^{-l}}{l^k} dl \tag{7}$$

If $l = \lambda p$, then $\Rightarrow dl = \lambda dp$, and for $l = \lambda, p = 1$ also for $l = \infty, p = \infty$. Therefore, equation (7) can be written as

$$\Rightarrow e^\lambda \int_1^\infty \frac{e^{-\lambda p}}{(p\lambda)^k} \lambda dp \Rightarrow \frac{e^\lambda}{\lambda^{k-1}} \int_1^\infty \frac{e^{-\lambda p}}{p^k} dp = \frac{e^\lambda}{\lambda^{k-1}} E_k(\lambda)$$

Hence

$$E[X^r] = \sum_{k=0}^r \binom{r}{k} \theta_2^{r-k} [\lambda(\theta_1-\theta_2)]^k \frac{e^\lambda}{\lambda^{k-1}} E_k(\lambda) \tag{8}$$

We know that

$$E_0(\lambda) = \frac{e^{-\lambda}}{\lambda} \tag{9}$$

and it can be easily obtained. However, $E_1(\lambda)$, $E_2(\lambda)$, etc. require extensive computations which cannot be done manually.

Putting $r=1$ in equation (8), we have first moment or arithmetic mean,

$$E[X] = \theta_2 + \lambda(\theta_1-\theta_2)e^\lambda E_1(\lambda) \tag{10}$$

Putting $r=2$ in equation (8), we get the second moment

$$E[X^2] = \theta_2^2 + 2\theta_2[\lambda(\theta_1-\theta_2)]e^\lambda E_1(\lambda) + (\theta_1-\theta_2)^2 \lambda e^\lambda E_2(\lambda) \tag{11}$$

Using (10) and (11), we can get the variance.

The parameters of the model can be obtained through the method of maximum likelihood. The likelihood function of the model is given by

$$L = \prod_{i=1}^{n} \frac{\lambda(\theta_2-\theta_1)}{(\theta_2-x_i)^2}\left[\exp\left\{\frac{-\lambda(x_i-\theta_1)}{(\theta_2-x_i)}\right\}\right] \qquad (12)$$

$$=\exp\left[-\lambda \sum_{i=1}^{n}\left(\frac{x_i-\theta_1}{\theta_2-x_i}\right)\right]\lambda^n(\theta_2-\theta_1)^n \prod_{i=1}^{n}\frac{1}{(\theta_2-x_i)^2} \qquad (13)$$

and the log likelihood is

$$LL = -\lambda \sum_{i=1}^{n}\left(\frac{x_i-\theta_1}{\theta_2-x_i}\right) + n\,ln\,\lambda + n\,ln(\theta_2-\theta_1) + \sum_{i=1}^{n} ln\left[\frac{1}{(\theta_2-x_i)^2}\right] \qquad (14)$$

Now, differentiating with respect to λ we get

$$\frac{\partial\, ln\,\lambda}{\partial\lambda} = -\sum_{i=1}^{n}\left(\frac{x_i-\theta_1}{\theta_2-x_i}\right) + \frac{n}{\lambda} = 0 \qquad (15)$$

$$\Rightarrow \frac{n}{\lambda} = \sum_{i=1}^{n}\left(\frac{x_i-\theta_1}{\theta_2-x_i}\right) \Rightarrow \hat{\lambda} = \frac{n}{\sum_{i=1}^{n}\left(\frac{x_i-\theta_1}{\theta_2-x_i}\right)} \qquad (16)$$

The application of the model requires setting up lower bound (ϑ_1) and upper bound (ϑ_2) of the female age at marriage. In case of female age at marriage less than the lower bound the model will give a negative estimate of λ. Similarly, if the upper bound is lower than the maximum female age at marriage, the model will give a negative estimate of λ. It is, therefore, necessary to fix the lower and upper bounds of the female age at marriage. We assume that the lower bound of the model is the female age at menarche. On the other hand, the upper bound of the model can be set to be equal to or more than the maximum reported female age at marriage.

The goodness of fit of the model can be tested through the K-S test of goodness of fit which is a nonparametric test of the equality of one-dimensional probability distributions (Kolmogorov, 1933; Smirnov, 1933). This test is based on the empirical cumulative distribution function (ECDF). Given N ordered data points $X_1, X_2, ..., X_N$, the ECDF is defined as

$$E_N = \frac{n(i)}{N} \qquad (17)$$

where $n(i)$ is the number of points less than X_i and X_i are ordered from the smallest to the largest value. Equation (17) is a step function that increases by 1/N at the value of each ordered data point. The K-S test of goodness of fit is based on the maximum distance between observed and expected distributions. It is defined as absolute maximum difference between observed and expected cumulative distributions, or

$$D = \max_{1\le i\le N}\left|F(X_i) - \frac{i}{N}\right|, \qquad (18)$$

where F is the theoretical cumulative distribution being tested which must be a continuous and must be fully specified (mean and standard deviation estimated from the data in a normal distribution). The hypothesis regarding the distributional form is rejected if D is greater than the critical value obtained from a table. At 5 per cent level of significance, the critical value of D large sample is obtained by $1.36/\sqrt{N}$.

Application of the Model

We have applied the above model to analyse the distribution of female age at marriage in India and its constituent states based on the data available through different rounds of the National Family Health Survey (NFHS). The NFHS programme has been initiated by the Government of India, Ministry of Health and Family Welfare. The International Institute of Population Sciences, Mumbai is responsible for organising the survey. The first round of NFHS was carried out in 1992-93 and the fifth and the latest round was carried out in 2019-21. The present analysis is based on the data available from the first and the fourth round (2015-16) of NFHS. During the first round of NFHS, information about the age at marriage was collected from 3034 currently married women aged 15-49 years. During the fourth round of NFHS, information about the age at marriage was collected from 26534 currently married women aged 15-49 years. The lower and upper bounds of the model have been taken as 12 years and 35 years respectively. The data available from NFHS suggest that the proportion of females getting married after 35 years of age was very small so that these women were excluded from the analysis. Similarly, the proportion of females getting married before 12 years of age has also been found to be very small.

The estimate of the parameter λ of the model depends upon the lower and upper bounds of the model chosen in advance. Alternative values of the lower and the upper bounds of the model can be chosen depending upon the reported data. For the given values of the lower and the upper bounds of the model, the value of λ the positive skewness in the distribution of the age at marriage. This implies that the higher the value of λ the low the mean age at marriage or the mean age at marriage is less than the median age at marriage. It is also obvious that λ will be large only when $(\vartheta_2\text{-}x_i)>(x_i\text{-}\vartheta_1)$. On the other hand, a small value of λ implies that the distribution of age at marriage is negatively skewed which implies high mean age at marriage or the mean age at marriage is higher than the median age at marriage. In other words, there is inverse relationship between λ, the parameter of the model and the mean age at marriage. A decrease in the parameter λ over time implies an increase in the mean age at marriage whereas an increase in the parameter λ implies a decrease in the mean age at marriage. In Uttar Pradesh, the parameter λ decreased from 4.002 in 1992-93 to 2.407 in 2015-16 according to NFHS which means that the female age at marriage in the state has increased over time. Based on the data available from the first round of NFHS, the female mean age at marriage in Uttar Pradesh was 15.9 years in 1992-93 which increased to 17.47 years in 2015-16.

We have first fitted the model to the distribution of female age at marriage in Uttar Pradesh to examine the suitability of the model in describing the distribution of female age at marriage using the data from the first (1992-93) and the fourth round (2015-16) of NFHS. Table 1 presents the results of fitting the model to the data from Uttar Pradesh. The maximum absolute difference (K-S test value) between the observed and expected vales of the cumulative probability of marriage up to a certain age is estimated to be 0.073 for 1992-93. Similarly, the maximum absolute difference for the period 2015-16 is estimated to be and 0.117. These values suggest that the model proposed in this paper provides a very good fit to the observed data. This is also confirmed with the mean age at marriage.

Table 1: Observed and estimated cumulative probability female marriage at specific ages in Uttar Pradesh, 1992-93 and 2015-16.

Female age at marriage	1992-93		2015-16	
(years)	Observed	Expected	Observed	Expected
12-14	0.207	0.166	0.100	0.104
14-16	0.524	0.451	0.310	0.303
16-18	0.743	0.671	0.566	0.488
18-20	0.884	0.826	0.768	0.652
20-22	0.953	0.924	0.882	0.788
22-24	0.976	0.974	0.939	0.890
24-26	0.991	0.994	0.971	0.956
26-28	0.995	0.999	0.985	0.989
28-30	0.997	1.000	0.993	0.999
30-32	0.999	1.000	0.997	1.000
32-34	1.000	1.000	1.000	1.000
Mean age at marriage	15.90	(15.87)	17.47	(17.67)
λ	4.002		2.407	
Value of K-S test	0.073		0.117	

Source: Authors' calculations

Figure 1 shows the observed and the fitted cumulative probability of distribution of age at marriage of females in age in Uttar Pradesh. The figures again confirm that the model proposed in this paper describes the distribution of the age at marriage of females quite satisfactorily. There, however, appears some deviation between the observed and fitted values of the cumulative probability of marriage by age in the middle ages of the reproductive period. This difference is comparatively narrower in 1992-93 than in 2015-16. One possible reason for the difference between the observed and estimated cumulative probability of female marriage by age may be the errors associated with the reporting of the age at marriage of females in the household surveys and in population census. It is well known that reported age at marriage of females in the household surveys as well as in population census is associated with many errors. These include, among others, recall lapse, especially in older illiterate women and errors associated with digit preference. In India, marriage of females at age less than the minimum legal age at marriage is prohibited by law and is subject to litigation. In such a scenario, there is also a strong probability that the respondents during the household surveys may not be reporting the correct age at marriage females, especially when the female has got married before reaching the minimum legal age at marriage. It is obvious from figure 1 that the model proposed here can be used for ironing out the errors associated with the reported age at marriage of females.

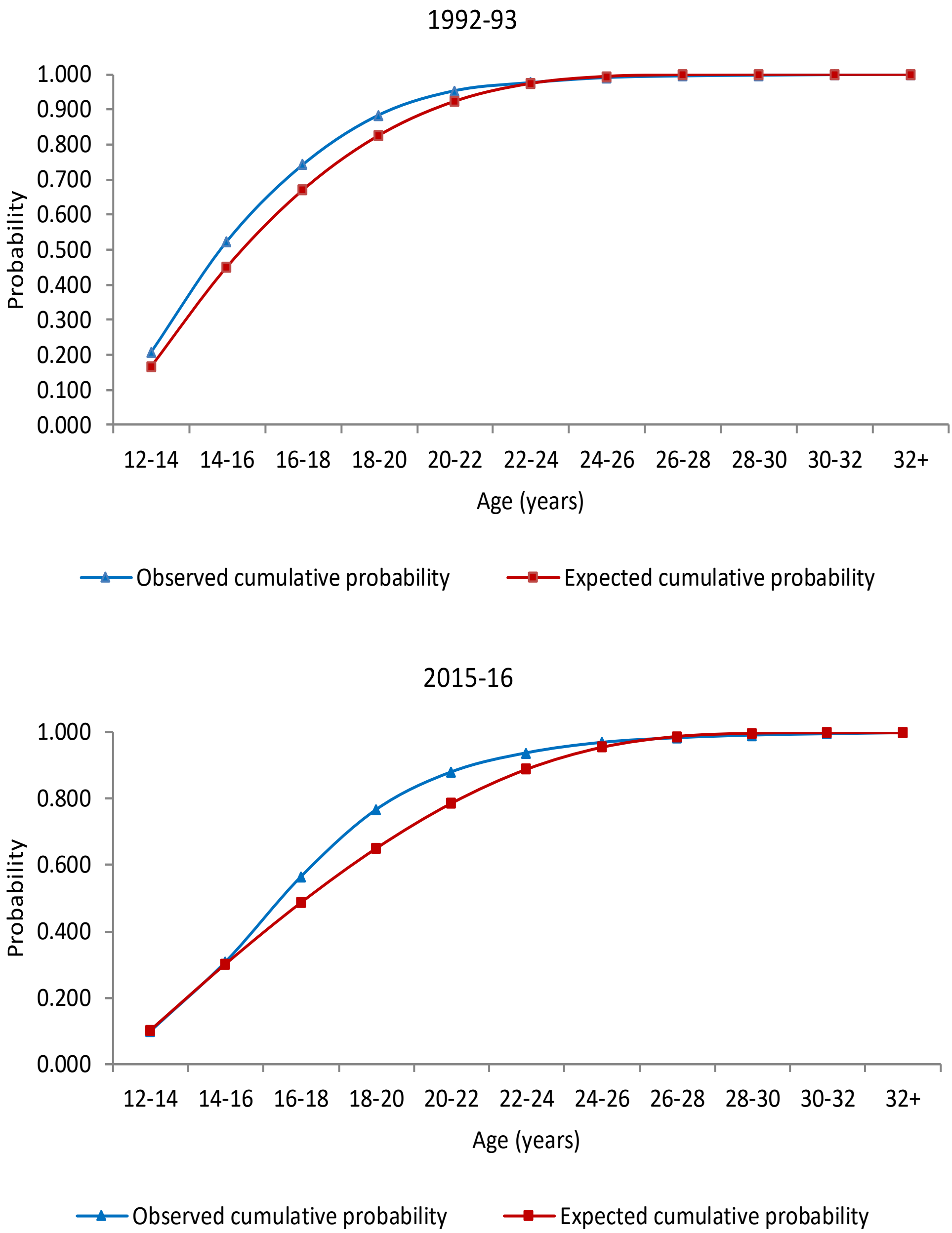

Figure 1: Observed and fitted values of cumulative probability of female age at marriage by age, Uttar Pradesh.

Table 2: Estimate of λ and implied female mean age at marriage in India and states, 1992-93 and 2015-16.

States	1992-93						2015-16					
	λ			Mean age at marriage			λ			Mean age at marriage		
	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural	Total
India	1.789	2.815	2.334	18.44	16.72	17.34	1.310	1.731	1.571	19.53	18.43	18.78
Assam	1.527	2.712	2.044	18.65	16.91	17.65	0.811	1.203	1.118	20.99	19.69	19.90
Haryana	2.261	4.448	3.219	17.76	15.86	16.61	1.634	1.980	1.838	19.40	18.58	18.88
Punjab	1.885	2.175	2.085	19.39	18.54	18.78	1.204	1.389	1.313	20.79	20.26	20.46
Bihar	3.162	4.837	4.183	16.53	14.88	15.37	2.246	2.558	2.509	17.61	17.13	17.19
Madhya Pradesh	2.598	4.830	3.812	16.69	15.13	15.62	1.703	2.703	2.261	18.45	16.94	17.44
Rajasthan	2.768	5.048	4.200	16.79	15.30	15.67	1.824	2.700	2.355	18.57	17.23	17.64
Uttar Pradesh	2.528	5.001	4.002	17.54	15.30	15.90	1.844	2.759	2.407	18.50	17.05	17.47
Gujarat	1.925	2.929	2.456	18.52	17.14	17.65	1.351	1.764	1.574	19.62	18.60	19.01
Maharashtra	2.352	4.448	3.081	17.68	15.60	16.63	1.503	2.045	1.791	19.34	18.29	18.70
Orissa	2.880	4.040	3.606	16.99	16.03	16.32	1.311	1.653	1.566	19.71	18.92	19.09
West Bengal	1.677	4.272	2.957	17.96	15.55	16.24	1.416	2.394	1.983	18.97	17.45	17.90
Andhra Pradesh	3.059	5.249	4.195	16.69	14.98	15.58	1.982	2.855	2.467	18.10	16.90	17.33
Karnataka	2.289	3.599	2.971	18.04	16.24	16.90	1.239	1.485	1.381	20.03	19.27	19.56
Kerala	1.356	1.581	1.506	20.02	19.26	19.49	1.091	1.049	1.065	20.97	21.06	21.02
Tamil Nadu	1.711	2.804	2.316	18.62	17.09	17.60	1.342	1.731	1.524	19.81	18.73	19.24

Source: Authors' calculations

Table 2 presents results of fitting the model to the data on female age at marriage for different states of the country for the total population and for rural and urban populations separately. The female mean age at marriage varies widely across the states of the country included in the analysis. The model suggests that the female mean age at marriage in 1992-93 was the lowest in Bihar followed by Andhra Pradesh, Madhya Pradesh, Rajasthan, and Uttar Pradesh. There are the states where the female mean age at marriage was less than 16 years and well below the national average. In 2015-16, the female mean age at marriage was less than the legal minimum age of female marriage in six states – Bihar followed by Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Rajasthan, and West Bengal. On the other hand, female mean age marriage was the highest in Kerala in both 1992-93 and 2015-16. In 1992-93, the female mean age at marriage was more than 18 years in only two states – Kerala and Punjab whereas, Kerala was the only state in 2015-16 where the female mean age at marriage was more than 21 years. Besides Kerala, the female mean age at marriage is estimated to be more than 20 years in Punjab in 2015-16.

The urban-rural difference in the female mean age at marriage is also revealing. In 1992-93, the female mean age at marriage in the urban areas of the country was more than 1.7 years higher than that in the rural areas. This difference has narrowed down to almost one year in 2015-16. Among different states, the urban-rural difference in the female mean age at marriage is estimated to be the widest in West Bengal but the narrowest in Kerala in 1992-93. In 2015-16 also the urban-rural difference in the female mean age at marriage was the widest in West Bengal but, the female mean at marriage in the rural areas of Kerala has been higher than that in the urban areas of the state. Kerala is the only state in the country where the female mean age at marriage appear to be higher than that in the urban areas. The decrease in the urban-rural gap in the female mean age at marriage between 1992-93 and 2015-16 has been the most rapid in Bihar followed by Haryana, Karnataka, and Maharashtra. By contrast, there has been virtually no change in the urban-rural difference in the female mean age at marriage in Madhya Pradesh during 1992 through 2016. In Rajasthan, Odisha, Punjab, and Gujarat also, there has been only a marginal decrease in the urban-rural difference in the female mean age at marriage.

The rate of increase in the female mean age at marriage in the rural areas of the country has been higher than that in the urban areas during the period under reference. In the rural areas of the country, the female mean age at marriage increased by more than 7 per cent per year between 1992-93 and 2015-16 whereas the rate of increase in the urban areas was less than 5 per cent per year. Similarly, the rate of increase in the rural female mean age at marriage has been higher than that in the urban areas in all states (Table 3). The most rapid increase in the female mean age at marriage is estimated in the rural areas of Karnataka during 1992-2016. By contrast, the rate of increase in the female mean age at marriage has been the slowest during this period in the urban areas of Kerala followed by Uttar Pradesh. In addition, the average annual rate of increase in the female mean age at marriage in the urban areas was less than 5 per cent per year in West Bengal, Bihar, and Gujarat. The decrease in the urban-rural difference in the female mean age marriage has primarily been due to the slow increase in the female mean age at marriage in the urban areas in all states.

Table 3: Proportionate change in λ and the mean age at marriage of females in India and states.

States	Proportion (per cent) change between 1992-93 and 2015-16					
	λ			Mean age at marriage		
	Urban	Rural	Total	Urban	Rural	Total
India	-26.77	-38.51	-32.69	5.91	10.23	8.30
Assam	-46.89	-55.64	-45.30	12.55	16.44	12.75
Haryana	-27.73	-55.49	-42.90	9.23	17.15	13.67
Punjab	-36.13	-36.14	-37.03	7.22	9.28	8.95
Bihar	-28.97	-47.12	-40.02	6.53	15.12	11.84
Madhya Pradesh	-34.45	-44.04	-40.69	10.55	11.96	11.65
Rajasthan	-34.10	-46.51	-43.93	10.60	12.61	12.57
Uttar Pradesh	-27.06	-44.83	-39.86	5.47	11.44	9.87
Gujarat	-29.82	-39.77	-35.91	5.94	8.52	7.71
Maharashtra	-36.10	-54.02	-41.87	9.39	17.24	12.45
Orissa	-54.48	-59.08	-56.57	16.01	18.03	16.97
West Bengal	-15.56	-43.96	-32.94	5.62	12.22	10.22
Andhra Pradesh	-35.21	-45.61	-41.19	8.45	12.82	11.23
Karnataka	-45.87	-58.74	-53.52	11.03	18.66	15.74
Kerala	-19.54	-33.65	-29.28	4.75	9.35	7.85
Tamil Nadu	-21.57	-38.27	-34.20	6.39	9.60	9.32

Source: Authors' calculations.

Table 4 presents the observed and estimated cumulative probability of marriage up to a specified age for India and for its selected states during 2015-16. In India, according to NFHS, 90 per cent of females got married by 24 years of age in 2015-16 – 87 per cent in the urban areas and 91 per cent in the rural areas. This proportion, according to our model is 93 per cent – 88 per cent in the urban areas and 96 per cent in the rural areas. In Andhra Pradesh, Bihar, Madhya Pradesh, Odisha, Rajasthan, and Uttar Pradesh, at least 90 per cent females got married by 22 years of age. By contrast, only around 80 per cent of females got married by 24 years of age in Kerala whereas only around two-third of the females got married by 22 years of age. It is also clear from the table that in the rural areas, more females got married by 18 years of age as compared to females in the urban areas in the country and in all states. In the rural areas, at least 90 per cent of females got married by 20 years of age in Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, and West Bengal. By contrast, in the rural areas of Assam, Bihar, Haryana, Maharashtra, Rajasthan and Tamil Nadu, at least 90 per cent females got married by 22 years of age only. The comparison of estimated cumulative probability of marriage by age with the observed cumulative probability of marriage by age again confirms the appropriateness of the proposed model in describing the distribution of females by age at marriage.

Table 4: Observed and estimated proportion of females married by specific age in India and states, 2015-16.

Age (years)	Proportion of female married by age					
	Observed			Estimated		
	Urban	Rural	Total	Urban	Rural	Total
			Andhra Pradesh			
16	0.39	0.51	0.47	0.34	0.45	0.41
18	0.60	0.74	0.69	0.50	0.63	0.58
20	0.76	0.87	0.83	0.65	0.78	0.73
22	0.86	0.94	0.91	0.78	0.89	0.85
24	0.93	0.97	0.96	0.88	0.96	0.93
			Assam			
16	0.21	0.27	0.26	0.16	0.22	0.21
18	0.37	0.46	0.45	0.25	0.35	0.33
20	0.52	0.63	0.61	0.35	0.47	0.45
22	0.65	0.75	0.74	0.46	0.60	0.58
24	0.75	0.84	0.83	0.59	0.73	0.70
			Bihar			
16	0.43	0.49	0.48	0.38	0.42	0.41
18	0.67	0.71	0.70	0.55	0.59	0.59
20	0.81	0.85	0.85	0.70	0.74	0.74
22	0.90	0.92	0.92	0.82	0.86	0.85
24	0.95	0.96	0.96	0.91	0.94	0.94
			Gujarat			
16	0.22	0.32	0.28	0.25	0.31	0.28
18	0.43	0.54	0.50	0.38	0.46	0.43
20	0.64	0.72	0.69	0.51	0.61	0.57
22	0.79	0.85	0.83	0.65	0.74	0.70
24	0.88	0.92	0.91	0.77	0.85	0.82
			Haryana			
16	0.21	0.28	0.25	0.29	0.34	0.32
18	0.43	0.53	0.50	0.44	0.50	0.48
20	0.65	0.75	0.71	0.58	0.65	0.62
22	0.82	0.88	0.85	0.72	0.78	0.76
24	0.92	0.94	0.93	0.83	0.88	0.87
			Karnataka			
16	0.23	0.29	0.27	0.23	0.27	0.25
18	0.41	0.48	0.45	0.35	0.41	0.39
20	0.58	0.66	0.63	0.48	0.55	0.52
22	0.73	0.78	0.76	0.61	0.68	0.65
24	0.84	0.87	0.86	0.74	0.80	0.78
			Kerala			
16	0.14	0.12	0.13	0.21	0.20	0.20
18	0.28	0.28	0.28	0.32	0.31	0.31

Age (years)	Proportion of female married by age					
	Observed			Estimated		
	Urban	Rural	Total	Urban	Rural	Total
20	0.48	0.47	0.47	0.44	0.43	0.43
22	0.68	0.67	0.67	0.57	0.55	0.56
24	0.81	0.81	0.81	0.70	0.68	0.69
			Madhya Pradesh			
16	0.36	0.52	0.47	0.30	0.43	0.38
18	0.58	0.74	0.69	0.45	0.61	0.55
20	0.74	0.86	0.82	0.60	0.76	0.70
22	0.84	0.93	0.90	0.73	0.87	0.82
24	0.91	0.96	0.94	0.84	0.95	0.92
			Maharashtra			
16	0.26	0.33	0.31	0.27	0.35	0.31
18	0.47	0.57	0.53	0.41	0.51	0.47
20	0.65	0.76	0.72	0.55	0.66	0.62
22	0.79	0.88	0.84	0.69	0.79	0.75
24	0.89	0.94	0.92	0.81	0.89	0.86
			Odisha			
16	0.25	0.29	0.28	0.24	0.29	0.28
18	0.45	0.51	0.50	0.37	0.44	0.42
20	0.63	0.71	0.70	0.50	0.59	0.57
22	0.76	0.83	0.82	0.64	0.72	0.70
24	0.86	0.91	0.90	0.76	0.84	0.82
			Punjab			
16	0.10	0.10	0.10	0.22	0.25	0.24
18	0.27	0.31	0.30	0.35	0.39	0.37
20	0.50	0.58	0.55	0.47	0.52	0.50
22	0.71	0.78	0.75	0.60	0.66	0.64
24	0.85	0.90	0.88	0.73	0.78	0.76
			Rajasthan			
16	0.32	0.45	0.41	0.32	0.43	0.39
18	0.54	0.70	0.65	0.47	0.61	0.56
20	0.73	0.86	0.82	0.62	0.76	0.72
22	0.85	0.94	0.91	0.75	0.87	0.84
24	0.93	0.97	0.96	0.86	0.95	0.92
			Tamil Nadu			
16	0.22	0.31	0.27	0.25	0.31	0.27
18	0.41	0.53	0.47	0.38	0.46	0.42
20	0.62	0.72	0.67	0.51	0.60	0.56
22	0.76	0.84	0.80	0.64	0.74	0.69
24	0.87	0.92	0.89	0.77	0.85	0.81
			Uttar Pradesh			
16	0.32	0.48	0.43	0.32	0.44	0.40

Age (years)	Proportion of female married by age					
	Observed			Estimated		
	Urban	Rural	Total	Urban	Rural	Total
18	0.56	0.73	0.68	0.48	0.62	0.57
20	0.75	0.87	0.84	0.63	0.77	0.72
22	0.86	0.94	0.92	0.76	0.88	0.84
24	0.93	0.97	0.96	0.87	0.95	0.93
			West Bengal			
16	0.32	0.44	0.40	0.26	0.40	0.34
18	0.54	0.70	0.65	0.39	0.57	0.50
20	0.70	0.86	0.81	0.53	0.72	0.65
22	0.81	0.92	0.89	0.66	0.84	0.78
24	0.88	0.96	0.93	0.79	0.93	0.89
			India			
16	0.26	0.36	0.33	0.34	0.45	0.41
18	0.46	0.58	0.54	0.50	0.63	0.58
20	0.64	0.75	0.71	0.65	0.78	0.73
22	0.78	0.85	0.83	0.78	0.89	0.85
24	0.87	0.91	0.90	0.88	0.96	0.93

Source: Authors' calculations.

Conclusions

In this paper, we have proposed a probability model that describes the distribution of the age at marriage of females. Application of the model to the data available from the National Family Health Survey suggests that the model provides a very good fit to the observed data. The model can be used for prediction purposes and for smoothing the data on female age at marriage as it is well known that the reported data on female age at marriage are associated with number of errors including errors associated with digit preference and recall lapse. The proposed model has only one parameter which depends upon the lower and upper bounds of the model. Changing the upper and lower bounds of the model leads to the change in the parameter of the model. As such, the model can be used for simulation purposes also. By changing the lower and upper bounds of the model, one can obtain the likely estimates of the mean age marriage which may be useful for formulating policies designing programmes directed towards modifying the distribution of age at marriage of females.

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Influence of Household Food Insecurity on Nutritional Status of Scheduled Castes Children in Rural Areas of Barabanki District, Uttar Pradesh, India

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Abstract

This study investigates the influence of household food insecurity on nutritional status of Scheduled Castes (SC) children in the rural area of Barabanki district, Uttar Pradesh by analysing the relationship between Household Food Insecurity Access Scale (HFIAS) and the nutritional status of children based the survey of 585 children from 300 SC households in the rural areas of Barabanki district of Uttar, India. The study finds a statistically significant association between child nutrition and household food insecurity.

Background

Food is essential for every individual. Household food security influences health and wellbeing of household members. The concept of food security includes availability, accessibility, fair use, and utilisation by household members throughout the year. Any dysfunction in the household food security system can lead to hunger and malnutrition - under or over nutrition (Behrman et al, 2004; Weingärtner, 2009) Household food insecurity and poverty are primary factors of poor nutritional status (Babatunde and Qaim, 2010). However, household food security cannot always yield a guarantee of good nutritional status and sometimes it shows plodding progress (Pheley et al, 2002; Stuff et al, 2004; Castetbon et al, 2009; Hossain et al, 2016). The household food insecurity is highly influential in deciding the nutritional status of women and children as a balanced diet, access to health care services and physical activities are the leading contributing factors of a healthy life (Kennedy et al, 2004; Badiane et al, 2018; Casey et al, 2005; Rose and Bodor, 2006; Spring, 2020; Tarasuk, 2001; Hyder et al, 2005).

The quality and quantity of food consumed depends on the availability, accessibility, and affordability of food (Gwatkin et al, 2005; Friesen, 2018). Existing evidence reveals that household food insecurity, poverty, and nutritional status are mutually and closely associated (Ramachandran, 2007; Antony and Laxmaiah, 2008). Factors that contribute to insufficient food intake include irregular public distribution system, social status, individual behaviour, cultural barriers, poverty, low mobility. Individuals having insufficient food intake are more likely to be under nourished than individuals having sufficient food intake in terms of quantity and quality (Varadharajan et al, 2013; Kumar and Kalita, 2017). Food insecurity remains a key issue because of its implications for individual health (Johnson et al, 2018). Food insecurity contributes to poor nutritional status which, in turn, affects individual work capacity leading to substantial loss in productivity (Upadhyay and Palanivel, 2011). It is well-known that the nutritional status of the population is the most important factor in public health and well-being (Sachs, 2012).

In India, the nutritional status of an individual is seriously influenced by her or his social class. The Scheduled Castes and Scheduled Tribes, as identified in the Indian Constitution, are the most deprived sub-groups of the population. National Family Health Survey 2015-16 (NFHS-4) shows that the nutritional status of Scheduled Castes children in the rural areas of the country is very poor (Government of India, 2017). More than half of the Scheduled Castes children are under nourished, and this proportion is higher than children of Other Castes (Jungari and Chauhan, 2017; Gupta and Coffey, 2020; Government of India, 2017).

The present paper analyses the influence of household food insecurity on the nutritional status of Scheduled Castes children in the rural areas of district Barabanki of Uttar Pradesh, India. It is based on primary data collected from 300 Scheduled Castes households. The NFHS-4 suggests that more than 51 per cent of children below 5 years of age in district Barabanki are stunted while more than 40 per cent are underweight. Because of very high prevalence of stunting, the proportion of children who are wasted is only around 12 per cent (Government of India, 2019). There is, however, no knowledge about the prevalence of child under nutrition in the rural areas of the district and that too in Scheduled Castes children. This paper explores the influence of household food insecurity on the nutritional status of Scheduled Castes children in the rural areas of the district.

Methods

The paper is based on the data available through a field study carried out in the rural areas of district Barabanki of Uttar Pradesh, India. A multi-stage sampling design was adopted to select the sample for the study. At the first stage, sub-districts were selected; at the second stage, villages were selected, and, at the last stage, households were selected using the systematic sampling procedure. The sample size of the study was 300 Scheduled Castes households in which 585 children below 15 years of age were identified. Height and weight of these children were measured following the standard measurement protocol. Based on the height and weight the nutritional status of the child was decided in terms of weight-for-age, height-for-age, and weight-for-height. In addition, child thinness was also calculated (World Health Organization, 2006; 2009) On the other hand, household food security was measured using the Household Food Insecurity Access Scale (HFIAS) (Coates et al, 2007).

Bivariate and multivariate techniques have been used to analyse the collected data. SPSS 20 and Stata 12 software packages were used for the analysis. The bivariate analysis is confined to the cross tabulation of the collected data by selected individual and household characteristics of the children while bivariate logistic regression analysis has been carried out to measure the influence of household food insecurity on the nutritional status of children. The bivariate logistic regression analysis leads to a logit model that derives the relative likelihood of the occurrence of the event of interest (Retherford and Choe, 2011). The dependent variable used in the study is a dichotomous variable having value 1 if the child was under nourished and value 0 if the child was not under nourished. The nutritional status was measured in terms of height-for-age (stunting), weight-for-height (wasting), and weight-for-age (underweight). The child was classified as under nourished if the z-score with respect to either height-for-age or weight-for-height or weight-for-age was less than -2 (World Health Organization, 2006; 2009). The independent variables used in the regression analysis include place of residence, type of house, household food insecurity, caste, living status of the household as revealed through the ration card, agriculture land size, livestock, age, and education of the mother of the child, gender of the child, and child education.

Results

Figure 1 depicts the distribution of the households surveyed by the food security status. Only 22 per cent households were found to be food secure households in the study population whereas almost a similar proportion was found to be severely food insecure. Moreover, around 26 per cent households were mildly food insecure while around 30 per cent households were moderately food insecure.

Table 1 shows variation in the household food security status by background characteristics of the households. The proportion of food insecure households is found to be the highest in that area where the proportion of Scheduled Castes (SC) households was high. Among different subcastes, household food insecurity has been found to be high in *Chamar* compared to *Pasi* and *Kori* communities. Similarly, household food insecurity has been found to be high in households below the poverty line as reflected through the ration card that the household had. More generally, the proportion of food insecure household has been found to decrease with the improvement in the standard of living of the household as reflected through the household wealth index - the higher the household wealth index the lower the proportion of food insecure households. Scheduled Castes constitute the deprived population group in the Indian society which is strongly stratified on the caste basis. Table 1 suggests that within this group there is wide variation in the household food security status.

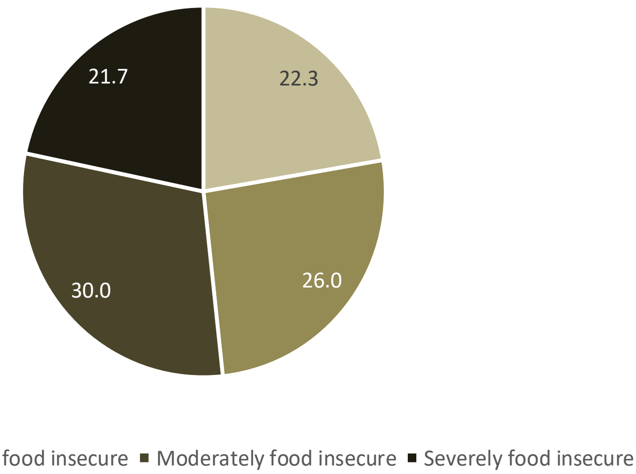

Figure 1: Distribution of households surveyed by food security status
Source: Authors

Table 1: Relationship in household's food security and selected household's covariates.

