INDIAN JOURNAL OF POPULATION AND DEVELOPMENT

VOLUME 3(2) JULY 2023 ISSN:2583-4827

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Journal Particulars

Title	Indian Journal of Population and Development
Frequency	Two times in a year
ISSN	
Publisher	Mewalal Chaurasia Foundation
Chief Editor	Aalok Ranjan Chaurasia
Copyright	Mewalal Chaurasia Foundation
Starting year	2021
Subject	Multi-disciplinary subjects
Language	English
Publication format	Electronic (online)
Phone number	755-2927778
E-mail	ijpd@mlcfoundation.org.in
Mobile	9425017555
Website	www.mlcfoundation.org.in/research/IJPD
Address	Mewalal Chaurasia Foundation 51, Lake City Farms (Ganesh Puri) Kalkheda Road, Neelbad Bhopal, MP-462044 India

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VOLUME 3(2) JULY 2023 ISSN:2583-4827

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INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 3(2), July 2023: 209-240

Male-Female Disparity in Child Survival in Districts of India

Aalok R Chaurasia

Abstract

This paper analyses male-female disparity in the probability of survival up to 15 years of age in districts of India. Based on estimates derived from the summary birth history data available from 2011 population census, the paper reveals that in majority of the districts of the country, male-female disparity in survival up to 15 years of age is quite marked in terms of either female survival advantage or male survival advantage. Majority of districts with marked male survival advantage are located in the northern part of the country. There is substantial inequality in male-female disparity in survival up to 15 years of age within district across mutually exclusive population sub-groups. The male-female disparity in survival up to 15 years of age is influenced largely by the male-female survival disparity in 5-9 and 10-14 years of age.

Introduction

District level analyses of child survival in India are rare because district level estimates of the risk of death during childhood are not available either through the civil registration system or the official sample registration system or through surveys like National Family Health Survey. The only source of data to estimate child mortality at the district level is the summary births history (SBH) data available through the decennial population census. These data have been used to estimate the risk of death during childhood at the district level using different indirect techniques of child mortality estimation. (Government of India, 1988; 1997; 2001; Mishra et al, 1994; Rajan et al, 2008; Ahuja, *no date*). In all these studies, the risk of death is estimated for the first five years of the life, although the National Policy for Children, 2013 recognises a person below the age of 18 years as the child (Government of India, 2013). District level estimates of the risk of death in children below 18 years of age are, however, not available. Similarly, truly little is known about within-district residence and social class variation in the risk of death in male and female children. A recent study has analysed excess female under-five mortality in districts of India following a regression residual approach (Guilmoto et al, 2018). This study does not analyse within-district variation in excess female under-five mortality across different social classes and does not consider the male-female disparity in the risk of death beyond five years of age. To the best of our knowledge, there is no study in India which has analysed the male-female disparity in the risk of death in children older than 5 years of age.

In this paper, we analyse male-female disparity in the probability of survival up to 15 years of age in the districts of India. We also analyse how male-female disparity in the probability of survival up to 15 years of age varies across different population sub-groups within the same district. Children below 15 years of age can be grouped into children below 1 year of age; children 1-4 years of age; children 5-9 years of age; and children 10-14 years of age. The rationale for this age grouping of children is grounded in the fact that both probability of survival and male-female disparity in the probability of survival is different in the four age groups as primary causes of death in the four age groups are essentially different. The probability of survival in the first 15 years of life, therefore, is the cumulation of the probability of survival in the four age groups. This means that male-female disparity in survival up to 15 years of age should be analysed in the context of the male-female disparity in survival in the first year of life, in 1-4 years of life, in 5-9 years of life, and in 10-14 years of life.

The paper is organised as follows. The next section of the paper outlines the analytical strategy followed while section three describes the data. The analytical strategy recognises that the probability survival in the first15 years of life varies by both sex and age so that male-female disparity in survival up to 15 years of age is the cumulative effect of male-female survival disparity by age. Inter-district and within-district variation in male-female disparity in survival in the first 15 years of life is discussed in the fourth section of the paper. The fifth section of the paper classifies districts based on the contribution of male-female disparity in survival different age groups to male-female disparity in survival in the first 15 years of life. The last section of the paper summarises main findings of the analysis and discusses their policy and programme implications.

Analytical Framework

The analysis of male-female disparity in survival is essentially an arbitrary procedure (Preston and Weed, 1976). There is no plausible theory or hypothesis about what the male-female disparity in survival in general and child survival in particular should be. Male-female disparity in the risk of death is attributed to both innate biological differences between sexes and social, cultural, and economic determinants of survival (Chaurasia, 1981; United Nations, 2011). The fact that females have two X chromosomes and male one probably confers a survival advantage on females (Naeye et al, 1971). The biological or genetic advantage of females has, however, been argued to be small and largely invariant across populations (Wisser and Vaupel, 2014). On the other hand, females face a range of discrimination in the family and the society because of a host of social, cultural, and economic factors, which may confer a survival disadvantage on them, particularly, after the first year of life. The observed male-female disparity in survival, therefore, is the net of the effect of biological or genetic factors and social, cultural, and economic factors. The relative contribution of biological or genetic factors and social, cultural, and economic factors and the interaction between the two in deciding male-female disparity in survival, however, remains unclear. The relative contribution of biological or genetic factors and social, cultural, and economic factors of male-female disparity in survival varies with age. In the first year of life, female children generally have better survival chances than male children

primarily because of biological or genetic factors. However, as age advances, social, cultural, and economic factors, are argued to become more dominant in deciding male-female disparity in survival.

The male-female disparity in survival can be measured in both relative and absolute terms. Historically, male-female disparity in survival has been measured in relative terms as the ratio of male to female probability of survival or, equivalently, the ratio of female to male probability of survival. There are very few studies which have analysed male-female disparity in survival in absolute terms or in terms of the arithmetic difference between male and female probability of survival (Wisser and Vaupel, 2014). However, both relative and absolute differences are influenced by the level of the survival probability (Preston and Weed, 1976; Houweling et al, 2007; Mackenbach, 2015). One problem with relative measures of disparity is that when male to female ratio of the risk of death goes up, the ratio of the reverse outcome (probability of survival) will go down, and vice versa (Scanlan, 2000). This ambiguity of relative measures does not apply to absolute measures. An advantage of measuring male-female disparity in absolute terms is that the arithmetic difference in male-female survival up to a given age can be decomposed into components attributed to male-female disparity in survival in different ages below the given age as the present paper shows.

In view of the hazards of measuring male-female disparity in survival in either relative or absolute terms, an alternative approach involves first establishing an empirically 'normal' relationship between male and female survival probability and then measuring male-female disparity as the deviation from the empirical 'normal' (Preston and Weed, 1976). This approach measures male-female disparity as the difference between the observed male-female disparity and the empirical 'normal.' One approach to establish empirical 'normal' relationship between male and female survival probability is to orthogonal regression, which minimises the sum of squared deviations perpendicular to the line (Preston and Weed, 1976). Orthogonal regression does not require the specification of a 'dependent' variable, a specification that is difficult in case of analysing the relationship between male and female survival probability. The orthogonal regression treats males and females symmetrically. The slope of the orthogonal regression is the geometric mean of the two slopes resulting using least square regression with male survival probability and female survival probability as 'dependent' variable.

The arithmetic difference and the ratio of male-female survival probability can, however, be related using the logarithmic mean of male and female survival probability. If p^m and p^f denote the male and female survival probability, then the logarithmic mean (*LM*) of pm and p^f is defined as (Carlson, 1972; Bhatia, 2008)

$$LM = \frac{p^m - p^f}{ln\left(\frac{p^m}{p^f}\right)} \quad (1)$$

which means that?

$$\frac{p^m}{p^f} = exp\left(\frac{p^m - p^f}{LM}\right) \quad (2)$$

Equation (2) suggests that the arithmetic difference between male-female survival probability up to 15 years of age, ∇, may be written as

$$\nabla = {}_{15}p_0^m - {}_{15}p_0^f = LM * ln\left(\frac{{}_{15}p_0^m}{{}_{15}p_0^f}\right) \quad (3)$$

The probability of survival up to 15 years of age may also be written as

$${}_{15}p_0 = {}_1p_0 * {}_4p_1 * {}_5p_5 * {}_5p_{10} \quad (4)$$

so that equation (3) becomes

$$\nabla = LM * \left[ln\left(\frac{{}_1p_0^m}{{}_1p_0^f}\right) + ln\left(\frac{{}_4p_1^m}{{}_4p_1^f}\right) + ln\left(\frac{{}_5p_5^m}{{}_5p_5^f}\right) + ln\left(\frac{{}_5p_{10}^m}{{}_5p_{10}^f}\right)\right] \quad (5)$$

or

$$\nabla = \partial_1 + \partial_2 + \partial_3 + \partial_4 \quad (6)$$

where

$$\partial_1 = LM * ln\left(\frac{{}_1p_0^m}{{}_1p_0^f}\right) \quad (7)$$

is the contribution of male-female disparity in the survival probability in the age group 0-1 year to the male-female disparity in the survival up to 15 years of age. Similarly, ∂_2 is the contribution of male-female disparity in the survival probability in the age group 1-4 years; ∂_3 is the contribution of male-female disparity in the survival probability in the age group 5-9 years; and ∂_4 is the contribution of male-female disparity in the survival probability in the age group 10-14 years to male-female disparity in the probability of survival up to 15 years of age.