Background Characteristics	Household food security status: Secure	Mildly insecure	Moderately insecure	Severely insecure	N
Residence area (SC%)					
Low SC area	24.0	26.0	31.0	19.0	100
Medium SC area	23.0	28.0	28.0	21.0	100
High SC area	20.0	24.0	31.0	25.0	100
Type of house					
Kachha	(16.7)	(37.7)	(20.8)	(25.0)	24
Semi-*Pucca*	23.4	24.1	31.4	21.1	261
Pucca	(13.3)	(40.0)	(20.0)	(26.7)	15
Caste					
Pasi	17.6	28.2	29.4	24.7	85
Chamar	24.9	23.8	31.2	20.1	189
Kori	(19.2)	(34.6)	(23.1)	(23.1)	26
Type of Ration Card					
Above Poverty Line	32.8	36.2	13.8	17.2	116
Below Poverty Line	15.8	19.6	40.2	24.5	184
Wealth index					
Low	17.0	29.0	29.0	25.0	100
Medium	22.0	33.0	24.0	21.0	100
High	28.0	25.0	20.0	17.0	100

Background Characteristics	Household food security status				N
	Secure	Mildly insecure	Moderately insecure	Severely insecure	
Landholding size					
Below 0.5 Acre	(9.1)	(9.1)	(40.9)	(40.9)	18
0.5 - 1.0 Acre	23.0	24.8	30.0	22.2	220
More than 1.0 Acre	25.0	39.6	25.0	10.4	48
Irrigation facility					
Full irrigation	22.7	24.3	30.8	22.3	247
Partial irrigation	25.6	30.8	23.1	20.5	39
No irrigation	(7.1)	(35.7)	(42.9)	(14.3)	14
Type of crop produced					
Rice	23.2	26.1	29.6	21.1	280
Wheat	(10.0)	(25.0)	(35.0)	(30.0)	20
Livestock					
Yes	52.0	22.6	32.1	20.2	216
No	21.3	27.3	29.2	22.2	84
Number of Cow/buffalos					
No cow	23.7	22.3	33.1	20.9	139
1-2	19.1	31.3	26.7	22.9	131
3 and above	30.0	20.0	30.0	20.0	30
Number of Goats					
No goat	22.9	25.3	29.5	22.3	166
1-3	14.8	31.5	27.8	25.9	54
4-5	26.4	24.5	35.8	13.2	53
6 and above	(29.9)	(22.2)	(25.9)	(25.9)	27
Total	22.3	26.0	30.0	21.7	300

Remarks: Figures in brackets are based on less than 30 observations.
Source: Authors' calculations.

The prevalence of under nutrition in children of the surveyed population has been found to be quite high. The prevalence of stunting was 50.3 per cent; the prevalence of wasting was 22.6 per cent while the prevalence of underweight was 65.8 per cent (Figure 2). One reason for relatively low prevalence of wasting may be very high prevalence of stunting in children. Figure 2 also shows that the prevalence of child under nutrition in the surveyed households is higher in boys compared to girls in all dimensions of child nutrition: height-for-age (stunting), weight-for-height (wasting), weight-for-age (underweight) and thinness.

Table 2 shows that the prevalence of child under nutrition by household-, mother-, and child-specific factors. The prevalence of stunting and wasting is higher in boys than girls but the prevalence of wasting and thinness is higher in girls relative to boys. The prevalence of stunting is higher in children below 6 years of age but the prevalence of underweight and thinness is higher in children more than 6 years of age. There appears no specific association between child nutrition and school enrolment.

The prevalence of stunting has been found to be higher in children living in high SC residential area, although the prevalence of underweight was the highest in medium SC area whereas the prevalence of thinness was the highest in low SC residential area. The prevalence of stunting, wasting and thinness was low in children living in *Pucca* houses compared to *Kachha* and Semi-*Pucca* houses. Among different communities, child under nutrition is relatively high in *Kori* community compared to *Chamar* and *Pasi* communities. The prevalence of child under nutrition is the highest among the households having the lowest household wealth index but the lowest in households with the highest household wealth index. Similarly, the size of the land possessed by the household is found to be associated with the nutritional status of children. Household food security status plays a key role in shaping children's health (Mahadevan and Hoang, 2016). The prevalence of child stunting is found to be low in food secure households compared to food insecure households. The same pattern may be seen in case of the prevalence of child underweight. However, the prevalence of wasting and the prevalence of thinness is found to be low in food insecure households as compared to food secure households. Table 2 also reveals that mother-specific factors such as age of the mother and her educational status have been found to be key influencing factors as regards the for nutritional status of children.

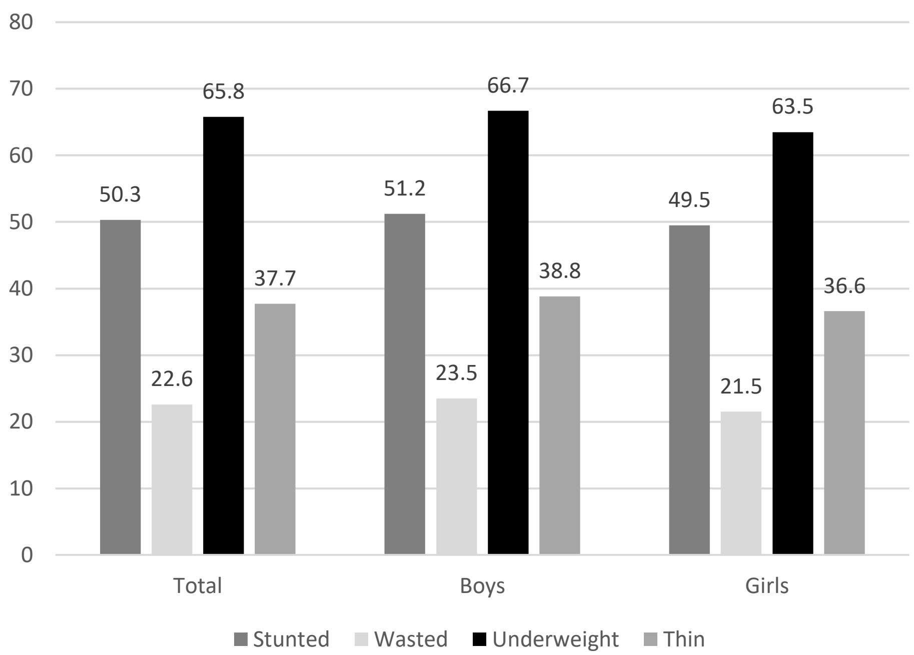

Figure 2: Prevalence of nutritional status in children (per cent).
Source: Authors.

Table 2: Nutritional status of children under 14 years' children by selected background characteristics.

Background characteristics	Stunted	Wasted	Underweight	Thin
Children Level Factors				
Age group (in years)				
Under 6 years	56.0	26.4	62.2	30.7
6-8	52.9	22.9	70.0	70.0
9-10	42.9	26.7	68.2	32.4
11-12	46.2	16.5	NA	0.0
13-14	44.6	10.7	NA	0.0
Sex				
Girl	51.2	23.5	63.5	38.8
Boy	49.5	21.5	67.8	36.6
Level of education				
Never enrolled	54.0	24.5	64.3	52.9
1^{st} Standard	59.0	12.9	68.6	59.7
2^{nd} Standard	52.3	22.7	67.9	43.2
3^{rd} Standard	40.4	27.7	74.1	42.6
4^{th} Standard	47.7	25.0	60.0	22.7
5^{th} Standard	40.0	23.6	63.6	12.7
6^{th} & above	41.0	13.1	57.0	06.6
Household Level Factors				
Agriculture land				
Below 0.5 Acre	36.4	13.6	71.4	50.0
0.5 - 1.0 Acre	51.7	24.4	65.3	36.9
More than 1.0 Acre	48.4	22.2	66.3	38.1
Household food security scale				
Food secure	46.3	31.3	60.7	41.5
Mildly food insecure access	52.6	18.1	63.7	37.7
Moderately food insecure access	48.6	22.7	64.6	36.7
Severely food insecure access	55.4	24.6	71.4	38.5
Livestock				
Yes	46.4	21.0	81.4	35.7
No	50.9	32.1	63.8	38.1
Number of cow/buffalos				
No cow	56.7	25.7	69.4	38.4
1-2	49.8	20.4	57.9	36.4
3 and above	50.0	23.3	42.9	47.8
Number of goats				
No goat	50.2	23.3	61.8	39.2
1-3	47.2	23.9	67.6	33.6
4-5	52.1	20.0	52.8	40.4
6 and above	59.3	22.2	71.4	35.0

Background characteristics	Stunted	Wasted	Underweight	Thin
Residence area				
Low SC area	48.3	20.2	62.8	40.4
Medium SC area	51.9	23.5	71.5	39.6
High SC area	50.8	23.9	63.2	33.7
Type of house				
Kachha	45.8	20.8	88.9	27.3
Semi-*Pucca*	49.8	22.7	64.9	38.8
Pucca	37.3	20.0	83.3	23.1
Caste				
Pasi	48.8	23.3	68.1	36.2
Chamar	50.4	21.7	63.4	36.8
Kori	57.4	30.8	83.3	59.1
Type of ration card				
Above poverty line	49.7	23.4	64.2	37.7
Below poverty line	51.2	21.1	66.7	37.8
Wealth status				
Poor	51.4	23.4	67.7	42.0
Medium	54.0	24.2	70.9	32.1
Rich	56.8	21.4	60.8	35.0
Mother Level Factors				
Mother's age (years)				
15-24	51.1	21.1	62.5	37.6
25-34	49.4	21.1	65.1	34.5
35-44	48.9	25.3	67.8	41.5
45-49	63.0	25.9	73.7	45.0
Mother's education				
No education	50.5	23.3	64.9	37.8
1-5 years	51.7	24.1	76.5	37.5
6-8 years	52.3	17.6	75.0	33.3
More than 8 years	50.0	12.5	71.4	35.7
Total	50.3	22.6	65.8	37.7

Source: Authors' calculations

The prevalence of child under nutrition by household food insecurity is shown in table 3. The proportion of stunted children was higher in those households without food to eat during the one month prior to the survey. Similarly, more than 50 per cent of the stunted children belonged to those households which had the inability to eat preferred food or had to eat a limited variety of food or had to eat fewer meals and had to sleep without food in the last one month. Likewise, a higher percentage of wasted children belonged to those households who had experiences of no food to eat during the last one month. However, prevalence of wasting, underweight and thinness has not been found to be influenced by such categories of household food insecurity such as limited variety of food, sleeping without food, and no food whole day and night.

Table 3: Percentage distribution of frequency of household's food insecurity by children nutritional status.

Food insecurity experience in one month	Stunted	Wasted	Underweight	Thin
Worry about insufficient food	48.8	22.1	66.1	37.9
Inability to eat preferred food	50.9	23.1	65.1	40.1
Had to eat a limited variety of food	58.6	21.4	67.4	33.3
Had to eat certain food items without choice	50.1	22.7	70.7	39.1
Had to eat smaller meals	45.8	22.9	64.3	36.6
Had to eat fewer meals	55.3	27.7	69.2	36.6
Had no food to eat	63.6	30.3	75.0	37.1
Had to sleep without food	53.8	19.2	81.2	40.9
Had to go day and night without eating any food	33.3	16.7	54.5	41.7
Total	50.3	22.6	65.8	37.7

Source: Authors' calculations

Table 4 shows results of the binary logistic regression analysis of the nutritional status of the child (stunted, wasted and thin) on the household food security status after controlling selected child-specific, household-specific, and mother-specific variables. The table confirms that household food security status has an influence on the nutritional status of children as measured in terms of stunting. The likelihood of a child to be stunted is higher in food insecure households compared to food secure households even after controlling a range of child-specific, household and mother related variables. In severely food insecure households, the probability of a child being stunted is found to be more than 2 time higher than in food secure households, although the likelihood of a child being stunted in mildly food insecure households has not been found to be statistically significantly different from the likelihood of a child being stunted in food secure households.

The relationship of child wasting with household food security status has, however, not been found to be strong. The likelihood of a child being stunted in severely food insecure households has not been found to be different from the likelihood of a child being wasted in food secure households. One reason is that the child wasting is influenced by child stunting. In stunted children, wasting may be low because of poor linear growth so that even if the weight of the child is low-for-age, the ratio of weight for height may be high and children may be classified as 'not wasted.' In case of mildly food insecure and moderately food insecure households, however, the likelihood of wasting in children is found to be statistically significantly higher than the likelihood of wasting in food secure households. On the other hand, the likelihood of a child being thin is found to be statistically significantly higher in severely food insecure households compared to the food secure households but the likelihood of a child being thin in mildly and moderately food insecure households is not found to be statistically significantly higher than the likelihood in food secure households.

Table 4: Results of binary logistic regression of child undernutrition on household food security.

Background characteristics	Dependent variables		
	Stunted	Wasted	Thin
Explanatory variable			
Household food security			
Food secure®	1.0	1.0	1.0
Mildly food insecure	1.210	1.201*	1.110
	(0.584-2.301)	(0.235-2.301)	(0.954-2.351)
Moderately food insecure	1.331*	1.320**	0.957
	(1.501-3.251)	(1.024-2.321)	(0.975-3.021)
Severely food insecure	2.213**	1.024	1.231*
	(2.351-5.320)	(0.954-8.301)	(1.024-3.214)
Confounding variables			
Age of the child			
Under 6 years®	1.0	1.0	1.0
6-8 years	0.804**	0.929**	1.240
	(0.471-0.753)	(1.094-1.748)	(0.580-2.352)
9-10 years	0.624*	0.859	1.187**
	(0.326-0.915)	(0.393-1.879)	(1.720-2.310)
11-12 years	0.757	0.723	2.301
	(0.366-1.565)	(0.146-0.947)	(0.201-5.320)
13-14 years	0.645	0.632**	2.370
	(0.281-1.483)	(0.079-0.873)	(3.210-14.320)
Sex of the child			
Girl®	1.0	1.0	1.0
Boy	0.964**	0.914*	0.938
	(1.063-1.861)	(0.026-0.881)	(0.545-1.615)
School enrolment			
Never enrolled®	1.0	1.0	1.0
1st Standard	1.535*	0.425	1.235*
	(0.792-0.975)	(0.173-1.045)	(0.143-0.890)
2nd Standard	1.216	1.003**	0.816
	(0.576-2.570)	(0.404-0.892)	(0.307-2.167)
3rd Standard	0.634	1.440	1.210
	(0.303-1.325)	(0.620-3.344)	(0.451-3.244)
4th Standard	1.020**	0.811***	1.899**
	(1.04-2.336)	(1.662-3.590)	(3.518-6.595)
5th Standard	0.748	0.834*	0.710
	(0.340-1.644)	(0.530-3.615)	(0.202-2.522)
6th & above	0.839	1.141	1.336
	(0.366-1.924)	(0.369-3.526)	(0.242-7.374)

Background characteristics	Dependent variables		
	Stunted	Wasted	Thin
Household agriculture land			
Below 0.5 Acre®	1.0	1.0	1.0
0.5 - 1.0 Acre	0.683*	2.223	0.619
	(0.644-0.983)	(0.584-0.862)	(0.058-1.764)
More than 1.0 Acre	0.505	0.820	0.572**
	(0.521-4.349)	(0.594-10.675)	(2.331-11.573)
Household livestock ownership			
Yes®	1.0	1.0	1.0
No	1.496	0.763**	1.578
	(0.646-3.484)	(0.138-0.723)	(0.345-7.214)
Number of cows in the household			
No cow®	1.0	1.0	1.0
1-2	0.797	0.933	0.385
	(0.415-1.533)	(0.417-2.089)	(0.121-1.222)
3 and more	0.911	1.244*	0.905*
	(0.359-2.316)	(1.417-3.709)	(1.196-4.179)
Number of goats in the household			
No goat®	1.0	1.0	1.0
1-3	0.811	1.425	0.417
	(0.409-1.607)	(0.641-3.188)	(0.120-1.445)
4-5	0.980*	0.822	0.453
	(1.477-2.015)	(0.330-2.047)	(0.141-1.457)
6 and more	1.164	1.293	0.364
	(0.434-3.120)	(0.408-4.099)	(0.071-1.865)
Location of the household			
Low SC area®	1.0	1.0	1.0
Medium SC area	0.853	1.076	0.507
	(0.361-1.571)	(0.417-2.283)	(0.129-1.996)
High SC area	1.125*	1.193	0.632
	(1.341-1.782)	(0.286-1.677)	(0.164-2.432)
Type of house			
Kachha®	1.0	1.0	1.0
Semi-*Pucca*	0.715	1.513*	0.870*
	(0.409-2.520)	(0.091-0.909)	(0.006-0.316)
Pucca	0.911*	0.833	0.470
	(1.858-7.824)	(0.267-2.595)	(0.002-1.413)

Background characteristics	Dependent variables		
	Stunted	Wasted	Thin
Sub-caste of the household			
Pasi®	1.0	1.0	1.0
Chamar	1.781	0.1.039	3.554*
	(0.879-3.610)	(0.457-2.360)	(1.030-12.262)
Kori	1.903	1.448	1.694
	(0.721-5.022)	(0.491-4.270)	(2.819-12.396)
Type of ration card			
Above poverty line®	1.0	1.0	1.0
Below poverty line	1.185**	0.981**	1.174**
	(0.751-0.964)	(0.573-0.806)	(1.541-2.546)
Household wealth status			
Poor®	1.0	1.0	1.0
Medium	1.109	1.226*	0.548**
	(0.637-1.930)	(0.624-0.895)	(1.002-1.861)
Rich	0.849**	0.815**	0.236
	(0.824-0.985)	(1.501-2.010)	(0.086-0.641)
Mother's age			
15-24 years®	1.0	1.0	1.0
25-34 years	1.057*	0.648**	1.776*
	(1.053-2.108)	(1.021-1.495)	(1.521-6.056)
35-44 years	0.831*	1.082	1.880**
	(0.418-0.652)	(0.487-2.404)	(0.195-0.708)
45-49 years	1.514	1.989*	4.114
	(0.569-4.024)	(1.323-1.828)	(0.698-2.247)
Mother's education			
No education®	1.0	1.0	1.0
1-5 years	1.049	0.942	0.915*
	(0.466-2.364)	(0.359-2.417)	(0.258-0.742)
6-8 years	1.365	0.464	1.924
	(0.954-3.935)	(0.115-1.870)	(421-8.798)
More than 8 years	0.955***	0.433***	2.833***
	(2.012-2.737)	(0.051-0.930)	(2.763-4.585)

Source: Authors' calculations

Discussions and Conclusions

This study has examined the influence of household food security on the nutritional status of children in Scheduled Castes households living in the rural areas. The study shows that the nutritional status of children of these households is directly related to the food security status of the household. Another important finding of the presented analysis is that there is variation in the prevalence of child under nutrition by sub-castes within the Scheduled Castes households. Scheduled Castes are popularly termed as 'untouchables' in the Indian society and, therefore, they are highly deprived and vulnerable population group which is reflected in terms of a high degree of household food insecurity. The present study shows that the deprivation and vulnerability of Scheduled Castes household as reflected through household food security has a strong influence on the nutritional status of Scheduled Castes children. Findings of the present study support the findings of previous research (Hallal et al, 2006; Coates et al, 2007; Bouchard et al, 2012). Poverty, food insecurity and malnutrition are the major barrier to achieve the Sustainable Development Goals (Branca et al, 2020; Weinreb et al, 2002).

The findings of the present study suggest that efforts should specifically be directed towards improving the household food security of Scheduled Castes households to address the high prevalence of child under nutrition in these households. There is a need to explore the reasons behind a high prevalence of food insecurity in Scheduled Castes households. In this context, it would also be useful to analyse the appropriateness, adequacy, efficiency, and effectiveness of the target public distribution system (PDS) of the country which is specifically directed towards improving the food availability at the household level. It may, however, be emphasised that the household food security is not the only factor that determines the nutritional status of children. There are a number of other factors also. However, the present study shows that even if these factors are controlled, the household food security has a strong impact on the nutritional status of children of Scheduled Castes households. This means that improving the household food security in Scheduled Castes households can contribute substantially towards accelerating the reduction in the prevalence of child under nutrition in Scheduled Castes.

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Spatial Clustering of Nutritional Status of Women in Uttar Pradesh, India

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Abstract

The objective of this paper is to analyse spatial clustering of nutritional status of non-pregnant women of reproductive age in Uttar Pradesh, India based on the data available through the National Family Health Survey, 2015-16. The nutritional status of non-pregnant women of reproductive age woman is measured in terms of Body Mass Index (BMI) and the variation in the nutritional status of non-pregnant women of reproductive age across the districts of the state is used for spatial cluster analysis. The analysis reveals that the districts of Uttar Pradesh can be grouped into four clusters based on the distribution of the nutritional status of non-pregnant women of reproductive age in the district which has implications for policy and planning for improving the nutritional status of the women of the state.

Introduction

The nutritional status of women is affected by a host of social, economic and cultural factors including poverty, inadequate availability of and access to health care services, low level of education, especially of females, limited employment opportunities for women; socio-cultural factors including social and cultural norms and practices, gender discrimination, domestic violence, sexual abuse, poor environmental hygiene; and demographic factors including reproductive life span, marriage and child bearing at a young age, demand for children and practice of family planning, unsafe abortions. Spatial diversity of these factors is well-known which implies that variation in the nutritional status of women has a spatial dimension. It is, therefore, imperative that the spatial dimension of the nutritional status of women is also taken into consideration at the policy level and in planning programming for improving the nutritional status of women. It has been observed that social, economic, and demographic characteristics of women largely remain invariant under identical spatial circumstances. Identification of geo-political clusters having similar nutritional status of women may help in adopting different approaches to improve the nutritional status of women. Such targeted approach may be more effective in meeting the challenge of nutrition in women compared to the population wide approaches.

Poor nutritional status of reproductive age women is one of the most important concerns in India. Poor nutritional status is an indication of insufficient intake of energy and essential nutrients to maintain good health. India ranks 101 out of 116 qualifying countries with a score of 27.5 in terms of hunger index 2021 (Grebmer et al, 2021). It is argued that the prevailing culture and traditional practices in India, especially during pregnancy and lactation is a major factor in the prevailing poor nutritional status of reproductive age women. According to the National Family Health Survey, 2015-16 (NFHS-4) 53 per cent of the reproductive age women; 50 per cent pregnant women; and 58 per cent lactating mothers are anemic (International Institute for Population Sciences and ICF, 2017). Responding to the prevailing situation, the Government of India launched the national-wide POSHAN Abhiyaan or National Nutrition Mission with specific focus on under nutrition among children, pregnant women, and lactating mothers (Government of India, 2021). Government of India has also launched a nutrition awareness programme, known as Anaemia Mukt Bharat, in association with United Nations Children's Fund (UNICEF) to bring about the behaviour change in people towards healthy living. The programme aims at reducing the prevalence of anaemia by three percentage points per year among children, adolescents, and reproductive age women by the year 2022.

The nutrition situation in Uttar Pradesh, the most populous state of the country is particularly serious. This state is the home of the largest number of under-nourished people in the country. The prevalence of under nutrition in the state is also amongst the highest in the world (UNICEF, 2016). At the same time, there appears only a marginal improvement in the situation during the past decade as is evident from the third and the fourth rounds of the National Family Health Survey. The prevalence of under nutrition is particularly high in the rural areas of the state where income and food security is low (Government of India, 2017). The Government of Utter Pradesh has launched the Uttar Pradesh State Nutrition Mission in 2014 to address the challenge of under nutrition in children and women with financial and technical support from UNICEF. From the geopolitical perspective, the state is divided into 71 districts as they existed at the 2011 population census. The available evidence indicates that there is a very substantial disparity across districts of the state in all dimensions of population and development. The data available from NFHS-4 suggest that the nutritional status of reproductive age women varies widely across the districts of the state.

The present study analyses the distribution of the nutritional status of reproductive age women in the districts of the state. The study also attempts to group or cluster districts to examine regional pattern, if any, in the within district distribution of nutritional status of reproductive age women. This clustering may help in identifying factors that have significant influence on the growth and development of the communities and contribute to designing and implementing appropriate regional and state-specific strategies for improving the nutritional status of reproductive age women.

The paper is organized as follows. The next section of the paper presents a snapshot of the status of women in Uttar Pradesh. The data used and the methodology adopted in the paper are discussed in section three of the paper. The paper is based on the data on the nutritional status of reproductive age women available through the fourth round of the National Family Health Survey carried out in 2015-16. Findings of the analysis are discussed in section four while the last section summarises the findings of the analysis and discusses their policy and the programme implications in the context of improving the nutritional status of reproductive age women in particular and reproductive health status of the people in general.

Status of Women in Uttar Pradesh

The status of women in Uttar Pradesh remains low by national standards. The female life expectancy at birth is 65.8 years which is less than the national average of 69 years (Government of India, 2020). In the rural areas of the state, the female life expectancy is less than 65 years. The maternal mortality ration in the state is 197 maternal deaths for every 100 thousand live births which is the second highest in the country (Government of India, 2020). The accounts for more than 16 per cent of the population of the country. The population density in the state is 828 person per Km^2. Between 2001 and 2011, the population of the state increased by more than 20 per cent. The population sex ratio in the state was 908 females for every 1000 males at the 2011 population census while the child sex ratio was 899 girls for every 1000 boys. Both population sex ratio and child sex ratio in the state are lower than the national average. At the 2011 population census, less than 60 per cent of females aged seven years and above were able to read and write with understanding and this proportion was well below the national average. Only 23 per cent of reproductive age women in the state have completed twelve or more years of schooling (Government of India, 2017).

The state is one of those few states of the country which are yet to achieve the replacement fertility. The total fertility rate in this state is estimated to be 2.9 births per women of reproductive age. In the rural areas of the state, the total fertility rate is more than 3 birth per woman of reproductive age (Government of India, 2020). The fertility of currently married reproductive age women is estimated to 6.8 births per currently married woman of reproductive age. In the urban areas of the state, total marital fertility rate is more than 7 births per married woman of reproductive age (Government of India, 2020). Around one-fifth of the women aged 20-24 years reported to have got married before reaching the legal minimum age of marriage of 18 years (Government of India, 2017). The median age at first marriage is estimated to be 18.5 years among women aged 20-49 years (Government of India, 2017). The contraceptive prevalence rate in the state is only 46 per cent which is well below the national average (Government of India, 2017). Less than half of the currently married women of the state received first antenatal check-up during the first trimester of their last pregnancy while only around 26 per cent had at least four antenatal care visits. Almost one third of the deliveries in the state occurred at home according to NFHS-4. Over one-third of women aged 15-49 years in the state have experienced physical or sexual violence according to NFHS-4 (Government of India, 2017).

More than one fourth of the women of the state were found to be under nourished having a BMI of less than 18.5 Kg/m^2 according to NFHS-4, although this proportion has decreased from more than 36 per cent in 2005-06 according to the third round of the National Family Health Survey (Government of India, 2017). On the other hand, more than 16 per cent of women were found to be obese having a BMI of more than 25 Kg/m^2 according to NFHS-4 and this proportion has increased from around 9 per cent in 2005-06 according to the third round of the National Family Health Survey. Within Uttar Pradesh, the proportion of women with low BMI varies widely across districts from almost 36 per cent in district Sitapur to less than 15 per cent in Gautam Buddha Nagar, Lucknow, and Kanpur Nagar districts of the state. On the other hand, more than 30 per cent women in district Ghaziabad are found to be obese, the highest in the state, whereas, in district Hamirpur, this proportion is found to be less than 7 per cent which is the lowest in the state.

Data and Methodology

The paper is based on the data available through the fourth round of the National Family Health Survey (NFHS-4). The National Family Health survey (NFHS) programme is the nationwide household sample survey programme which collects information on selected demographic and health parameters, including anthropometric measurements of children below five years of age and women in the reproductive age group (15-49 years). The programme was launched in 1992-93 and four rounds of the survey have been carried out while the fifth round is in progress. Details of the National Family Health Survey Programme are available elsewhere (Government of India, 2021). The present paper is based on the data available from the fourth round of the survey which was carried out during the period 2015-16 and is confined to currently married women in the reproductive age group who reported that they were not pregnant at the time of the survey. In Uttar Pradesh, 7166 currently married women in the reproductive age group reported that they were not pregnant at the time of the survey and these women are included in the present analysis. Out of these women, the BMI could be computed for 7129 women only. The average BMI of these 7129 women is estimated to be 22.229 ± 4.300.

The analytical strategy of the present analysis involved two steps. The first step was to characterise the nutritional status of currently married, non-pregnant women of reproductive age in each district of the state. We have characterised the distribution of the nutritional status of currently married non-pregnant women of reproductive age in terms of the distribution of BMI using four parameters of the distribution: 1) arithmetic mean; 2) standard deviation; 3) skewness or the deviation from normality; and 4) kurtosis or the peakedness of the distribution of currently married, non-pregnant, reproductive age women. For each district of the state, the four parameters, characterizing the distribution of the nutritional status in currently married, non-pregnant, reproductive age women, were calculated from the data available from NFHS-4. Inter-district variation in these four parameters, in combination, depicted how the distribution of the nutritional status of currently married, non-pregnant women of reproductive age varied across the districts of the state.

The second step in the analysis was related to the clustering of the districts using the four parameters of the distribution of BMI in currently married, non-pregnant women of reproductive age as classification variables. The k-means clustering method using the Euclidian distance between districts was used for clustering purpose (MacQueen, 1967). The clustering exercise grouped the districts of the state into mutually exclusive yet exhaustive clusters or groups of districts in such a way that the distribution of BMI of currently married, non-pregnant, reproductive age women of districts within the same cluster is very similar while that in districts of different clusters is different. The clustering exercise classifies a district in one and only one of the clusters identified. The distribution of BMI of the currently married, non-pregnant, women of reproductive age in different clusters identified through the clustering exercise, as characterised through the four parameters of the distribution, then, reflected how the nutritional status of currently married, non-pregnant, reproductive age women varied across different clusters or groups of districts identified through the clustering exercise. The analysis was carried out using the Statistical Package for Social Sciences (SPSS) software.

Results

Table 1 presents the distribution of currently married, non-pregnant, women of reproductive age by their nutritional status as reflected through BMI for the state and for its 71 districts as they existed at the time of NFHS-4. At the state level, the distribution of currently married, non-pregnant reproductive age women may be characterised as a leptokurtic positively skewed distribution with mean BMI of 22.229 and standard deviation 4.300. The distribution is positively skewed which means that the proportion of women having BMI less than the mean BMI is higher than the proportion of women having BMI more than the mean BMI. On the other hand, the distribution is leptokurtic which implies that there is only a small proportion of women with BMI substantially lower or higher than the mean BMI.

Table 1 also reveals that the distribution of the nutritional status currently married non-pregnant women of reproductive age, as reflected through BMI, varies widely across the districts of the state. The lowest value of BMI ranges from 10.01 to 16.85 across the districts of the state whereas the maximum value ranges from 29.49 to 43.21. On the other hand, the mean BMI ranges from 19.81 to 24.52 across the districts. There are 17 districts in the state where there was at least one currently married, non-pregnant woman of reproductive age with a BMI of just around 10 whereas there is no district in the state where all women had BMI at least 18.5 at the time of NFHS-4. There is only one district - district Hardoi – where the mean BMI is estimated to be less than 20 but there is no district in the state where the mean BMI is estimated to be at least 25. On the other hand, the skewness in the distribution of BMI in women ranges from 0.07 to 1.97 which means that there is no district where the proportion of women having BMI less than the mean BMI is smaller than the proportion of women having BMI larger than the mean BMI. The skewness in the distribution of BMI is very small in Kheri and Rai Bareli districts of the state but it is very high in Gonda and Pratapgarh districts. On the other hand, kurtosis in the distribution of BMI in women ranges from -0.89 to 7.32 across the districts. A negative value of kurtosis implies a platykurtic distribution which means that the tails of the distribution are small whereas the higher the value of kurtosis the longer the tails of the distribution which implies outliers and extreme values present in the distribution. There are 13 districts in the state where the kurtosis in the distribution of BMI in currently married non-pregnant women of reproductive age has been found to be negative which means that the distribution of BMI in women is platykurtic in these districts. In the remaining districts of the state, the distribution of BMI is leptokurtic as the value of kurtosis is found to be positive. In Pratapgarh, Gonda, and Hamirpur districts of the state, kurtosis in the distribution of BMI is estimated to be more than 7 which implies that the distribution of BMI in these districts has very long tails indicating presence of outliers and extreme values. This also means that there is very heavy concentration of BMI around the mean BMI. The inter-district coefficient of variation in the four parameters of the distribution of BMI in women is found to be the highest in case of kurtosis (1.321) but the lowest in case of standard deviation (0.116). It is clear from the table that the distribution of BMI in currently married non-pregnant women of reproductive age is different in different districts.

Table 2 presents results of the clustering exercise based on the four parameters of the distribution of BMI in currently married non-pregnant women of reproductive age in each district. The table indicates that the 71 districts of the state can be grouped into 4 clusters and as the distribution of BMI in currently married non-pregnant women of reproductive age in the four clusters is essentially different. Cluster 1 is the largest cluster comprising of 54 districts of the state. The mean BMI in the districts of this cluster ranges between 19.81 and 23.37 with an unweighted average of 21.95 and standard deviation 0.795. The cluster 2, on the other hand, comprises of 10 districts and the mean BMI, in these districts, ranges from 21.41 to 23.38 with an unweighted average of 21.20 and standard deviation 0.659. Clusters 3 and 4 are very small clusters comprising of 3 and 4 districts respectively. The BMI ranges between 23.68 and 24.52 in cluster 3 whereas it ranges between 20.41 and 22.75 in cluster 4. The three districts of cluster 3 constitute a geographical continuity as may be seen from figure 2. The clustering exercise thus reveals that the distribution of BMI in currently married non-pregnant reproductive age women in 17 districts of the state is different from the distribution of BMI that prevails in majority of districts of the state.

Table 1: Distribution of the body mass index (BMI) of currently married non-pregnant reproductive age women in Uttar Pradesh

State/District	Lowest	Mean	SD	Highest	Skewness	Kurtosis	N
Uttar Pradesh	10.01	22.23	4.30	43.21	0.84	1.20	7129
Saharanpur	13.61	22.76	4.48	36.74	0.71	0.01	178
Muzaffarnagar	15.35	23.38	5.09	43.03	1.41	3.37	84
Bijnor	12.71	22.04	4.17	33.63	0.70	0.30	97
Moradabad	14.97	23.01	4.52	37.40	0.73	0.37	197
Rampur	14.13	22.65	4.74	39.64	1.05	1.47	103
Jyotiba Phule Nagar	15.43	22.51	4.55	36.33	0.97	0.61	108
Meerut	14.81	24.52	4.66	39.03	0.35	0.15	245
Baghpat	14.85	23.68	4.60	33.06	0.18	-0.79	95
Ghaziabad	10.01	23.74	4.64	35.54	0.16	-0.40	191
Gautam Buddha Nagar	13.11	23.31	4.10	40.67	0.66	0.95	191
Bulandshahr	15.46	22.58	5.15	41.72	1.24	1.63	99
Aligarh	13.29	22.86	4.75	40.29	1.05	1.20	179
Mahamaya Nagar	10.01	22.83	5.05	34.87	0.49	-0.11	90
Mathura	16.16	23.37	3.79	33.44	0.64	-0.05	99
Agra	10.01	22.27	4.17	37.65	0.88	1.26	210
Firozabad	13.99	22.27	4.35	39.79	1.07	1.57	185
Mainpuri	16.58	22.58	4.16	35.40	0.94	0.49	96
Budaun	12.33	21.75	4.35	38.73	0.93	1.69	100
Bareilly	10.01	22.76	4.41	35.48	0.20	-0.12	192
Pilibhit	14.92	21.70	4.31	33.86	0.95	0.29	96
Shahjahanpur	13.36	21.42	4.51	37.86	0.75	0.84	92
Kheri	10.01	20.29	4.00	30.81	0.07	0.68	94
Sitapur	10.01	20.18	3.55	29.98	0.47	0.84	79
Hardoi	10.01	19.81	3.19	29.49	0.31	1.59	76
Unnao	15.57	21.32	3.62	30.65	0.80	0.00	85
Lucknow	10.01	22.85	4.91	39.00	0.54	1.60	116
Rae Bareli	10.01	21.83	3.55	31.94	0.08	0.96	89
Farrukhabad	15.67	22.48	3.93	36.64	0.90	1.14	86
Kannauj	14.57	21.83	4.00	35.46	1.24	1.86	83
Etawah	16.47	23.07	3.82	31.22	0.21	-0.89	91
Auraiya	15.74	21.68	4.06	37.68	1.56	3.30	80
Kanpur Dehat	16.34	22.15	3.92	35.28	1.32	1.67	79
Kanpur Nagar	14.74	22.66	3.89	40.60	0.97	2.37	165
Jalaun	15.70	21.79	3.54	32.59	0.75	0.91	66
Jhansi	13.88	22.62	4.21	41.51	0.89	2.18	143
Lalitpur	14.65	21.33	2.92	30.06	0.28	0.38	81
Hamirpur	14.43	20.41	3.23	36.24	1.86	7.32	68
Mahoba	10.01	20.86	4.11	31.03	0.58	0.63	59
Banda	10.01	21.38	3.95	32.09	0.49	0.86	77
Chitrakoot	16.34	21.65	3.63	37.36	1.44	3.54	90

State/District	Lowest	Mean	SD	Highest	Skewness	Kurtosis	N
Fatehpur	13.99	21.41	4.07	38.01	1.66	3.79	65
Pratapgarh	16.50	22.75	4.10	42.15	1.97	7.22	62
Kaushambi	14.83	20.74	3.47	31.95	0.97	1.26	71
Allahabad	15.69	22.39	4.47	41.17	1.27	3.07	81
Bara Banki	13.36	21.86	4.71	42.88	1.70	5.51	74
Faizabad	13.84	22.82	4.92	42.82	1.20	2.76	78
Ambedkar Nagar	10.01	21.60	4.24	33.89	0.40	0.90	92
Sultanpur	13.92	21.99	4.08	35.17	0.86	1.18	63
Bahraich	13.30	21.23	4.41	33.46	0.92	0.29	81
Shrawasti	13.32	21.31	4.10	35.91	0.87	1.76	72
Balrampur	10.01	21.83	4.31	36.47	1.27	3.15	90
Gonda	10.01	21.33	4.60	43.21	1.93	7.26	73
Siddharth Nagar	16.00	21.56	3.76	30.73	0.40	-0.87	65
Basti	15.17	21.60	3.57	30.17	0.71	-0.15	64
Sant Kabir Nagar	16.85	22.64	3.74	31.81	0.53	-0.52	75
Mahrajganj	15.59	22.29	4.49	36.36	0.98	0.52	71
Gorakhpur	15.89	22.38	3.98	34.13	0.59	0.03	76
Kushinagar	13.96	21.37	3.90	32.46	0.52	-0.31	81
Deoria	15.15	23.09	4.67	36.98	1.08	1.20	59
Azamgarh	14.66	22.28	4.13	34.27	0.70	0.34	54
Mau	15.89	21.72	3.25	31.76	0.71	0.20	71
Ballia	10.01	22.94	4.96	40.10	0.77	1.81	73
Jaunpur	15.18	22.00	4.23	33.60	0.58	-0.35	86
Ghazipur	15.19	21.52	3.62	30.47	0.57	-0.20	76
Chandauli	10.01	21.51	3.85	32.34	0.63	0.79	111
Varanasi	10.01	21.58	4.08	34.24	0.53	0.56	190
Sant Ravidas Nagar	16.13	22.12	3.61	29.63	0.31	-0.73	85
Mirzapur	14.76	21.27	4.27	36.53	1.24	1.89	86
Sonbhadra	14.97	21.09	3.48	33.84	1.23	2.08	100
Etah	15.55	21.58	4.37	40.28	1.42	3.43	82
Kanshiram Nagar	15.24	21.67	3.92	33.04	1.03	0.90	88

Source: Authors' calculations

Table 2: Results of the clustering of districts in terms of the distribution of BMI in currently married non-pregnant women of reproductive age in Uttar Pradesh

Cluster	Number of districts	Number of women	BMI			
			Mean	Standard deviation	Skewness	Kurtosis
1	54	5363	22.07	4.220	0.781	0.907
2	10	958	22.28	4.299	1.263	2.768
3	3	531	24.09	4.650	0.249	-0.188
4	4	277	21.56	4.280	1.838	6.492

Source: Authors' calculations

Table 2 also gives key parameters of the distribution of BMI in currently married non pregnant women of reproductive age in the four clusters identified through the clustering exercise. The distribution of BMI in women belonging to cluster 4 is characterised by the lowest mean BMI and the highest skewness and kurtosis among all clusters. By contrast, the distribution of BMI in women belonging to cluster 3 is characterised by the highest mean BMI and the lowest skewness and kurtosis among the four clusters. Both skewness and the kurtosis of the distribution of BMI are also quite high in cluster 2. The proportion of currently married non-pregnant women of reproductive age having BMI below 18.5 is 19.5 per cent in cluster 1; 16.6 per cent in cluster 2; 11.7 per cent in cluster 3; and 20.6 per cent in cluster 4. On the other hand, the proportion of currently married non-pregnant women of reproductive age having BMI more than or equal to 25 is 21.9 per cent in cluster 1; 20.6 per cent in cluster 2; 40.3 per cent in cluster 3; and only 14.1 per cent in cluster 4. The dendrogram depicting the linkage of districts in terms of the distribution of BMI of currently married non-pregnant women of reproductive age is depicted in figure 1 while the geographical distribution of districts belonging to different clusters is presented in figure 2. It may be seen from the figure 2 that the districts belonging to cluster 3 are geographically contiguous but there is little geographic contiguity in districts of cluster 2 or in districts of cluster 4.

Table 3: Composition of clusters of districts of Uttar Pradesh based on the distribution of the nutritional status of currently married non-pregnant reproductive age women in the district.

Cluster	Districts	
	Number	Name
Cluster 1	54	Saharanpur, Bijnor, Moradabad, Bulandshahr, Aligarh, Hathras, Mathura, Agra, Bareilly, Lucknow, Gorakhpur, Ballia, Rampur, Amroha, Firozabad, Mainpuri, Budaun, Pilibhit, Shahjahanpur, Hardoi, Unnao, Rae Bareli, Farrukhabad, Kannauj, Etawah, Kanpur Dehat, Jalaun, Banda, Ambedkar Nagar, Sultanpur, Balrampur, Siddharth Nagar, Basti, Sant Kabir Nagar, Mahrajganj, Kushinagar, Deoria, Azamgarh, Mau, Jaunpur, Ghazipur, Chandauli, Varanasi, Sant Ravidas Nagar, Mirzapur, Sonbhadra, Kasganj, Kheri, Sitapur, Lalitpur, Mahoba, Kaushambi, Bahraich, Shrawasti
Cluster 2	10	Mujaffarpur, Auriya, Kanpur Nagar, Jhansi, Chitrakoot, Fatehpur, Allahabad, Faizabad, Balrampur, Etah
Cluster 3	3	Meerut, Baghpat, Ghaziabad
Cluster 4	4	Hamirpur, Pratapgarh, Bara Banki, Gonda

Source: Authors' calculations

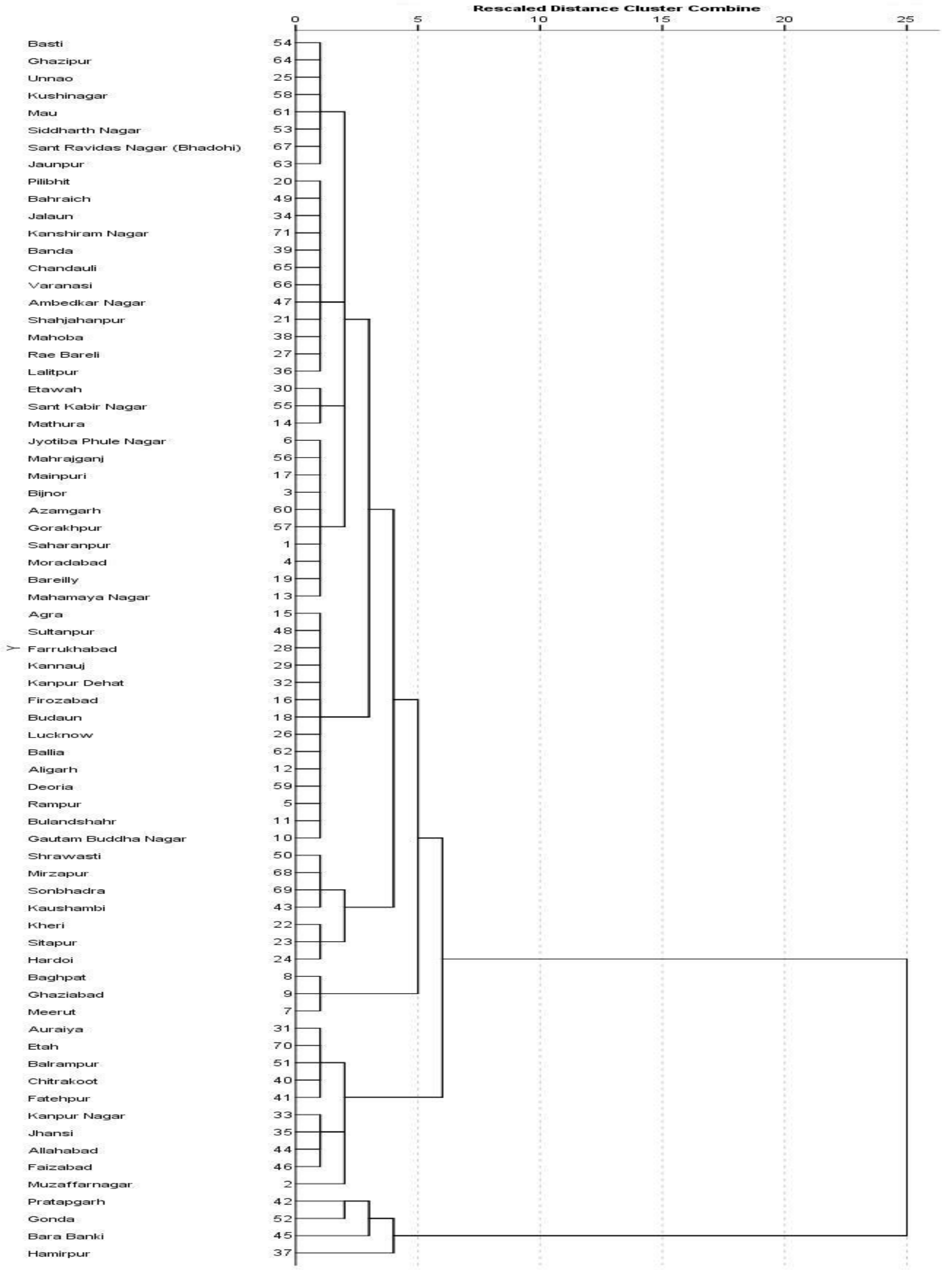

Figure 1: Dendrogram showing linkage of districts in terms of BMI in currently married non-pregnant women of reproductive age
Source: Authors

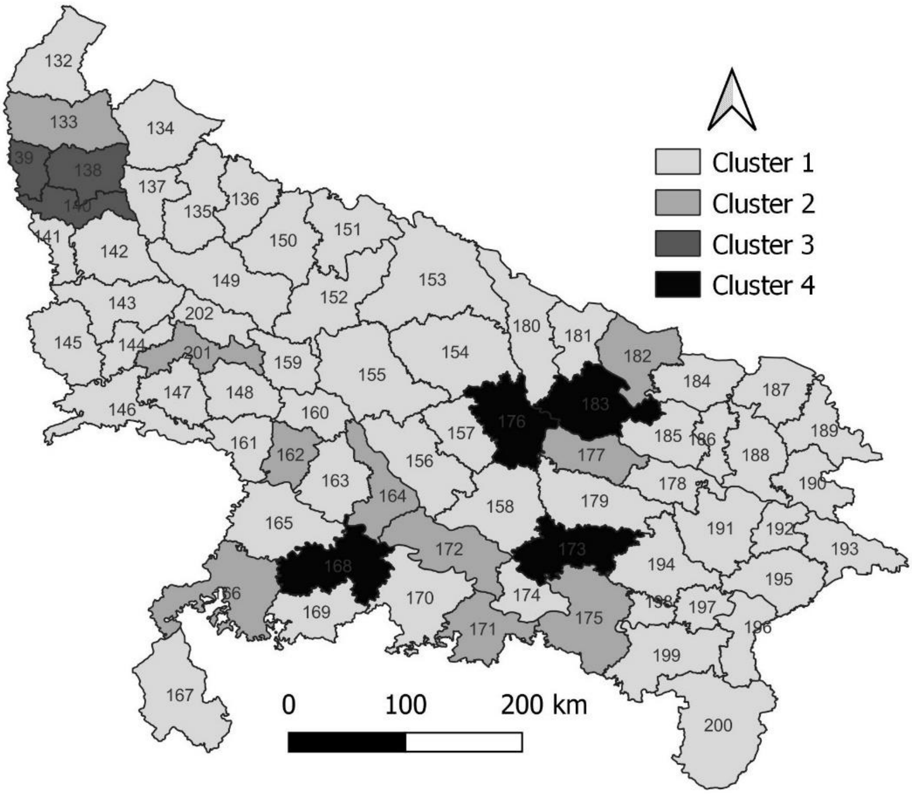

Figure 2: Cluster pattern in terms of distribution of BMI in currently married non-pregnant women of reproductive age
Source: Authors

Discussions and Conclusions

The present analysis depicts a high degree of inter-district volatility in the nutritional status of currently married non-pregnant women of reproductive age as revealed through the distribution of BMI. A comparison of the distribution of currently married non-pregnant women of reproductive age in terms of BMI suggests that the situation is particularly poor in four districts of the state – Hamirpur, Pratapgarh, Bara Banki and Gonda. The distribution of currently married non-pregnant women of reproductive age by their BMI in these districts is found to be contrastingly different from the distribution of BMI in currently married non-pregnant women of reproductive age in other districts of the state. Similarly, the distribution of currently married non-pregnant women of reproductive age in terms of their BMI has also been found to be contrastingly different in Meerut, Baghpat and Ghaziabad districts relative to other districts of the state. Reasons for the difference in the distribution of currently married non-pregnant reproductive age women by their nutritional status across the districts of the states are not known at present. The present analysis does not reveal any regional pattern in the distribution of the nutritional status of currently married non-pregnant reproductive age women. It appears that there are district-specific factors that influence the nutritional status of currently married non-pregnant women of reproductive age. This means that a district-based approach should be adopted for improving the nutritional status of women of reproductive age.

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Determinants of Modern Contraceptive Use Among Young Married Women in Five High Fertility States of India

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Abstract

In India, early marriage, low prevalence of modern contraceptive methods, and births among young married women remain a significant health and socio-demographic concern for women, their families, and communities. This paper analyses use of modern contraceptive methods among young married women aged 15-24 years in five high fertility states of India. Bivariate and multinomial logistic regression models were used to assess the association between a set of background predictors and use of modern contraceptives among young married women. Level of education, women's parity and son preference and religious affiliation of the young married women has been found to be most significant determinants in utilizing the modern spacing and permanent methods. The analysis also reveals that the determinants of modern spacing methods use are different from the determinants of the use of limiting methods. The analysis suggests that increasing years of schooling, improving comprehensive knowledge about different family planning methods, counselling for family planning with a focus on adolescent girls and young women may help in increasing the use of modern spacing methods among young married women thereby achieving the goal of sexual and reproductive health.

Background

The recent decade has witnessed a growing concern over the sexual and reproductive health of young women among family planning policy makers, health professionals, academics, researcher, and stakeholders in India. Universal access to Sexual and Reproductive Health (SRH) including family planning services by 2030 is a recognised goal that corresponds to targets 3.7 and 5.6 of the United Nations Sustainable Development Goals (SDGs). The indicator 3.7.2 of the SDGs explicitly refers to adolescent birth rate (Sánchez-Páez & Ortega, 2018). Unplanned pregnancies and births among young women have significant health and socio-demographic consequences for women, their families, and communities (Sedgh et al., 2014; Singh et al., 2010). Young married women in India have little scope to make fertility decisions and adopt a modern family planning methods because of a strong patriarchal society (Char et al., 2010; Ghule et al., 2015). Contraceptive use is identified as one of the proximate determinants of fertility (Bongaarts, 1978; 2015; Bongaarts and Potter, 1983; Casterline et al, 1984; Stover, 1998) and is an effective tool to prevent unintended pregnancy and regulate fertility (New et al, 2017; Stover and Ross, 2010).

Marriage at a young age exposes millions of adolescent girls and young women to pregnancy, abortion and various obstetric health complications resulting in increased risk of pregnancy related deaths in the developing countries (Mayor, 2004; Stover and Ross, 2010; Williamson et al, 2009) In India, more than 40 per cent women aged 15-24 years are currently married and the mean age at marriage of females is 18.6 years for women aged 25-49 years (Government of India, 2017). Cultural stigma and religious opposition, limited access and choices to family planning methods, fear of adverse side-effects, inadequate and poor quality of services, social myths and misconceptions and gender-based barriers are among the many reasons behind the very low use of modern contraceptive methods and high unmet need of family planning, especially among young married women (Joshi et al, 2015; Khurram et al, 2012; Mwaisaka et al, 2020; Uzma, 2017; Thulaseedharan, 2018). The official family welfare programme of the country is dominated by female sterilisation which accounts for more than two-third of all contraceptive use while the use of modern spacing methods remains low (Säävälä, 1999; Stephenson, 2006). Because of the dominance of permanent methods, the family planning needs of young married women in India remain grossly unmet. According to the National Family Health Survey (NFHS) 2015-16, less than 27 per cent of the demand for family planning among currently married women aged 15-19 years in India is satisfied by modern family planning methods while the modern family planning methods prevalence is only 10 per cent (IIPS and ICF 2017). This means that young married women in India face a high risk of unintended pregnancy.

It is in the above context that the present paper attempts to analyse the determinants of the use of modern family planning methods among young married women – currently married women aged 15-24 years - in five high fertility states of India - Bihar, Uttar Pradesh, Madhya Pradesh, Jharkhand, and Rajasthan. The total fertility rate, in these states, remains higher than the national average and ranges from 3.2 births per woman of reproductive age in Bihar to 2.5 births per woman of reproductive age in Jharkhand and Rajasthan according to the official Sample Registration System (Government of India, 2018). The paper has two objectives. The first objective of the paper is to analyse the prevalence of modern family planning methods among young married women in five states along with the proportionate use of different family planning methods or the method mix. The second objective, on the other hand, is to analyse the determinants of the use of modern family planning methods among young married women in the five high fertility states.

Materials and Methods

The study is based on the data collected under the National Family Health Survey (NFHS) 2015-16 (International Institute for Population Sciences and ICF, 2017). The NFHS 2015-16 covered 44,266 young married women (currently married women in the age group 15-24 years) in the five high fertility states covered in the present analysis - 8,853 in Bihar; 5,176 in Jharkhand; 10,091 in Madhya Pradesh; 7,182 in Rajasthan; and 12,964 in Uttar Pradesh. Using these data, we have estimated method-specific prevalence of different modern family planning methods and calculated the proportionate distribution of modern family planning methods currently being used by young married women to estimate modern methods prevalence rate (mCPR) and method mix among young married women. We have also carried out bivariate analysis to examine how mCPR, method-specific prevalence and method mix varies by individual and social and economic characteristics of the young married women. Finally, logistic regression analysis has been carried out to examine the influence of different social, economic, demographic, and other contextual factors on the use of modern spacing methods and permanent methods. The analysis has been carried out for each of the five states separately as both fertility and family planning use among young married women varies across the five states included in the analysis.

The dependent variables used in the logistic regression analysis are dichotomous variables. We have compared young married women not using any modern family planning method with young married women using modern spacing methods - intra-uterine device (IUCD), injectable, pill, emergency pill, condom, lactational amenorrhoea method (LAM), standard day method (SDM) and other modern method - and young married women using permanent methods – female and male sterilisation. On the other hand, independent variables in the logistic regression analysis include religion (Hindu and Non-Hindu); years of schooling of the young married women (no schooling, 1-5 years of schooling, 5-9 years of schooling, 10-11 years of schooling, and schooling of 12 and more years); standard of living based on the household wealth index (poor, middle, and rich); caste (marginalised - Scheduled Tribes and Scheduled Castes - and not-marginalised - Other Backward Classes and General castes; residence (urban and rural); intra-household status of young married woman (only married woman in the household and more than one married women in the household); number of living children to the young married woman; son preference (young married women having at least one son, young married women having no son, and women not having any child), Desired/ideal number of children reported by the young married woman; interaction with the front line health workers in the three months preceding the survey categorised into two groups (yes, no); exposure to mass media about family planning messages during the three months preceding the survey categorised into two groups (yes, no); and the knowledge of at least three modern family planning methods (yes, no). Multicollinearity among the independent variables was checked before carrying out the logistic regression analysis. Statistical Package for the Social Sciences (SPSS Version 22.0) was used for the analysis.

Results

Table 1 presents mCPR, prevalence of different modern contraceptive methods and unmet need for modern contraceptive methods among young married women in the five states. The mCPR and prevalence of different modern contraceptive method was higher in young married women aged 20-24 years compared to young married women aged 15-19 years. Across the five states, mCPR in young married was the lowest in Bihar but the highest in Rajasthan. Among different modern family planning methods, condom was the most popular one and its prevalence was also the lowest in Bihar but the highest in Rajasthan in both young married women aged 15-19 years and young married women aged 20-24 years. Use of permanent methods was not popular among the young married women in all states.

Table 2 presents prevalence of modern spacing methods and permanent methods in five states. The prevalence of modern spacing methods was also the highest in Rajasthan and the lowest in Bihar, but the prevalence of permanent methods was the highest in Madhya Pradesh but the lowest in Uttar Pradesh. Madhya Pradesh is the only state where the prevalence of permanent methods in young married women was higher than the prevalence of modern spacing methods. Table 2 also presents the prevalence of modern family planning methods (mCPR) in young married women by various social economic and family related variables. The mCPR was higher in non-Hindu young married women in Madhya Pradesh compared to Hindu young married women. In other states, however, mCPR was higher in Hindu compared to non-Hindu young married women. In all states, mCPR was the highest in rich young married women. Similarly, mCPR was higher in young married women living in urban areas and in young married women belonging to not-marginalised castes in all the five states. The mCPR appears to be directly related to the years of schooling of the young married women as it was the highest in young married women with at least 12 years of schooling in all states. Similarly, mCPR was relatively higher in young married women not living with other married women in the family compared to young married women living with other married women in the family. The table also shows that the parity and the son preference also play an important role in deciding the use of modern family planning methods by the young married women. The mCPR was low in young married women who did not have any child or were having only girl child/ren compared to women having at least one son in all the five states. Young married women who desired two or less than two children were having higher mCPR compared to women who desired at least three children. The prevalence of modern family planning methods has also been found to be higher in young married women exposed to mass media compared to young married women not exposed to mass media. The knowledge of at least three modern family planning methods by the young married women has also been found to be related to relatively higher prevalence of modern family planning methods in young married women. However, no substantial difference in mCPR is found between young married women who interacted with FLWs during the last three months preceding the survey compared to young married women who had no interaction.

Table 1. Prevalence of modern family planning methods (mCPR) and method-specific prevalence in young married women in five high fertility states of India, 2015-16.

Prevalence rate	States									
	Bihar (BI)		Jharkhand (JH)		Madhya Pradesh (MP)		Rajasthan (RA)		Uttar Pradesh (UP)	
	15-19	20-24	15-19	20-24	15-19	20-24	15-19	20-24	15-19	20-24
Modern methods prevalence (mCPR)	1.5	6.4	5.5	14.3	7.5	20.3	10.5	22.2	5.6	14.2
Method-specific prevalence										
Pill	0.5	0.5	1.9	2.5	0.5	1.8	1.2	2.6	0.5	1.0
IUD	0.1	0.5	0.5	1.3	0.3	0.8	0.8	1.2	0.3	0.9
Injection	0.1	0.2	0.0	0.1	0.1	0.2	0.1	0.3	0.1	0.2
Condom	0.7	1.0	2.3	2.5	5.5	6.2	7.8	10.8	4.6	10.3
Female sterilisation	0.1	4.1	0.4	7.4	1.0	11.1	0.4	7.1	0.0	1.5
Male sterilisation	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0
Lactational Amenorrhoea method (LAM)	0.0	0.1	0.3	0.5	0.0	0.1	0.1	0.1	0.1	0.1
Standard days method (SDM)	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
Other Modern Methods	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: International Institute for Population Sciences and ICF (2017).

Table 2: Modern methods prevalence of mCPR and prevalence of modern spacing methods and permanent methods in young married women in five high fertility states of India 2015-16.

Background Characteristics	Prevalence of modern spacing methods (Per cent)					Prevalence of permanent methods (Per cent)					Prevalence of modern methods (Per cent)				
	BI	JH	MP	RA	UP	BI	JH	MP	RA	UP	BI	JH	MP	RA	UP
Religion															
Non-Hindu	1.6	6.3	16.9	17.1	12.7	1.1	2.1	4.6	2.8	0.1	2.7	8.4	21.5	19.8	12.8
Hindu	2.1	6.4	8.1	13.8	11.5	3.4	7.0	9.9	6.4	1.5	5.5	13.4	17.9	20.2	13.0
Wealth Index															
Poor	1.5	5.1	4.5	9.3	7.0	2.9	5.2	11.7	6.4	1.6	4.4	10.3	16.1	15.7	8.6
Middle	3.0	9.0	10.8	13.4	12.2	3.8	8.8	7.9	7.2	1.2	6.8	17.8	18.7	20.6	13.4
Rich	5.5	10.5	16.8	19.9	19.4	2.7	4.7	5.6	4.7	0.9	8.3	15.2	22.5	24.6	20.3
Caste															
Marginalised	1.6	5.0	5.7	11.7	9.2	2.9	4.8	10.7	6.5	1.5	4.5	9.8	16.5	18.2	10.8
Non-marginalised	2.2	7.4	11.0	15.8	12.6	3.1	6.3	8.7	5.7	1.2	5.3	13.7	19.6	21.4	13.9
Residence															
Rural	1.8	5.7	6.7	12.6	9.7	2.9	5.5	10.7	6.3	1.4	4.7	11.2	17.4	18.9	11.2
Urban	4.2	9.4	15.4	21.4	19.9	4.2	6.7	5.3	4.3	0.8	8.4	16.1	20.8	25.7	20.6
Years of schooling															
0 years	1.0	3.7	4.0	9.6	7.7	3.7	6.6	14.9	8.7	2.0	4.7	10.3	18.9	18.3	9.7
<5 years	0.9	4.8	5.7	9.4	11.9	4.3	7.9	13.2	8.1	1.2	5.1	12.7	18.9	17.5	13.2
5-9 years	1.7	6.0	8.6	13.1	11.2	2.8	6.7	9.2	6.3	1.5	4.6	12.6	17.8	19.4	12.7
10-11 years	3.6	6.7	13.1	20.6	13.6	2.1	3.8	4.7	4.0	0.9	5.7	10.4	17.9	24.6	14.4
12th years and above	4.7	10.6	16.0	21.4	14.9	1.9	4.2	2.6	1.7	0.6	6.6	14.8	18.7	23.1	15.5

Background Characteristics	Prevalence of modern spacing methods (Per cent)					Prevalence of permanent methods (Per cent)					Prevalence of modern methods (Per cent)				
	BI	JH	MP	RA	UP	BI	JH	MP	RA	UP	BI	JH	MP	RA	UP
Respondents' intrahousehold status															
With other women	1.9	5.4	8.7	13.9	10.6	2.2	4.9	6.6	4.6	0.9	4.1	10.3	15.3	18.6	11.4
Only woman	2.2	7.4	8.6	14.5	13.3	4.1	6.5	13.1	7.9	1.9	6.3	13.9	21.7	22.4	15.2
Parity and son preference															
No Child	0.8	3.3	5.2	8.2	4.3	0.0	0.0	0.1	0.0	0.0	0.8	3.3	5.2	8.2	4.4
At least 1 son	2.9	7.6	10.1	18.5	18.3	7.3	12.7	20.8	14.3	3.3	10.1	20.4	30.9	32.7	21.6
Only girl child/ren	2.7	8.2	11.0	16.4	13.7	0.2	0.7	1.5	0.3	0.2	2.9	8.9	12.4	16.7	13.9
Respondent's ideal no. of children															
2 or less	2.5	7.2	9.1	15.0	13.0	3.3	6.7	9.7	5.8	1.4	5.8	13.9	18.8	20.9	14.4
3 and above	1.4	4.5	5.9	8.8	8.8	2.7	3.4	8.6	6.8	1.2	4.1	7.9	14.4	15.6	10.0
Media exposure for FP msg.															
No	0.9	3.7	3.7	10.0	7.0	2.8	5.7	11.4	6.5	1.6	3.6	9.5	15.1	16.6	8.5
Yes	3.1	8.2	10.7	15.7	13.7	3.3	5.7	8.7	5.8	1.2	6.4	13.9	19.5	21.5	14.8
Knowledge of Modern FP Method															
No or < 3 methods	0.2	0.7	0.5	3.2	1.0	1.9	2.5	6.9	5.8	0.0	2.1	3.2	7.4	8.9	1.0
At least 3 methods	2.5	7.0	9.3	14.5	12.1	3.3	6.1	9.7	6.0	1.4	5.8	13.1	19.0	20.4	13.5
FLW interaction															
No	2.0	6.7	8.4	14.7	10.8	2.6	6.2	9.1	6.4	1.2	4.6	12.9	17.5	21.2	12.0
Yes	2.2	5.8	9.0	13.2	13.0	3.8	4.9	9.9	5.2	1.4	6.0	10.7	18.9	18.4	14.4
Total	2.1	6.4	8.7	14.2	11.7	3.0	5.7	9.5	6.0	1.3	5.1	12.1	18.2	20.2	13.0

Source: Authors' calculations

The variation in the use of modern spacing methods by different characteristics of young married women has also been found to be different from the variation in the use of permanent methods. The prevalence of modern spacing methods was the lowest in Bihar but the highest in Rajasthan whereas the prevalence of permanent methods was the lowest in Uttar Pradesh but the highest Madhya Pradesh. The prevalence of modern spacing methods was higher in non-Hindu young married women of Madhya Pradesh and Rajasthan compared to that in Hindu young married women but, in the other three states, the prevalence of modern spacing methods was higher in Hindu young married women compared non-Hindu young married women. On the other hand, the prevalence of permanent methods was lower in non-Hindu young married women compared to Hindu young married women in all states.

The standard of living is found to be directly related to the use of contraceptive methods in young married women in all five states – the higher the standard of living the higher the mCPR. The prevalence of modern spacing methods increases with the increase in the stand of living in all states but this is not the case with the prevalence of permanent methods. In Madhya Pradesh and Uttar Pradesh, prevalence of permanent methods decreases with the increase in the standard of living whereas in other states, the prevalence of these methods is the highest in young married women with middle standard of living as measured through the household wealth index. Similarly, the prevalence of modern spacing method was higher in urban compared to rural areas in all the five states but the prevalence of permanent methods was higher in the rural compared to the urban areas in Madhya Pradesh, Rajasthan, and Uttar Pradesh.

The number of years of schooling of young married women is found to be directly related to the use of modern spacing methods – the higher the number of years of schooling the higher the prevalence of modern spacing methods in all the five states. This is, however, not the case in the use of permanent methods. In Madhya Pradesh, Rajasthan, and Uttar Pradesh, the higher the number of years of schooling the lower the prevalence of permanent methods whereas the prevalence of permanent methods was relatively the highest in young married women with less than five years of schooling compared to other young married women.

Type of the family also influenced the use of family planning among young married women. The mCPR was higher in young married women of those families where there was no other no other married women in the family compared to young married women of those families where there was at least one married woman in the family. The prevalence of both modern spacing methods and permanent methods was also higher in in young married women of those families where there was no other married woman in the family. Similarly, the mCPR and the prevalence of both modern spacing methods the permanent methods was relatively high in young married women having at least one son compared to young married women who were having either on child or were having only girl child/ren in all states. Table 2 also shows that the use of family planning methods in young married women was directly related to the family size preferences of the young married women in all the states.