Equation (6) holds for every population which means that variation in ∇ can be analysed in terms of ∂_1, ∂_2, ∂_3, and ∂_4 through an additive model using the exploratory data analysis technique of mean polish (Selvin, 1996) which is similar to median polish technique with median replaced by mean (Tukey, 1977). Equation (6), when applied to different populations, leads to a two-way table with rows representing populations and columns representing ∂_1, ∂_2, ∂_3, and ∂_4. The mean polish technique then divides the contribution of the male-female disparity in survival probability in an age group in population *j* into four components – a grand mean or average male-female disparity in survival across all populations and all age groups (g); average male-female disparity in survival across populations in a given age group *i* ($\bar{a}_i$); average male-female disparity in survival across age groups in population *j* (d^j); and a residual component which is specific to the age group *i* and population *j* (r_{ij}). For example, for population *j*, the contribution of the male-female disparity in survival probability in the age group 0-1 year (∂_1) to male-female disparity in survival up to 15 years of age may be decomposed as

$$\partial_1^j = g + \bar{a}_1 + d^j + r_1^j \quad (8)$$

Similarly,

$$\partial_2^j = g + \bar{a}_2 + d^j + r_2^j \quad (9)$$

$$\partial_3^j = g + \bar{a}_3 + d^j + r_3^j \quad (10)$$

$$\partial_4^j = g + \bar{a}_4 + d^j + r_4^j \quad (11)$$

Since

$$\nabla^j = \partial_1^j + \partial_2^j + \partial_3^j + \partial_4^j \quad (12)$$

It follows that.

$$\nabla^j = \sum_{i=1}^{c} g + \sum_{i=1}^{c} \bar{a}_i + \sum_{i=1}^{c} d^j + \sum_{i=1}^{c} r_i^j \quad (13)$$

Notice that by construction.

$$\sum_{i=1}^{c} \bar{a}_i = 0 \quad (14)$$

$$\sum_{i=1}^{c} r_i^j = 0 \quad (15)$$

So that equation (13) reduces to

$$\nabla^j = c * g + c * \sum_{i=1}^{c} d^j = \nabla_n + \nabla_j \quad (16)$$

Equation (16) suggests that male-female disparity in the probability of survival up to 15 years of age, measured in terms of the arithmetic difference between male-female survival probability comprises of two components. One component is common to all populations (∇_n), while the second component is specific to the population (∇_j). The common component may be perceived as the empirical 'normal' while the specific component (∇_j) is the deviation of the observed male-female disparity in survival up to 15 years of age in population *j* from the empirical 'normal'. It is obvious that $\nabla_j > 0$ indicates female disadvantage while $\nabla_j < 0$ indicates the male disadvantage in survival up to 15 years of age. When $\nabla_j = 0$, male-female disparity in the probability of survival up to 15 years of age in population *j* is equal to the empirical 'normal'. In this paper, we measure male-female disparity in the probability of survival up to 15 years of age in district *j* by ∇_j or the deviation of the observed male-female disparity in the probability of survival up to 15 years of age in district *j* from the empirical 'normal' derived from equation (16). The male-female disparity in survival up to 15 years of age may be termed as marginal female advantage if ($-0.005 \leq \nabla_j < 0$); moderate female advantage if ($-0.010 \leq \nabla_j < -0.005$); and high female advantage if ($\nabla_j < -0.010$). Similarly, male-female disparity in survival may be termed as marginal male advantage if ($0 < \nabla_j < 0.005$); moderate male advantage if ($0.005 \leq \nabla_j < 0.010$); and high male advantage if ($\nabla_j \geq 0.010$). When $\nabla_j = 0$, there is no male-female disparity.

Equation (13) also suggests that empirical 'normal' contribution of male-female disparity in the probability of survival in the age group *i* to the empirical 'normal' male-female disparity in the probability of survival up to 15 years of age is given by.

$$\nabla_{ni} = g + \bar{a}_i \quad (17)$$

Similarly, the contribution of male-female disparity in the probability of survival in the age group *i* to male-female disparity in the probability of survival up to 15 years of age in population *j* may be calculated as

$$\nabla_{ji} = d_i^j + r_i^j \quad (18)$$

Data

The analysis is based on the summary birth history data – number of children ever born and number of children surviving - available through the 2011 population census of India. These data are tabulated by the age of the currently married women in the reproductive age group (15-49 years) for 640 districts of the country as they existed at the time of 2011 population census for the total population and for population sub-groups classified by residence (rural and urban) and social class (Scheduled Castes and Scheduled Tribes). Based on these data, we have estimated the probability of death in the age group less than 1 year; less than 5 years; less than 10 years; and less than 15 years for each of the 640 districts for the total population and for the rural, urban, Scheduled Castes, Scheduled Tribes, and Other Castes population and for 12 mutually exclusive yet exhaustive population subgroups: 1) rural Scheduled Castes male; 2) rural Scheduled Castes female; 3) rural Scheduled Tribes male; 4) rural Scheduled Tribes female; 5) rural Other Castes male; 6) rural Other castes female; 7) urban Scheduled Castes male; 8) urban Scheduled Castes female; 9) urban Scheduled Tribes male; 10) urban Scheduled Tribes female; 11) urban Other Castes male; and 12) urban Other castes female following the indirect technique of child mortality estimation (Maultree et al, 2013). Using these estimates, we have calculated the probability of survival for the 12 mutually exclusive and exhaustive population sub-groups for the age group less than 1 year, 1-4 years, 5-9 years, 10-14 years, and 0-14 years for each of the 640 districts. These estimates constituted the database for the present analysis. Estimates of child survival probability for different population sub-groups could not be calculated for all the 640 districts because there was either no population of some of the population sub-groups in the district or the population of the sub-group was too small to provide reliable estimates of the probability of death and hence the probability of survival in these population sub-groups in the district.

Results

Table 1 and figure 1 present the empirical 'normal' male-female disparity in the probability of survival up to 15 years of age across 640 districts of the country for the total population and for different population sub-groups. In the urban population, the empirical 'normal' female survival advantage is higher than that in the rural population. Among different social classes, the empirical 'normal' female survival advantage is the lowest in Scheduled Tribes but the highest in Other Castes. Similarly, the empirical 'normal' female survival advantage is the lowest in rural Other Castes but the highest in the urban Other Castes. In the rural population, the empirical 'normal' female survival advantage in the Scheduled Castes is higher than that in the Scheduled Tribes but, in the urban areas, the empirical 'normal' female survival advantage in Scheduled Tribes is higher than that in Scheduled Castes. The empirical 'normal female survival advantage is the lowest in the Other Castes in the rural areas, but the highest in the urban areas across the three social classes.

Table 1 and figure 1 also show the contribution of the empirical 'normal' male-female disparity in the probability of survival up to 15 years of age in different age groups

to the empirical 'normal' male-female disparity in the probability of survival in the first 15 years of life. The male-female disparity in the probability of survival in the age groups below 1 year, 5-9 years and 10-14 years contributes to the increase in the female survival advantage in the age group 0-14 years but the male-female disparity in the probability of survival in the age group 1-4 years contributes to the decrease, instead increase, in the female survival advantage in the age group 0-14 years. In all the population sub-groups, there is female survival disadvantage or, equivalently, male survival advantage in the age group 1-4 years. Because of the female survival disadvantage in the age group 1-4 years, the female survival advantage in the age group 0-14 years is substantially lower than that determined by the female survival advantage in age groups below 1 year, 5-9 years and 10-14years.

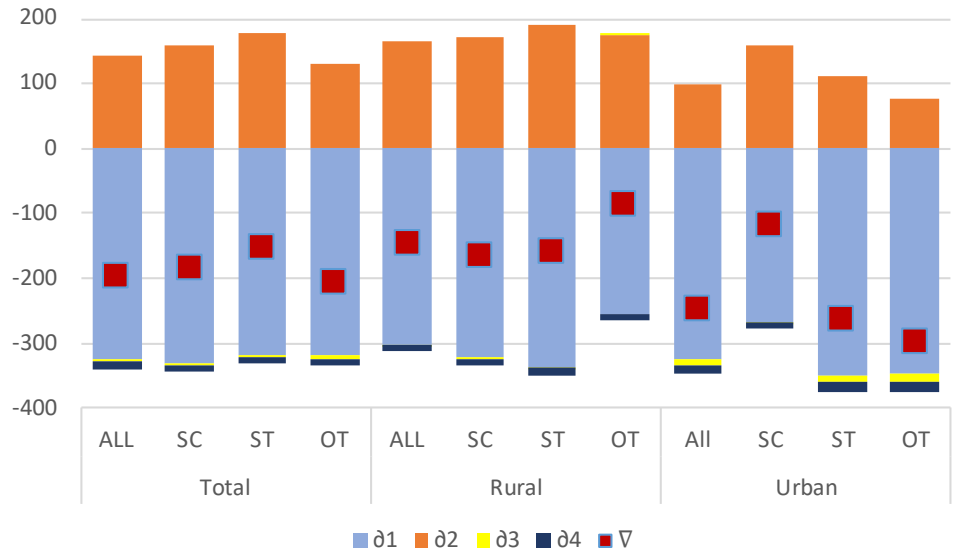

Figure 1: Empirical 'normal' male-female disparity in probability of survival up to 15 years of age (per 100 thousand births) in India and in different population sub-groups.
Source: Author

It may also be seen from table 1 and figure 1 that the empirical 'normal' female survival advantage in the age group 0-14 years is primarily due to the empirical 'normal' female survival advantage in the first year of life, although a substantial proportion of the empirical 'normal' female survival advantage in the first year of life is compromised by empirical 'normal' female survival disadvantage in the age group 1-4 years. Compared to the contribution of the empirical 'normal' male-female disparity in the probability of survival in the first year of life and in the 1-4 years of life to the empirical 'normal' male-female disparity in the probability of survival in the age group 0-14 years, the contribution of the empirical 'normal' male-female disparity in the probability of survival in the age groups 5-9 years and 10-14 years is quite small. The male-female disparity in the probability of survival in the first 15 years of life in the country is determined mainly by the male-female disparity

in the probability of survival in the first five years of life. However, the male-female disparity in the probability of survival in the first year of life is favourable to females but the male-female disparity in the probability of survival in 1-4 years of life is favourable to males.

Table 1: Empirical 'normal' male-female disparity (per 100 thousand births) in the survival up to 15 years of age across districts of India.

Population	Male-female disparity	Contribution of male-female disparity the age group				Number of districts
		<1	1-4	5-9	10-14	
	∇	∂_1	∂_2	∂_3	∂_4	
Total	-195	-323	144	-5	-11	640
Scheduled Castes	-184	-331	161	-3	-11	579
Scheduled Tribes	-154	-319	178	-2	-11	556
Other Castes	-205	-317	130	-6	-11	639
Rural	-145	-301	167	-1	-10	631
Scheduled Castes	-164	-322	171	-2	-11	565
Scheduled Tribes	-157	-337	191	-1	-11	540
Other Castes	-86	-257	176	2	-8	630
Urban	-248	-324	98	-10	-12	636
Scheduled Castes	-119	-268	158	0	-9	567
Scheduled Tribes	-262	-349	112	-11	-14	502
Other Castes	-298	-348	77	-13	-14	632

Source: Author's calculations

District level variation in male-female disparity in the probability of survival up to 15 years of age from the empirical 'normal' male-female disparity in the probability of survival in the first five years of life is quite marked as may be seen from table 2. There are 81 (13 per cent) districts where female survival advantage in the age group 0-14 years is high ($\nabla<-0.010$). In these districts, the probability of survival of a female newborn during the first 15 years of life is substantially higher than that of a male newborn. By contrast, in 122 (19 per cent) districts, male survival advantage is high ($\nabla\geq0.010$) which implies that, in these districts, the probability of survival of a female newborn in the first 15 years of life is low than that of a male newborn. On the other hand, there are 139 (22 per cent) districts where the female survival advantage in the first 15 years of life is moderate ($-0.01\leq\nabla<-0.005$). Similarly, there are 109 (17 per cent) districts where the male survival advantage in the first 15 years of life is moderate ($0.005\leq\nabla<0.010$). This leaves 248 (39 per cent) districts in the country where the male-female disparity in survival in the first 15 years of life may be termed as marginal ($-0.005\leq\nabla<0.005$). In 183 (29 per cent) districts, female survival advantage in the first 15 years of life is either moderate or high whereas in 209 (33 per cent) districts male survival advantage in the first 15 years of life is either moderate or high. Out of the 640 districts of the country, the female survival probability in the first 15 years of life is higher than the male survival probability in 322 districts or in around half of the districts. In the remaining 318 (almost 50 per cent) of the districts, the male probability of survival in the first 15 years of life is higher than the female survival probability. In other words, the 640 districts of the country are almost evenly distributed as regards the female advantage or female disadvantage in the probability of survival in the first 15 years of life.