Table 3: Results of the logistic regression analysis of Transition from non-users to users of "any modern spacing" and "permanent" methods, NFHS-4, 2015-16 (AOR)

Background variables	Dependent variable									
	Use of modern spacing methods					Use of permanent methods				
	Bihar	Uttar Pradesh	Madhya Pradesh	Rajasthan	Jharkhand	Bihar	Uttar Pradesh	Madhya Pradesh	Rajasthan	Jharkhand
Religion										
Non-Hindu	0.86	0.96	1.39**	1.2	1.06	0.3***	0.09***	0.56**	0.36***	0.28***
(Hindu)	1	1	1	1	1	1	1	1	1	1
Wealth Index										
Poor	0.65*	0.43***	0.41***	0.69***	0.78	0.92	0.79	1.01	0.77*	0.87
Middle	0.73	0.67***	0.79**	0.84*	1.11	1.22	0.83	0.9	0.96	1.58*
(Rich)	1	1	1	1	1	1	1	1	1	1
Caste										
Marginalised	1.01	0.93	0.85*	0.95	0.89	0.9	0.99	1.01	0.97	0.74**
(Non-marginalised)	1	1	1	1	1	1	1	1	1	1
Place of residence										
Rural	0.74	0.68***	0.84**	0.74***	0.94	0.71*	1.4	1.6***	1.26	1.06
(Urban)	1	1	1	1	1	1	1	1	1	1
Number of years of schooling										
0 years	0.5**	0.69***	0.52***	0.51***	0.56**	2.59***	3.29***	3.47***	3.94***	2.59***
Below 5 years	0.34**	0.96	0.64**	0.46***	0.63	2.98***	1.71	3.35***	3.55***	2.93***
5-9 years	0.6**	0.86**	0.8**	0.59***	0.69**	1.8**	2.38***	2.41***	2.77***	2.03**
10-11 years	1	0.93	0.92	1.08	0.67**	1.29	1.28	1.58*	2.61**	1.03
(12 years and above)	1	1	1	1	1	1	1	1	1	1

Background variables	Dependent variable									
	Use of modern spacing methods					Use of permanent methods				
	Bihar	Uttar Pradesh	Madhya Pradesh	Rajasthan	Jharkhand	Bihar	Uttar Pradesh	Madhya Pradesh	Rajasthan	Jharkhand
Respondents' living status in Household										
With other women	0.79	0.76***	0.9	0.92	0.63***	0.78*	0.67**	0.63***	0.76**	0.87
(Only woman)	1	1	1	1	1	1	1	1	1	1
Parity and son preference										
No Child	0.29***	0.26***	0.38***	0.38***	0.34***	0.09*	0.09**	0.04***	NA	NA
At least 1 son	1.16	1.5***	1.25**	1.52***	1.06	30.23***	21.42***	17.23***	56.27***	21.16***
(Only girl(s))	1	1	1	1	1	1	1	1	1	1
Ideal number of children										
2 or less	1.32	1.26**	1.19	1.55***	1.35**	1.32**	1.48**	1.77***	1.29*	2.21***
(3 and above)	1	1	1	1	1	1	1	1	1	1
Media exposure to family planning messages										
No	0.47***	0.71***	0.57***	0.8**	0.6***	0.8	0.93	0.87	0.74**	1.1
(Yes)	1	1	1	1	1	1	1	1	1	1
Knowledge of modern family planning methods										
Less than 3 methods	0.07**	0.14***	0.1***	0.37**	0.16***	0.65**	NA	0.48***	1.13	0.42**
(At least 3 methods)	1	1	1	1	1	1	1	1	1	1
Interaction with FLW										
No	1.16	1.19**	1.16*	1.51***	1.6***	1.06	1.7***	1.33***	2.11***	2.3***
(Yes)	1	1	1	1	1	1	1	1	1	1

*** P<0.001; ** P<0.05; * P<0.1; () - Reference category

Source: Authors' calculations

Exposure to family planning messages through mass median such as radio, television, newspaper, magazine, wall paintings has been found to have an impact on the use of modern family planning methods by young married women. The mCPR was higher in those young married women who were exposed to mass median compared to young married women who were not exposed to mass media. Similarly, the mCPR was higher in young married women who had the knowledge of at least three modern family planning methods compared to young married women who either had no knowledge of any modern family planning method or young married women who had knowledge of less than three modern family planning methods.

Results of the regression analysis are presented in table 3. The use of modern spacing methods by young married women is found to be related directly to the standard of living, years of schooling of the young married woman, exposure to mass media, knowledge about at least three family planning methods, and son preference in all state. On the other hand, the effect of other independent variables on the use of modern spacing methods by young married women has been found to be statistically significant in only selected states. For example, the effect of religion and caste on the use of modern spacing methods by young married women is found to be statistically significant in Madhya Pradesh only whereas the effect of the interaction with frontline health workers of the use of modern spacing methods by young married women has not been found to be statistically significant in Bihar and Jharkhand. Similarly, the ideal number of children desired has not been found to be associated with the use of modern spacing methods in Madhya Pradesh, but it has statistically significant effect in the remaining four states. Table 3 suggests that there are some common factors that influence the use of modern spacing methods by young married women in all the five states and, at the same time, there are factors that influence the use of modern spacing methods by young married women in selected states

On the other hand, religion, and number of years of schooling of young married woman is found to be statistically significantly associated with the use of permanent family planning methods in all the five states. Other explanatory variables like caste, standard of living, and place of residence have not been found to have any effect on the use of permanent family planning methods. Young married women of religions other than Hindu religion are less likely to use permanent family planning methods compared to Hindu young married women in all states. On the other hand, young married women having less than 10 years of schooling are more likely to use permanent family planning methods compared to young married women having at least 12 years of schooling in all states.

The table also suggests that exposure of young married women to family planning messages through mass media does not have any impact on the use of permanent family planning methods in all states except Rajasthan where young married women exposed to family planning messages through mass media are more likely to use permanent methods compared to young married women who are not exposed to mass median messages about family planning. On the other hand, young married women of Bihar, Madhya Pradesh and Jharkhand who have knowledge of at least three family planning methods are more likely to use permanent family planning methods compared to young married women who have knowledge of less than three family planning methods or have no knowledge of any family planning method. Similarly, young married women having at least one son are very highly likely to use permanent family planning methods compared to young married women who have only daughters in all states. Another influencing factor in the use of permanent family planning methods is the perception of young married women about intended or ideal family size in all states.

Discussion

Family planning is one of the twenty great public health achievements of the 20th century (Centre for Diseases Control, 1999). Availability of family planning services allows individuals and couples to achieve desired birth spacing and family size, and contributes to improved health outcomes for women, children, and families (Sonfield et al, 2014). There are many social, health and economic adversities faced by women, especially, young married women of reproductive age which prevent them from for practising family planning. In this paper, we have identified some of the barriers like strong son preference, poor knowledge about at least any three modern family planning methods, women's educational status and their fertility intentions that inhibit young married women from using modern family planning methods to avoid unintended pregnancies by either spacing or preventing births. Studies elsewhere suggest that young married women face extreme social pressure to prove their fecundity soon after marriage and they have little decision-making power. Lack of mobility, isolation, and services providers worker bias further restricts their access to information, services and supplies that they need to regulate their fertility. (Sarkar et al, 2015; Woog et al, 2015).

The present study reveals that condom is the most preferred contraceptive method followed by female sterilization among the YMW. Simultaneously, the use of injectables and IUCD has shown negligible popularity among YMW. Further, the study reveals that determinants of the use of modern spacing methods in young married women is different from the use of permanent methods in five high fertility states of India. Religion of the young married women has not been found to have an impact on the use of modern spacing methods in all states except Madhya Pradesh. However, religion of the young married woman plays a significant role in the use of permanent family planning methods. The non-Hindu young married women are predominantly Muslim community in which use of sterilisation to prevent birth is very low as some schools of Islam allow for the use of only some spacing methods (Rai and Unisa, 2013).

The educational status of young married women, measured in terms of number of years of schooling, has been found to be a significant factor in the use of both modern spacing and permanent family planning methods. The level of education is found to be positively associated with the use of modern spacing method but negatively associated with the use of permanent methods in all states. On the other hand, caste, place of residence and household standard of living as measured through the household wealth index have not been found to have a telling impact on the use of permanent family planning methods among young married women in all states. However, young married women with low or average standard of living and living in the rural areas are more likely to use modern spacing methods as compared to young married women with high standard of living and living in the urban areas in Uttar Pradesh, Madhya Pradesh, and Rajasthan but not in Bihar and Jharkhand.

The study has also found an association of the type of family with the use of modern family planning methods by young married women. Young married women living jointly with other married women such as mother-in-law and sister-in-law in the family have been found to be having lower probability of using permanent family planning methods in Bihar, Uttar Pradesh, Madhya Pradesh, and Rajasthan compared to young married women not living with other married women. Similarly, the type of family of the young married women has also been found to be associated with the use of modern spacing methods in Uttar Pradesh and Jharkhand but not in Bihar, Madhya Pradesh, and Rajasthan. Previous studies also support these findings (Char et al, 2010; Ghule et al, 2015; Khurram et al, 2012). It has been observed that young married women living with other married women in the family are pressurised and motivated not only to deliver child within the first or the second year of marriage but also to deliver a male child, especially in the rural areas (Arokiasamy, 2002; Ghule et al, 2015). The effect of the preference for a on the use of different modern family planning methods by young married women is also very much evident from the present study. These observations confirm the dominance of the prevailing social stigma about son preference and patriarchal system in India as far as the use of modern family planning methods by young married women is concerned (Mannan, 1988; Nair et al, 2019). Similarly, the perception about the ideal or the desired family size has also been found to be a dominating factor in the use of modern family planning methods by young married women in some states included in the present analysis but not in all states presumably due to state-specific factors.

The present study also suggests that improving the knowledge about different modern family planning methods – spacing as well as limiting – can contribute towards improving the use of modern family planning methods in young married women in all the five states. This observation is consistent with previous studies (Jabeen et al, 2020). However, exposure to mass media has not been found to have any impact on the use of permanent family planning methods by young married women in the five states. On the other hand, in contrast to previous studies (Gallo et al, 2013; Maravilla et al, 2016), the present study has not found any impact of the interaction with front-line family planning services providers on the use of modern family planning methods by young married women in the five states. It appears that the quality of family planning counselling by from-line family services providers in these high fertility states is too poor to have any telling impact on the use of family planning methods by young married women.

Conclusions

The use of modern family planning methods in young married women, married women in the age group 15-24 years, in the five high fertility states of India has been found to be very low according to the data available from the National Family Health Survey 2015-16. The main reasons are lack of knowledge about different types of modern family planning methods and contextual factors like educational status, religious beliefs, and social stigma of son preference. Marriages of women at a young age is quite common in these states which leads initiation of sexual activities without adequate exposure and knowledge to different sexual and reproductive health related issues and concerns and end up with pregnancies at a young age. It is, therefore, important that the family planning services delivery system addresses these gaps by reaching young married women and advocating and promoting use of suitable modern family planning methods at different stages of reproductive life. At the same time increasing the educational status of young married women may also contribute towards improving the sexual and reproductive health of the young married women. Meaningful engagement of young married women of these states in developmental activities is necessary to realise FP2020 (now FP2030) commitments and vision of access, choice, and quality of family planning services inclusive in nature and to make the motto "no one to leave behind" a success in India. Young married women are main stakeholders in driving change towards a better future for themselves, and the country.

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Effect of Age at Marriage and Duration of Cohabitation on Unwanted Fertility in North-East India

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Abstract

In this paper we estimate the proportion of unwanted births in eight north-eastern states of India based on the data on ideal number of children, children ever-born and wantedness of the last child from NFHS-4. We also analyse how the age at marriage influences the proportion of unwanted births. Our analysis suggests that using the data on ideal number of children and children ever born, about 16 per cent of all births reported during NFHS-4 were unwanted but using data on the wantedness of the last birth, about 4 per cent of the most recent births were unwanted. Our analysis also shows that women who married after reaching 18 years of age had higher probability of reporting wanted births compared to women who married before 18 years of age. Duration of cohabitation has also been found to play an important significant role in deciding unwanted fertility.

Introduction

Unwanted births constitute a substantial proportion of all births in the developing countries. Reducing the number of unwanted births has important social, health and demographic consequences. At the individual level, preventing unwanted births enhances the well-being of women and their children. At the societal level, reducing the number of unwanted births leads to reduction in fertility rates. Measuring the level of unwanted fertility accurately and identifying factors associated with variations in unwanted fertility can, therefore, provide valuable information to policy makers. Research on unwanted fertility also improves our understanding of the process of transition from high to low fertility. The risk of having unwanted births or unintended fertility may be influenced by the lack of access to contraceptive methods, illegal sexual behaviour, religious beliefs, lack of knowledge about contraceptive methods. The risk of unwanted birth may also be influenced by the age at marriage and the duration of cohabitation.

Fertility intentions can be classified as wanted and unwanted. Births are classified as wanted if they were wanted at any time the time of delivery or earlier. Any live birth or current pregnancy that is reported as unwanted at the time of pregnancy is considered as unwanted whereas, a birth which is reported wanted later is considered as mistimed. Most countries witness a significant proportion of unwanted births or unintended fertility due to various reasons. Unwanted fertility is the consequence of unintended pregnancies. It is estimated based on the data from the fourth round of the National Family Health Survey (NFHS) 2015-16 that nearly one fourth of the pregnancies in India were unintended (Dutta et al, 2015). It has also been observed that the proportion of unwanted pregnancies has increased from NFHS 1998-88 to NFHS 2005-06. It has also been found that the likelihood of mistimed a pregnancy is more among young women whereas unwanted pregnancy is more among older women.

The risk of unintended pregnancy can be influenced by various characteristics of the women. In a study in Shanghai, China, has found that the level of education and employment of the woman were not related to the risk of unintended pregnancy (Shahbazin and Gholamy, 2015; Chen and Cleland, 2004). However, another study has found that level of education and employment status of the women is highly significantly related to the risk of unintended pregnancy (Dutta et al, 2015). Chen and Cleland (2004) have found that unintended pregnancies were common among married couples in Shanghai because of low contraceptive use and young women are more likely to have an unintended pregnancy after the first birth.

Unwanted births can occur among women of different social, demographic, and economic characteristics (Bankole et al, 2006). Unwanted births are found to be associated with the delay in prenatal care, no breast feeding of the new-born, poor health during childhood and poor relationship between the mother and the child which consequently affect the health of both (Mosher et al, 2012). Unwanted births raise the level of fertility. However, mistimed births have been found to have minimal effect on the level of fertility.

There are many studies in India that have analysed unwanted fertility and the causal effects of a range of social, economic, and demographic variables on unwanted fertility (Kulkarni and Choe, 1998; Singh et al, 2018; Sebastian et al, 2014)). There is, however, virtually no study, to the best of our knowledge, which has analysed the level of unwanted fertility in the north-eastern region of the country and explored the factors that are associated with the prevailing levels of unwanted fertility in the states of this region. The north-eastern region of India comprises of eight states – Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, and Sikkim. The total population of these eight states was 45.8 million at the 2011 population census which constituted around 3.8 per cent population of the country. The social, economic, cultural, and demographic context of the north-east region is very different from the rest of the country which has implications for fertility intentions and fertility levels. The latest National Family Health Survey 2019-21 suggests that fertility varies widely across the eight states of the region ranging from only 1.3 births per woman of reproductive age in Sikkim to 3.3 births per woman of reproductive age in Meghalaya (Government of India, 2021).

This paper has two objectives. The first objective is to estimate the level of unwanted fertility in the north-east region of the country and in the eight constituent states of the region using the data available from the fourth round of the National Family Health Survey 2015-16. Data from the latest National Family Health Survey 2019-20 are not yet available to carry out similar analysis. The second objective of the paper is to examine whether the age at marriage of the woman and the duration of cohabitation has any effect on the level of unwanted fertility. The paper is expected to enhance the understanding of fertility dynamics in the north-east region of the country.

Data and Methodology

The paper is based on the data available through the fourth round of the National Family Health Survey (NFHS-4) that was launched by the Government of India, Ministry of Health and Family Welfare and conducted by the International Institute for Population Sciences, Mumbai during 2015-2016 (Government of India, 2017). The NFHS-4 covered all states of the country and surveyed 699,686 women aged 15-49 years. In the eight states constituting the north-east region of the country, the survey covered 98702 households and interviewed 71286 currently married women aged 15-49 years. The eight states that constitute the north-east region of the country are: Sikkim, Arunachal Pradesh, Nagaland, Manipur, Mizoram, Tripura, Meghalaya, and Assam.

Estimating the prevalence of unwanted fertility is a challenging task as it has been observed that there is a tendency to rationalise births unwanted before the delivery as wanted births after the delivery (Casterline and El-Zeini, 2007). Respondents may feel that declaring a birth as unwanted is a violation of social norms. This paper employs two methods to estimate the proportion of unwanted births. The first method is based on the direct question related to the wantedness of the last birth at the time of the survey. In NFHS-4, women were asked “At the time you become pregnant, did you want to become pregnant then; did you want to wait until later; or did you not want (more) children at all.” The answer options to the question were “Then,” “Later” and “Not at all.” If the respondent’s answer was “Then” the birth was classified as wanted, while all other births were classified as unwanted. Based on this question, all births during the three years prior to the survey were classified as either wanted or unwanted. The limitation of this approach, however, is that the response of women may be biased as they sometimes rationalise an unwanted birth prior to conception as wanted birth after delivery. It has been observed that during the retrospective inquiry, women may be reluctant to classify a child, who is already born, as the unwanted child (Bongaarts, 1990).

The second method is based on the total number of children ever born and the ideal number of children desired. This method was developed by Lightbourne (1985) and is based on the opinion of the respondent about the ideal number of children that they wanted, and the actual number of children ever born. In NFHS-4, women were asked "If you could go back to the time when you did not have any child and could choose exactly the number of children to have in your whole life, how many would that be". If the ideal number of children reported by the respondent is greater than or equal to the children ever born at time of interview, then the respondent is classified as having no unwanted birth. If the ideal number of children is less than the number of children ever born, then the difference between the children ever born and the ideal number of children wanted is taken as the number of unwanted births and the respondent is classified as having unwanted birth(s). The limitation of this approach is that it is not possible to classify a particular birth as wanted or unwanted. The advantage is that this method considers all children ever born to the respondent.

For analysing the correlates of women having unwanted births, we have classified women as having only wanted births and women having both wanted and unwanted births. Women having only wanted births are coded as 1 while women having unwanted births also are coded as 0. On the other hand, the independent variables included in the analysis are current age and education of the woman, her age at the time of the marriage, duration of cohabitation, knowledge of contraceptive methods, use of contraceptive methods, intention and unmet need of contraceptive, number of living children and fertility intentions. The age at the time of the marriage is categorised into three categories: early age at marriage (<18 years); average age at marriage (between 18 and 25 years); and late age at marriage (≥25 years). The duration of cohabitation is also categorised into three categories: less than 5 years; 5-15 years; and at least 15 years. The knowledge of the woman about different contraceptive methods was categories into two categories: knows any method; and knows no method. Unmet need is divided into four categories. The unmet need is categorised as "Yes" for those women who were fecund and sexually active at the time of the survey and were not using any contraceptive method but reported that they did not want any child. The unmet need is categorised as "No" for those women who were using a contraceptive method to regulate their fertility. The unmet need is categorised as "Failure" for those women who had delivered a child despite using a contraceptive method. Finally, the unmet need is categorised as "Others" for those women who reported no unmet need or who were not married or who were either infecund or menopaused. The current age of the woman is categorised into three categories: 15-25 years; 25-35 years; and 35 years and above. Fertility intention is categorised into three categories: wanted child; undecided; and not wanted child. Finally, education of the woman is categorised into four categories: no education; primary level education; secondary level education; and higher education.

The analytical strategy involves three steps. The first step is to estimate the proportion of unwanted births. At the second stage of the analysis, bivariate analysis is carried out to analyse the variation in women having unwanted births by independent variables included in the analysis. Finally, logistic regression analysis is carried out to analyse the association of the women having only wanted births with the independent variables including the use of contraceptive methods, duration of cohabitation, and unmet need of family planning by calculating the odds ratios.

Results

Table1 presents estimates of the proportion of unwanted births based on two methods in the north-east region of India and its eight constituent states. It may be seen from the table that the proportion of unwanted births obtained from method 1 (retrospective method) are substantially lower than the proportion of unwanted births based on method 2 (difference between total living children and ideal number of children). Based on method 1, about 4 per cent of the recent births in the region are unwanted in the region whereas using the method 2, the proportion of unwanted births is estimated to be almost 16 per cent. Within the region, Sikkim has the highest proportion of unwanted births based on method 2 but Arunachal Pradesh has the highest proportion of unwanted births based on method 1. On the other hand, the proportion of unwanted births based on method 2 is the lowest in Mizoram whereas the proportion of unwanted births based on method 1 is the lowest in Sikkim. The two methods of estimating the proportion of unwanted births give two different perspectives of unwanted fertility. The method 1 gives the immediate perspective of unwanted fertility whereas the method 2 provides the long term or the life-time perspective of unwanted fertility.

Table 1: Ever-married women and estimates of unwanted fertility from two methods in north-eastern India

Region/State	Women interviewed for wantedness of the last birth	Proportion of last birth unwanted (Per cent)	Women interviewed for CEB and ideal number of children	Total number of children ever born	Proportion of unwanted children (Per cent)
North-east	28671	4.4	63832	175165	15.6
Arunachal Pradesh	3842	9.4	9266	25635	19.7
Assam	8529	5.0	19843	51711	22.3
Manipur	4427	3.0	8493	22941	11.2
Meghalaya	3104	3.0	5400	17242	9.2
Mizoram	3591	2.4	7590	22125	3.5
Nagaland	3110	4.7	6485	21299	13.3
Sikkim	899	1.4	3179	6838	29.0
Tripura	1169	1.5	3576	7374	13.5

Source: Authors

Table 2: Variation in the proportion of unwanted births estimated from method 2 (difference between children ever born and ideal number of children) by selected characteristics of the respondents.

Characteristics of the respondents	Proportion of births (Per cent)		N
	Wanted	Unwanted	
Age at marriage			
<18 years	68.7	31.3	24693
18-25 years	81.3	18.7	28539
25 years and above	88.9	11.1	8049
Duration of cohabitation			
Less than 5 years	96.1	3.9	11089
5-15 years	82.1	17.9	27136
15 years and more	62.6	37.4	23056
Current age			
15-25 years	93.3	6.7	10588
25-35 years	80.8	19.2	24343
35-50 years	67.7	32.3	26350
Number of living children			
0-2	92.9	7.1	34467
3-4	64.4	35.6	20363
5 and more	34.6	65.4	6451
Fertility preference			
Want another child	96.3	3.7	13360
Undecided	85.4	14.6	7831
Do not want another child	69.4	30.6	40090
Knowledge of contraceptive methods			
Knows any method	77.3	22.7	61278
Knows no method	100.0	0.0	3
Unmet need			
Yes	77.8	22.2	11426
No	76.1	23.9	24708
Failure	68.5	31.5	73
Others	78.2	21.8	25074
Education			
No education	61.9	38.1	14339
Primary	72.7	27.3	11005
Secondary	84.1	15.9	32286
Higher	91.8	8.2	3651

Source: Authors' calculations

Table 2 shows the variation in the proportion of unwanted births estimated based on method 2 by different characteristics of the respondents. The proportion of unwanted births decreases with the increase in the age at the time of the marriage of the respondent. The proportion of unwanted births is the lowest in women who were married at an age of 25 years or more. By contrast, the proportion of unwanted births increases with the increase in the current age and the duration of cohabitation of the woman. Similarly, the proportion of unwanted births is very high in woman having at least five children and in women who did not want any more children. The proportion of unwanted births has been found to be the highest in women with contraceptive failure. On the other hand, the proportion of unwanted births is found to be the highest in women with no education but the lowest in women with higher education. Finally, the proportion of unwanted births is estimated to be zero in women who had no knowledge any contraceptive method.

Results of the logistic regression analysis are presented in table 3. The dependent variable in the regression analysis the woman of reproductive age who is coded as 1 if she does not have any unwanted birth according to method 2 and 0 if she has at least one unwanted birth based on method 2. The table shows that relative to Arunachal Pradesh, the odds of a woman with only wanted birth is more than seven times in Mizoram and more than four times in Meghalaya but only around 28 per cent in Sikkim and less than 50 per cent in Assam. On the other hand, odds of woman with only wanted births is 44 per cent higher in women who are married after reaching 25 years of age as compared to women who are married before 18 years of age. Similarly, the odds of women with only wanted births is lower in women having a duration of cohabitation of at least five years as compared to women having a duration of cohabitation of less than five years. The odds of women with only wanted births is also found to be lower in women aged at least 25 years compared to compared to women 15-25 years and in women having at least three children compared to women having less than two children. The odds of a wanted birth is found to be directly associated with the fertility intentions of women. The odds of a wanted birth is the lowest in women who did not want any more children as compared to women who wanted a child. The odds of women with only wanted births is also found to be 38 per cent higher in women who did not have any unmet need for family planning compared to women who have any unmet need for family planning. The odds of women with only wanted births has also been found to increase with the increase in the level of education of the woman. Women having higher level of education have been found to be 33 per cent more likely to have only wanted births compared to women have no education. Finally, the odds of women having only wanted births is found to be higher in women who wanted another child immediately as compared to women who were uncertain about to have or not to have another child or women who did not want to have another child at all. It is clear from table 3 that the characteristics of women, especially, their age at the time of the marriage and the total period of cohabitation since marriage have strong influence on whether a woman is having only wanted births or is having both wanted and unwanted births during her reproductive life. It appears that a higher proportion of women below 25 years of age have total number of children ever born which are less than the ideal number of children desired. This is not the case with women at least 25 years of age.

Table 3: Results of the logistic regression analysis of women with only wanted births (method 2) in the north-east region of India.

Independent variables	Regression coefficient β	'p'	Odds ratio (e^{β})
State			
Arunachal(ref)			
Assam	-0.715	0.000	0.489
Manipur	0.527	0.000	1.694
Meghalaya	1.436	0.000	4.205
Mizoram	2.066	0.000	7.892
Nagaland	0.681	0.000	1.976
Sikkim	-1.258	0.000	0.284
Tripura	-0.422	0.000	0.656
Age at marriage			
Less than 18 years (ref)			
18-25 years	0.244	0.000*	1.277
25 and above	0.364	0.000*	1.440
Duration of cohabitation			
Less than 5 years (ref)			
5-15 years	-0.245	0.000*	0.783
15 years and above	-0.339	0.000*	0.713
Current age			
15-25 years (ref)			
25-35 years	-0.266	0.000*	0.766
35-50 years	-0.279	0.000*	0.757
Number of living children			
0-2 (ref)			
3-4	-2.04	0.000*	0.130
5 and more	-3.576	0.000*	0.028
Fertility intention			
Want another (ref)			
Undecided	-0.802	0.000*	0.448
Want no more	-1.132	0.000*	0.323
Unmet need			
Yes (ref)			
No	0.323	0.000	1.381
Failure	-0.269	0.396	0.764
Others	0.188	0.000	1.207
Education			
No education			
Primary	0.059	0.085	1.061
Secondary	0.188	0.000	1.207
Higher	0.285	0.000	1.330
-2log likelihood	44575.835		
Number of observations	61281		

Source: Authors' calculations

Discussions and Conclusions

Estimation of the levels and differentials in unwanted fertility may be useful from the perspective of population policy and programmes directed towards promoting the use of family planning to regulate fertility. In this paper, we have attempted to estimate the unwanted fertility in the north-east region of India in terms of the proportion of unwanted births in currently women aged 15-49 years. The proportion of unwanted births is estimated using two approaches. The first approach classifies the last birth as wanted or unwanted. The second approach, on the other hand, estimates the proportion of unwanted births based on the difference between total number of children ever born and the ideal number of children desired. Both methods have limitations as regards estimation of unwanted fertility.

The present analysis reveals that the there is big difference in the proportion of unwanted births based on the two methods of classifying births as wanted and unwanted. The estimates of the proportion of unwanted births based on the retrospective method are substantially lower than the estimates of the proportion of unwanted births based on the different between the number of children ever born and the ideal number of children desired a currently married woman. In earlier studies also, it has been reported that the retrospective account of the wantedness of the last birth may lead to significant underestimation of the true level of unwanted fertility (Koenig, 2006; Casterline and El-Zeini, 2007).

The present analysis reveals that there is significant variation in the proportion of unwanted births across the states of the north-east region irrespective of the method used for estimating the proportion of unwanted births. These variations suggest that there are state-specific factors that influence the level of unwanted fertility across the states of the region. Very little is currently known about these factors. There is a need to carry out state-specific analysis to understand the determinants of unwanted fertility in the region as reflected through the proportion of unwanted births.

The analysis also shows that the main determinants of unwanted fertility in the region is the age at the time of the marriage of the woman and effectiveness of the practice of family planning in preventing unwanted births. This suggests that the proportion of unwanted births in currently married women of reproductive age in the region can be reduced substantially by improving the effectiveness and efficiency of the efforts directed towards meeting the fertility regulation needs of women. A reinvigoration of the family planning services delivery system in the region from the perspective of preventing unwanted births in currently married women of reproductive age may be the need of the time. The reduction in the proportion of unwanted births in the currently married women of reproductive age will have an impact on the level of fertility in the region which has been found to vary widely across the states of the region.

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An EM Algorithm Approach to Estimate Parameters of Fluctuating Nature of PPA

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Abstract

The Aim of this paper is to use the EM algorithm to estimate parameters of the distribution of the duration of postpartum amenorrhea (PPA). A mixture of the Gumbel distribution has been used to fit the bimodal distribution the duration of postpartum amenorrhea in four states of India - West Bengal, Gujarat, Himachal Pradesh, and Andhra Pradesh. The appropriateness of the model and the estimation technique is examined using data from National Family Health Survey-4 (2015-16) of India.

Introduction

The major determinant that approximates the natural fertility condition is the breastfeeding behaviour. Breastfeeding lengthens the interval between successive births by delaying the resumption of ovulation. Intensive and sustained breastfeeding can result in years of postpartum amenorrhea (PPA). In societies where intensive breastfeeding is the norm, couples tend to have longer intervals between successive births and lower completed fertility (Howie and McNeilly, 1982; Wood, 1994). The length of the duration of postpartum amenorrhoea (PPA), therefore, has been subject of intensive research in the context of fertility transition. The PPA is defined as the period between the termination of the pregnancy and the resumption of the menstruation. Breastfeeding and PPA are closely related. Breast milk production is dependent on the peptide hormone prolactin, which also has a role in inhibiting ovulation after delivery. Prolactin levels depend, in turn, on suckling stimulus. It has been established that more frequent suckling delays the resumption of ovulation and is, therefore, a key factor in variations in the duration of postpartum amenorrhoea between women and between populations (Konner and Worthman, 1980). Different studies have shown the relationship between duration of breastfeeding and duration of PPA (Jones 1989; 1990; Singh and Singh, 1989; Singh et al, 1990; Nath et al, 1993; Nath et al, 1994; Mukherjee et al, 1994; Singh et al, 1999). There are also studies that explain the mechanism through which breastfeeding delays the return of the menstrual cycle after the termination of pregnancy (Lunn et al, 1984).

There are many studies that suggest that the distribution of the duration of postpartum amenorrhoea – the duration between the termination of the pregnancy and the resumption of the menstruation - is bimodal (Ford and Kim, 1987; Huffman et al, 1987; Potter and Kobrin, 1981) which suggests that there are distinct subgroups of women with short and long duration of amenorrhoea. It is argued that the duration of amenorrhoea is short in situations where breastfeeding is absent because of pregnancy loss or infant death, or confusion of postpartum bleeding with resumption of menses (Holman et al, 2006). There are many studies that have attempted to model the distribution of the duration of PPA (Barrette, 1969; Lesthaeghe and Page, 1980; Potter and Kobrin, 1981). Barrette (1969) has used the modified Pascal distribution; Lesthaeghe and Page (1980) have used the logit model; and Potter and Kobrin have used the mixed geometric negative binomial distribution. Ford and Kim (1987), on the other hand, have used the mixture of two extreme value distributions to model the duration of PPA in the presence of censored cases. A multi-centre study conducted by the World Health Organization has found that the distribution of the duration of PPA is bimodal in which one subgroup had a mean time 3-4 months to the resumption of menses after delivery while the other subgroup had a mean time of around 9 months to the resumption of menses (Le Strat and Thalabard, 2001).

In India, like in many other countries, data about the duration of PPA are available from household surveys such as the National Family Health Survey. However, the quality of data obtained from these household surveys is regarded as poor as women do not exactly remember the correct time of the return of menses after the termination of pregnancy which results in gross heaping in the distribution. In order to address the problems of data quality associated with the data on the duration of PPA available from the household surveys, different models have been developed to study the distribution of the duration of PPA including finite mixture probability models. In the present study, we have used the mixture Gumbel distribution (Jhonson and Kotz, 1970) to model the distribution of the duration of PPA. In previous studies, non-linear maximisation, or minimisation (NLM) techniques have been used to model the distribution of the duration of PPA. These techniques are based on an assumed probabilistic distribution. In this paper, we attempt to fit a model to the distribution of the duration of PPA using the expectation-maximisation (EM) technique which is particularly suited to deal with the problem of missing data. The EM technique provides an iterative solution to obtain the density estimate of a dataset by searching across different probability distributions and their parameters.

Mixture Model and Estimation

The model used in the present paper is based on the extreme value distribution. The distribution function of the model is given by:

$$F(x) = \exp\left(-\exp\left(-\frac{(x-\alpha)}{\beta}\right)\right), \alpha, \beta > 0 \qquad (1)$$

and the density function is given by:

$$f(x;\alpha,\beta) = \frac{1}{\beta}\exp\left(-\frac{x-\alpha}{\beta} - \exp\left(-\frac{(x-\alpha)}{\beta}\right)\right) \quad (2)$$

The model has two parameters α and β that need to be estimated. The parameter α is the location parameter while the parameter β is the scale or dispersion parameter. The model contains a mixing parameter *a* which lies between 0 and 1.

We write the mixture model as:

$$f(x) = af_1(x) + (1-a)f_2(x) \quad (3)$$

for simplifying the calculations, we put $a=w_1$ and $1\text{-}a=w_2$ so that w_1 and w_2 are the mixture weights of (3). In equation (3) the first extreme value distribution is denoted by $f_1(x)$ and the second is denoted as $f_2(x)$. The required density function is given by

$$f_m(x) = \frac{a}{\beta_1}\exp\left(-\frac{(x-\alpha_1)}{\beta_1} - \exp\left(-\frac{(x-\alpha_1)}{\beta_1}\right)\right) + \frac{((1-a))}{\beta_2}\exp\left(-\frac{(x-\alpha_2)}{\beta_2} - exp\left(-\frac{(x-\alpha_2)}{\beta_2}\right)\right) \quad (4)$$

The mixture distribution can be written as

$$F_m(x) = a\exp\left(-\exp\left(-\frac{x-\alpha_1}{\beta_1}\right)\right) + (1-a)\exp\left(-\exp\left(-\frac{x-\alpha_2}{\beta_2}\right)\right) \quad (5)$$

The parameter *a* of equation (4) is the proportion of women having short duration of PPA (less than 6 months) so that 1-*a* is the proportion of women having long duration of PPA. The other parameters (α_1, β_1), (α_2, β_2) denote the mean and variance of the distribution of short duration PPA and long duration PPA, respectively. These parameters can be estimated using the maximum likelihood estimation methods if the value of *a* is known. When the parameter *a* is unknown, the parameters are estimated by maximising the likelihood through an iterative procedure by using the EM algorithm which was developed for situation when the data are incomplete or missing (Dempster et al, 1997). The basic idea behind the EM procedure is to relate the missing data problem with a complete data problem for which maximising the likelihood is the simplest way. The EM algorithm is widely used in the estimation of mixture models (Meng and Pedlow, 1992). The general formulation of the algorithm is similar to the one proposed by Hindenes (2017), McLachlan and Krishnan (1996) and Otiniano (2017).