Table 2: Distribution of districts by male-female disparity in the probability of survival in the first 15 years of life by residence and social class.

Male-Female disparity in the probability of survival in the first 15 years of life	Social class			
	All social classes	Scheduled Castes	Scheduled Tribes	Other Castes
		Total population		
High female advantage (∇<-0.010)	81	95	164	108
Moderate female advantage (-0.01≤∇<-0.005)	102	87	59	75
Marginal female advantage (-0.005≤∇<0)	139	103	87	137
Marginal male advantage (-0≤∇<0.005)	109	78	70	110
Moderate male advantage (0.005≤∇<0.010)	87	76	56	81
High male advantage (∇≥0.010)	122	140	120	128
No data	0	61	84	1
		Rural population		
High female advantage (∇<-0.010)	102	123	161	123
Moderate female advantage (-0.01≤∇<-0.005)	94	72	62	94
Marginal female advantage (-0.005≤∇<0)	128	98	84	105
Marginal male advantage (-0≤∇<0.005)	106	62	58	110
Moderate male advantage (0.005≤∇<0.010)	81	71	56	61
High male advantage (∇≥0.010)	120	139	119	137
No data	9	75	100	10
		Urban population		
High female advantage (∇<-0.010)	102	132	192	109
Moderate female advantage (-0.01≤∇<-0.005)	68	68	34	64
Marginal female advantage (-0.005≤∇<0)	120	64	38	112
Marginal male advantage (-0≤∇<0.005)	140	67	39	131
Moderate male advantage (0.005≤∇<0.010)	73	55	46	71
High male advantage (∇≥0.010)	133	181	153	145
No data	4	73	138	8

Source: Author's calculations

The proportion of districts having either substantial female survival advantage or substantial male survival advantage in the first 15 years of life varies across different population sub-groups. In the rural population, 196 (31 per cent) districts have substantial female survival advantage in the first 15 years of life while 201 (32 per cent) districts have substantial male survival advantage in the first 15 years of life so that in 234 (37 per cent) districts of the country, either female or male survival advantage is, at best, marginal (Table 2). The corresponding proportions in the urban population are 27 per cent, 32 per cent and 41 per cent, respectively. Similarly, the proportion of districts having substantial female survival advantage in the first 15 years of life is the highest in Scheduled Tribes while the proportion of districts having substantial male survival advantage in the first 15 years of life is the highest in Scheduled Castes. On the other hand, the proportion of districts having marginal male-female disparity in the probability in the first 15 years of life is the highest in Other Castes. Among the six mutually exclusive population sub-groups, the proportion of districts having substantial female survival advantage in the first 15 years of life is the highest in Urban Scheduled Tribes while the proportion of districts having substantial male

survival advantage in the first 15 years of life is the highest in urban Scheduled Castes. On the other hand, the proportion of districts where male-female disparity in the probability of survival in the first 15 years of life is the highest in urban Other Castes. Table 2 also suggests that the inter-district variation in the male-female disparity in the probability of survival in the first 15 years of life in India is determined by the within-district variation in male-female disparity across the six mutually exclusive population sub-groups. It may, however, be noted that the rural-urban distribution and the social class composition of the population is different in different districts of the country and these variations also have an impact on the inter-district variation in male-female disparity in the probability of survival up to 15 years of age.

Districts according to the male-female disparity in survival up to 15 years of age are not distributed uniformly across different states and Union Territories of the country. There is a clear north-south divide in the male-female disparity in survival up to 15 years of age in the total population and in all population sub-groups as may be seen from figures 2 through 13. In the northern part of the country, male advantage in survival up to 15 years of age appears to be the norm in all population sub-groups. Majority of the districts having male survival advantage or female survival disadvantage in the first 15 years of life are located in the northern part of the country (Figure 2). On the other hand, the situation appears to be mixed in the southern part of the country where there is female survival advantage in majority of the districts. At the same time, the magnitude of male-female disparity in survival up to 15 years of age is marginal in a substantial proportion of districts of this region while there is only a small proportion of districts where male advantage in survival is substantial. There are six states/Union Territories – Delhi, Uttar Pradesh, Bihar, and Nagaland – where there is no district where female survival advantage in the first 15 years of life is either high or moderate. On the other hand, there is no district in Himachal Pradesh, West Bengal, Chhattisgarh, Andhra Pradesh, and Kerala where the male survival advantage in the first 15 years of life is either moderate or high. In West Bengal, the male-female disparity in survival up to 15 years of age is marginal in 16 of the 19 districts or in more than 84 per cent districts of the state. In Punjab, Haryana, Nagaland, Maharashtra, Andhra Pradesh, and Kerala also, the male-female disparity in the probability of survival up to 15 years of age is found to be marginal in more than 60 per cent of the districts (Table 3).

The male-female disparity in survival up to 15 years of age is also found to vary across the six mutually exclusive population sub-groups in each district. There are only 42 (6.6 per cent) districts in the country where female children have a survival advantage over male children in all the six mutually exclusive population sub-groups (Figure 14). Similarly, there are only 61 (9.5 per cent) districts in the country where male children have a survival advantage over female children in all the six mutually exclusive population sub-groups. In the remaining districts of the country, the survival advantage of either female or male children over male or female children in one or more mutually exclusive population sub-groups is associated with the survival disadvantage of either female or male children over male or female children in other population sub-groups. This indicates that, even within a district, the factors that determine the male-female disparity in survival up to first 15 years of life are different for different population sub-groups.

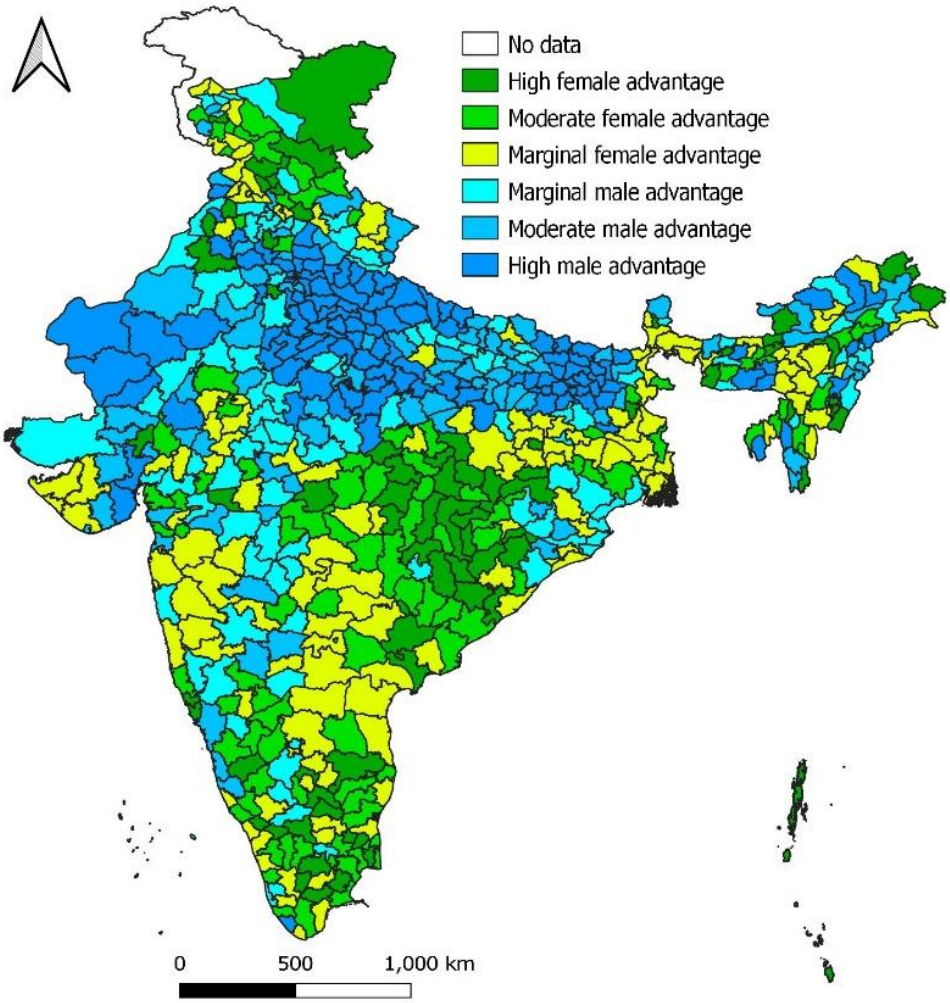

Figure 2: Inter-district variation in male-female disparity in child survival - total population.
Source: Author

Remarks:
High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

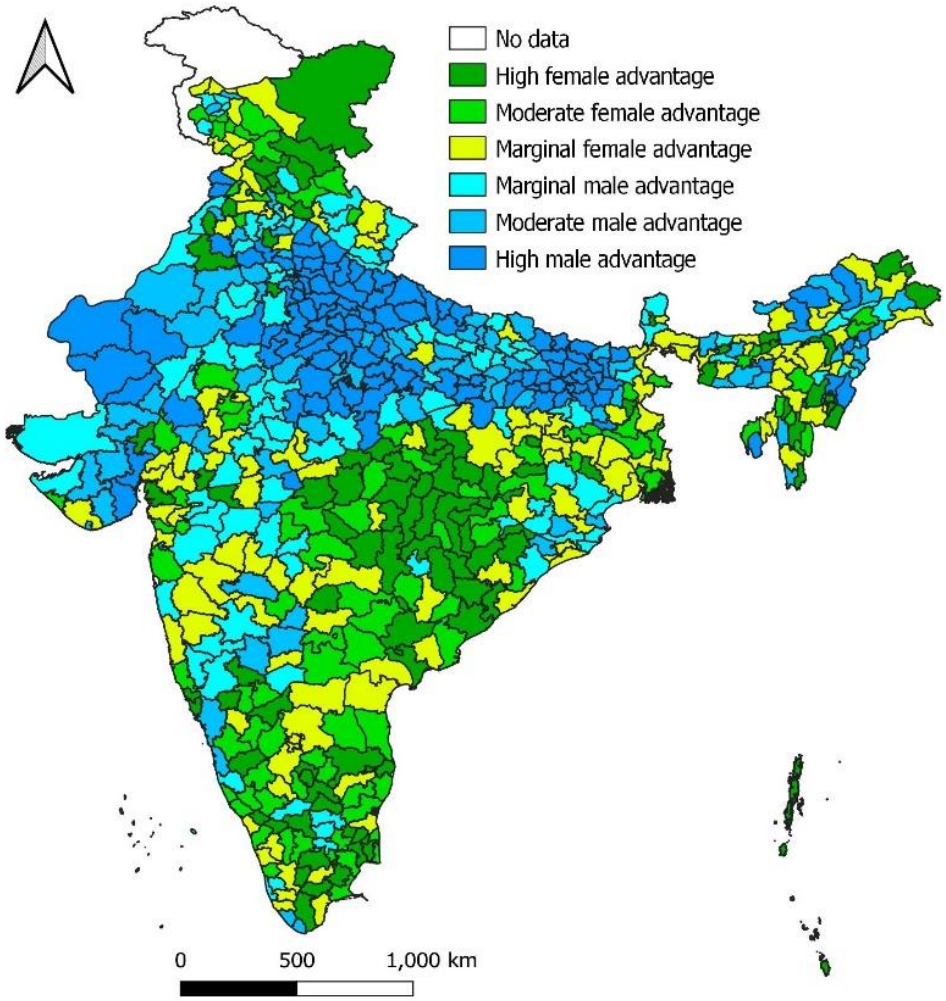

Figure 3: Inter-district variation in male-female disparity in child survival - rural population.
Source: Author

Remarks:
High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

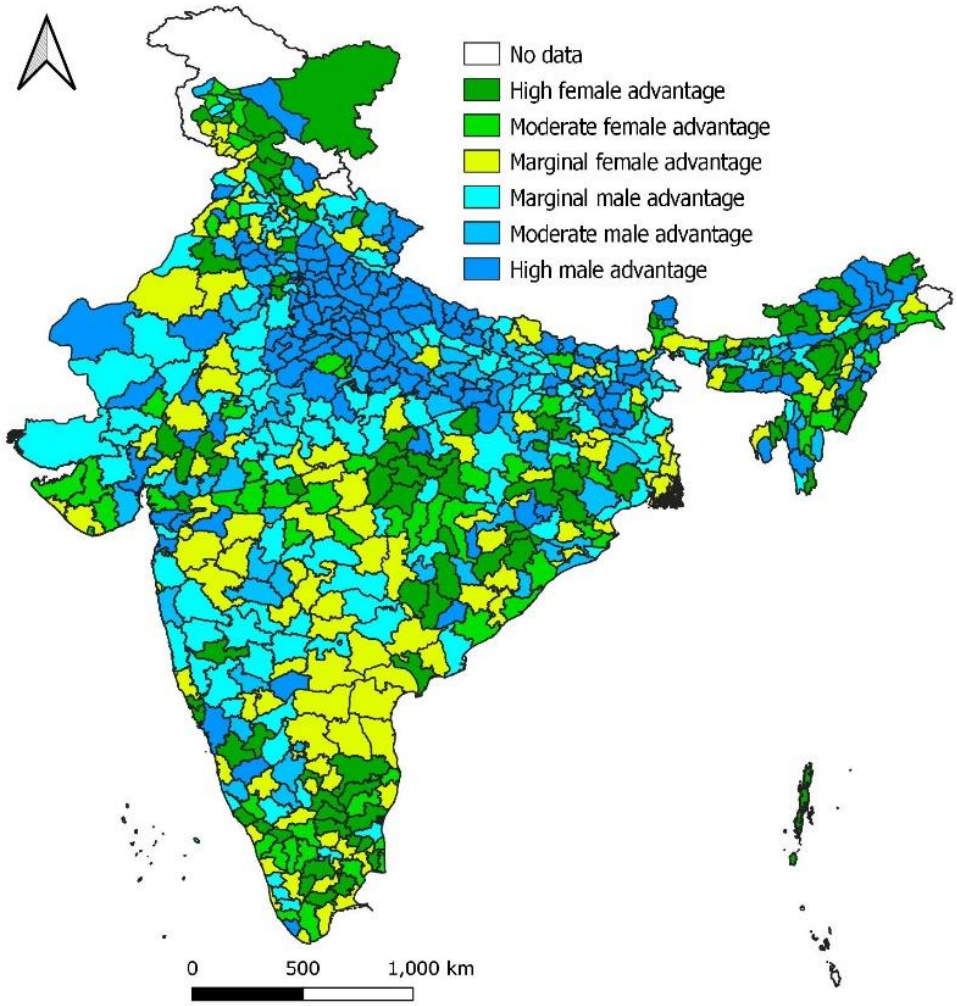

Figure 4: Inter-district variation in male-female disparity in child survival - urban population.
Source: Author

Remarks:
High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

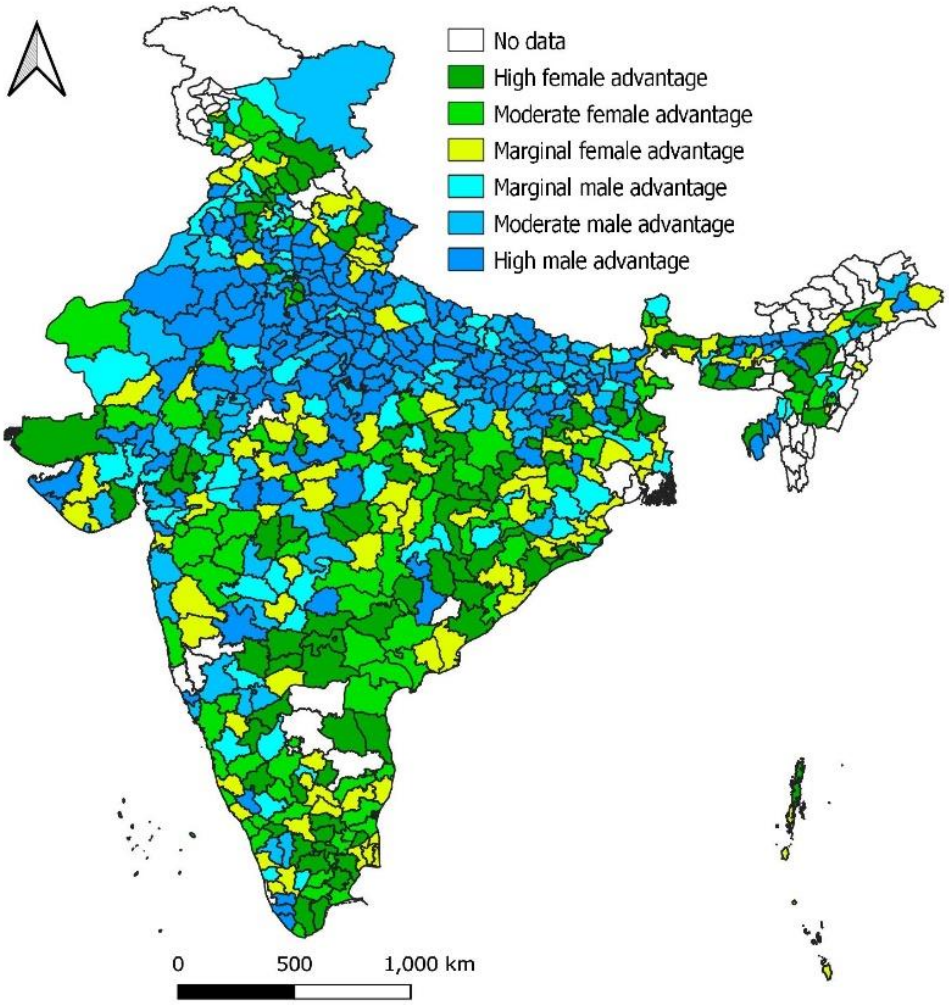

Figure 5: Inter-district variation in male-female disparity in child survival - Scheduled Castes total.
Source: Author
Remarks: High female advantage ($\nabla<-0.010$)
Moderate female advantage ($-0.01\leq\nabla<-0.005$)
Marginal female advantage ($-0.005\leq\nabla<0$)
Marginal male advantage ($-0\leq\nabla<0.005$)
Moderate male advantage ($0.005\leq\nabla<0.010$)
High male advantage ($\nabla\geq0.010$)

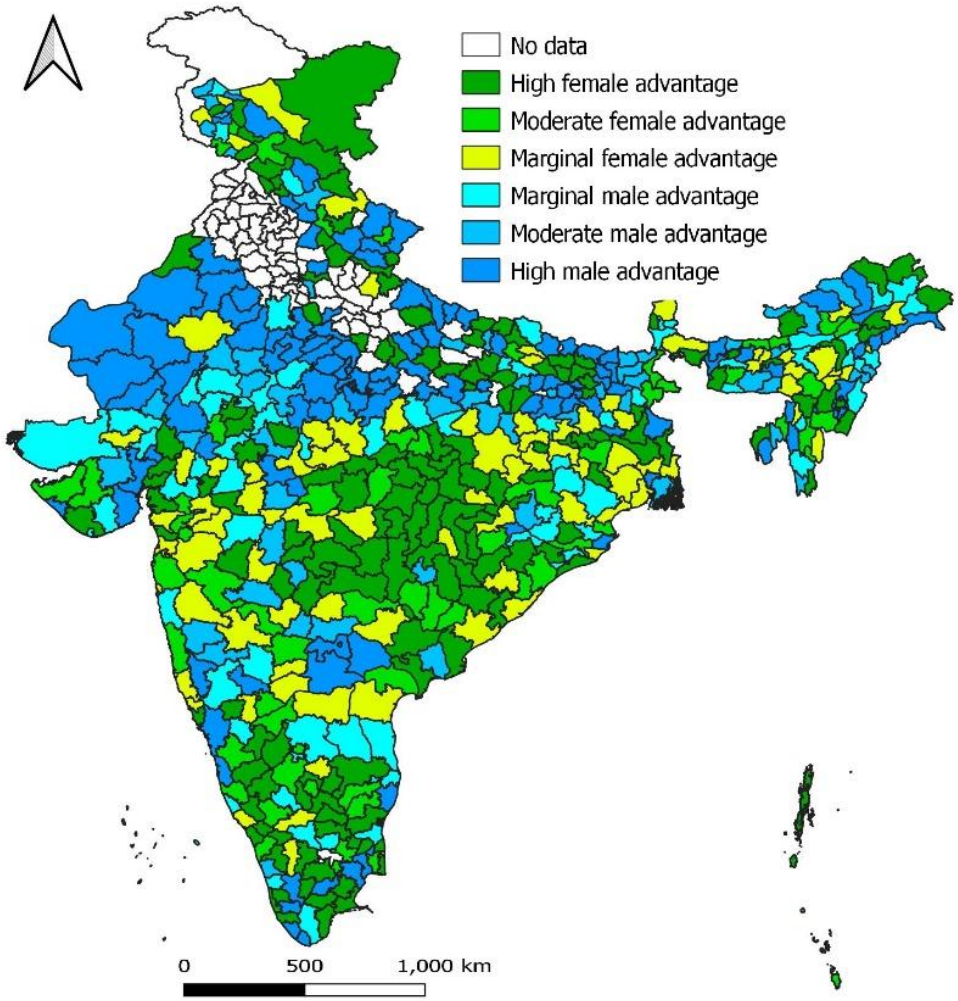

Figure 6: Inter-district variation in male-female disparity in child survival - Scheduled Tribes total.
Source: Author
Remarks: High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