Let us consider a random sample $x=x_1,\ldots,x_n$ from the observed variable X, with the distribution function $f_x(x;\theta)$. Here $\theta=(\theta_1, \ldots, \theta_n) \in \Omega$ are the parameters to be estimated and Ω denotes the parameter space. Further assume that there is some unobservable data y, with random variable Y, such that z=(x,y) denotes the complete data. Let $f_{xy}(x;y;\theta)$ is the distribution of the complete data. The estimation task, then, is to maximise the likelihood associated with the complete data, $L_c(z;\theta)$ or maximising the log likelihood of the complete data $l_c=\log L_c(z;\theta)$. However, the log likelihood of the complete dataset is unknown. Therefore, the expectation of the complete data may be obtained from the observed data. The $\theta^{(k)}$, are the current parameter estimates that we have used to evaluate the expectation and θ and new parameters that we optimize to increase Q. Let

$$\left(\theta, \theta^{(k)}\right) = E_{\theta^{(k)}}[l_c(z;\theta)|x] \tag{6}$$

denotes the expectation of the observed data which is incomplete. Here $E_{\theta}(k)$ denotes the expectation of the observed data with parameters $\theta^{(k)}$. There are two steps in each iteration of the algorithm. The first step is the expectation (E) step, and the second step is the maximisation (M) step. For each iteration, we first compute the expected likelihood of the complete dataset using equation (6) and then maximise the expected likelihood such that

$$Q\left(\theta^{k+1};\theta^{k}\right) \geq Q\left(\theta;\theta^{k}\right) \forall \theta \epsilon\, \Omega \tag{7}$$

The two steps are repeated until the convergence is achieved.

In the present case, let us consider mixture of two Gumbel distributions,

$$f_X(x;\theta) = \sum_{j=1}^{2}(w_j\, \alpha_j \beta_j), w_1 + w_2 = 1 \tag{8}$$

Here $\theta=(w_1, w_2, \alpha_1, \beta_1, \alpha_2, \beta_2)$; $w_1,w_2>0$ and $x=(x_1, \ldots, x_n)$ is a vector of observed duration of PPA so that fitting of the model can be formulated as an incomplete data problem. Let Y is a latent variable such that $y= (y_1, \ldots, y_n)$ denotes the missing data vector. Here, the variable y_i is treated as a two-dimensional indicator variable with first and second variable equal to either 1 or 0 if the observation $x_i$either did or did not arise from the first and second mixture component, respectively.

$y_{ij} = 1$, if x_i belongs to the jth component,

$y_{ij} = 0$, if x_i does not belong to the jth component.

We can write the log likelihood of the complete dataset, z=(x,y) as

$$l_c(\theta, y) = \sum_{i=1}^{n} \log f_{x,y}(x_i, y_i\,;\theta) = \sum_{i=1}^{n} \log(f_y(y_i\,;\theta) f_{x|y}(x_i|y_i;\theta)$$

$$= \sum_{i=1}^{n}\sum_{j=1}^{2} \log(w_j\, f_j(x_j;\alpha_j,\beta_j))^{y_{ij}} = \sum_{i=1}^{n}\sum_{j=1}^{2} y_{ij} \log\left(w_j\, f_j(x_j;\alpha_j,\beta_j)\right) \tag{9}$$

As y is unknown, the log likelihood of the complete dataset cannot be computed. Instead, the EM algorithm considers the conditional expectation of $l_c(\theta,y)$ given the complete dataset and the values of current parameter $\theta^{(k)}$ where Y is now treated as a random variable. The conditional expectation is given by

$$Q(\theta, \theta^{(k)}) = E_{\theta^k}[l_c(z;\theta)\,|\,x, \theta^{(k)}]$$

$$= \sum_{i=1}^{n}\sum_{j=1}^{2} P(y_{ij} = 1|y_i, \theta^{(k)}) \log w_j f_j\left(x_i;\alpha_j,\beta_j\right) = \sum_{i=1}^{n}\sum_{j=1}^{2} h_{ij}^{k} \log w_j\, f_j(x_j;\alpha_j,\beta_j) \tag{10}$$

here $h_{ij}^{k}$is defined as the probability that $x_i$belongs to component j, given the current estimates. That is $h_{ij}^{k} = P(y_{ij} = 1|y_i, \theta^{(k)})$. We need to compute h_{ij}^{k} in the E-step in order to obtain the expected complete log-likelihood while in the M-step we maximize it with respect to θ.

Since $f_j(x_j; \alpha_j, \beta_j)$ is the Gumbel distribution function given by equation (2), we have

$$Q(\theta, \theta^{(k)}) = \sum_{i=1}^{n} \sum_{j=1}^{2} h_{ij}^{(k)} \log\left[\frac{w_j}{\beta_j} \exp\left[-\left(\frac{x_i-\alpha_j}{\beta_j} + \exp\left(-\frac{x_i-\alpha_j}{\beta_j}\right)\right)\right]\right] \quad (11)$$

In order to maximise this with respect to θ, we can write

$$\arg\max Q(\theta, \theta^{(k)}) = \arg\max \sum_{i=1}^{n} \sum_{j=1}^{2} h_{ij}^{(k)} \left[\log \frac{w_j}{\beta_j} - \left(\frac{x_i-\alpha_j}{\beta_j} + \exp\left(-\frac{x_i-\alpha_j}{\beta_j}\right)\right)\right] \quad (12)$$

The Lagrangian function for the above equation will be

$$L = \sum_{i=1}^{n} \sum_{j=1}^{2} h_{ij}^{(k)} \left[\frac{x_i-\alpha_j}{\beta_j} + \exp\left(-\frac{x_i-\alpha_j}{\beta_j}\right) + \log w_j - \log\beta_j\right] - \lambda\left(\sum_{j=1}^{2} w_j - 1\right), \quad (13)$$

here λ is the Lagrange multiplier. By computing the partial derivatives of L with respect to parameters α_j, β_j, w_j and λ, expressions for parameters are obtained which optimise the expected value of log-likelihood for the complete dataset.

Duration of PPA in Selected States of India

We have applied the above model to examine the pattern of the duration of PPA in selected states of India based on the data available through the National Family Health Survey (NFHS-4) 2015-2016 (Government of India, 2017). The NFHS-4 provides data about the duration of PPA in completed months only. However, we have considered the duration of PPA as a continuous variable because a continuous variable can be mathematically treated in an easier way than a discrete variable. Because of the poor quality of the data about the duration of PPA available from the National Family Health Survey, it is quite difficult to model the distribution of the duration of PPA. This problem can be addressed to some extent using the approach outlined in this paper. We restrict the analysis to bimodal pattern of the distribution of the duration of PPA since the model incorporates only the bimodal pattern of distribution.

The parameters of the model have been obtained by solving the EM algorithm described above. The model fitting is based on the information about the duration of PPA after the last-but-one birth as reported by ever-married women in the age group 15-49. The analysis has been carried out for four states: West Bengal, Gujarat, Himachal Pradesh, and Andhra Pradesh.

The estimates of the parameters of the model are given in table 1. The present model is only limited to incorporate up to two modes only. The goodness of fit of the model has been tested by Kolmogorov Smirnov (K-S) test statistic. Table 2 shows the observed and expected values of the mean and standard deviation of the observed distribution of the duration of PPA along with the mean and standard deviation of the distribution derived from the model. It is obvious from table 2 that based on the K-S test statistic, the proposed modelling approach provides good fit to the data on the duration of PPA in four states available from the National Family Health Survey 2015-16. It is also clear from table 1 that the distribution of the duration of PPA in all the four states is bimodal.

Table 1 :Estimated values of parameters of the model

States	Parameters				
	α_1	β_1	α_2	β_2	a
West Bengal	0.37	1.69	11.79	2.67	0.66
Gujarat	3.18	3.89	12.21	4.91	0.78
Himachal Pradesh	4.13	5.10	17.01	5.63	0.79
Andhra Pradesh	4.03	4.78	11.88	4.05	0.81

Source: Authors' calculations

Table 1 suggests that the distribution of the duration of PPA in the four states is different. In Gujarat, the first mode of the distribution of the duration of PPA is at around 3-4 months while the second mode is at around 12-13 months. The proportion of women with short duration PPA in the state is around 80 per cent (parameter *a*). The observed mean and median duration of PPA is about 7 months which means that 50 per cent of the women in the state resume their menses around 7 months after the termination of pregnancy. In Himachal Pradesh and Andhra Pradesh also, the first mode is at around 4 months but the second mode in Himachal Pradesh is at around 17 months whereas it is at around 12 months in Andhra Pradesh. The proportion of women with short duration of PPA is around 80 per cent in both states. The observed mean and median duration of PPA in Andhra Pradesh are 7 months and 6 months respectively but 8 months and 7 months in Himachal Pradesh.

Table 2: Observed and estimated values of parameters of the model

States	Observed values		Estimated values		'p'
	Mean	SD	Mean	SD	
West Bengal	5.59	2.18	5.42	2.72	0.988
Gujarat	7.15	5.17	7.53	5.19	0.883
Himachal Pradesh	8.53	6.01	9.8	6.68	0.897
Andhra Pradesh	7.00	3.99	7.26	4.17	0.961

Source: Authors' calculations

In West Bengal, the distribution of the duration of PPA is significantly different from the distribution of the duration of PPA in the other three states. Around two-third of the women in West Bengal start menstruating within one month of the termination of pregnancy so that the mean duration of PPA in the state is the lowest amongst the four states included in the analysis. Since the primary determinant of the duration of PPA is the duration and pattern of breasting including suckling frequency, it appears that in around two third women of the state, breastfeeding duration and patterns have virtually little impact on the duration of PPA. This also implies that, that the duration and the pattern of breastfeeding, in these women, has negligible impact on their fertility. At least half of the women in West Bengal start menstruating within six months of the termination of their pregnancy compared to more than 8 months in Himachal Pradesh and around 7 months in Andhra Pradesh and Gujarat. Table 1 and Table 2 suggest that the distribution of the duration of PPA in the four states is essentially different. There appear state-specific factors that influence the duration of PPA which has implications for fertility regulation.

Conclusions

The postpartum infecundity, primarily due to postpartum amenorrhoea, is one of the proximate determinants of fertility (Bongaarts, 1978). Information about the duration of postpartum amenorrhoea is usually collected through retrospective enquiries during household surveys and the quality of the information so collected is of poor quality to analyse the patterns of duration of postpartum amenorrhoea. In this paper, we have proposed a modelling approach based on the extreme value mixture distributions along with the use of EM algorithm that can be used to analyse the pattern of the duration of postpartum amenorrhoea even if the data quality is poor. The EM algorithm is one of the commonly used techniques for determining parameters of mixture models when there are missing values in the data.

Using the data available from the National Family Health Survey 2015-2016, the present analysis also suggests that the distribution of the duration of PPA in four states of India – West Bengal, Gujarat, Himachal Pradesh, and Andhra Pradesh – is different, although bimodal. The bimodal distribution of the duration of PPA can be attributed to numerous factors including the poor quality of data. There is extensive literature that suggests that breastfeeding is an important reason for the delay in ovulation after the termination of pregnancy (McNeilly, 1977; Billewicz, 1979; Habicht et al, Mishra et al, 2021) and discontinuation of breastfeeding is a crucial factor in the short duration of PPA as observed in four states. Breastfeeding, particularly, sucking exerts pressure which raises the level of the hormone prolactin and results in suppressing the ovarian activity and delay in the return of menses. It has been reported the longer the duration of breastfeeding the longer the period of the return of menstruation after the termination of pregnancy (Singh et al, 2012).

The nutritional status of woman also plays a key role in decided the length of PPA. It has been observed in a study based on the data from the National Family Health Survey 1998-1999 that the duration of PPA is significantly longer in under-nourished women as compared to the duration of PPA in well-nourished women (Dwivedi, 2010). Our analysis, however, suggests that, in the four states, a small proportion of woman have long duration of PPA. In almost 80 per cent women in three of the four states, the duration of PPA is short. It is only in West Bengal where around 33 per cent of the women are estimated to be having long duration of PPA according to the data available through NFHS-4. At the same time, around two-third women in West Bengal have very short duration PPA.

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Caesarean Births in India: A Preliminary Analysis of Associated Factors

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Abstract

The proportion of caesarean births has increased in India from less than 3 per cent in 1992-93 to more than 21 per cent in 2019-21. In the urban areas, nearly one-third births are caesarean births while this proportion is nearly 50 per cent in private health facilities. A high proportion of caesarean births seems unnecessary and motivated by non-medical interests. This paper uses data from the latest National Family Health Survey, 2019-2021 to analyse factors associated with inter-state variation in the proportion of caesarean births. The analysis reveals that inter-state variation in the proportion of caesarean births is significantly positively associated with inter-state variation in the proportion of women with high sugar level and the proportion of women with elevated blood pressure in case of births in private and public facilities and in the urban areas whereas inter-state variation in the proportion of women with at least 10 years of schooling is significantly but negatively associated with inter-state variance in the proportion of caesarean births in private facilities and in urban areas. In rural areas, education of the woman and prevalence of female sterilisation has a positive impact on the proportion of caesarean deliveries. For the total population (rural + urban), female sterilization and obesity in women show a significant positive association. The paper recommends monitoring of counselling practices advocating caesarean deliveries to curtail unnecessary caesarean births which may have negative health consequences for both women and children.

Introduction

Globally, births delivered by caesarean section (C-section) are on the rise, accounting for 21 per cent of all childbirths (WHO, 2021). Caesarean section is a life-saving surgery to deal with pregnancy-related complications so that a woman can give birth to a healthy child. It is used for saving the life of the baby and/or the mother. Caesarean procedure may be necessary in many delivery complications including breach presentation, rupture of the uterus, cord prolapses, foetus distress, and when the woman suffers from gestational diabetes or high blood pressure (American Pregnancy Association, 2021). It is estimated that, usually, a C-section prevalence of 10-15 per cent is necessary to prevent premature maternal and neonatal death (WHO, 2015). It is also estimated that a C-section rate of less than 5 per cent indicates that a considerable proportion of women do not have access to emergency obstetric care services, whereas a C-section rate of more than 15 per cent indicates overuse of the procedure that does not have medical justification (Bhatia et al, 2020). When this method is overused, it becomes a matter of concern.

The existing evidence suggests that the prevalence of C-section is increasing (Al Rifai, 2014; Khawaja et al, 2004; Radha et al, 2015; Radhakrishnan et al, 2017; Subedi, 2012; Stavrou et al, 2011). It is estimated that more than one out of every five deliveries in the world are C-section deliveries (Betran et al, 2021). Although, delivery through surgical procedure is beneficial in case of medical emergency, yet it needs to be opted with caution and must be avoided when not necessary as there are known complications for both the woman and the neonate (Gayathry et al, 2017; Betran et al, 2016). The current trend, however, shows that many C-sections are unnecessary. A high prevalence of C-section deliveries puts women and children at risk of short- and long-term health concerns. It is projected that by the year 2030, almost 29 per cent of the deliveries in the world would be C-section deliveries (Betran et al, 2021) which is medically unacceptable.

The fourth round of the National Family Health Survey (NFHS 2015-16) in India had reported that out of a total of 195,366 institutional births, 35,671 births - 15,165 in public facilities and 20,506 births in private facilities – were delivered through C-section or were caesarean births (Bhatia et al, 2020). This means that caesarean births accounted for 17.2 per cent of total births - 11.9 per cent in public facilities and 40.9 per cent in private facilities. Between NFHS -1 (1992-93) and NFHS-4 (2015-16), the proportion of caesarean births increased from 2.9 per cent to 17.2 per cent. In public facilities, this proportion increased from 7.2 per cent to 11.9 per cent, while in private facilities from 12.3 per cent to 40.9 per cent. A high proportion of caesarean births in private health facilities and the rapid increase in this proportion raises some questions about the motivation behind the rapid increase in adopting this surgical procedure to conducting delivery. This concern has also been felt at the global level because the global C-section rate is estimated to have increased from 6.7 per cent in 1990 to 19.1 per cent in 2014 (Betran et al, 2016) and 21 per cent in 2021 (WHO, 2021). Several reasons have been put forward to explain the global rise in caesarean births. These include women preferences, practice of defensive medicine, socio-cultural factors, financial incentives (Gibbons et al, 2010), and changes in obstetric practices (MacDorman et al, 2008). Research carried out in India suggests that the C-section birth rate in India is significantly associated with age, educational attainment, wealth quintile, obesity, or high Body Mass Index (BMI) of woman, pregnancy complications, and previous caesarean births (Roy et al, 2021; Mohanty et al, 2019).

An increase in the proportion of caesarean births is also associated with the preference for C-section by some women. Women with secondary infertility fear normal delivery when they become pregnant again as it may reduce their chances to have a live birth (Kirchengast and Hartmann, 2019; Chavarro et al, 2020). The level of education of a woman has also been found to be linked to enhanced apprehension toward normal delivery which can cause prolonged and excruciating pain (Hofberg and Ward, 2003). Due to the anxiety related to prolonged labour during normal vaginal delivery, some women prefer C-section delivery (Suwanrath et al, 2021) even though it costs more (Bhatia et al, 2020). From the perspective of the health facility, a C-section delivery usually takes less time in the sense that it overcomes the uncertainty of the duration of labour and pays more than a normal delivery (Johnson and Rehavi, 2016; Dongre and Surana, 2018). It is in the interest of private health facilities to promote C-section deliveries for their financial gains (Bhatia et al, 2020). Studies have also shown that C-section delivery is recommended more for those women who have health insurance coverage (Hoxha et al, 2017).

In India, the results of the NFHS-5 show that 32.3 per cent of the births in urban areas and 47.4 per cent in private health facilities are cesarean births. Does it mean that C-section was necessary for all of them? In the absence of the necessary data to answer this question, the present study attempts to investigate the factors that may have led to a high proportion of caesarean births. The individual level data from NFHS-5 are not yet available, although state level fact sheets based on NFHS-5 data are available. The present study, therefore, analyses spatial variation in the prevalence of caesarean births in the country, in its rural and urban areas, and in the private and public health facilities. It also investigates correlates of caesarean births and attempts to determine some of the factors that may predict the spatial variation in the proportion of caesarean births in India.

Methodology

Data Source. This study uses data from the fifth round of the National Family Health Survey (NFHS)-5 (2019-2021). The NFHS is a multi-stage, stratified survey conducted in a representative sample of households throughout India. The survey provides national and state-level estimates of selected indicators related to fertility, infant and child mortality, practice of family planning, maternal and child health, reproductive health, nutrition, anaemia, and utilisation and quality of health and family planning services. The present study uses state level estimates of the proportion of caesarean births available from NFHS-5 (Government of India, n.d.). The NFHS-5 factsheets also provide estimates of the proportion of caesarean births based on the data from NFHS-4 (2015-2016) which also permit analysing the trend in the proportion of caesarean deliveries in different states; in rural and urban areas of different states; and in public and private health facilities. Details about the size of the sample, sample design, data processing and quality aspects of the data collected during fourth and fifth rounds are documented in the country report (Government of India, 2017).

Variables Considered. In NFHS-5, currently married women in the age group 15-49 years were asked about the place of their last delivery which was classified as public health facility – government hospital, dispensary, health centre or other government health institutions – and private health facility - private hospital, maternity home, or private health institutions. For each reported birth, it was also asked whether the delivery was normal, or it was a C-section delivery. Based on this information, the proportion of caesarean births have been calculated for 28 states of the country as they existed at the time of NFHS-5. The proportion of caesarean births to total births is taken as the dependent or the study variable for the present analysis. On the other hand, seven independent or the explanatory variables have been used in the analysis: 1) proportion of women aged 15-49 years having 10 or more years of schooling; 2) proportion of women aged 15-49 years who were sterilised; 3) proportion of women aged 15-49 years using Intrauterine Contraceptive Device/Postpartum Intrauterine Contraceptive Device (IUD/PPIUD); 4) Proportion of women aged 15-49 years who had at least 4 antenatal care visits during their last pregnancy; 5) proportion of women who were having high or very high blood sugar level (>140 mg/dl) or women who were taking medicine to control blood sugar; 6) proportion of women with elevated blood pressure (systolic >=140 mm of Hg and/or diastolic >=90 mm of Hg) or women taking medicine to control blood pressure; and 7) proportion of women who were overweight or obese (BMI >=25.0 kg/m^2).

Data Analysis. This study has investigated state-level changes in the proportion of caesarean births in recent years in the rural and urban areas in public and private health facilities. State level maps have been used to depict the spatial variation in the proportion of caesarean births in the country. Finally, the state-level data have been analysed to examine the association between the proportion of caesarean births and selected independent variables. The simple zero order correlation coefficient of the proportion of caesarean births with all the independent variables is found to be statistically significant in the combined (rural and urban) population as well as separately in rural and urban populations. Therefore, stepwise regression analysis was carried out to analyse the effect of each of the seven independent variables on the proportion of caesarean births. The analysis has also been carried out separately for caesarean births in public facilities and caesarean births in private facilities.

Results

The proportion of caesarean births in India has increased from 17.2 per cent in 2015-2016 to 21.5 per cent in 2019-2021. This proportion is substantially higher in the urban areas, but the increase in this proportion has been different in rural and urban areas. The proportion of caesarean births increased from 28.2 per cent to 32.3 per cent in the urban areas but from 12.8 per cent to 17.6 per cent in the rural areas (Figure 1). In the private health facilities, the proportion of caesarean births increased from 40.9 per cent in 2015-2016 to 47.4 per cent in 2019-2021 whereas this proportion increased from 11.9 per cent to 14.3 per cent in the public health facilities (Figure 2). In the rural areas, the proportion of caesarean births is within the range recommended by WHO, but in the urban areas, this proportion is not only well above the recommended WHO norm, but the increase is also quite alarming. The trend in this proportion in the rural areas, however, indicates, that the proportion of caesarean births has also crossed the upper limit recommended by the WHO.

Figure 3 shows the variation in the proportion of caesarean births across the states of the country during 2019-2021 as revealed through NFHS-5. There are only eight states where the proportion of caesarean births to total births is within the range recommended by the WHO (10-15 per cent) and most of these states are located in the central part of the country. In 18 states of the country, the proportion of caesarean births exceed 15 per cent. These states include all northern and southern states and some states in the north-eastern part of the country. There are only two states - Nagaland and Mizoram – where the proportion of caesarean births is less than 10 per cent. The very low proportion of caesarean births in these states raises questions about the availability and use of health services.

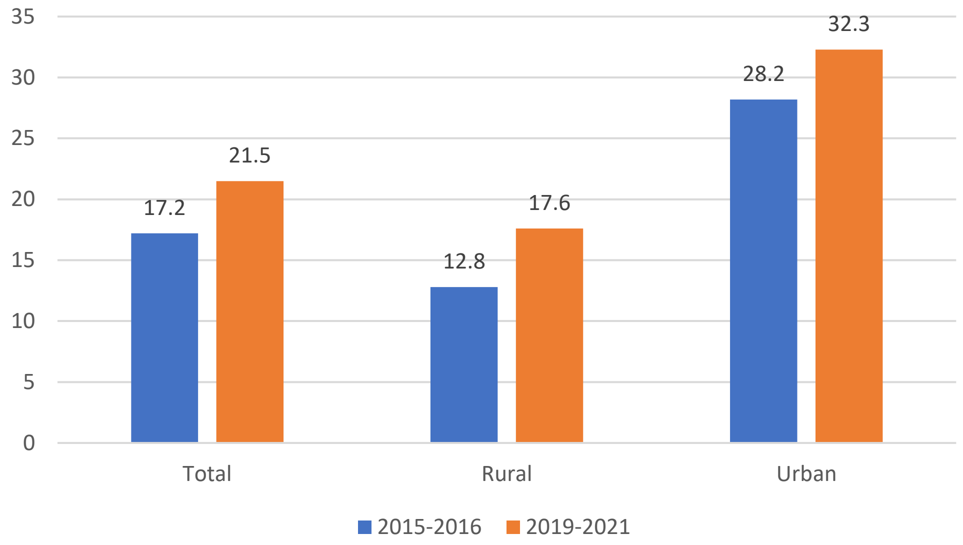

Figure 1: Proportion (per cent) of caesarean births in India, 2015-2106 and 2019-2021
Source: Authors

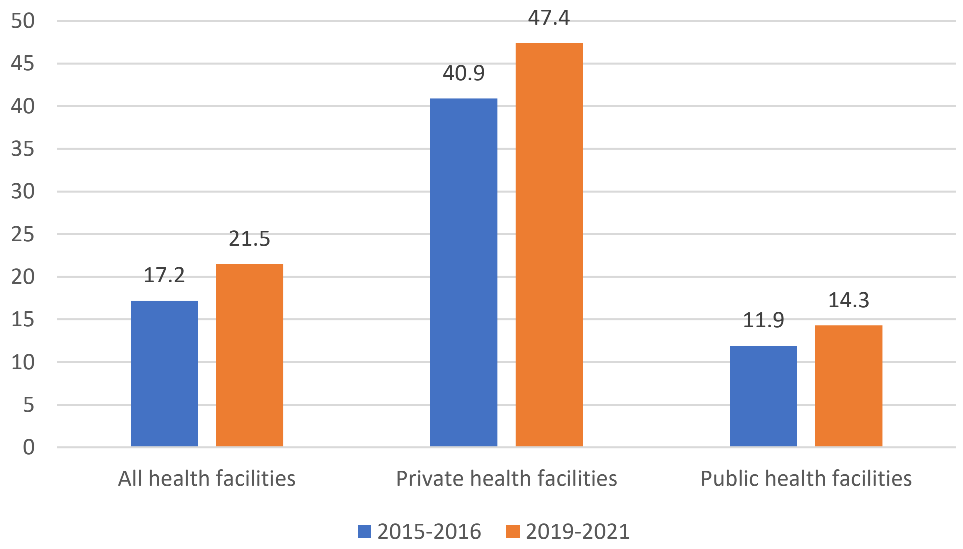

Figure 2: Proportion (per cent) of caesarean births in public and private health facilities, 2015-2016 and 2019-2021
Source: Authors

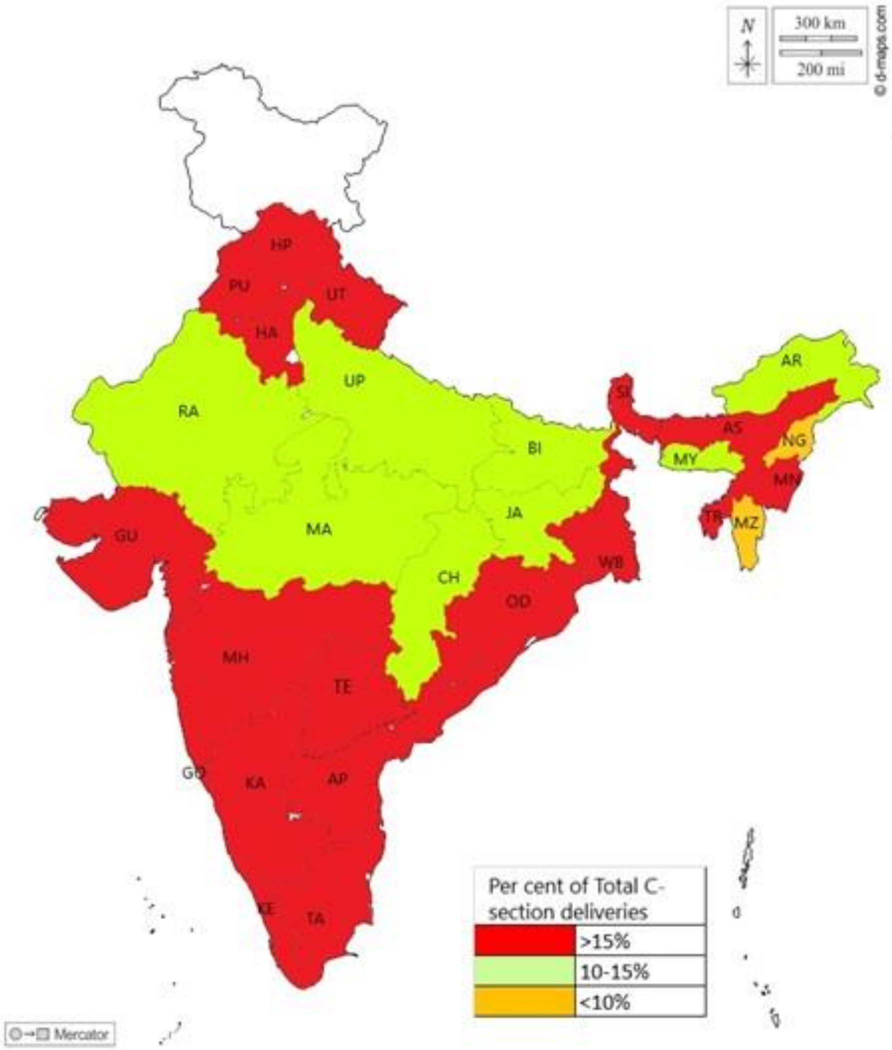

Figure 3: Inter-state variation in the proportion (per cent) of caesarean births in India 2019-2021
Source: Authors

Figure 4 shows the inter-state variation in the proportion of caesarean births in the rural population. The pattern is very similar to that in the combined population (Figure 3). There are, however, some differences. There are only five states where the proportion of caesarean births ranges between 10-15 per cent in the rural areas. There are 17 states where this proportion is more than 15 per cent whereas in six states, it is less than 10 per cent. In Andhra Pradesh and Telangana, more than half of the births are reported to be caesarean births. Figure 5 illustrates that in all states, the proportion of caesarean births in urban areas is higher than that in rural areas, although the gap varies.

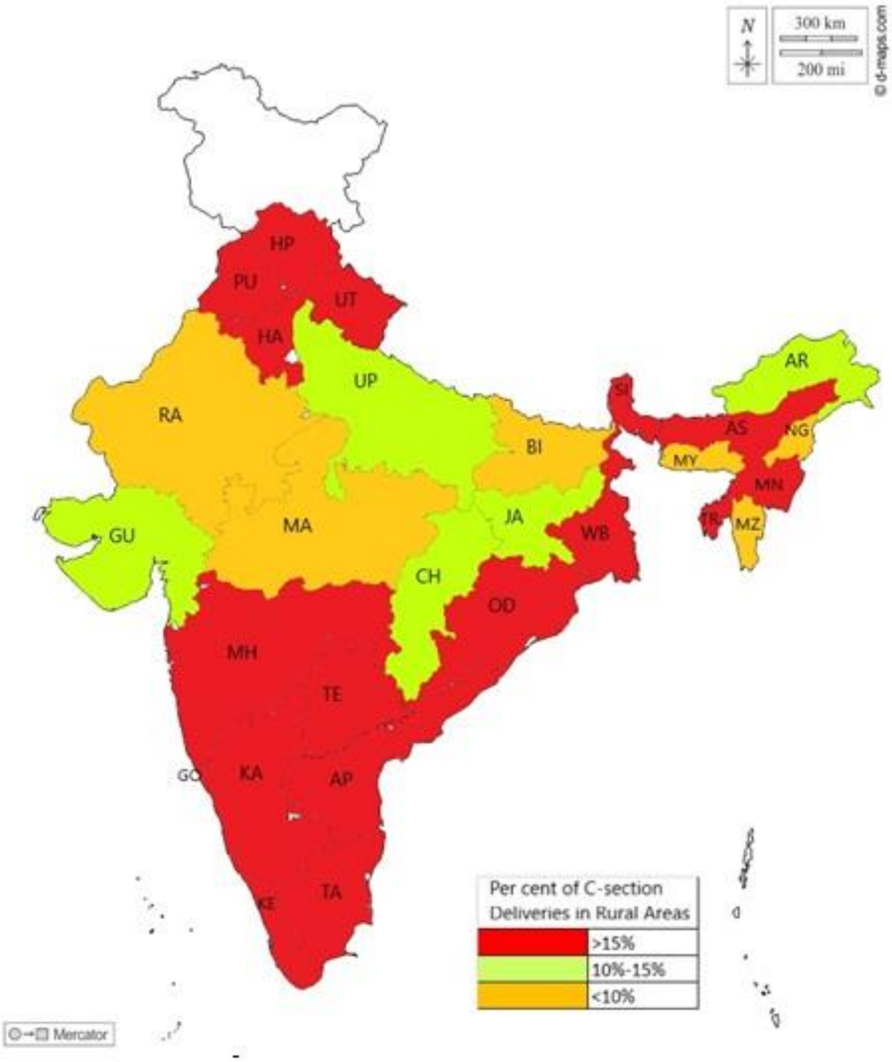

Figure 4: Inter-state variation in the proportion (per cent) of caesarean births in the rural population, 2019-2021
Source: Authors

Figure 6 depicts inter-state variation in the proportion of caesarean births in the private health facilities while Figure 7 depicts inter-state variation in the public health facilities. Telangana and West Bengal are the only two states where the proportion of caesarean births is more than 75 per cent of all births in private health facilities. There are 12 states where more than half of all births in private health facilities are caesarean births. Nagaland is the only state where this proportion is less than 25 per cent. In all states, the proportion of caesarean births in the private health facilities is alarmingly high.

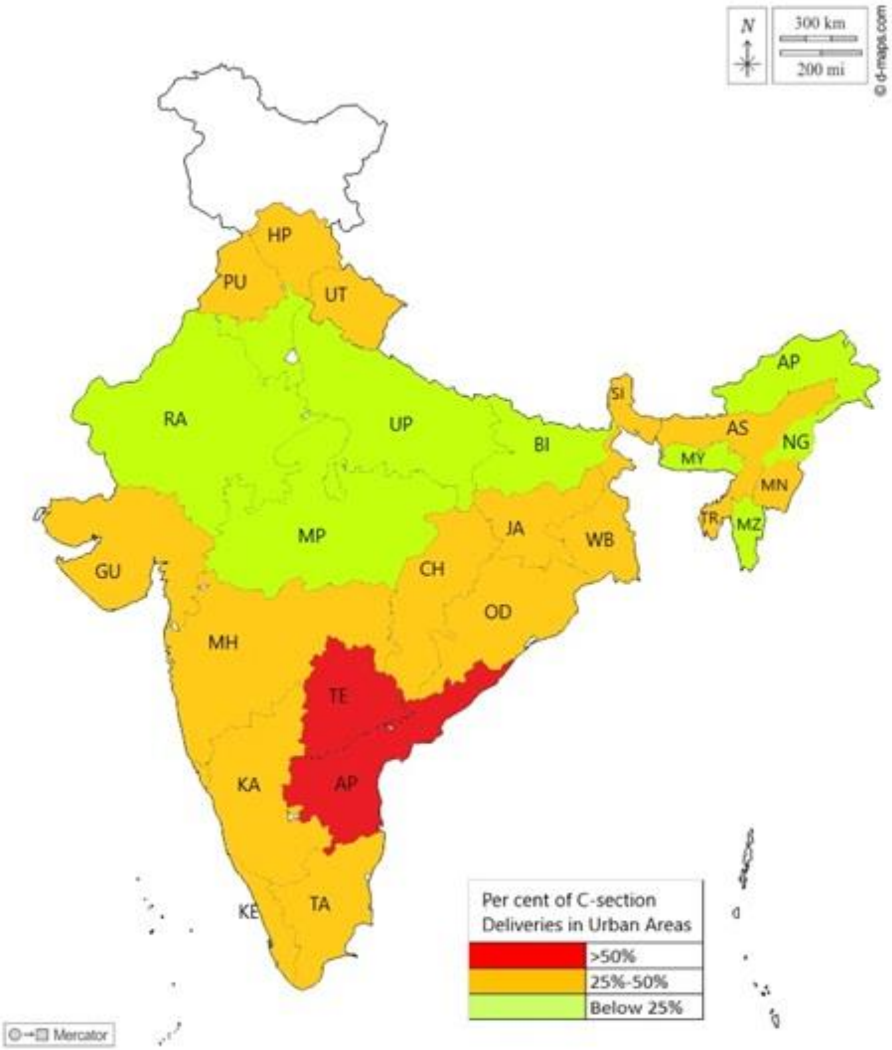

Figure 5: Inter-state variation in the proportion (per cent) of caesarean births in the urban population 2019-2021
Source: Authors

On the other hand, there are nine states where caesarean births account for less than 10 per cent of all births in public health facilities. In five states, this proportion ranges between 10-15 per cent. This leaves fourteen states where caesarean births are more than 15 per cent of all births in public health facilities. Figures 1 and 7 indicate that in Rajasthan, Uttar Pradesh, Bihar, Madhya Pradesh, Chhattisgarh, and Jharkhand, the overall proportion of caesarean births is in the range recommended by WHO, but the proportion of caesarean births is less than 10 per cent of all deliveries in the public health facilities.