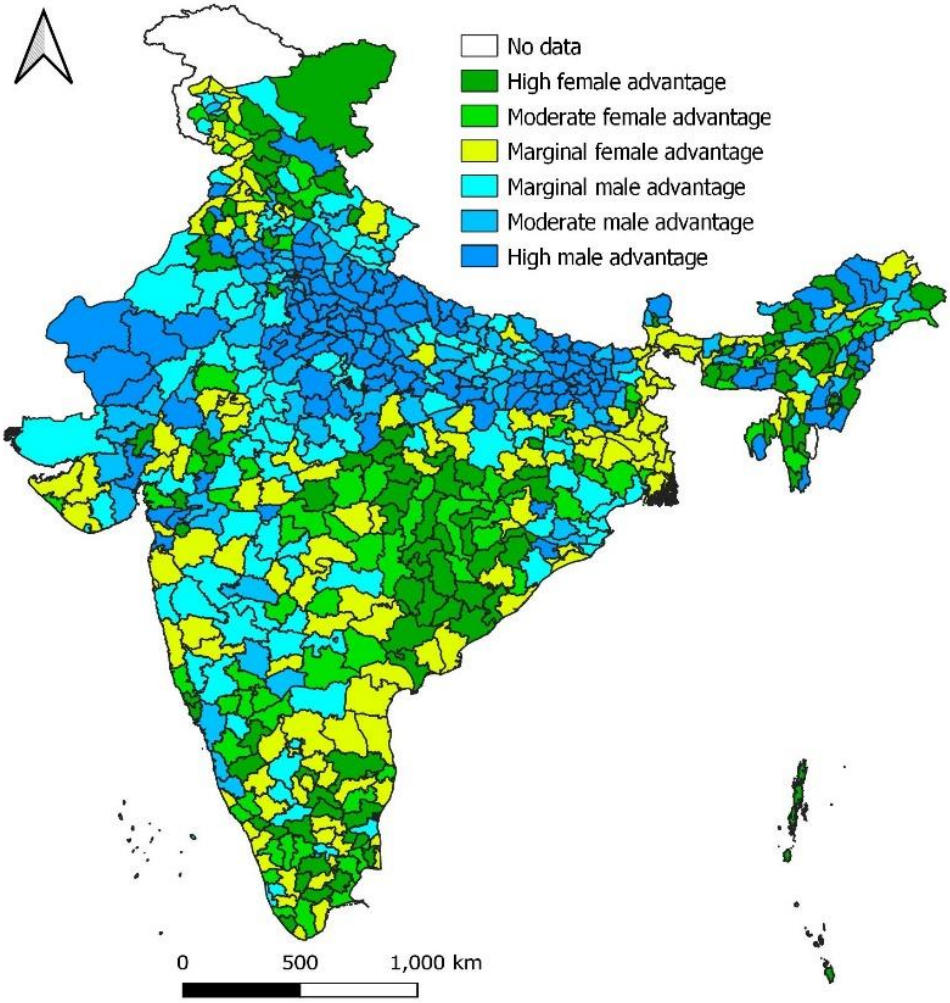

Figure 7: Inter-district variation in male-female disparity in child survival - Other Castes total.
Source: Author
Remarks: High female advantage ($\nabla<-0.010$)
Moderate female advantage ($-0.01\leq\nabla<-0.005$)
Marginal female advantage ($-0.005\leq\nabla<0$)
Marginal male advantage ($-0\leq\nabla<0.005$)
Moderate male advantage ($0.005\leq\nabla<0.010$)
High male advantage ($\nabla\geq0.010$)

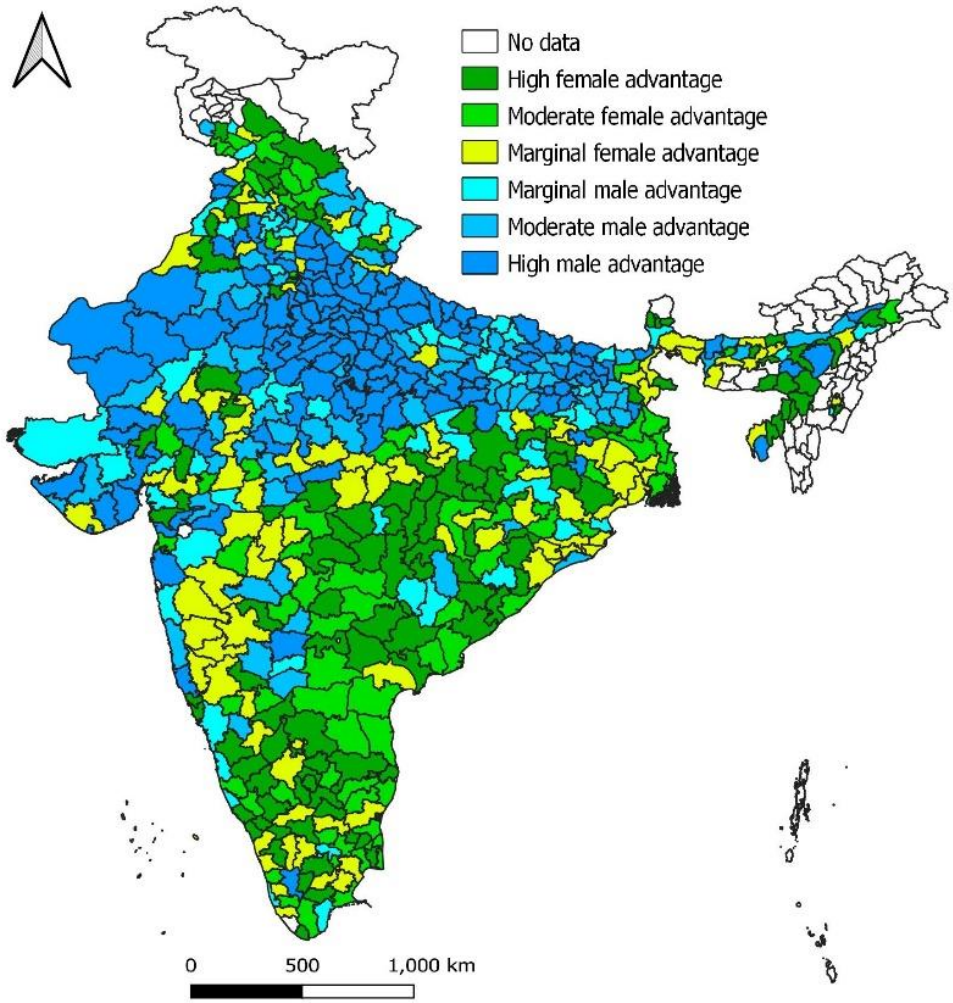

Figure 8: Inter-district variation in male-female disparity in child survival - Scheduled Castes rural.
Source: Author
Remarks: High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

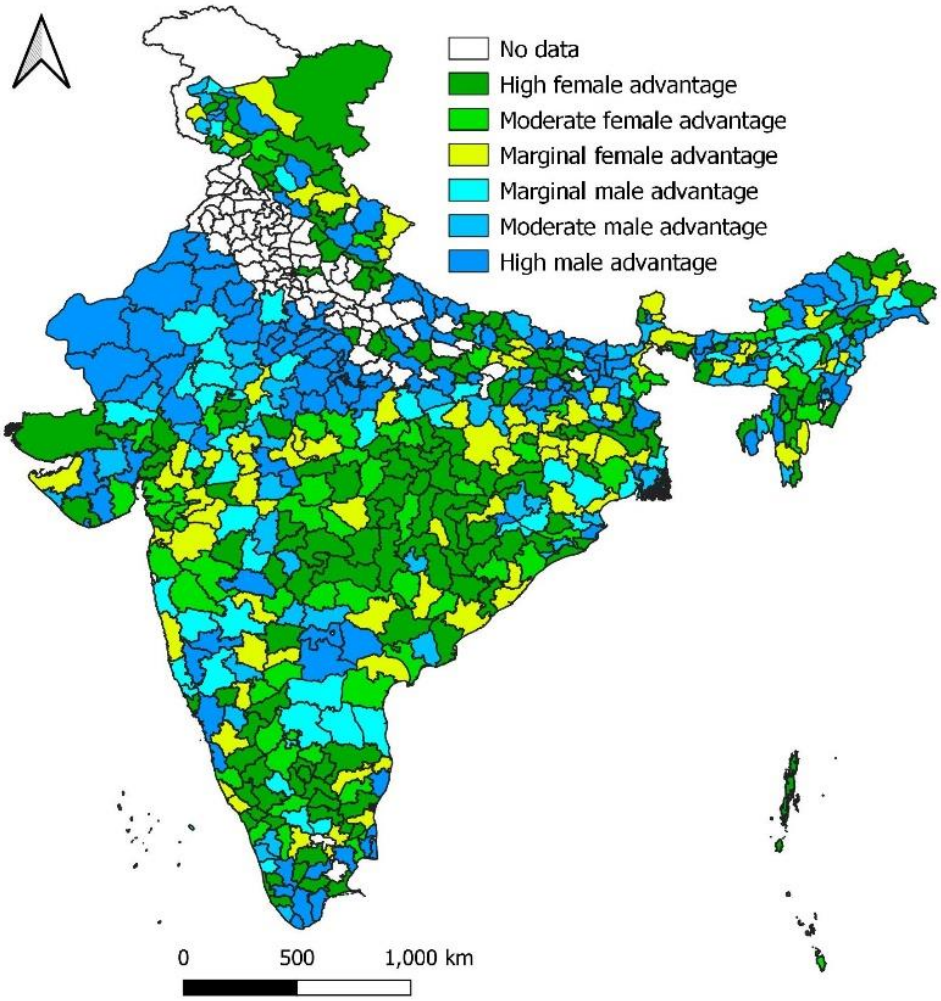

Figure 9: Inter-district variation in male-female disparity in child survival - Scheduled Tribes rural.
Source: Author
Remarks: High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