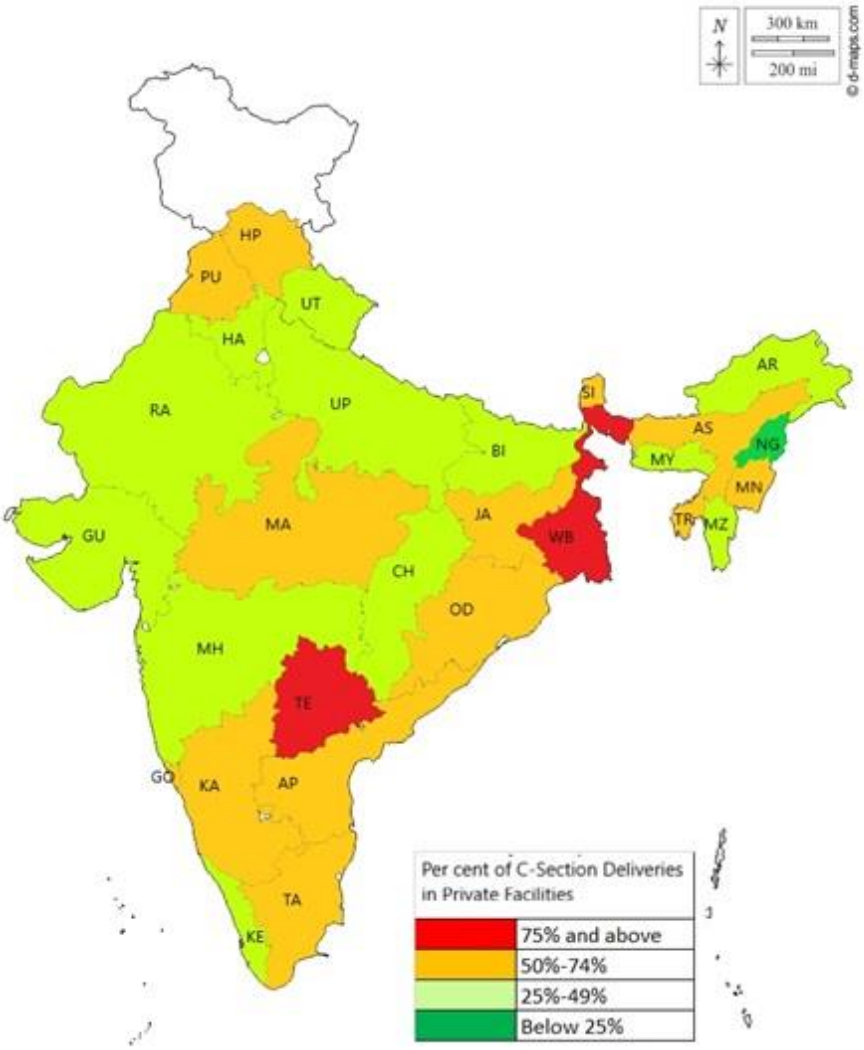

Figure 6: Inter-state variation in the proportion (per cent) of caesarean births in the private health care facilities 2019-2021
Source: Authors

Table 1 provides detailed information about caesarean births in rural and urban areas and in private and public health facilities. Telangana has the highest proportion of caesarean births (60.7 per cent) whereas Nagaland has the lowest (5.2 per cent). In Tamil Nadu and Andhra Pradesh, caesarean births account for more than two-fifths of all births. In Nagaland, Mizoram, and Bihar, less than 10 per cent of all births are caesarean births. There are only seven states - Arunachal Pradesh, Jharkhand, Madhya Pradesh, Meghalaya, Rajasthan, and Uttar Pradesh – where the proportion of caesarean births ranges between 10-15 per cent.

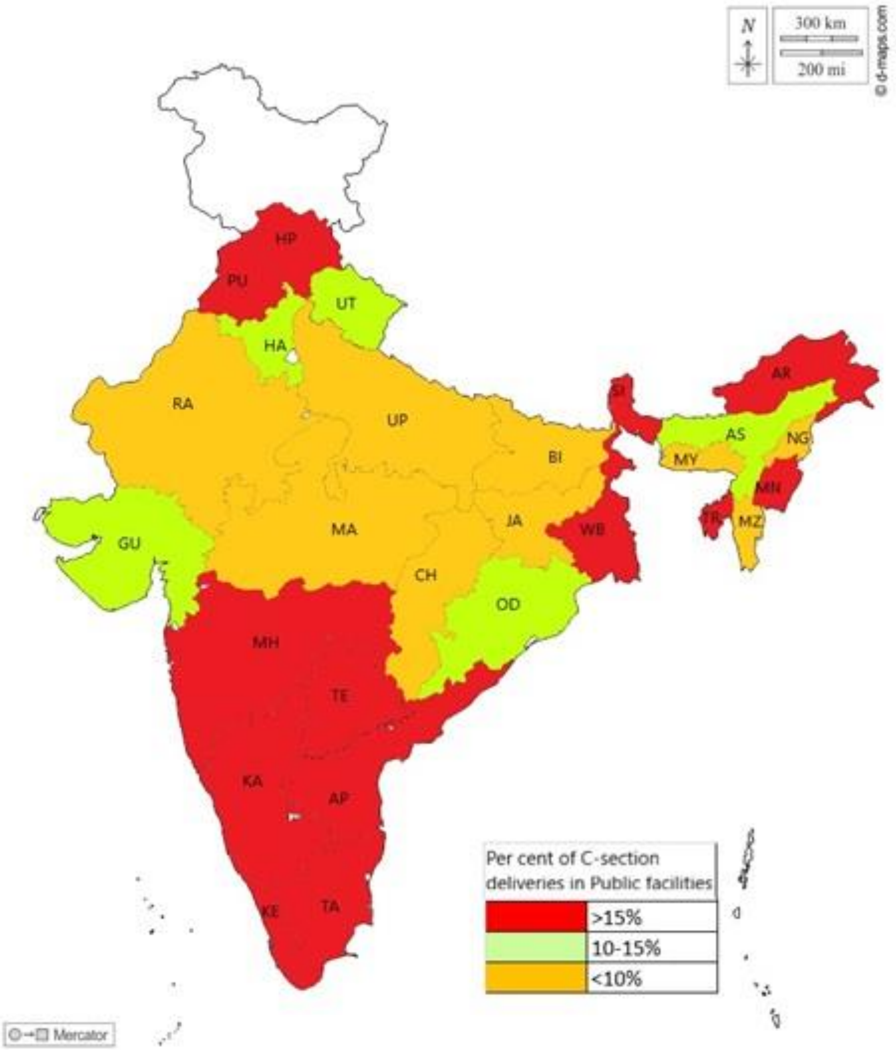

Figure 7: Inter-state variation in the proportion (per cent) of caesarean births in private health facilities, 2019-2021
Source: Authors

In the urban areas, on the other hand, nearly two-third (64.3 per cent) of all births in Telangana and more than half (50.5 per cent) of all births in Andhra Pradesh are reported to be caesarean births. By comparison, Nagaland is the only state in the country where caesarean births account for less than 10 per cent of all births in the urban areas. Besides Nagaland, there is no other state in the country where caesarean births accounted for less than 15 per cent of all births in the urban areas according to the data available from NFHS-5 as recommended by the WHO. Very high proportion of caesarean births in the urban areas of all but one states is a matter of public health concern.

Table 1: Proportion (per cent) of caesarean births to all births in India and states, 2019-2021.

State	All health facilities			Private health facilities			Public health facilities		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
India	21.5	17.6	32.3	47.4	46.0	49.3	14.3	11.9	22.7
Andhra Pradesh	42.4	39.3	50.5	63.0	61.4	66.1	26.6	25.2	30.9
Arunachal Pradesh	14.8	14.4	17.1	47.3	43.8	56.3	17.0	17.4	15.0
Assam	18.1	15.6	39.2	70.6	66.9	78.8	15.2	13.9	26.7
Bihar	9.7	8.8	15.7	39.6	40.6	36.7	3.6	3.5	4.7
Chhattisgarh	15.2	11.3	31.2	57.0	54.5	60.4	8.9	7.1	17.8
Goa	39.5	40.1	39.1	50.0	56.6	46.6	31.5	29.6	32.9
Gujrat	21.0	15.3	30.7	30.8	25.0	38.0	12.4	8.8	20.3
Haryana	19.5	17.8	23.5	33.9	33.4	34.9	11.7	10.9	14.4
Himachal Pradesh	21.0	20.3	26.2	51.4	52.6	46.7	17.4	17.2	19.8
Jharkhand	12.8	10.2	25.8	46.7	46.1	47.7	7.0	6.1	12.4
Karnataka	31.5	29.4	35.2	52.5	52.8	52.3	22.6	22.2	23.3
Kerala	38.9	38.7	39.1	39.9	40.4	39.4	37.2	36.1	38.8
Madhya Pradesh	12.1	8.8	23.3	52.3	53.2	51.4	8.2	6.5	15.3
Maharashtra	25.4	21.5	30.6	39.1	37.3	40.9	18.3	15.1	23.2
Manipur	25.6	19.7	38.0	53.2	49.6	57.8	24.7	19.7	33.9
Meghalaya	10.8	6.1	21.6	40.8	34.6	51.0	9.2	8.1	15.2
Mizoram	8.2	4.8	16.8	30.4	29.4	30.7	9.8	5.0	13.7
Nagaland	5.2	3.6	9.8	23.6	30.1	19.7	8.0	6.1	12.5
Odisha	21.6	19.5	34.1	70.7	71.5	68.6	15.3	14.2	22.3
Punjab	38.5	38.4	38.8	55.5	57.0	53.4	29.9	29.1	31.4
Rajasthan	10.4	8.1	19.7	26.9	24.4	33.0	7.2	5.5	15.3
Sikkim	32.8	26.9	43.1	55.4	44.0	*	30.4	25.9	40.4
Tamil Nadu	44.9	42.9	47.5	63.8	66.7	61.5	36.0	35.1	37.5

State	All health facilities			Private health facilities			Public health facilities		
	Total	Rural	Urban	Total	Rural	Urban	Total	Rural	Urban
Telangana	60.7	58.4	64.3	81.5	80.6	82.7	44.5	44.3	44.8
Tripura	25.1	18.6	47.5	69.3	54.7	95.7	22.7	17.6	40.4
Uttar Pradesh	13.7	11.0	24.2	39.4	37.8	42.6	6.2	4.7	14.4
Uttarakhand	20.4	16.7	28.6	43.3	40.9	47.0	14.0	10.7	21.4
West Bengal	32.6	28.6	43.5	82.7	84.4	80.2	22.9	20.3	31.7

*Percentage not shown; based on fewer than 25 unweighted cases.
Source: Authors

It is astonishing to observe from table 1 that more than four out of every five births in the private health facilities in West Bengal and Telangana are caesarean births. In the north-eastern states of Assam and Tripura, and in the eastern state of Odisha, nearly 70 per cent, and in the southern states of Tamil Nadu and Andhra Pradesh, more than 60 per cent of births in private health facilities are caesarean births. Almost all births in private health care facilities (95.7 per cent) in the urban areas of Tripura are reported to be caesarean births. This unbelievable proportion needs further investigation and is a matter of serious concern from the perspective of the health of the mother and the child.

In the public health facilities, proportion of caesarean births is substantially lower than that in private health facilities in all states. However, in many states, the proportion of caesarean births is higher than 15 per cent in public health facilities. The proportion of caesarean births in the public health facilities is the highest in Telangana (44.5 per cent), followed by Kerala (37.2 per cent), and Tamil Nadu (36.0 per cent). In the urban areas, more than two-fifth of births in public health facilities are reported to be caesarean births in Telangana, Tripura, and Sikkim.

Table 2 shows how inter-state variation in the proportion of caesarean births is related to the inter-state variation in explanatory variables included in the analysis. In the combined (rural and urban) population, inter-state variation in indicators of maternity care is found to be more strongly correlated with the inter-state variation in the proportion of caesarean births compared to indicators of family planning use and educational status of women. The inter-state variation in the proportion of caesarean births is however statistically significantly correlated with the inter-state variation in all independent variables except the proportion of currently married women using IUD/PPIUD. Results are quite similar for the rural population. In the urban population, however, inter-state variation in the proportion of women with at least 10 years of education is not found to be statistically significantly correlated with the inter-state variation in the proportion of caesarean births.

It may also be seen from table 2 that, in case of private health facilities, inter-state variation in none of the independent variables is statistically significantly associated with the inter-state variation in the proportion of caesarean births. In case of public health facilities, however, inter-state variation in indicators of maternity care and educational status of women is found to be statistically significantly associated with inter-state variation in the proportion of caesarean births, but variation in indicators of family planning use is not found to be statistically significantly associated with variation in the proportion of caesarean births.

Stepwise regression analysis has been carried out to explore how inter-state variation in the proportion of caesarean births is influenced by the inter-state variation in the seven independent or explanatory variables described above. The results of the stepwise regression analysis are presented in table 3. The stepwise regression analysis has been carried out for the total (rural and urban) population and separately for rural and urban populations. The stepwise regression analysis has also been carried out separately for births in public health facilities and births in private health facilities to explore how inter-state variation in the independent variables influence inter-state variation in the proportion of caesarean births in private health facilities and inter-state variation in the proportion of caesarean births in public health facilities.

Table 2: Simple zero order correlation coefficient of the proportion of caesarean births with selected independent variables.

Factor	Indicator	Total	Rural	Urban	Private facility	Public facility
Education of women	1. Proportion of women (15-49 years) with at least 10 years of schooling	0.449*	0.528**	-0.023	-0.164	0.540**
Family planning	2. Proportion of currently married women (15–49 years) using female sterilization	0.492**	0.471*	0.434*	0.165	0.315
	3. Proportion of currently married women (15–49 years) using IUD/PPIUD	-0.298	-0.266	-0.395*	-0.349	-0.156
Maternity care	4. Proportion of mothers who had at least 4 antenatal care visits	0.624***	0.683***	0.500**	0.334	0.584**
	5. Proportion of women with high or very high blood sugar level (>140 mg/dl) or taking medicine to control blood sugar level	0.706***	0.573***	0.734***	0.355	0.712***
	6. Proportion of women with elevated blood pressure (systolic >=140 mm of Hg and/or diastolic >=90 mm of Hg) or taking medicine to control blood pressure	0.637***	0.622***	0.681***	0.283	0.727***
	7. Proportion of women (age 15-49) who are overweight or obese (BMI >=25.0 kg/m^2)	0.760***	0.739***	0.633***	0.218	0.773***

* $p < 0.05$; ** $p < 0.01$; *** $p < .001$

Source: Authors

Table3: Results of the stepwise regression analysis of the proportion of caesarean births on independent variables.

Indicator	Total		Rural		Urban		Private facility		Public facility	
	b	β	b	β	b	β	b	β	b	β
1. Proportion of women with 10 or more years of schooling			0.457**	0.461	-0.364*	-0.284	-0.852**	-0.714		
2. Proportion of women using female sterilization as family planning method	0.227*	0.316	0.300*	0.409						
3. Proportion of women using IUD/PPIUD as family planning method										
4. Proportion of mothers who had at least 4 antenatal care visits										
5. Proportion of women who are overweight or obese as reflected through BMI	1.013**	0.678								
6. Proportion of women having high or very high level of blood sugar					1.426**	0.510	1.837*	0.488	1.264**	0.497
7. Proportion of women having elevated blood pressure, either systolic or diastolic or both					1.671**	0.533	1.736*	0.516	1.185**	0.523
R^2 / Adjusted R^2	R^2	R^2_{Ajd}	R^2	R^2_{Ajd}	R^2	R^2_{Ajd}	R^2	R^2_{Ajd}	R^2	R^2_{Ajd}
	0.670	0.644	0.442	0.397	0.743	0.711	0.436	0.366	0.734	0.713
N	28	28	28	28	28	28	28	28	28	28

*p< .05; **p < .01

b – unstandardized coefficient; β - standardized coefficient

Source: Authors

The results of the stepwise regression analysis suggest that inter-state variation in the selected independent variables used in the analysis has a statistically significant influence on the inter-state variation in the proportion of caesarean births and these variables are different for different population groups. In case of combined population, inter-state variation in the proportion of women who are obese or overweight and the proportion of women who are sterilized have a significant impact on inter-state variation in the proportion of caesarean births. In the rural population, inter-state variation in the proportion of women who are sterilized and the proportion of women who have 10 or more years of schooling are found to be statistically significantly associated with the inter-state variation in the proportion of caesarean births.

In the urban areas, however, the inter-state variation in the proportion of caesarean births is found to be statistically significantly associated with the inter-state variation in the proportion of women with elevated blood pressure, proportion of women with high or very high level of blood sugar, and proportion of women with at least 10 years of schooling. Among the three predictor variables, the regression coefficient of the proportion of women having elevated blood pressure and higher level of blood sugar are positive but that of the proportion of women with at least 10 years of schooling is negative which implies that, other things being equal, the higher the proportion of women with at least 10 years of schooling in the urban areas of a state, the lower is the proportion of caesarean births in the urban part of that state. However, out of these three predictors, the association of the variation in the proportion of caesarean births with the elevated blood pressure is the strongest while it is weakest for women with 10 or more years of schooling.

In case of births in private health facilities, the pattern is the same as in the urban population. The variables that have a statistically significant impact on the variation in the proportion of caesarean births are the proportion of women with elevated blood pressure, the proportion of women with high or very high blood sugar level, and the proportion of women with 10 or more years of schooling. The regression coefficient of the proportion of women with at least 10 years of schooling is negative in this case also while that of the proportion of women having elevated blood pressure and high level of blood sugar are positive. However, the association of the proportion of women with at least 10 years of schooling is stronger than that of the proportion of women having elevated blood pressure or high blood sugar. On the other hand, in case of births in public health facilities, the independent variables that affect the proportion of caesarean births statistically significantly are the proportion of women with elevated blood pressure and the proportion of women with high or very high level of blood sugar.

Table 3 suggests that after controlling the effect of other variables, the proportion of women using IUD/PPIUD and the proportion of women who had at least four antenatal care visits, do not impact the variation in the proportion of caesarean births in any population group. On the other hand, in the private and public health facilities and in the urban population, main factors behind a caesarean birth are elevated blood pressure and high blood sugar level of women during pregnancy. The educational level of women, 10 years or beyond, influences the variation in caesarean births in rural as well as in urban areas and also in private health care facilities. In rural areas, it has a positive impact but a negative impact in the urban areas on the proportion of caesarean births.

Discussion

Caesarean births are increasing at an alarming rate in India and the proportion of caesarean births is found to be exceptionally high in private health facilities in the urban areas. According to WHO, caesarean births should range between 10-15 per cent of all births to protect women and children from the consequences of complications of pregnancy and delivery. Caesarean births more than 15 per cent of all births is generally deemed unnecessary and may drain resources and may also have an adverse impact on the health of women and children. Viewed from this perspective, the data available through NFHS-5 suggest that the proportion of caesarean births in India and in most of its states is unacceptably high and is a major public health concern. The situation appears to be alarming in the urban areas of the country where majority of the births in private health facilities are caesarean births. At the same time, there are states where caesarean births account for less than 10 per cent of all births in public health facilities which suggests that a substantial proportion of those women who are in need emergency care at the time of delivery are devoid of such care.

The proportion of caesarean births is found to be relatively high in the southern states and in some northern and north-eastern states of the country. By contrast, the proportion of caesarean births is within the range recommended by the World Health Organization in the central region of the country, extending from Rajasthan to Bihar and Jharkhand and in two north-eastern states. It is generally argued that there is a positive association between the level of socio-economic development and the proportion of caesarean births. However, the present study, based on the latest state level data, suggests that the higher the proportion of women having at least 10 years of schooling the lower the proportion of caesarean births in the urban areas but the higher the proportion of women with 10 or more years of schooling the higher the proportion of caesarean births in the rural areas. Given the different nature of the relationship between the proportion of caesarean births and the proportion of women with at least 10 years of schooling, there is a need to further examine the role of the level of education of the woman in deciding the type of delivery using the micro-level data. Such data, however, are not currently available through NFHS-5.

The high proportion of caesarean births in private health facilities in India is not surprising as, in many low and middle-income countries, a high proportion of caesarean births in private health care institutions is reported (Guilmoto and Dumont, 2019; Beogo et al., 2017). In India also, many studies have reported an abnormally high proportion of caesarean births in private health facilities (Bhartia et al, 2020; Johnson and Rehavi, 2016). The big difference in the proportion of caesarean births in private health facilities as compared to that in the public health facilities can be ascribed to the quality of services in the private health care institutions. In any case, the exceptionally high proportion of caesarean births in private health facilities raises questions about the motives of private health care services providers. It is argued that private health care services providers motivate and convince and even force women to go for a C-section delivery either on one pretext or the other as a C-section delivery is financially lucrative for private health institutions, even though this practice is entirely unethical.

It has also been argued that a high proportion of caesarean births in private health facilities is due to an increase in the health insurance coverage. A study in the United States of America has concluded that the probability of a caesarean birth is less in women having public health insurance as compared to women having private health insurance (Hoxha et al, 2017). In India, health insurance coverage, combined with the lack of oversight of the private health sector, is argued to be creating an ideal environment for private health facilities to provide biased information to women and engage in physician-induced demand, resulting in a high proportion of caesarean births even when they are medically not necessary (Bhatia et al, 2020).

There are also studies that suggest that caesarean births are more common among urban dwellers, wealthier women, and those with a higher level of education (Singh et al, 2018; Mishra and Ramanathan, 2002). A high proportion of caesarean births in the urban areas may also be explained by the higher prevalence of obesity due in the urban areas to the lack of physical activities and hypertension due to hectic life (Aroor et al, 2013). On the other hand, the proportion of caesarean births is found to be directly related to the proportion of women with elevated blood pressure and high blood sugar level. This is expected as elevated blood pressure at the time of delivery and gestational diabetes are medical emergencies and, therefore, contra-indication for normal delivery (American Pregnancy Association, 2021). The data available from NFHS-5 suggest that the proportion of women with elevated blood pressure and high blood sugar varies widely across the states of the country. Reasons for the variation in the proportion of women having elevated blood pressure and diabetes need to be examined in the context of the variation in the proportion of caesarean births. It appears that there are state-specific factors that contribute to the variation in the proportion of women with elevated blood pressure and gestational diabetes.

Another contraindication for normal delivery is obesity which is more prevalent in middle- and upper-class women (Srivastava et al, 2020). This means that a higher proportion of obese women is directly related to a higher proportion of caesarean births as is revealed in the present study. On the other hand, check-up during the antenatal period has not been found to be associated with the proportion of caesarean births even in private health care institutions. Other studies, however, suggest that antenatal care check-ups at private health care facilities increase the likelihood of the caesarean births that could otherwise be avoided (Kathuria and Raj, 2020; Singh et al, 2018; Mishra and Ramanathan, 2002).

The proportion of women who are sterilized is associated with the proportion of C-section deliveries. It might be due to the convenience of performing sterilization right after the caesarean birth as it prevents another surgery and hospital stay if the woman does not want any more children.

There is also evidence that suggests that some women prefer C-section delivery over normal vaginal delivery for fear of natural birth, health risks, negative previous experiences with childbirth, biased information about C-section delivery, and superstitious beliefs about auspicious birth dates (Suwanrath et al, 2021). Some of these reasons might be applicable to women in India also but NFHS-5 did not collect data on maternal preference for delivery. The maternal preference for C-section births is also associated with the level of education of woman and household income (Kathuria and Raj, 2020). The present study indicates that the increase in the level of education of the woman leads to a decrease in the probability of a caesarean birth in the urban areas. It seems that with the increase in the level of education, concerns about negative consequences of C-section delivery (risk of infection, injury, scar) also increase leading to the preference for normal delivery. On the other hand, in the rural areas, with increase in the educational level of women chances of caesarean births also go up. The plausible explanation could be that it is easier to convince rural women compared to urban women about the need and benefits of caesarean delivery.

The very high proportion of caesarean births, particularly in private health care institutions in India, as revealed through the preliminary data from the latest NFHS-5, calls for institutionalising a monitoring system to investigate the reasons and factors behind the high and increasing proportion of caesarean births in the country. Such a monitoring system is also necessary for an appropriate policy response and necessary programme interventions to ensure that the proportion of caesarean births is neither more than 15 per cent of all births nor less than 10 per cent of all births as recommended by the World Health Organization. There is also a need to come up with appropriate programme strategies that include unbiased maternal counselling about normal versus C-section delivery.

Conclusions

The data available from the latest National Family Health Survey in India suggest that caesarean births in the country have emerged as a major public health challenge and the situation appears to be precarious in states like West Bengal and Telangana where private health care facilities appear to be conducting C-section deliveries indiscriminately. C-section delivery must be opted only when the life of the woman and/or the child is at risk. Unnecessary C-section deliveries may cause maternal and foetal injuries, infections, and additional costs related to childbirth.

The present study has found that the elevated blood pressure of the woman and high level of blood sugar are the most important predictors of the caesarean births with elevated blood pressure being a stronger predictor of the two. This is expected as elevated blood pressure at the time of delivery is a medical emergency and normal delivery is not recommended in such a situation. The proportion of women with elevated blood pressure at the time of delivery is found to vary widely across the states of the country. Identification of the factors behind the elevated blood pressure at the time of delivery may provide the information that may be helpful in reducing the proportion of caesarean births.

The present study uses state level aggregate data which has several limitations for an in-depth analysis of the determinants of caesarean births in India. The individual level data from NFHS-5 are not yet available. It is recommended that more in-depth analysis should be carried out using the individual-level data to understand more about the factors associated with caesarean births.

Based on the findings of the present analysis, there is a need of monitoring the data from health care facilities – public and private - for checking unnecessary C-section deliveries and for providing counselling about the benefits of the normal delivery during the antenatal period.

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Urban-Rural Disparity in Family Planning Use in India, 1992-2021

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Abstract

This paper analyses urban-rural disparity in family planning use in India and in its constituent states and Union Territories during 1992-1993 through 2019-2021. The analysis reveals that urban-rural disparity in family planning use in India has decreased significantly largely because of relatively slow increase in family planning use in the urban population of the country as compared to the rural population. The paper also reveals that urban-rural disparity in the use of traditional family planning methods has increased in recent years because of relatively more rapid increase in the use of traditional methods in the urban population as compared to the rural population. The paper calls for reinvigorating family planning services delivery system in the urban population of the country. The paper also reveals significant variation in urban-rural disparity in family planning use across states/Union Territories of the country.

Introduction

The urban-rural disparity in family planning use in India is well-known. According to the latest National Family Health Survey 2019-2021 (NFHS-5), more than 69 per cent of the currently married women in the reproductive age group (15-49 years) in the urban population or their husband were practising a family planning method at the time of the survey compared to around 65 per cent currently married women in the reproductive age group in the rural population (Government of India, 2021). In 1992-1993, these proportions were 51 per cent and 37 per cent respectively (Government of India, 1997). The urban-rural disparity in use is also not the same for different family planning methods which can be grouped into two categories – modern family planning methods and traditional family planning methods. Modern family planning methods are defined as technological products or medical procedures that affect the natural reproduction process (Hubacher and Trussell, 2015) and include contraceptive pills, condoms (male and female), intrauterine device (IUD), sterilisation (male and female), injectables, hormone implants, patches, diaphragms, spermicidal agents (foam/jelly), and emergency contraception. Modern family planning methods are further divided into permanent methods (male and female sterilisation) and modern spacing methods (all modern methods other than male and female sterilisation). Traditional family planning methods, on the other hand, include those methods that regularly track cervical mucus, such as the Billing's method, those that track a woman's body temperature, frequent and regular breastfeeding during the first six months after birth, and abstinence during certain times of the menstrual cycle. The context of the use of permanent methods, modern spacing methods and traditional family planning methods are different. Permanent methods are nearly cent per cent effective in preventing conception, but they are not reversible. Modern spacing methods are reversible but the effectiveness of different modern spacing methods in preventing conception is different for different methods. Traditional family planning methods are also reversible, but they are mostly considered less effective in preventing conception (International Institute for Population Sciences, 2010), although it is argued that they can be highly effective if used with dedication and proper knowledge (Johnson-Hanks, 2002). According to the National Family Health Survey, 58.5 per cent of the currently married women in the reproductive age group or their husband were using a modern family planning method in the urban population corresponding to 55.5 per cent in the rural population in 2019-2021. In 1992-1993, these proportions were 45 per cent and 33 per cent respectively. It is, however, not necessary that use of different family planning methods is always high either in the urban as compared to the rural or in the rural as compared to the urban population. There may be a possibility that use of a family planning method is higher in urban than in rural population, but use of other family planning method is higher in rural than in urban population. The sum of the urban-rural difference in the use of different family planning methods, therefore, may not reflect the true urban-rural disparity in family planning use. There is, therefore, the need to measure the urban-rural disparity in the use of different family planning methods separately, and then combine the method-specific urban-rural disparity in use into a single index of urban-rural disparity in family planning use. This paper is an attempt in this direction.

Reasons for urban-rural disparity in family planning use are not known. The literature is scanty on the urban–rural difference in the use of different family planning methods. The urban-rural disparity in the use of different family planning methods reflects the difference in the choices and preferences of urban couples as compared to choices and preferences of rural couples about different family planning methods. The urban-rural disparity in the use of different family planning methods may also reflect the difference in the availability and access to different family planning methods in urban and rural populations. There are some studies in India which have analysed the urban-rural difference in family planning use (Majumdar et al, 1972; Reddy, 1984; Gore and Katkuri, 2016; Nagdeve and Bharti, 2003). These studies, however, focus on either a specific population group or a specific family planning method. There is, to the best of our knowledge, no study which has analysed the urban-rural disparity in family planning use in India through a pan-India perspective. Such an analysis is relevant to understand the impact of official family planning policies and programmes and for strengthening the family planning services delivery system. It can be conjectured that urban-rural disparity is different for different family planning methods and the contribution of the urban-rural disparity in use of different methods to the urban-rural disparity in family planning use may be different because of the proportionate share of different methods in total family planning use is different.

In this paper, we develop an index to measure the urban-rural disparity in family planning use that considers both urban-rural disparity in the use of different family planning methods and the proportionate share of different methods in total family planning use. We use the disparity index so developed to analyse urban-rural disparity in family planning use in India and in its constituent states/Union Territories during the period 1992-1993 through 2019-2021 using the data available through the National Family Health Survey. To the best of our knowledge, the present analysis is the first to highlight the urban-rural disparity in family planning use in India and has relevance to strengthening the family planning services delivery system which largely remains official in its organisation and implementation.

The paper is organised as follows. The next section of the paper develops the index of urban-rural disparity in family planning use. Section three describes the data source used in the analysis. The paper is based on the estimates of the prevalence of modern spacing methods, permanent methods, and traditional family planning methods available from the five rounds of the National Family Health Survey that have been carried out in 1992-1993; 1998-1999; 2005-2006; 2015-2016; and 2019-2021. Section four discusses patterns and trends in the prevalence of different family planning methods in urban and rural populations. The urban-rural disparity in family planning use is presented and discussed in section five of the paper. Section six decomposes the change in urban-rural disparity in family planning use into change in urban-rural disparity in different methods, and the change in family planning method mix. The last section of the paper summarises main findings of the analysis and discusses their relevance for improving the family planning services delivery system in the country in the context of meeting the family planning needs of the people.

Urban-Rural Disparity in Family Planning Use

The measurement of urban-rural disparity in family planning use is essentially an arbitrary procedure. Ideally, there should be no urban-rural disparity in the use of different family planning methods. There are, however, both endogenous and exogenous factors because of which family planning use is different in urban and rural populations. The main endogenous factor is the organisation of family planning services in urban and rural populations. The delivery of family planning services in India is an integral component of the public health care delivery system. In the rural population of the country, a nested, three tier public health care delivery system is in place in which every rural habitation is nested into the health sub-centre; every health sub-centre is nested into the primary health centre;

and every primary health centre is nested into the community health centre. This nested system ensures, at least on paper, that every rural currently married woman of reproductive age is mapped into the family planning services delivery system. Moreover, an extension approach is adopted for the delivery of family planning services in the rural population. In the urban areas, nested public health care delivery system does not exist, and the delivery of family planning services is essentially clinic or hospital-based which does not ensure mapping of every currently married urban woman of reproductive age into the family planning services delivery system.

There are many exogenous factors also that influence family planning use in urban and rural populations. The use of different family planning methods is found to be directly related to the educational status of women and the level of woman education is higher in urban than in rural population. The availability and access to different family planning methods, especially, modern spacing methods, is also better in urban than in rural population. It is also argued that urban-rural disparity in family planning use may be because of the difference in the number of children desired. Urban-rural disparity in the use of different family planning methods may be viewed as the inequality that reflects the inability of either urban or rural women in achieving their desired family size because of problems of availability and accessibility of family planning methods. Finally, a range of social and cultural factors also influence family planning use in urban and rural populations.