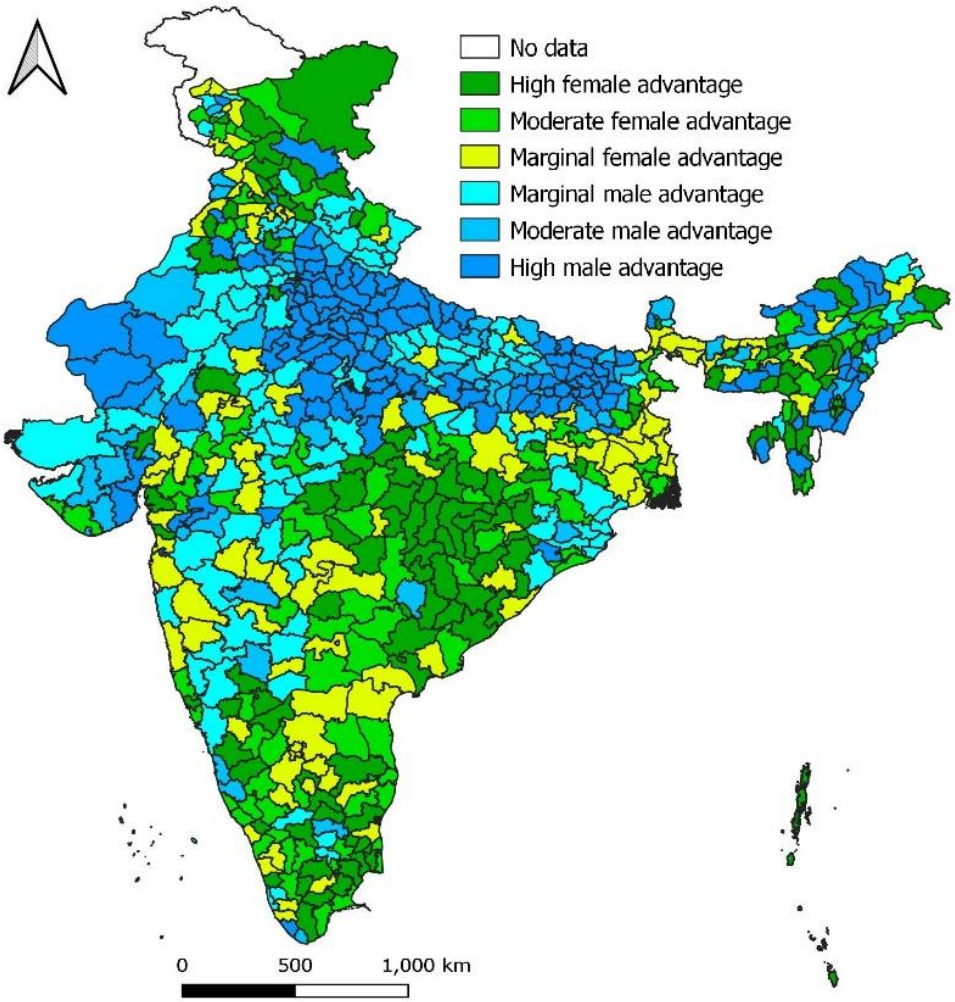

Figure 10: Inter-district variation in male-female disparity in child survival - Other Castes rural.
Source: Author
Remarks: High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

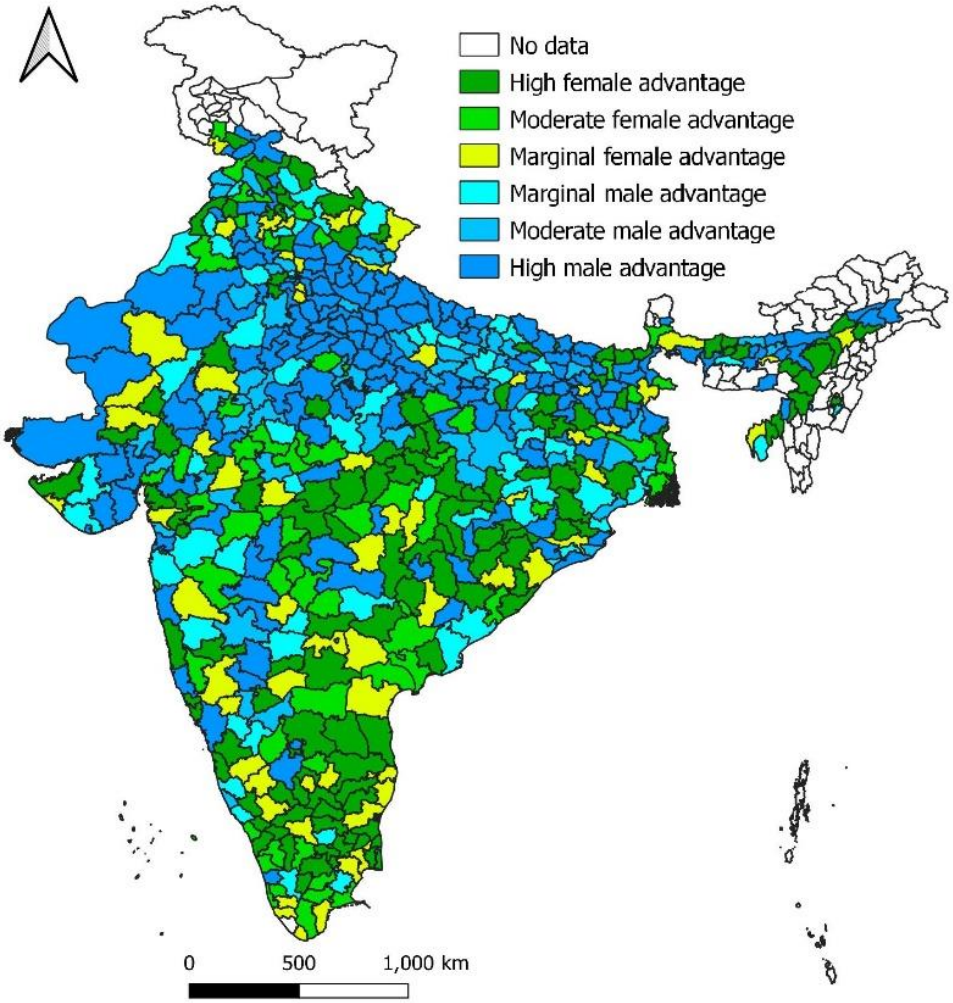

Figure 11: Inter-district variation in male-female disparity in child survival - Scheduled Castes urban.
Source: Author
Remarks: High female advantage ($\nabla<-0.010$)
Moderate female advantage ($-0.01\leq\nabla<-0.005$)
Marginal female advantage ($-0.005\leq\nabla<0$)
Marginal male advantage ($-0\leq\nabla<0.005$)
Moderate male advantage ($0.005\leq\nabla<0.010$)
High male advantage ($\nabla\geq0.010$)

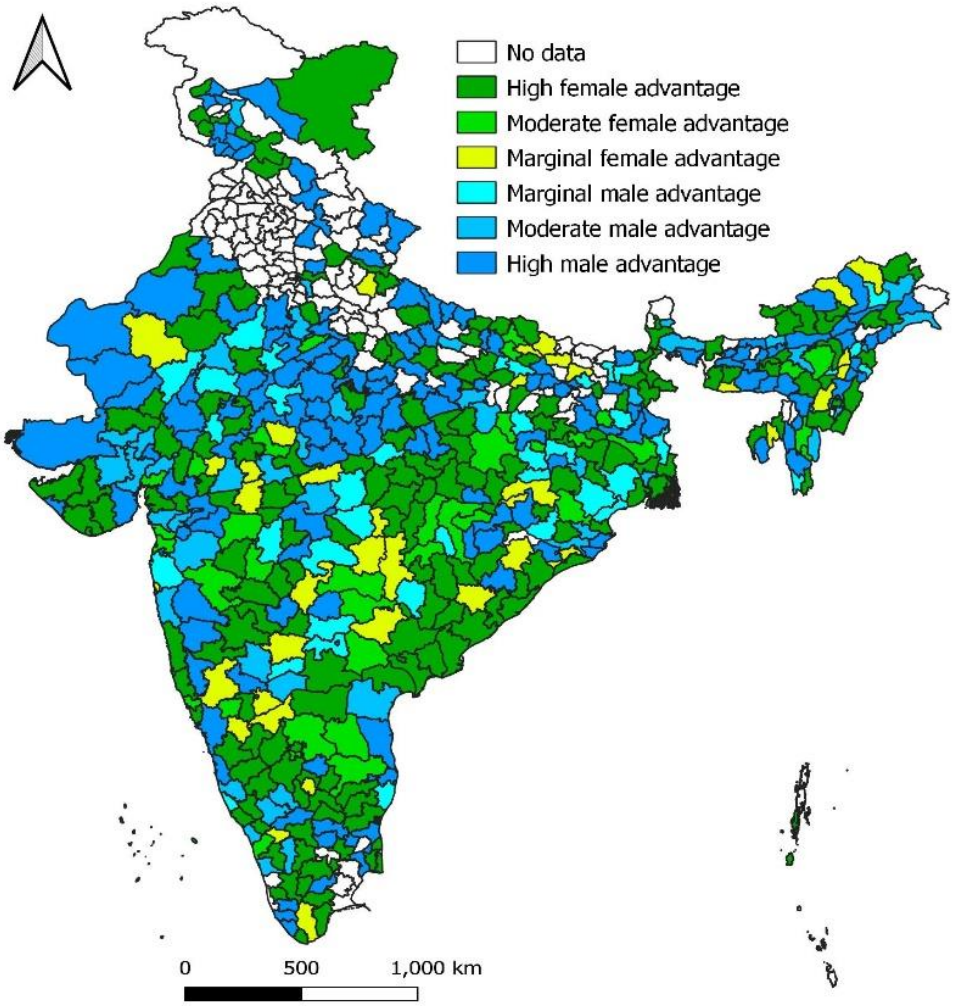

Figure 12: Inter-district variation in male-female disparity in child survival - Scheduled Tribes urban.