The urban-rural disparity in family planning use can be measured in both absolute and relative terms. In absolute terms, urban-rural disparity in family planning use is the sum of the arithmetic difference between the prevalence of different family planning methods in urban and rural populations. If u_i is the prevalence of method i in the urban population and r_i is the prevalence in the rural population, then the absolute urban-rural disparity in family planning use is defined as

$$AD = \sum_{i=1}^{n} AD_i = \sum_{i=1}^{n}(u_i - r_i) \tag{1}$$

Where n is the number of family planning methods available. The method-specific urban-rural difference in prevalence, AD_i, can be both positive and negative. When $u_i > r_i$, $AD_i > 0$. When $u_i < r_i$, $AD_i < 0$. When $u_i = r_i$, $AD_i = 0$. The larger the deviation of AD_i from 0 the greater the urban-rural disparity in the use of family planning method i. AD is the algebraic sum of method-specific AD_i. An advantage of AD is that the change in AD between two points in time can be decomposed into the change in AD_i as follows

$$\nabla AD = AD^2 - AD^1 = \sum_{i=1}^{n}(u_i^2 - u_i^1) - (r_i^2 - r_i^1) = \sum_{i=1}^{n} \nabla u_i - \nabla r_i = \sum_{i=1}^{n} \nabla AD_i \tag{2}$$

On the other hand, in relative terms, the urban-rural disparity in family planning use, RD, is defined as the ratio of family planning prevalence in the urban population to the family planning prevalence in the rural population

$$RD = u/r \tag{3}$$

Where u is the family planning prevalence in urban population and r is the family planning prevalence in the rural population. When there is no disparity in family planning use, $RDI=1$. When $u>r$, $RD>1$. When $u<r$, $RD<1$. The larger the deviation of RD from 1 the greater the urban-rural disparity in family planning use.

The use of the arithmetic difference between or the ratio of urban to rural family planning prevalence to measure urban-rural disparity in family planning use is, however, hazardous because both are highly influenced by the level of family planning use and the two tend to change in opposite directions with the change in the level of use often leading to contradictory evidence of the trend in urban-rural disparity (Preston and Weed, 1976). The magnitude of both arithmetic difference and ratio is necessarily limited by the magnitude of family planning prevalence in urban and rural areas since the prevalence ranges between 0 and 1. The limitations of the arithmetic difference and the ratio in measuring urban-rural disparity can be circumvented by using the logit transformation of the prevalence. The logit of the prevalence p is defined as

$$logit(p) = ln\left(\frac{p}{1-p}\right) \; for\; p \in (0,1) \tag{4}$$

The logit transformation maps probability or prevalence which range between 0 and 1 to real numbers which range between $-\infty$ and $+\infty$. On the other hand, square of the logit transformation maps probability The urban-rural disparity in the use of the family planning method i, D_i, may now be defined as

$$D_i = logit(u_i) - logit(r_i) = ln\left(\frac{u_i}{1-u_i}\right) - ln\left(\frac{r_i}{1-r_i}\right) = \; ln\left[\frac{u_i/(1-u_i)}{r_i/(1-r_i)}\right] \tag{5}$$

When $u_i=r_i$, $D_i=0$ and there is no urban-rural disparity in the use of method i. It may be noticed that D_i can be both positive and negative. When D_i is positive, use of method i is higher in urban population compared to rural population. When D_i is negative, use of method i is higher in rural population compared to urban population and the larger the deviation of D_i from 0, the larger the urban-rural disparity in the use of method i. The advantage of using the logit transformation in constructing the urban-rural disparity index D_i is that the use of logit transformation reduces the effect of the level of family planning use. Notice that $logit(p_i)$ is nothing but the logarithm of the odds of family planning use. It is well known that the odds of family planning use are exorbitantly high when the level of family planning use is very high. Similarly, the odds of family planning use are very low when the level of family planning use is very low. The use of logit transformation reduces the level effect by significantly reducing very high values of odds ratio when the level of family planning use is very high.

The urban-rural disparity in family planning use may now be constructed as the algebraic sum of method-specific urban-rural disparity in use, D_i. This sum, however, may not reflect the true urban-rural disparity in family planning use as D_i may be positive for some methods, but negative for others so that the sum of D_i of different methods may be equal to either zero or close to zero. To circumvent this problem, we construct the urban-rural disparity index in terms of the square of D_i values. Constructing the urban-rural disparity index as the sum of square of D_i values gives more weight to that method in which urban-rural disparity in use is high compared to that method in which the urban-rural disparity in use is low. This implies that the decrease in urban-rural disparity in the use of those methods in which the disparity in use is high leads to a faster decrease in urban-rural disparity in family planning use compared to those methods in which the disparity in use is low. This is a desirable property of the disparity index.

The sum of square of D_i values, however, gives equal weight to all family planning methods irrespective of their proportionate share in total family planning use. It is logical to argue that more weight should be given in the construction of the disparity index to that method which has a high proportionate share compared to that method which has low proportionate share in total family planning use. If w_i is the proportionate share of method i in total family planning use, then the index D of urban-rural disparity in family planning use may be constructed as

$$D = \sum_{i=1}^{n} w_i * D_i^2 \qquad (6)$$

The index D may be constructed by measuring the urban-rural disparity in the use of different family planning methods separately or by measuring urban-rural disparity in the use of three categories of family planning methods: 1) modern spacing methods; 2) permanent methods; and 3) traditional methods. The reason for grouping different family planning methods into three categories is that the context of using three categories of family planning methods is essentially different. Permanent methods are used only when the family formation process is complete, or the desired family size is achieved as these methods are not reversible. Modern spacing methods are reversible and are used primarily to delay the first birth or to space the interval between successive births. Traditional methods are also reversible, but their use is generally argued to reflect the unmet need of modern spacing methods because of the limited availability and access of these methods. Traditional family planning methods do not require any supply network. They are also not supported by the official family planning efforts.

In the present analysis, we have grouped different family planning methods into three categories: 1) modern spacing methods; 2) permanent methods; and 3) traditional family planning methods. We have calculated the prevalence of permanent methods as the proportion of currently married women aged 15-49 years or their husband using any permanent method (female or male sterilisation). On the other hand, the prevalence of modern spacing methods is calculated as the difference between the prevalence of modern methods (permanent and spacing) and the prevalence of permanent methods. Finally, the prevalence of traditional methods is calculated as the difference between all methods (modern and traditional) prevalence and prevalence of modern methods. This strategy is adopted as many family planning methods are grouped into other methods in the calculation of the prevalence.

Data

The analysis is built upon the estimates of the prevalence of different family planning methods in urban and rural populations available through different rounds of the National Family Health Survey (NFHS). The National Family Health Survey programme was instituted by the Government of India in 1992 to generate key indicators of health and family planning based on the statistically representative household survey. Five rounds of the survey have so far been carried out (Government of India, 1995; 2000; 2007; 2017; 2021). The first three rounds of the NFHS provided estimates of the prevalence of different family planning methods in urban and rural populations for the country and for the constituent states and Union Territories of the country. The fourth and the fifth rounds of the NFHS provided estimates of method-specific prevalence rates for the districts of the country for the total population but not for urban and rural populations because of sample size restrictions so that district level analysis of the urban-rural disparity in family planning use is not possible. Details about the organisation of NFHS are given elsewhere (Government of India, 2021) and not repeated here. The population of the country has been divided into urban and rural populations according to the criteria of classifying a settlement as an urban settlement adopted at the time of 2011 population census. The population of all urban settlements constitutes the urban population. Settlements which are not classified as urban settlement are rural settlements and the total population of all rural settlements constitutes the rural population of the country.

Family Planning Use in Urban and Rural Population

Estimates of the prevalence of modern spacing methods, permanent methods, and traditional methods in urban and rural populations of the country and in its constituent states and Union Territories are presented in the Appendix table 1. The prevalence of modern spacing methods and the prevalence of traditional methods in India has always been higher in the urban population. However, prevalence of permanent methods was higher in the urban population up to 2005-2006 only. After 2005-2006, prevalence of permanent methods has become higher in the rural population. Combining all methods, the urban-rural difference in family planning use has always been higher in the urban population of the country. Among constituent states and Union Territories, Maharashtra is the only state/Union Territory where family planning use has always been higher in the rural population. In 17 states/Union Territories, family planning use has always been higher in the urban population whereas in 16 states/Union Territories, family planning use has been higher in urban population at one time but in rural population at other time.

The prevalence of different family planning methods has varied widely in both urban and rural populations across states/Union Territories. During 2019-2021, prevalence of permanent methods was higher in the rural population in 26 states/Union Territories whereas prevalence of modern spacing methods was higher in rural population in only 7 states/Union Territories and prevalence of traditional methods in 6 states/Union Territories. There are only two states/Union Territories – Andaman and Nicobar Islands and Sikkim - where family planning use has been higher in the rural population throughout the period under reference. Similarly, there are only two states – Jharkhand and Tripura – where family planning use has always been higher in the urban population. In the remaining states/Union Territories, urban-rural difference in the use of modern spacing methods permanent methods and traditional methods has been in different direction.

Prior to 2015-2016, there was no state/Union Territory in the country where the prevalence of modern spacing methods was higher in the rural population than in the urban population. However, in 2015-2016 and 2019-2021, there were 7 states/Union Territories where use of modern spacing methods was higher in rural as compared to the urban population. Similarly, there were 10 states where use of permanent methods was relatively high in rural than in urban population in 1992-1993. This number decreased to 9 in 1998-1999 but increased to 17 in 2005-2006 and 22 in 2015-2016. On the other hand, the number of states/Union Territories where use of traditional methods was relatively high in the rural population decreased from 3 in 1992-1993 to 1 in 1998-1999 but increased to 5 in 2005-2006 and 7 in 2015-2016. In 2019-2021, the use of traditional methods was higher in the rural population as compared to the urban population in 6 states/Union Territories.

The change in the urban-rural difference in family planning prevalence is due to the change in the urban-rural difference in the prevalence of modern spacing methods, permanent methods, and traditional methods. In India, the increase in the use of all three categories of family planning methods has been more rapid in the rural population than the increase in the urban population (Table 1). The urban-rural difference in family planning use in the country decreased by more than 10 per cent points between 1992-1993 and 2019-2021 and most of this decrease is attributed to the decrease in the urban-rural difference in the use of permanent methods as the increase in the use of these methods in the urban population has been very slow relative to the increase in the rural population. There are only 8 states – Andhra Pradesh, Arunachal Pradesh, Assam, Haryana, Karnataka, Mizoram, Tripura, and Uttar Pradesh – where the increase in use of all the three categories of family planning methods has been more rapid in the rural population as compared to the urban population between 1993-1993 and 2019-2021. On the other hand, there is no state in the country where the increase in the use of all the three categories of family planning methods has been more rapid in the urban population as compared to the the rural population. As such, in all but three states, urban-rural difference in family planning use has narrowed down over time. The three states where urban-rural difference in family planning use has widened between 1992-1993 and 2019-2021 are Goa, Gujarat, and Maharashtra. Table 1 suggests that the trend in the use of modern spacing methods, permanent methods and traditional family planning methods has been different in different states. Table 1 also suggests that, within each state, the trend in the use of modern spacing methods, permanent methods and traditional methods has, in general, been different.

Table 1: Increase in the prevalence of family planning methods in urban and rural populations in India and states/Union Territories between 1992-1993 and 2019-2021.

	Increase in urban population				Increase in rural population				Urban-Rural difference in increase			
	p_s	p_p	p_t	p	p_s	p_p	p_t	p	p_s	p_p	p_t	p
India (IN)	0.103	0.029	0.050	0.182	0.131	0.091	0.063	0.285	-0.028	-0.062	-0.013	-0.103
Andaman & Nicobar Islands (AN)	na	na	na	na	na	na	na	na	na	na	na	na
Andhra Pradesh (AP)	-0.029	0.176	-0.005	0.142	-0.024	0.302	-0.002	0.276	-0.005	-0.126	-0.003	-0.134
Arunachal Pradesh (AR)	0.154	0.004	0.017	0.175	0.212	0.088	0.087	0.387	-0.058	-0.084	-0.070	-0.212
Assam (AS)	0.220	-0.133	-0.096	-0.009	0.321	-0.043	-0.072	0.206	-0.101	-0.090	-0.024	-0.215
Bihar (BI)	0.065	0.013	0.120	0.198	0.066	0.188	0.094	0.348	-0.001	-0.175	0.026	-0.150
Chandigarh (CD)	na	na	na	na	na	na	na	na	na	na	na	na
Chhattisgarh (CH)	na	na	na	na	na	na	na	na	na	na	na	na
Daman & Diu (DD)	na	na	na	na	na	na	na	na	na	na	na	na
Dadra & Nagar Haveli and Daman & Diu (DN)	na	na	na	na	na	na	na	na	na	na	na	na
Delhi (DE)	0.078	-0.051	0.131	0.158	0.122	-0.031	0.069	0.160	-0.044	-0.020	0.062	-0.002
Dadra and Nagar Haveli (DA)	na	na	na	na	na	na	na	na	na	na	na	na
Goa (GO)	0.225	0.058	-0.072	0.211	0.221	-0.087	0.033	0.167	0.004	0.145	-0.105	0.044
Gujarat (GU)	0.139	-0.089	0.118	0.168	0.092	-0.016	0.071	0.147	0.047	-0.073	0.047	0.021
Haryana (HA)	0.138	-0.035	0.052	0.155	0.181	0.004	0.077	0.262	-0.043	-0.039	-0.025	-0.107
Himachal Pradesh (HP)	0.108	-0.145	0.085	0.048	0.135	-0.029	0.064	0.170	-0.027	-0.116	0.021	-0.122
Jammu & Kashmir (JA)	0.089	-0.055	-0.086	-0.052	0.235	-0.089	-0.008	0.138	-0.146	0.034	-0.078	-0.190
Jharkhand (JH)	na	na	na	na	na	na	na	na	na	na	na	na
Karnataka (KA)	0.049	0.148	-0.021	0.176	0.059	0.154	-0.008	0.205	-0.010	-0.006	-0.013	-0.029
Kerala (KE)	0.001	-0.068	-0.001	-0.068	-0.004	0.020	-0.029	-0.013	0.005	-0.088	0.028	-0.055
Ladakh (LA)	na	na	na	na	na	na	na	na	na	na	na	na
Lakshadweep (LK)	na	na	na	na	na	na	na	na	na	na	na	na

	Increase in urban population				Increase in rural population				Urban-Rural difference in increase			
	p_s	p_p	p_t	p	p_s	p_p	p_t	p	p_s	p_p	p_t	p
Madhya Pradesh (MA)	0.099	0.077	0.061	0.237	0.063	0.440	-0.118	0.385	0.036	-0.363	0.179	-0.148
Maharashtra (MH)	-0.257	0.376	0.010	0.129	0.078	0.031	0.013	0.122	-0.335	0.345	-0.003	0.007
Manipur (MN)	-0.023	-0.100	0.295	0.172	0.072	-0.102	0.339	0.309	-0.095	0.002	-0.044	-0.137
Meghalaya (MY)	0.061	-0.128	0.007	-0.060	0.132	-0.024	-0.010	0.098	-0.071	-0.104	0.017	-0.158
Mizoram (MZ)	0.053	-0.325	-0.008	-0.280	0.138	-0.307	-0.001	-0.170	-0.085	-0.018	-0.007	-0.110
Nagaland (NG)	0.267	0.012	0.125	0.404	0.229	0.100	0.119	0.448	0.038	-0.088	0.006	-0.044
Odisha (OD)	0.147	-0.126	0.274	0.295	0.179	-0.015	0.230	0.394	-0.032	-0.111	0.044	-0.099
Puducherry (PD)	na	na	na	na	na	na	na	na	na	na	na	na
Punjab (PU)	0.070	-0.119	0.105	0.056	0.103	-0.094	0.073	0.082	-0.033	-0.025	0.032	-0.026
Rajasthan (RA)	0.190	-0.026	0.107	0.271	0.150	0.197	0.088	0.435	0.040	-0.223	0.019	-0.164
Sikkim (SI)	na	na	na	na	na	na	na	na	na	na	na	na
Tamil Nadu (TA)	-0.015	0.210	-0.028	0.167	0.035	0.178	-0.010	0.203	-0.050	0.032	-0.018	-0.036
Telangana (TE)	na	na	na	na	na	na	na	na	na	na	na	na
Tripura (TR)	0.253	-0.112	-0.083	0.058	0.300	-0.085	-0.050	0.165	-0.047	-0.027	-0.033	-0.107
Uttar Pradesh (UP)	0.212	-0.022	0.166	0.356	0.217	0.057	0.167	0.441	-0.005	-0.079	-0.001	-0.085
Uttarakhand (UT)	na	na	na	na	na	na	na	na	na	na	na	na
West Bengal (WB)	0.230	0.015	-0.088	0.157	0.249	-0.019	-0.057	0.173	-0.019	0.034	-0.031	-0.016

p Prevalence of all family planning methods
p_s Prevalence of modern spacing methods
p_p Prevalence of permanent methods
p_t Prevalence of traditional methods
na Not available
Source: Authors' calculations

Table 2 presents urban-rural odds ratio in family planning use in India and states/Union Territories. In the country, the odds of using a family planning method in the urban population was more than 77 per cent higher than the odds of using a family planning method in the rural population in 1992-1993 which reduced to around 18 per cent in 2019-2021 (Figure 1). On the other hand, the odds of using a modern spacing method in the urban population was 3.76 times higher than the odds of using a modern spacing method in 1992-1993 which reduced to 1.43 times in 2019-2021 whereas the odds of using a permanent method in the urban population was around 1.19 times higher than the odds of using a permanent method in the rural population. This means that the probability of using a permanent method in the urban population was about 19 per cent higher than the probability of using a permanent method in the rural population. The odds ratio of the use of permanent methods in urban and rural populations reduced to 1.03 in 2005-2006 which means that probability of using a permanent method in the urban population was only 3 per cent higher than the probability of using a permanent method in the urban population. In 2015-2016, the odds ratio of the use of permanent methods in urban and rural population further decreased to around 0.98 and to almost 0.90 in 2019-2021. An odds ratio of 0.98 implies that the probability of using a permanent method in the urban population is 2 per cent lower than the probability of using a permanent method in the rural population whereas an odds ratio of 0.90 implies that the probability of using a permanent method in the urban population is 10 per cent lower than the probability of using a permanent method in the rural population. In other words, the prevalence of permanent family planning methods in India is now higher in the rural population as compared to the urban population.

As regards the use of traditional family planning methods, the odds of using a traditional method in the urban population was 1.56 times the odds of using a traditional method in the rural population in 1992-1993 which means that the probability of using a traditional family planning method in the urban population was almost 56 per cent higher than the probability of using a traditional family panning method in the rural population. However, the urban-rural difference in the prevalence of traditional family planning methods decreased quite rapidly after 1992-1993 so that, by 2015-2016, the probability of using a traditional family planning method in the urban population was less than 4 per cent higher than the probability of using a traditional family planning method in the rural population. However, after 2015-2016, there has been more rapid increase in the prevalence of traditional methods in the urban population as compared to that in the rural population so that, in 2019-2021, the probability of using a traditional family planning method in the urban population was almost 8 per cent higher than the probability of using a traditional family planning method in the rural population of the country. It appears that the increase in the use of modern spacing methods and permanent family planning methods in the urban population of the country has not been able to keep pace with the increase in the use of these methods in the rural population of the country in the last 30 years.

In many states/Union Territories, urban-rural odds ratio in family planning use was less than 1 in 2019-2021 meaning that family panning use in the urban population of these states/Union Territories was lower than that in the rural population. The most notable of these states/Union Territories is Sikkim where odds of family planning use in the urban population was more than 63 per cent lower than that in the rural population. In Dadra & Nagar Haveli and Daman & Diu also, odds of family planning use in the urban population are almost 33 per cent lower than that in the rural population. By contrast, odds of family planning use in the urban population are more than 66 per cent higher than that in the rural population in Goa and 50 per cent in Tripura.

There is high degree of volatility in the urban-rural odds ratio in family planning use over time and across states/Union Territories and considerable inconsistency in the trend in this ratio in many states/Union Territories. There appear state/Union Territory specific factors that may be responsible for the observed volatility in the urban-rural disparity in the use of different family planning methods. These factors are largely unknown. One of these factors may be the difference in the organisation of family planning delivery services in urban and rural populations in different states/Union Territories. There may also be exogenous factors such as the degree of urbanisation, composition of the urban population by size class of urban settlements and the difference in the level of social and economic development in urban and rural areas in different states/Union Territories.

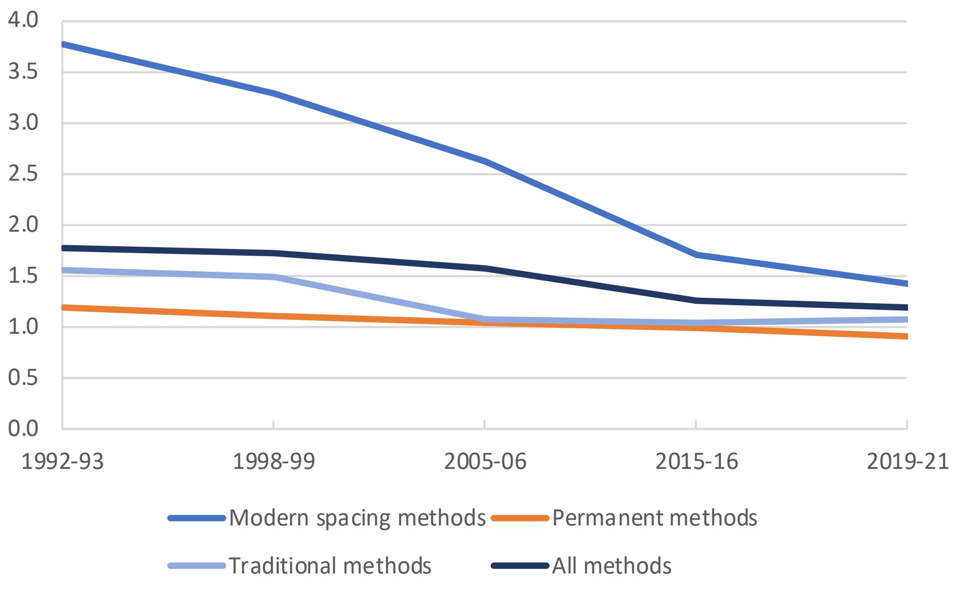

Figure 1: Urban-Rural odds ratio in the use of all methods, modern spacing methods, permanent methods, and traditional family planning use in India, 1992-1993 through 2019-2021.
Source: Authors

Table 2: Urban-rural odds ratio in family planning use in India and states/Union Territories, 1992-1993 through 2019-2021.

Country/State/Union Territory	Period	Urban-Rural odds ratio in			
		Modern spacing methods	Permanent methods	Traditional methods	All methods
India	1992-1993	3.765	1.186	1.559	1.772
	1998-1999	3.284	1.109	1.493	1.723
	2005-2006	2.621	1.034	1.071	1.577
	2015-2016	1.701	0.983	1.037	1.249
	2019-2021	1.427	0.899	1.078	1.184
Andaman & Nicobar Islands	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	0.556	0.708	0.508	0.569
	2019-2021	0.904	0.551	0.597	0.432
Andhra Pradesh	1992-1993	1.504	1.554	3.357	1.687
	1998-1999	5.673	1.021	2.213	1.239
	2005-2006	4.597	0.919	0.832	1.005
	2015-2016	7.085	0.867	na	0.928
	2019-2021	2.826	0.923	5.020	0.981
Arunachal Pradesh	1992-1993	1.903	1.644	3.549	2.486
	1998-1999	1.366	1.576	2.048	1.798
	2005-2006	1.734	0.771	1.564	1.260
	2015-2016	0.985	0.651	0.512	0.722
	2019-2021	1.010	0.810	1.029	0.902
Assam	1992-1993	2.481	1.914	1.419	2.468
	1998-1999	1.318	1.118	1.551	1.563
	2005-2006	2.199	1.127	0.957	1.621
	2015-2016	1.056	1.058	1.102	1.124
	2019-2021	0.842	1.049	1.348	1.030
Bihar	1992-1993	4.796	2.226	2.591	2.994
	1998-1999	4.419	1.661	1.777	2.144
	2005-2006	2.700	1.559	2.127	2.238
	2015-2016	2.609	1.474	4.074	1.804
	2019-2021	1.900	0.859	1.508	1.374
Chandigarh	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	na	na	na	na
	2019-2021	na	na	na	na
Chhattisgarh	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	5.418	1.076	1.917	1.898
	2015-2016	2.404	0.869	1.598	1.245
	2019-2021	1.481	0.968	1.071	1.235

Country/State/Union Territory	Period	Urban-Rural odds ratio in			
		Modern spacing methods	Permanent methods	Traditional methods	All methods
Dadra & Nagar Haveli	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	1.847	0.658	0.098	0.728
	2019-2021	na	na	na	na
Dadra & Nagar Haveli and Daman & Diu	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	na	na	na	na
	2019-2021	1.925	0.401	1.589	0.663
Daman & Diu	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	3.112	0.420	na	0.608
	2019-2021	na	na	na	na
Delhi	1992-1993	1.165	1.065	1.248	1.248
	1998-1999	1.567	0.713	1.470	1.146
	2005-2006	1.924	0.548	1.276	1.127
	2015-2016	1.085	0.739	1.019	0.868
	2019-2021	0.951	0.942	1.776	1.310
Goa	1992-1993	1.796	0.746	2.971	1.314
	1998-1999	1.710	1.109	1.308	1.424
	2005-2006	1.924	0.864	1.489	1.335
	2015-2016	1.838	4.098	1.068	3.185
	2019-2021	1.229	1.499	0.826	1.662
Gujarat	1992-1993	3.824	0.829	2.096	1.231
	1998-1999	3.912	0.672	2.418	1.220
	2005-2006	2.842	0.678	0.947	1.080
	2015-2016	2.532	0.601	2.923	1.016
	2019-2021	2.351	0.593	1.878	1.385
Haryana	1992-1993	4.162	0.672	2.527	1.576
	1998-1999	3.370	0.536	2.033	1.343
	2005-2006	2.903	0.395	2.473	1.217
	2015-2016	1.325	0.600	1.237	0.762
	2019-2021	1.655	0.552	1.292	1.031
Himachal Pradesh	1992-1993	4.400	0.723	2.080	1.787
	1998-1999	4.741	0.533	1.670	1.424
	2005-2006	3.619	0.403	1.684	1.063
	2015-2016	1.612	0.668	1.633	1.033
	2019-2021	2.123	0.411	1.683	1.060

Country/State/Union Territory	Period	Urban-Rural odds ratio in			
		Modern spacing methods	Permanent methods	Traditional methods	All methods
Jammu and Kashmir	1992-1993	3.654	0.881	1.751	2.107
	1998-1999	1.924	2.001	1.184	2.716
	2005-2006	1.361	1.683	2.320	2.509
	2015-2016	1.349	1.567	0.725	1.576
	2019-2021	1.028	1.048	0.705	0.967
Jharkhand	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	3.130	2.188	3.633	3.819
	2015-2016	1.976	1.107	1.710	1.411
	2019-2021	1.246	1.004	1.316	1.273
Karnataka	1992-1993	3.191	0.880	2.268	1.188
	1998-1999	4.077	0.774	4.497	1.109
	2005-2006	3.857	0.613	2.307	0.821
	2015-2016	2.879	0.672	4.532	0.771
	2019-2021	1.631	0.860	1.605	1.068
Kerala	1992-1993	1.226	1.123	1.370	1.348
	1998-1999	1.340	1.008	1.087	1.105
	2005-2006	1.739	0.869	0.949	1.019
	2015-2016	1.179	0.996	1.000	1.024
	2019-2021	1.345	0.789	2.163	1.056
Ladakh	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	na	na	na	na
	2019-2021	0.901	0.979	1.559	0.965
Lakshadweep	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	2.603	0.613	4.837	1.642
	2019-2021	1.074	1.232	0.665	0.865
Madhya Pradesh	1992-1993	3.728	3.737	0.071	1.819
	1998-1999	6.538	1.135	1.954	1.795
	2005-2006	6.195	0.673	1.889	1.333
	2015-2016	3.590	0.654	1.822	1.016
	2019-2021	2.550	0.567	1.336	0.976
Maharashtra	1992-1993	25.716	0.067	4.269	0.945
	1998-1999	2.547	0.615	3.037	0.839
	2005-2006	4.308	0.534	2.107	0.982
	2015-2016	2.281	0.625	2.510	0.932
	2019-2021	1.887	0.675	1.745	0.969

Country/State/Union Territory	Period	Urban-Rural odds ratio in			
		Modern spacing methods	Permanent methods	Traditional methods	All methods
Manipur	1992-1993	2.760	1.078	1.339	1.830
	1998-1999	1.449	1.415	1.092	1.474
	2005-2006	1.048	1.160	1.414	1.406
	2015-2016	0.932	1.371	1.225	1.142
	2019-2021	1.058	1.349	0.941	1.013
Meghalaya	1992-1993	1.795	3.021	0.699	2.134
	1998-1999	3.170	8.687	1.522	5.173
	2005-2006	3.124	3.341	1.319	3.442
	2015-2016	0.955	2.807	2.992	1.691
	2019-2021	0.751	1.393	1.000	0.908
Mizoram	1992-1993	1.390	1.138	3.280	1.305
	1998-1999	1.640	1.562	0.398	1.888
	2005-2006	1.225	1.310	1.502	1.486
	2015-2016	1.196	1.353	na	1.356
	2019-2021	0.663	1.132	1.670	0.815
Nagaland	1992-1993	1.375	2.807	na	2.121
	1998-1999	1.917	2.078	1.781	2.481
	2005-2006	1.668	2.029	1.760	2.187
	2015-2016	1.496	1.236	1.191	1.434
	2019-2021	1.313	0.906	1.058	1.244
Odisha	1992-1993	3.999	1.343	1.546	1.734
	1998-1999	3.617	0.868	1.460	1.384
	2005-2006	2.354	0.861	1.796	1.523
	2015-2016	1.518	0.864	1.128	1.220
	2019-2021	1.168	0.795	1.302	1.194
Puducherry	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	0.521	1.163	1.605	1.061
	2019-2021	1.626	0.772	2.248	0.974
Punjab	1992-1993	1.808	0.797	1.234	1.263
	1998-1999	2.543	0.408	1.826	1.407
	2005-2006	1.542	0.487	1.852	0.898
	2015-2016	1.449	0.670	1.393	1.068
	2019-2021	1.334	0.646	1.406	1.145
Rajasthan	1992-1993	4.552	1.852	0.271	2.267
	1998-1999	3.360	1.171	1.979	1.723
	2005-2006	4.664	1.448	1.498	2.814
	2015-2016	2.798	0.739	1.000	1.283
	2019-2021	1.852	0.684	1.125	1.135

Country/State/Union Territory	Period	Urban-Rural odds ratio in			
		Modern spacing methods	Permanent methods	Traditional methods	All methods
Sikkim	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	1.142	1.070	1.403	1.322
	2015-2016	0.718	0.550	2.012	0.551
	2019-2021	0.503	0.835	0.736	0.366
Tamil Nadu	1992-1993	3.184	0.728	1.780	1.070
	1998-1999	4.552	1.041	2.634	1.461
	2005-2006	2.588	0.800	1.235	0.951
	2015-2016	1.901	1.000	1.000	1.079
	2019-2021	1.241	0.838	1.346	0.916
Telangana	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	na	na	na	na
	2015-2016	4.061	1.041	na	1.130
	2019-2021	2.148	0.925	1.929	1.067
Tripura	1992-1993	1.784	1.594	1.293	2.235
	1998-1999	na	na	na	na
	2005-2006	1.031	0.921	1.119	1.060
	2015-2016	0.787	1.509	1.220	1.182
	2019-2021	1.039	1.653	1.122	1.503
Uttar Pradesh	1992-1993	4.549	1.326	2.708	2.347
	1998-1999	5.720	1.361	1.506	2.584
	2005-2006	3.092	1.211	0.960	1.957
	2015-2016	2.681	0.805	1.245	1.722
	2019-2021	1.607	0.712	1.098	1.345
Uttarakhand	1992-1993	na	na	na	na
	1998-1999	na	na	na	na
	2005-2006	2.859	0.496	2.100	1.408
	2015-2016	2.052	0.477	1.705	1.029
	2019-2021	1.978	0.496	1.150	1.217
West Bengal	1992-1993	2.323	0.707	1.533	1.287
	1998-1999	1.632	0.714	1.806	1.519
	2005-2006	1.404	0.794	1.411	1.352
	2015-2016	1.206	0.616	1.275	0.874
	2019-2021	1.207	0.835	1.396	1.274

Source: Authors' calculations

Urban-Rural Disparity in Family Planning Use

Estimates of the index *D* reflecting the urban-rural disparity in family planning use in India and in its constituent states and Union Territories are presented in table 3 along with estimates of D_s, D_p, and D_t reflecting, respectively, the urban-rural disparity in the use of modern spacing methods, permanent methods, and traditional family planning methods. In India, the urban-rural disparity in family planning use has decreased very sharply during over time and, in 2019-2021, the index D is estimated to be 0.042 which implies that there is now virtually little urban-rural disparity in family planning use in the country. The decrease in the urban-rural disparity in use of modern spacing methods, as measured by the index D_s, decreased from 1.326 in 1992-1993 to 0.356 in 2019-2021. On the other hand, the urban-rural disparity in the use of permanent methods turned negative in 2015-2016 suggesting that the use of permanent methods became higher in the rural population of the country as compared to its urban population and the gap between the prevalence of permanent methods in rural and urban population widened further in 2019-2021. By contrast, the urban-rural disparity in the use of traditional family planning methods decreased up to 2015-16 but increased in 2019-2021 because of the more rapid increase in the use of traditional family planning methods in the urban population as compared to the increase in the rural population.

Among the constituent states/Union Territories of the country, urban-rural disparity in family planning use varies widely (Figure 2). In 2019-2021, urban-rural disparity in family planning use was the highest in the Union Territory of Dadra & Nagar Haveli and Daman and Diu, closely followed by Himachal Pradesh. In these two states/Union Territories, the family planning use is substantially high in the urban population as compared to the rural population. The urban-rural disparity in family planning use has also been found to be high in Gujarat, Madhya Pradesh, and Uttarakhand. In all these states/Union Territories, family planning use is substantially higher in urban population as compared to the rural population. On the other hand, there is virtually no urban-rural disparity in family planning use in Manipur. The urban-rural disparity in family planning use has also been found to be either low or very low in most of the states and Union Territories of the country. There are 10 states and Union Territories of the country where the urban-rural disparity in family planning use is found to be lower than the national average.

Table 3 also suggests that, in general, urban-rural disparity in family planning use has decreased in 2019-2021 compared to 1992-1993 in most of the states and Union Territories of the country with the decrease being the most marked in Maharashtra and Madhya Pradesh. There are only five states – Delhi, Gujarat, Himachal Pradesh, Kerala, and Mizoram – where the urban-rural disparity in family planning use has increased in 2019-2021 compared to the urban-rural disparity in family planning use in 1992-1993. The increase in the urban-rural disparity in family planning use has been the most marked in Himachal Pradesh followed by Gujarat. More importantly, in the recent years, between 2015-2016 and 2019-2021, the urban-rural disparity in family planning use has increased in 11 states and Union Territories of the country. The increase in the urban-rural disparity in family planning use during this period has again been the most marked in Himachal Pradesh. In addition to Himachal Pradesh, the urban-rural disparity in family planning use has also increased quite substantially in Kerala.