Source: Author

Remarks: High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

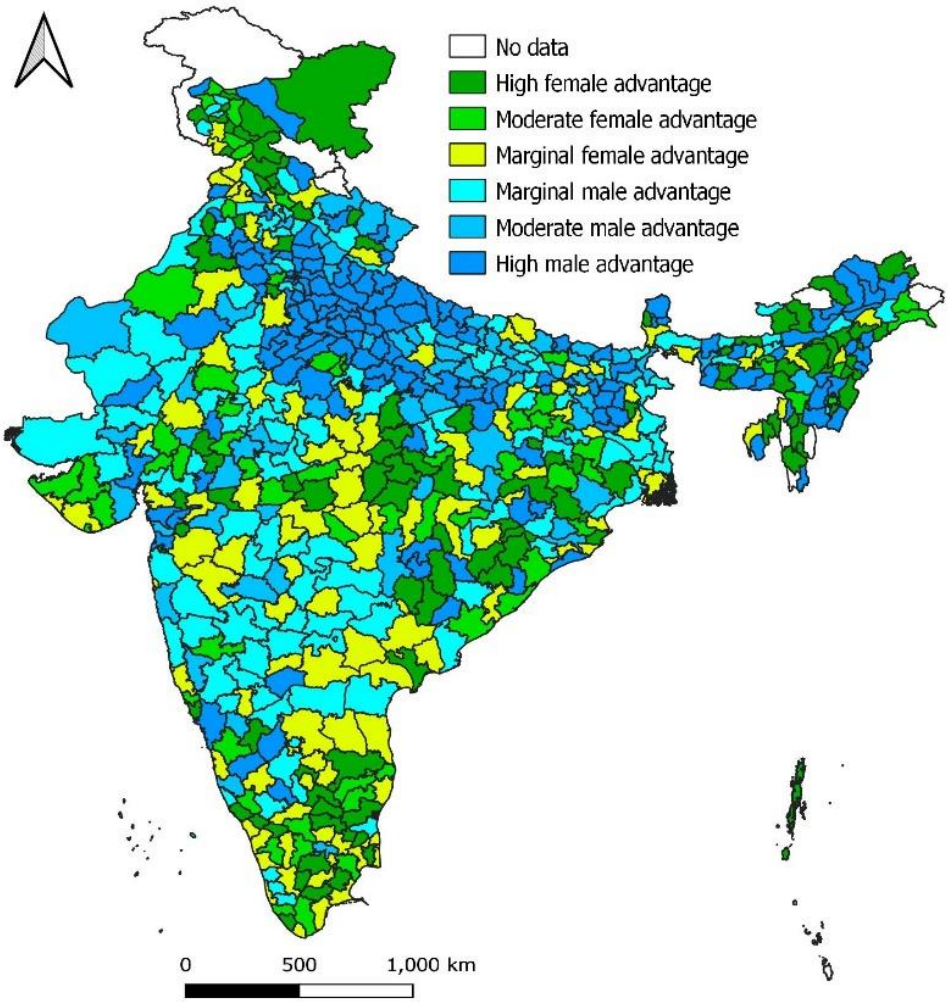

Figure 13: Inter-district variation in male-female disparity in child survival - Other Castes urban.
Source: Author
Remarks: High female advantage ($\nabla < -0.010$)
Moderate female advantage ($-0.01 \leq \nabla < -0.005$)
Marginal female advantage ($-0.005 \leq \nabla < 0$)
Marginal male advantage ($-0 \leq \nabla < 0.005$)
Moderate male advantage ($0.005 \leq \nabla < 0.010$)
High male advantage ($\nabla \geq 0.010$)

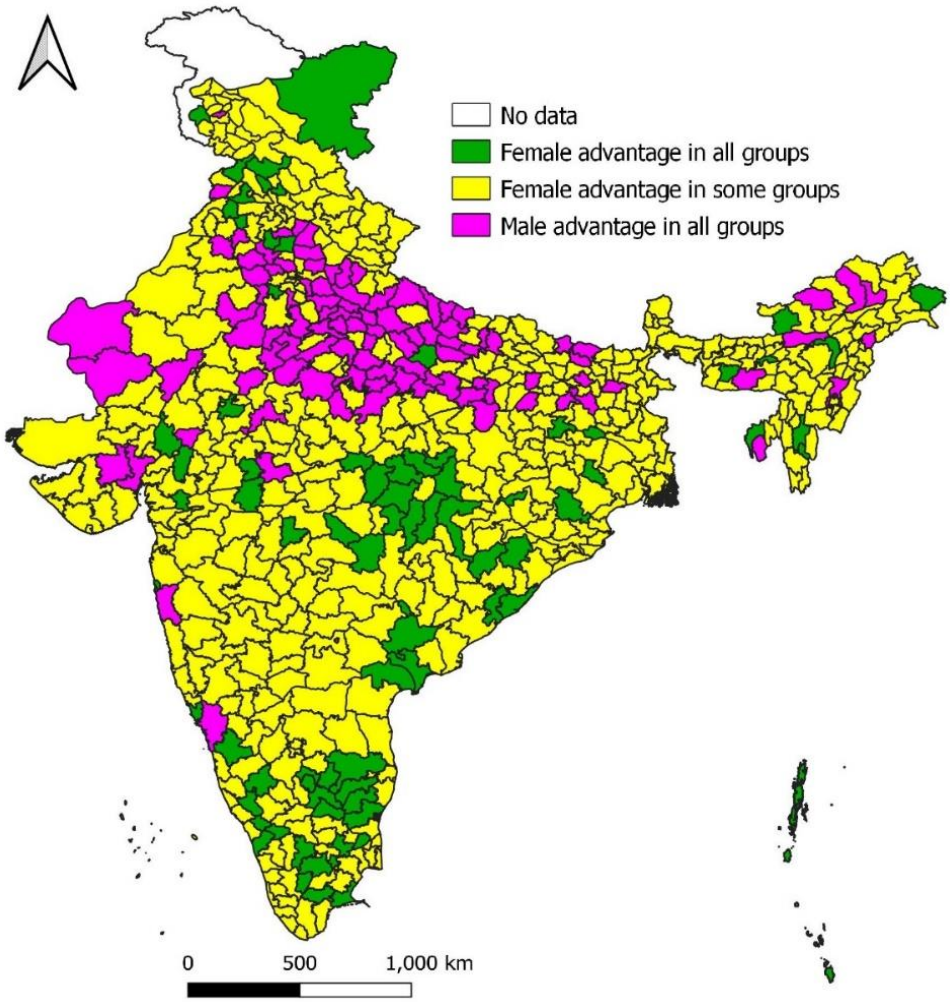

Figure 14: Within-district male-female disparity in survival up to 15 years of age.
Source: Author

Table 3: Distribution of districts by male-female disparity in the probability of survival up to 15 years of age across states/Union Territories.

Country/State/ Union Territory	Male-female disparity in survival in 0-14 years of age						Number of districts
	Female advantage			Male advantage			
	High	Moderate	Marginal	Marginal	Moderate	High	
Andaman & Nicobar Islands	3	0	0	0	0	0	3
Andhra Pradesh	4	5	13	1	0	0	23
Arunachal Pradesh	3	0	4	1	4	4	16
Assam	5	6	8	4	3	1	27
Bihar	0	0	1	3	7	27	38
Chandigarh	0	1	0	0	0	0	1
Chhattisgarh	8	7	2	1	0	0	18
Dadra & Nagar Haveli	0	0	1	0	0	0	1
Daman & Diu	0	1	1	0	0	0	2
Delhi	0	0	0	3	2	4	9
Goa	2	0	0	0	0	0	2
Gujarat	1	5	7	4	7	2	26
Haryana	2	1	1	3	7	7	21
Himachal Pradesh	6	5	0	1	0	0	12
Jammu & Kashmir	2	6	7	5	2	0	22
Jharkhand	3	4	9	5	2	1	24
Karnataka	2	10	6	7	5	0	30
Kerala	1	4	6	3	0	0	14
Lakshadweep	0	0	0	0	0	1	1
Madhya Pradesh	6	9	8	11	8	8	50
Maharashtra	1	8	14	10	2	0	35
Manipur	4	1	2	1	0	1	9
Meghalaya	1	1	1	1	0	3	7

Country/State/ Union Territory	Male-female disparity in survival in 0-14 years of age						Number of districts
	Female advantage			Male advantage			
	High	Moderate	Marginal	Marginal	Moderate	High	
Mizoram	1	2	1	1	2	1	8
Nagaland	0	0	2	5	2	2	11
Odisha	7	5	6	9	3	0	30
Puducherry	4	0	0	0	0	0	4
Punjab	2	1	7	5	2	3	20
Rajasthan	1	1	2	11	7	11	33
Sikkim	1	0	1	1	1	0	4
Tamil Nadu	11	13	7	1	0	0	32
Tripura	0	2	1	0	0	1	4
Uttar Pradesh	0	0	2	7	17	45	71
Uttarakhand	0	1	4	4	4	0	13
West Bengal	0	3	15	1	0	0	19
India	81	102	139	109	87	122	640

Source: Author's calculations

The male-female disparity in the probability of survival up to 15 years of age is the cumulation of the male-female disparity in the probability of survival in age groups below 1 year; 1-4 years; 5-9 years; and 10-14 years. We have carried out a classification modelling exercise using the classification and regression tree (CRT) technique to classify districts by the male-female disparity in the probability of survival up to 15 years of age in terms of the contribution of male-female disparity in survival probability in age groups below 1 year; 1-4 years; 5-9 years; and 10-14 years to the male-female disparity in survival probability in 0-14 years of age. Districts were classified into six categories for the purpose of classification modelling exercise: 1) districts having high female survival advantage; 2) districts having moderate female survival advantage; 3) districts having marginal female survival advantage; 4) districts having marginal male survival advantage; 5) districts having moderate male survival advantage; and 6) districts having high male survival advantage. The independent variables included contribution of male-female disparity in survival in the first year of life; in 1-4 years of life; in 5-9 years of life; and in 10-14 years of life to the male-female disparity in survival in the first 15 years of life. Results of the classification modelling exercise are presented in table 4 and the associated classification tree is depicted in Figure 15.

The classification modelling exercise suggests that 640 districts of the country can be grouped into 6 mutually exclusive, yet exhaustive groups or clusters of districts based on the contribution of male-female disparity in survival in the age groups 5-9 years and 10-14 years and the male-female disparity in survival up to 15 years of age in different groups of districts identified through classification modelling exercise is different. The first group or cluster comprises of 80 districts and all districts of this cluster have high female survival advantage in the first 15 years of life. The high female survival advantage in districts of this cluster is mainly because of the high female survival advantage in the age group 10-14, although a part of this advantage is compensated by male survival advantage in the age group 5-9 years. The second cluster or group of districts comprises of 109 districts out of which 102 districts have moderate female survival advantage, 1 district has high female survival advantage and 6 districts have marginal female survival advantage. The female survival advantage in these districts is also due to the female survival advantage in the age group 10-14 years as the survival advantage is favourable t males in the age group 5-9 years. The third cluster comprises of 134 districts and in 131 districts of this cluster, the probability of survival during the first 15 years of life is marginally favourable to females because of the female survival advantage in the age group 10-14 years. The survival probability in the age group 5-9 years continues to be unfavourable to females in districts of this cluster also. The fourth cluster of districts has 105 districts and 103 districts of this cluster have marginal male survival advantage while 2 districts have marginal female survival advantage. The distinguishing feature of the districts of this cluster is that the probability of survival in the age group 5-9 years is favourable to males. The fifth cluster of districts has 89 districts and all, but 3 districts of this cluster have moderate male survival advantage while 3 have marginal male survival advantage. The male survival advantage in the first 15 years of life in districts of this cluster is mainly because of substantial male survival advantage in the age group 5-9 years. Finally, the sixth and the last cluster has 123 districts and all, but 1 district of this cluster have high male survival advantage while one district has moderate male survival advantage in the first 15 years of life mainly because of high male survival advantage in 5-9 years of age.