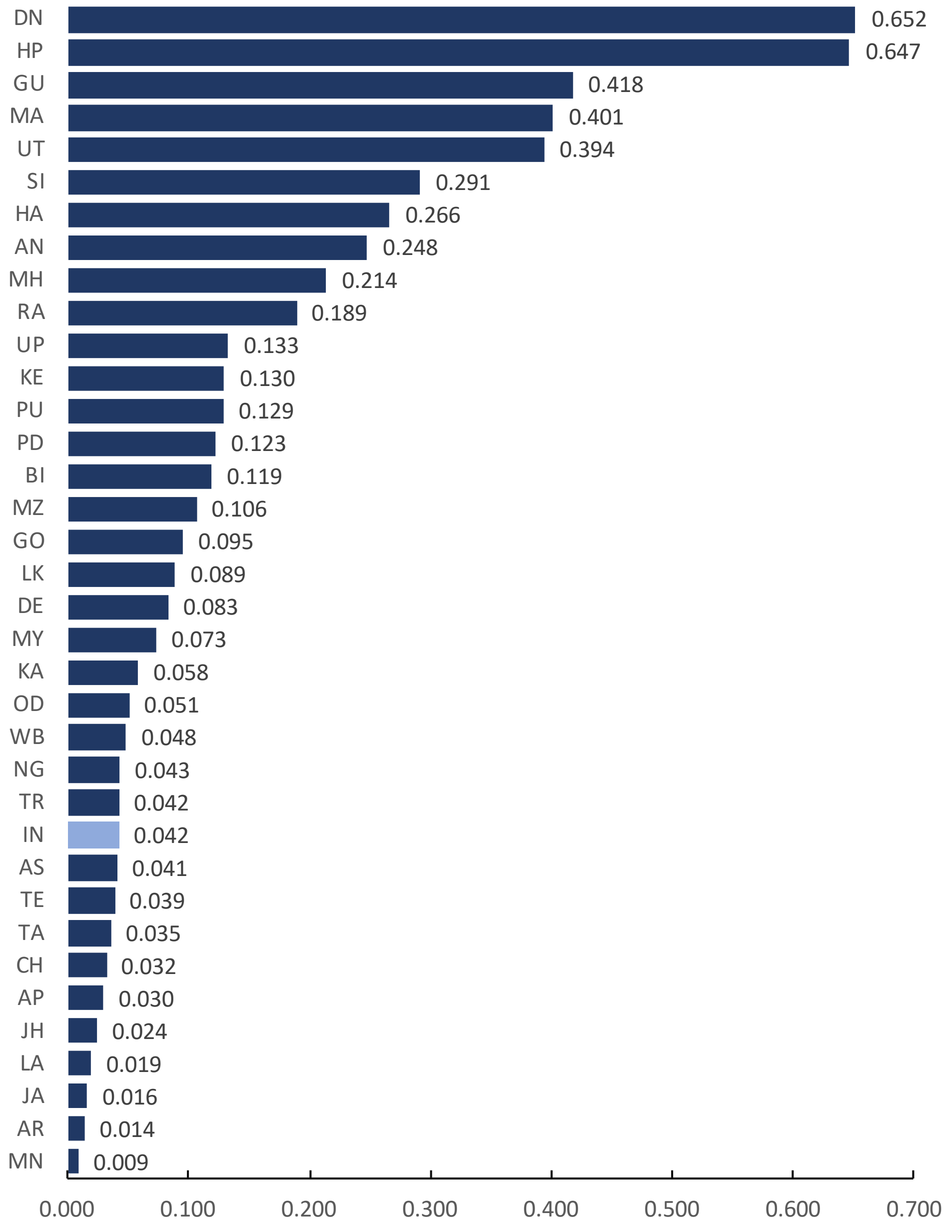

Figure 2: Urban-Rural disparity in family planning use in states/Union Territories in India, 2019-2021.
Remarks: There is no rural population in Chandigarh (CD). Dadra and Nagar Haveli (DA) and Daman and Diu (DD) are merged into Dadra & Nagar Haveli and Daman and Diu (DN)
Source: Authors

Table 3: Urban-rural disparity in the use of family planning methods, 1992-2021.

Country/State/Union Territory	Period				
	1992-1993	1998-1999	2005-2006	2015-2016	2019-2021
	All family planning methods (Index *D*)				
India	0.284	0.225	0.170	0.060	0.042
Andaman and Nicobar Islands	na	na	na	0.177	0.248
Andhra Pradesh	0.204	0.104	0.048	0.054	0.030
Arunachal Pradesh	0.555	0.192	0.166	0.137	0.014
Assam	0.311	0.096	0.156	0.005	0.041
Bihar	0.892	0.439	0.358	0.300	0.119
Chandigarh	na	na	na	na	na
Chhattisgarh	na	na	0.311	0.129	0.032
Daman & Diu	na	na	na	0.909	na
Dadra & Nagar Haveli and Daman & Diu	na	na	na	na	0.657
Delhi	0.018	0.156	0.347	0.038	0.083
Dadra and Nagar Haveli	na	na	na	0.221	na
Goa	0.354	0.071	0.148	1.347	0.095
Gujarat	0.271	0.449	0.312	0.454	0.418
Haryana	0.595	0.621	0.944	0.186	0.266
Himachal Pradesh	0.442	0.634	0.991	0.188	0.647
Jammu & Kashmir	0.411	0.401	0.282	0.141	0.016
Jharkhand	na	na	0.889	0.100	0.024
Karnataka	0.172	0.274	0.370	0.223	0.058
Kerala	0.028	0.008	0.051	0.002	0.130
Ladakh	na	na	na	na	0.019
Lakshadweep	na	na	na	1.384	0.089
Madhya Pradesh	1.880	0.405	0.579	0.387	0.401
Maharashtra	7.551	0.334	0.703	0.319	0.214
Manipur	0.333	0.088	0.067	0.032	0.009
Meghalaya	0.709	2.138	1.068	0.398	0.073
Mizoram	0.054	0.215	0.065	0.069	0.106
Nagaland	na	0.451	0.355	0.093	0.043
Odisha	0.243	0.201	0.209	0.065	0.051
Puducherry	na	na	na	0.050	0.123
Punjab	0.139	0.742	0.377	0.146	0.129
Rajasthan	0.606	0.257	0.584	0.288	0.189
Sikkim	na	na	0.027	0.231	0.291
Tamil Nadu	0.262	0.223	0.113	0.023	0.035
Telangana	na	na	na	0.082	0.039
Tripura	0.163	na	0.006	0.076	0.042
Uttar Pradesh	0.744	0.782	0.360	0.338	0.133
Uttarakhand	na	na	0.718	0.513	0.394
West Bengal	0.211	0.208	0.088	0.121	0.048

Country/State/Union Territory	Period				
	1992-1993	1998-1999	2005-2006	2015-2016	2019-2021
	Modern spacing methods (Index D_s)				
India	1.326	1.189	0.964	0.527	0.356
Andaman and Nicobar Islands	na	na	na	-0.600	-0.101
Andhra Pradesh	0.408	1.736	1.525	1.958	1.039
Arunachal Pradesh	0.643	0.312	0.551	-0.015	0.010
Assam	0.908	0.276	0.788	0.055	-0.172
Bihar	1.568	1.486	0.993	0.950	0.642
Chandigarh	na	na	na	na	na
Chhattisgarh	na	na	1.690	0.871	0.393
Daman & Diu	na	na	na	1.134	na
Dadra &Nagar Haveli and Daman & Diu	na	na	na	na	0.655
Delhi	0.152	0.449	0.654	0.078	-0.050
Dadra and Nagar Haveli	na	na	na	0.614	na
Goa	0.586	0.537	0.655	0.608	0.206
Gujarat	1.341	1.364	1.045	0.933	0.855
Haryana	1.426	1.215	1.066	0.282	0.504
Himachal Pradesh	1.482	1.556	1.286	0.478	0.753
Jammu & Kashmir	1.296	0.654	0.308	0.299	0.028
Jharkhand	na	na	1.141	0.681	0.220
Karnataka	1.160	1.405	1.350	1.048	0.489
Kerala	0.204	0.293	0.553	0.155	0.296
Ladakh	na	na	na	na	-0.104
Lakshadweep	na	na	na	0.945	0.071
Madhya Pradesh	1.316	1.878	1.824	1.289	0.936
Maharashtra	3.247	0.935	1.461	0.819	0.635
Manipur	1.015	0.371	0.047	-0.073	0.056
Meghalaya	0.585	1.154	1.139	-0.046	-0.287
Mizoram	0.329	0.494	0.203	0.177	-0.412
Nagaland	0.318	0.651	0.511	0.399	0.272
Odisha	1.386	1.286	0.856	0.415	0.155
Puducherry	na	na	na	-0.647	0.486
Punjab	0.592	0.933	0.433	0.370	0.288
Rajasthan	1.516	1.212	1.540	1.030	0.616
Sikkim	na	na	0.132	-0.331	-0.687
Tamil Nadu	1.158	1.516	0.951	0.616	0.216
Telangana	na	na	na	1.485	0.765
Tripura	0.579	na	0.030	-0.241	0.038
Uttar Pradesh	1.515	1.744	1.129	0.985	0.474
Uttarakhand	na	na	1.050	0.721	0.682
West Bengal	0.843	0.490	0.339	0.188	0.188

Country/State/Union Territory	Period				
	1992-1993	1998-1999	2005-2006	2015-2016	2019-2021
	Permanent methods (Index D_p)				
India	0.171	0.103	0.034	-0.019	-0.106
Andaman and Nicobar Islands	na	na	na	-0.344	-0.595
Andhra Pradesh	0.441	0.020	-0.084	-0.143	-0.081
Arunachal Pradesh	0.497	0.455	-0.261	-0.429	-0.211
Assam	0.649	0.111	0.119	0.055	0.048
Bihar	0.800	0.507	0.444	0.390	-0.152
Chandigarh	na	na	na	na	na
Chhattisgarh	na	na	0.073	-0.142	-0.032
Daman & Diu	na	na	na	-0.868	na
Dadra &Nagar Haveli and Daman & Diu	na	na	na	na	-0.913
Delhi	0.063	-0.339	-0.601	-0.307	-0.059
Dadra and Nagar Haveli	na	na	na	-0.420	na
Goa	-0.293	0.103	-0.146	1.407	0.405
Gujarat	-0.187	-0.398	-0.389	-0.512	-0.522
Haryana	-0.397	-0.623	-0.930	-0.508	-0.594
Himachal Pradesh	-0.324	-0.629	-0.908	-0.405	-0.888
Jammu & Kashmir	-0.127	0.694	0.521	0.449	0.047
Jharkhand	na	na	0.783	0.101	0.004
Karnataka	-0.127	-0.256	-0.490	-0.398	-0.151
Kerala	0.116	0.008	-0.140	-0.008	-0.237
Ladakh	na	na	na	na	-0.021
Lakshadweep	na	na	na	-0.483	0.209
Madhya Pradesh	1.318	0.127	-0.397	-0.427	-0.568
Maharashtra	-2.698	-0.487	-0.627	-0.467	-0.393
Manipur	0.075	0.347	0.148	0.296	0.299
Meghalaya	1.105	2.162	1.206	1.033	0.332
Mizoram	0.130	0.446	0.270	0.304	0.124
Nagaland	1.032	0.731	0.708	0.206	-0.099
Odisha	0.295	-0.142	-0.149	-0.146	-0.230
Puducherry	na	na	na	0.150	-0.259
Punjab	-0.227	-0.896	-0.720	-0.403	-0.437
Rajasthan	0.616	0.158	0.370	-0.307	-0.380
Sikkim	na	na	0.067	-0.600	-0.180
Tamil Nadu	-0.318	0.040	-0.223	0.002	-0.176
Telangana	na	na	na	0.041	-0.078
Tripura	0.466	na	-0.082	0.414	0.503
Uttar Pradesh	0.282	0.308	0.192	-0.221	-0.339
Uttarakhand	na	na	-0.700	-0.737	-0.702
West Bengal	-0.347	-0.337	-0.231	-0.482	-0.181

Country/State/Union Territory	Period				
	1992-1993	1998-1999	2005-2006	2015-2016	2019-2021
	Traditional methods (Index D_t)				
India	0.444	0.401	0.068	0.040	0.075
Andaman and Nicobar Islands	na	na	na	-0.699	-0.515
Andhra Pradesh	1.211	0.795	-0.183	2.122	1.613
Arunachal Pradesh	1.267	0.717	0.447	-0.670	0.028
Assam	0.350	0.439	-0.043	0.094	0.299
Bihar	0.952	0.575	0.754	1.473	0.410
Chandigarh	na	na	na	na	na
Chhattisgarh	na	na	0.651	0.481	0.069
Daman & Diu	na	na	na	5.168	na
Dadra &Nagar Haveli and Daman & Diu	na	na	na	na	0.463
Delhi	0.222	0.385	0.244	0.021	0.574
Dadra and Nagar Haveli	na	na	na	-2.117	na
Goa	1.089	0.268	0.398	0.066	-0.191
Gujarat	0.740	0.883	-0.055	1.061	0.630
Haryana	0.927	0.709	0.905	0.206	0.256
Himachal Pradesh	0.732	0.513	0.521	0.487	0.520
Jammu & Kashmir	0.560	0.169	0.842	-0.321	-0.350
Jharkhand	na	na	1.290	0.536	0.274
Karnataka	0.819	1.504	0.836	1.393	0.473
Kerala	0.314	0.083	-0.053	-0.026	0.772
Ladakh	na	na	na	na	0.444
Lakshadweep	na	na	na	1.562	-0.407
Madhya Pradesh	-2.641	0.670	0.636	0.601	0.290
Maharashtra	1.451	1.111	0.745	0.916	0.557
Manipur	0.292	0.088	0.347	0.198	-0.061
Meghalaya	-0.358	0.420	0.277	1.123	0.000
Mizoram	1.188	-0.922	0.406	1.610	0.513
Nagaland	na	0.577	0.565	0.175	0.056
Odisha	0.436	0.378	0.586	0.127	0.264
Puducherry	na	na	na	0.518	0.810
Punjab	0.210	0.602	0.616	0.325	0.341
Rajasthan	-1.307	0.682	0.404	-0.007	0.118
Sikkim	na	na	0.339	0.776	-0.306
Tamil Nadu	0.576	0.968	0.211	-0.032	0.297
Telangana	na	na	na	3.118	0.657
Tripura	0.257	na	0.113	0.198	0.115
Uttar Pradesh	0.996	0.409	-0.041	0.219	0.094
Uttarakhand	na	na	0.742	0.523	0.140
West Bengal	0.427	0.591	0.345	0.239	0.334

Remarks: na – data not available
Source: Authors' calculations

The change in the urban-rural disparity in family planning use is the result of the change in the urban-rural disparity in modern spacing methods, permanent methods, and traditional family planning methods. There is, however, a high degree of volatility in the change, over time in the urban-rural disparity in the use of modern spacing methods, permanent methods, and traditional methods across states/Union Territories as well as within each state/Union Territory (Table 3). In general, urban-rural disparity in the use of modern spacing methods has decreased while urban-rural disparity in the use of permanent methods has turned negative in most of the states and Union Territories while it remains positive in majority of states/Union Territories in case of traditional methods.

Discussion and Conclusions

The present analysis is probably the first to analyse the urban-rural disparity in family planning use in India. The available evidence suggests that family planning use has always been higher in the urban population as compared to the rural population of the country but the urban-rural disparity in family planning use has decreased rapidly over time. The primary reason behind the decrease in the urban-rural disparity in family planning use has been the slow increase in family planning use in the urban population relative to the rural population of the country. There has, however, been little attempt to measure the urban-rural disparity in family planning use and to explore the factors responsible for the disparity in the urban-rural disparity in family planning use in the country. The evidence world over suggests that family planning use in the urban population is higher than the family planning use in the rural population because of a number of factors. An important factor that contributes to higher family planning use in the urban population is the easy availability and access to a range of family planning methods, especially modern spacing methods. In addition, higher level of education, especially of women, and better life-style factors in the urban population as compared to the rural population are also responsible for relatively higher family planning use in the urban population. However, the reasons behind relatively slow increase in family planning use in India, as revealed through the present analysis are not known at present. The family planning use in India remains low by international standards and one possible reason may be the slow increase in the use of family planning methods in the urban population of the country.

The relatively higher family planning use in the urban population in India is primarily due to higher use of modern spacing methods. This is expected as the availability and access to modern family planning methods is generally better in the urban population as compared to the rural population. However, the urban-rural gap in the use of modern spacing methods has narrowed down considerably in the country because of the faster increase in the use of these methods in the rural population relative to the urban population. It appears that the family planning services delivery system in the urban population is not able to meet the need of modern spacing methods of the urban population. The use of traditional methods has also increased recently more rapidly in the urban population as compared to the rural population which also supports the view that the family planning services delivery system is not able to meet the need of modern spacing methods of the urban population as the use of traditional methods is seen as a reflection of the unmet need for modern spacing methods. It appears that the availability of and access to modern spacing methods is not uniform in different sub-groups of the urban population and there are sub-groups where availability of and access to modern spacing methods is compromised. The urban population of the country is highly heterogenous. Urban settlements in India are divided into six categories based on their population size: 1) urban settlements having at least 100 thousand population; 2) urban settlements having population in the range of 50000-99999; 3) urban settlements having population in the range of 20000-49999; 4) urban settlements having population in the range 10000-19999; 5) urban settlements having population in the range 5000-9999; and 6) urban settlements with a population of less than 5000 (Government of India, 2001). There is little information about the variation in family planning use across different size class of urban settlements. At the same time, within the same urban settlement, family planning use may be different in different population sub-groups, especially urban poor, and urban non-poor. The increase in the urban population in the country has primarily been the result of large rural to urban migration in search of better livelihood opportunities. It appears that this migrant population remains devoid of the access to modern family planning methods.

The use of permanent family planning methods in India is now higher in the rural population as compared to the urban population which also indicates that the family planning services delivery system in the urban population is not in good shape. One reason is that the family planning services delivery system is a part of the public health care system in the country and the presence of the public health care system in the urban population, especially, the primary health care system, may be termed as notional, at best. There is heavy concentration of private health care facilities in the urban population, especially in large, metropolitan urban settlements. The services available from these private health facilities are costly and beyond the reach of the urban poor. Under the National Health Mission, there are attempts to strengthen urban primary health care services including family planning services but there remains substantial scope for improvement.

The urban-rural disparity in family planning use is found to be exceptionally high in four states - Himachal Pradesh, Gujarat, Madhya Pradesh, and Telangana - and in the Union Territory of Dadra & Nagar Haveli and Daman & Diu. The high urban-rural disparity in family planning use in these states and Union Territories is the result of the low family planning use in the rural population. On the other hand, the urban-rural disparity in family planning use is found to be low in most of the states and Union Territories. It appears that there are state-specific factors that influence the urban-rural disparity in family planning use. An understanding of state-specific factors responsible for the prevailing urban-rural disparity in family planning use may help in reducing the urban-rural disparity in family planning use at the state/Union Territory level.

From the policy perspective, the present analysis calls for reinvigorating the family planning services delivery system in the urban population of the country. The current policy of family planning services delivery in India does not distinguish between family planning services delivery in the urban population and family planning services delivery in the rural population. We recommend that the approach for the delivery of family planning services in the country should be different for urban and rural populations because the organisation of the family planning services delivery in the urban population is different from the organisation of family planning services delivery in the rural population. The recent increase in the use of traditional family planning methods in the urban population of the country also justifies adopting such a stratified approach for the delivery of family planning services delivery in urban and rural populations. Although India has now achieved the replacement fertility, yet role of family planning in India's development is going to remain crucial because of health and other benefits of family planning and because of the important role of family planning in managing the future population growth in the country.

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Appendix table 1: Prevalence of modern spacing methods, permanent methods, and traditional methods of family planning in urban and rural areas of India and states/Union Territories, 1992-2021.

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
India	1992-93	0.117	0.336	0.058	0.511	0.034	0.299	0.038	0.371
	1998-99	0.134	0.378	0.07	0.582	0.045	0.354	0.048	0.447
	2005-06	0.169	0.389	0.082	0.640	0.072	0.381	0.077	0.530
	2015-16	0.153	0.360	0.059	0.572	0.096	0.364	0.057	0.517
	2019-21	0.220	0.365	0.108	0.693	0.165	0.390	0.101	0.656
Andaman & Nicobar Islands	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	0.060	0.352	0.016	0.428	0.103	0.434	0.031	0.568
	2019-21	0.175	0.310	0.059	0.544	0.190	0.449	0.095	0.734
Andhra Pradesh	1992-93	0.043	0.513	0.010	0.566	0.029	0.404	0.003	0.436
	1998-99	0.049	0.574	0.011	0.634	0.009	0.569	0.005	0.583
	2005-06	0.027	0.645	0.005	0.677	0.006	0.664	0.006	0.676
	2015-16	0.014	0.667	0.003	0.684	0.002	0.698	0	0.700
	2019-21	0.014	0.689	0.005	0.708	0.005	0.706	0.001	0.712
Arunachal Pradesh	1992-93	0.137	0.153	0.105	0.395	0.077	0.099	0.032	0.208
	1998-99	0.152	0.275	0.046	0.473	0.116	0.194	0.023	0.333
	2005-06	0.200	0.194	0.079	0.473	0.126	0.238	0.052	0.416
	2015-16	0.152	0.083	0.030	0.265	0.154	0.122	0.057	0.333
	2019-21	0.291	0.157	0.122	0.570	0.289	0.187	0.119	0.595
Assam	1992-93	0.109	0.227	0.287	0.623	0.047	0.133	0.221	0.401
	1998-99	0.124	0.182	0.228	0.534	0.097	0.166	0.160	0.423
	2005-06	0.229	0.143	0.288	0.660	0.119	0.129	0.297	0.545
	2015-16	0.283	0.101	0.165	0.549	0.272	0.096	0.152	0.520

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
	2019-21	0.329	0.094	0.191	0.614	0.368	0.090	0.149	0.607
Bihar	1992-93	0.085	0.307	0.033	0.425	0.019	0.166	0.013	0.198
	1998-99	0.071	0.283	0.035	0.389	0.017	0.192	0.020	0.229
	2005-06	0.094	0.319	0.093	0.506	0.037	0.231	0.046	0.314
	2015-16	0.053	0.268	0.024	0.345	0.021	0.199	0.006	0.226
	2019-21	0.150	0.320	0.153	0.623	0.085	0.354	0.107	0.546
Chandigarh	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	na	na	na	na	na	na	na	na
	2019-21	0.365	0.193	0.217	0.775	na	na	na	na
Chhattisgarh	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	0.135	0.454	0.065	0.654	0.028	0.436	0.035	0.499
	2015-16	0.131	0.442	0.044	0.617	0.059	0.477	0.028	0.564
	2019-21	0.172	0.477	0.064	0.713	0.123	0.485	0.060	0.668
Dadra & Nagar Haveli	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	0.068	0.234	0.002	0.304	0.038	0.317	0.020	0.375
	2019-21	na	na	na	na	na	na	na	na
Dadra & Nagar Haveli and Daman & Diu	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	na	na	na	na	na	na	na	na
	2019-21	0.228	0.309	0.098	0.635	0.133	0.527	0.064	0.724

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
Daman & Diu	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	0.096	0.220	0.003	0.319	0.033	0.402	0	0.435
	2019-21	na	na	na	na	na	na	na	na
Delhi	1992-93	0.316	0.233	0.058	0.607	0.284	0.222	0.047	0.553
	1998-99	0.284	0.28	0.076	0.640	0.202	0.353	0.053	0.608
	2005-06	0.337	0.228	0.106	0.671	0.209	0.350	0.085	0.644
	2015-16	0.277	0.196	0.057	0.530	0.261	0.248	0.056	0.565
	2019-21	0.394	0.182	0.189	0.765	0.406	0.191	0.116	0.713
Goa	1992-93	0.093	0.274	0.145	0.512	0.054	0.336	0.054	0.444
	1998-99	0.100	0.294	0.133	0.527	0.061	0.273	0.105	0.439
	2005-06	0.140	0.246	0.127	0.513	0.078	0.274	0.089	0.441
	2015-16	0.100	0.216	0.016	0.332	0.057	0.063	0.015	0.135
	2019-21	0.318	0.332	0.073	0.723	0.275	0.249	0.087	0.611
Gujarat	1992-93	0.109	0.381	0.037	0.527	0.031	0.426	0.018	0.475
	1998-99	0.137	0.396	0.085	0.618	0.039	0.494	0.037	0.570
	2005-06	0.196	0.381	0.099	0.676	0.079	0.476	0.104	0.659
	2015-16	0.137	0.275	0.059	0.471	0.059	0.387	0.021	0.467
	2019-21	0.248	0.292	0.155	0.695	0.123	0.410	0.089	0.622
Haryana	1992-93	0.204	0.283	0.093	0.580	0.058	0.370	0.039	0.467
	1998-99	0.229	0.305	0.138	0.672	0.081	0.450	0.073	0.604
	2005-06	0.337	0.228	0.100	0.665	0.149	0.428	0.043	0.620
	2015-16	0.236	0.315	0.049	0.600	0.189	0.434	0.040	0.663
	2019-21	0.342	0.248	0.145	0.735	0.239	0.374	0.116	0.729
Himachal Pradesh	1992-93	0.243	0.387	0.074	0.704	0.068	0.466	0.037	0.571
	1998-99	0.257	0.382	0.104	0.743	0.068	0.537	0.065	0.670

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
	2005-06	0.357	0.355	0.025	0.737	0.133	0.577	0.015	0.725
	2015-16	0.216	0.288	0.073	0.577	0.146	0.377	0.046	0.569
	2019-21	0.351	0.242	0.159	0.752	0.203	0.437	0.101	0.741
Jammu and Kashmir	1992-93	0.226	0.275	0.143	0.644	0.074	0.301	0.087	0.462
	1998-99	0.168	0.429	0.083	0.680	0.095	0.273	0.071	0.439
	2005-06	0.190	0.368	0.125	0.683	0.147	0.257	0.058	0.462
	2015-16	0.251	0.309	0.090	0.650	0.199	0.222	0.120	0.541
	2019-21	0.315	0.220	0.057	0.592	0.309	0.212	0.079	0.600
Jharkhand	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	0.144	0.355	0.101	0.600	0.051	0.201	0.030	0.282
	2015-16	0.096	0.329	0.042	0.467	0.051	0.307	0.025	0.383
	2019-21	0.137	0.377	0.146	0.660	0.113	0.376	0.115	0.604
Karnataka	1992-93	0.087	0.404	0.029	0.520	0.029	0.435	0.013	0.477
	1998-99	0.084	0.480	0.035	0.599	0.022	0.544	0.008	0.574
	2005-06	0.090	0.502	0.016	0.608	0.025	0.622	0.007	0.654
	2015-16	0.042	0.429	0.009	0.480	0.015	0.528	0.002	0.545
	2019-21	0.136	0.552	0.008	0.696	0.088	0.589	0.005	0.682
Kerala	1992-93	0.069	0.504	0.109	0.682	0.057	0.475	0.082	0.614
	1998-99	0.062	0.512	0.081	0.655	0.047	0.510	0.075	0.632
	2005-06	0.111	0.474	0.104	0.689	0.067	0.509	0.109	0.685
	2015-16	0.048	0.458	0.028	0.534	0.041	0.459	0.028	0.528
	2019-21	0.070	0.436	0.108	0.614	0.053	0.495	0.053	0.601
Ladakh	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
	2015-16	na	na	na	na	na	na	na	na
	2019-21	0.291	0.169	0.046	0.506	0.313	0.172	0.030	0.515
Lakshadweep	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	0.048	0.099	0.153	0.300	0.019	0.152	0.036	0.207
	2019-21	0.096	0.214	0.208	0.518	0.090	0.181	0.283	0.554
Madhya Pradesh	1992-93	0.116	0.346	0.015	0.477	0.034	0.124	0.176	0.334
	1998-99	0.123	0.402	0.027	0.552	0.021	0.372	0.014	0.407
	2005-06	0.179	0.384	0.048	0.611	0.034	0.481	0.026	0.541
	2015-16	0.136	0.354	0.027	0.517	0.042	0.456	0.015	0.513
	2019-21	0.215	0.423	0.076	0.714	0.097	0.564	0.058	0.719
Maharashtra	1992-93	0.443	0.065	0.021	0.529	0.030	0.508	0.005	0.543
	1998-99	0.116	0.451	0.018	0.585	0.049	0.572	0.006	0.627
	2005-06	0.188	0.452	0.027	0.667	0.051	0.607	0.013	0.671
	2015-16	0.158	0.449	0.032	0.639	0.076	0.566	0.013	0.655
	2019-21	0.186	0.441	0.031	0.658	0.108	0.539	0.018	0.665
Manipur	1992-93	0.172	0.144	0.127	0.443	0.070	0.135	0.098	0.303
	1998-99	0.128	0.186	0.135	0.449	0.092	0.139	0.125	0.356
	2005-06	0.153	0.095	0.297	0.545	0.147	0.083	0.230	0.460
	2015-16	0.091	0.038	0.121	0.250	0.097	0.028	0.101	0.226
	2019-21	0.149	0.044	0.422	0.615	0.142	0.033	0.437	0.612
Meghalaya	1992-93	0.078	0.199	0.042	0.319	0.045	0.076	0.059	0.180
	1998-99	0.183	0.206	0.064	0.453	0.066	0.029	0.043	0.138
	2005-06	0.176	0.191	0.070	0.437	0.064	0.066	0.054	0.184
	2015-16	0.152	0.124	0.052	0.328	0.158	0.048	0.018	0.224
	2019-21	0.139	0.071	0.049	0.259	0.177	0.052	0.049	0.278

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
Mizoram	1992-93	0.096	0.462	0.013	0.571	0.071	0.430	0.004	0.505
	1998-99	0.141	0.506	0.004	0.651	0.091	0.396	0.010	0.497
	2005-06	0.180	0.460	0.003	0.643	0.152	0.394	0.002	0.548
	2015-16	0.190	0.194	0	0.384	0.164	0.151	0	0.315
	2019-21	0.149	0.137	0.005	0.291	0.209	0.123	0.003	0.335
Nagaland	1992-93	0.082	0.124	0	0.206	0.061	0.048	0	0.109
	1998-99	0.182	0.196	0.089	0.467	0.104	0.105	0.052	0.261
	2005-06	0.168	0.150	0.101	0.419	0.108	0.080	0.060	0.248
	2015-16	0.152	0.103	0.059	0.314	0.107	0.085	0.050	0.242
	2019-21	0.349	0.136	0.125	0.610	0.29	0.148	0.119	0.557
Odisha	1992-93	0.079	0.372	0.023	0.474	0.021	0.306	0.015	0.342
	1998-99	0.125	0.327	0.088	0.540	0.038	0.359	0.062	0.459
	2005-06	0.187	0.314	0.093	0.594	0.089	0.347	0.054	0.490
	2015-16	0.223	0.260	0.130	0.613	0.159	0.289	0.117	0.565
	2019-21	0.226	0.246	0.297	0.769	0.200	0.291	0.245	0.736
Puducherry	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	0.030	0.585	0.008	0.623	0.056	0.548	0.005	0.609
	2019-21	0.091	0.521	0.046	0.658	0.058	0.585	0.021	0.664
Punjab	1992-93	0.239	0.304	0.085	0.628	0.148	0.354	0.070	0.572
	1998-99	0.352	0.188	0.178	0.718	0.176	0.362	0.106	0.644
	2005-06	0.292	0.226	0.099	0.617	0.211	0.375	0.056	0.642
	2015-16	0.328	0.325	0.112	0.765	0.252	0.418	0.083	0.753
	2019-21	0.309	0.185	0.190	0.684	0.251	0.260	0.143	0.654
Rajasthan	1992-93	0.085	0.383	0.003	0.471	0.020	0.251	0.011	0.282

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
	1998-99	0.12	0.349	0.035	0.504	0.039	0.314	0.018	0.371
	2005-06	0.207	0.413	0.037	0.657	0.053	0.327	0.025	0.405
	2015-16	0.225	0.355	0.062	0.642	0.094	0.427	0.062	0.583
	2019-21	0.275	0.357	0.110	0.742	0.170	0.448	0.099	0.717
Sikkim	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	0.25	0.267	0.114	0.631	0.226	0.254	0.084	0.564
	2015-16	0.209	0.148	0.012	0.369	0.269	0.24	0.006	0.515
	2019-21	0.289	0.147	0.119	0.555	0.447	0.171	0.155	0.773
Tamil Nadu	1992-93	0.098	0.347	0.064	0.509	0.033	0.422	0.037	0.492
	1998-99	0.085	0.466	0.031	0.582	0.02	0.456	0.012	0.488
	2005-06	0.067	0.525	0.016	0.608	0.027	0.58	0.013	0.62
	2015-16	0.041	0.494	0.006	0.541	0.022	0.494	0.006	0.522
	2019-21	0.083	0.557	0.036	0.676	0.068	0.600	0.027	0.695
Telangana	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	na	na	na	na	na	na	na	na
	2015-16	0.020	0.563	0.005	0.588	0.005	0.553	0	0.558
	2019-21	0.042	0.627	0.021	0.690	0.020	0.645	0.011	0.676
Tripura	1992-93	0.139	0.254	0.318	0.711	0.083	0.176	0.265	0.524
	1998-99	na	na	na	na	na	na	na	na
	2005-06	0.273	0.171	0.224	0.668	0.267	0.183	0.205	0.655
	2015-16	0.255	0.176	0.237	0.668	0.303	0.124	0.203	0.63
	2019-21	0.392	0.142	0.235	0.769	0.383	0.091	0.215	0.689
Uttar Pradesh	1992-93	0.138	0.158	0.024	0.320	0.034	0.124	0.009	0.167
	1998-99	0.176	0.190	0.082	0.448	0.036	0.147	0.056	0.239
	2005-06	0.232	0.192	0.139	0.563	0.089	0.164	0.144	0.397

Country/State/Union Territory	Year	Urban				Rural			
		Modern spacing methods	Permanent methods	Traditional methods	All methods	Modern spacing methods	Permanent methods	Traditional methods	All methods
	2015-16	0.247	0.151	0.158	0.556	0.109	0.181	0.131	0.421
	2019-21	0.350	0.136	0.190	0.676	0.251	0.181	0.176	0.608
Uttarakhand	1992-93	na	na	na	na	na	na	na	na
	1998-99	na	na	na	na	na	na	na	na
	2005-06	0.361	0.231	0.061	0.653	0.165	0.377	0.03	0.572
	2015-16	0.293	0.191	0.055	0.539	0.168	0.331	0.033	0.532
	2019-21	0.415	0.180	0.140	0.735	0.264	0.307	0.124	0.695
West Bengal	1992-93	0.111	0.254	0.253	0.618	0.051	0.325	0.181	0.557
	1998-99	0.182	0.282	0.270	0.734	0.12	0.355	0.170	0.645
	2005-06	0.206	0.293	0.256	0.755	0.156	0.343	0.196	0.695
	2015-16	0.303	0.227	0.160	0.690	0.265	0.323	0.130	0.718
	2019-21	0.341	0.269	0.165	0.775	0.300	0.306	0.124	0.730

p Prevalence of all family planning methods
p_s Prevalence of modern spacing methods
p_p Prevalence of permanent methods
p_t Prevalence of traditional methods
na Not available
Source: Government of India (1997; 2000; 2007; 2017; 2021)