Table 4: Results of the classification of districts in terms of male-female disparity in survival up to 15 years of age per 1000 live births by the contribution of male-female disparity in survival in age groups 0-1 year, 1-4 years, 5-9 years, and 10-14 years

Node ID	Contribution of male-female disparity in survival in the age group per 1000 live births				Male-female disparity in survival in the age group 0-14 years per 1000 live births						Total
					Female advantage			Male advantage			
	0-1	1-4	5-9	10-14	High	Moderate	Marginal	Marginal	Moderate	High	
9	All	All	≤0.005	≤-0.300	80	0	0	0	0	0	80
10	All	All	≤0.005	>-0.300 ≤-0.135	1	102	6	0	0	0	109
6	All	All	≤0.005	>-0.135	0	0	131	3	0	0	134
7	All	All	>0.005 ≤0.315	All	0	0	2	103	0	0	105
8	All	All	>0.315 ≤0.665	All	0	0	0	3	86	0	89
2	All	All	>0.665	All	0	0	0	0	1	122	123
All	All	All	All	All	81	102	139	109	87	122	640

Source: Author's calculations

Figure 15: Classification of districts by male-female (M-F) disparity in survival (per 1000 live births) in 0-14 years of age by the contribution of M-F disparity in survival (per 1000 live births) in age groups 0-1 year, 1-4 years, 5-9 years, and 10-14 years.
Source: Author

The accuracy of the classification modelling exercise in classifying a district by male-female disparity in survival up to 15 years of age is found to be 97.5 per cent. There are only 16 districts where classification based on the model differed from the actual observation which shows that the classification modelling exercise has served the purpose. The most important classification variable is found to be the contribution of the male-female disparity in the probability of survival in the age group 10-14 years, closely followed by the male-female disparity in the probability of survival in the age group 5-9 years. The importance of the male-female disparity in survival in the age group 1-4 years in deciding the male-female disparity in the probability of survival up to 15 years of age has been found to be the lowest among the four independent variables used in the classification modelling exercise. The analysis also reveals that the contribution of male-female disparity in survival in the first year of life and male-female disparity in the probability of survival in 1-4 years of life to the male-female disparity in the probability of survival in the 15 years of age across the districts. The male-female disparity in the probability of survival up to 15 years of age is determined largely by the male female disparity in the probability of survival in the age groups 5-9 years and 10-14 years. The contribution of the variation in male-female disparity in the probability of survival in either first of life or in 1-4 years of life to the variation in the probability of survival in the first 15 years of life is not significant.

The classification modelling exercise highlights the importance of male-female disparity in survival in the age groups 5-9 years and 10-14 years in deciding the male-female disparity in survival in the age group 0-14 years across the districts of the country. Male-female disparity in survival in the age groups 0-1 year and 1-4 years also matters in determining the male-female disparity in survival in the age group 0-14 years but the contribution of the male-female disparity in survival in 0-1 year and 1-4 years of age in deciding the male-female disparity in 0-14 years of age is not as important as the contribution of male-female disparity in survival in the age groups 5-9 years and 10-14 years. This observation bears significance at the policy and programme level as the strategy and the interventions required for addressing male-female disparity in survival in age groups 5-9 years and 10-14 years are different from the strategy and interventions required for addressing male-female disparity in survival in age groups 0-1 year and 1-4 years.

Discussions and Conclusions

This paper follows a non-parametric approach to establish empirical 'normal' male-female disparity in the probability of survival in the first 15 years of life across the districts of India. Based on district level estimates of the risk of death in the first 15 years of life derived from the summary birth history data from the 2011 population census, our analysis suggests that the empirical 'normal' male-female disparity in child survival up to 15 years of age in the country is marginally favourable to female in the total population and in the six mutually exclusive yet exhaustive population sub-groups. Deviations from this empirical 'normal' across the districts are substantial and in more than 60 per cent districts of the country, the male-female disparity in the probability of survival up to 15 years of age is quite marked. The analysis also reveals that districts having marked male survival advantage or marked female survival disadvantage are mostly located in the northern part of the country.

In some states and Union Territories, there is not a single district with female survival advantage up to 15 years of age. Similarly, in some states and Union Territories, there is not a single district with male survival advantage. The analysis also reveals that there is substantial male-female disparity in the probability of survival in the first 15 years of life within district across the 6 mutually exclusive and exhaustive population sub-groups characterised by the residence and social class. There are very few districts in the country where there is female survival advantage in all the 6 mutually exclusive and exhaustive population sub-groups in the district. Similarly, there are very few districts where there is male survival advantage in all the 6 mutually exclusive and exhaustive population sub-groups. In most of the districts of the country, female survival advantage or male survival disadvantage in 0-15 years of age in some population sub-groups is found to be associated with female survival disadvantage or male survival advantage in other population sub-groups. Moreover, the classification modelling exercise suggests that inter-district variation in the male-female disparity in the probability of survival in age groups 5-9 years and 10-14 years largely determines the inter-district variation in male-female disparity in the probability of survival in the age group 0-14 years.

The findings of the present analysis have important policy and programme implications. Although, the male-female disparity in child survival varies widely across the districts of the country yet there are districts where this disparity is quite marked either in favour of females or in favour of males. This means that a district-based approach is needed to address the male-female disparity in child survival in these districts. A high female advantage in child survival may be due to low probability of survival of male children from the empirical 'normal.' Similarly, high male advantage in child survival may be due to exceptionally low probability of survival of female children from the empirical 'normal. There is a need to examine the district-specific factors that may be responsible for the male-female disparity in child survival in the district.

The analysis has also revealed that there is substantial male-female disparity in child survival within the district across mutually exclusive population sub-groups classified by residence and social class. This means that the male-female disparity in child survival is also influenced by the residence and social class composition of the population. Reduction in the within-district variation in male-female disparity in child survival across population sub-groups classified by residence and social class may contribute to the reduction in male-female disparity in child survival in the district. Planning and programming for improving child survival at the district should, therefore, be directed towards reducing the variation in the male-female disparity in child survival across different population sub-groups within the same district by evolving and adopting different strategy of addressing male-female disparity in child survival in different population sub-groups. This is important as the present analysis has revealed that there are only a few districts in the country where the direction of the male-female disparity in child survival is the same in all the population sub-groups within the district classified by residence and social class and the composition of population by residence and social class is different in different districts. Lastly, planning and programming for reducing male-female disparity in child survival should also give particular attention to male-female disparity in survival in children older than 5 years of age as male-female disparity in survival in these children varies widely across the districts of the country.

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INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 3(2), July 2023: 241-274

Reproductive Health Advances in Bangladesh: National Policies, Selected Outcomes, and Improved Equity

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Abstract

This paper announces major gains for women in Bangladesh in multiple features. It also shows welcome equity improvements between the poor and the rich over time pertaining to later marriage and first births; pregnancy-related services; short birth-interval and high order births; contraceptive use, and maternal and child mortality. These gains are the result of decades of efforts by Bangladesh to strengthen health infrastructures and to encourage the private sector and NGOs, with a deliberate focus upon reproductive health. This evidence is based on eight nationally representative Demographic and Health Surveys (DHS) carried out in the country over a period of 24 years. These remarkable developments appear to reflect the impact of the series of national policies and programmes covering both public and private sectors and NGOs. We recommend that these efforts should be augmented, and the revolution in reproductive behaviour should be repeatedly traced. The documentation of the change in Bangladesh presented in this paper may also gain the attention of other countries in the region.

Background

The last two decades have seen increasing international attention to reproductive health of women, most notably, in the international goals promulgated by the United Nations. The Millennium Development Goals (MDGs), running from 2000 to 2015 (United Nations, 2000), have been succeeded by the Sustainable Development Goals (SDG) adopted in 2015 (United Nations, 2015) to run through 2030. These goals have sharpened the emphasis upon sexual and reproductive health and rights, especially of women. Sub-goals include adolescent birth rate, coverage of births by skilled personnel, maternal mortality, and infant and child mortality. Bangladesh has accorded special attention to reproductive health issues of women and closely related concerns in all of its five-year plans. In the Fifth Five-Year Plan (1998-2003), a "sector-wide approach" (SWAP) was adopted in the form of an integrated health and population programme which was designed to expand access to essential health care services and to reduce further population growth rate (Government of Bangladesh, 1998). The second SWAP, launched in 2003, aimed at achieving further improvements in health, population, and nutrition (HPN) of the population, especially the vulnerable groups. The goal was to increase the availability and use of services that were

both equitable and affordable. Another aim was a reduction in the total fertility rate (TFR) (Government of Bangladesh, 2004; 2008; 2011a). An early review of these initiatives has been carried out using the data from the Demographic and Health Surveys (DHS) through 2011 to trace the progress in the key reproductive health indicators and to assess programme effects (Ahsan et al, 2015).

The third SWAP (2011-16) incorporated MDGs related to HIV/AIDs and maternal and infant/child mortality (Government of Bangladesh, 2011b). Improvements in the health care system were envisaged, especially, to address special needs of women, children, adolescents, the elderly, and the poor. The goal of achieving replacement level fertility was also included and the use of long-acting and permanent family planning methods and reducing the unmet need of family planning was emphasised (Government of Bangladesh, 2011b). The aim was to raise the contraceptive prevalence rate to 72 per cent of the married women and to achieve the replacement level fertility (TFR=2.1) by the year 2015 (Government of Bangladesh, 2014).

The fourth SWAP (2017-22) incorporated modified strategies and activities to improve both access to and quality of health care services including maternal and child health, nutrition, family planning, reproductive health, and adolescent health. Better equity across income groups was stressed, along with financial protection for the needed services. This coincided with the adoption of the Sustainable Development Goals (SDGs) by the United Nations in September 2015 (United Nations, 2015) and with the evolving attention to lower maternal and child mortality and decline in the prevalence of HIV/AIDS. The 8th Five Year Plan (2020-2025) of the country is continuing with these features, including targets related to maternal mortality, skilled attendance at birth, adolescent births, contraceptive use, and total fertility rate (Government of Bangladesh, 2020). All the SWAPs implemented in the country since 1998 have been "pro-poor" and have contributed to the promotion of equity through the reduction in the rich-poor gap in health-related outcomes, especially, outcomes related to the reproductive health of women.

At the same time, the private health sector and NGOs in the country experienced major expansion of services during this period, notably for the social marketing of contraceptives. Income generation through small loans was also a new departure. The Bangladesh Rural Advancement Committee (BRAC), founded in 1972, focused on low-interest loans and other microfinancing opportunities for the poor women (Chowdhury and Bhuiya, 2004). The scope of the BRAC was subsequently expanded to cover social development programmes in education, health care, and empowerment of women. The BRAC has now established its operations in 11 other countries in South Asia and sub-Saharan Africa. Another initiative taken by Bangladesh was the creation of the Grameen Bank in the mid-1970s, which advanced microcredit through loans to those poor women who could not qualify for regular bank loans. Through the Grameen Bank and the BRAC, the concept of micro-financing to help lift women out of poverty is now well-established in Bangladesh.

The health infrastructure in Bangladesh is extensive and works upward from the village to higher administrative levels. At the grassroots level, there are over 4,000 Union Health and Family Welfare Centres (UHFWCs). At the next level of the administrative hierarchy, there are over 490 rural Upazila Health Complexes, and then there are numerous

Maternal and Child Welfare Centres (MCWCs) at various levels to provide maternal health care services. Some 7600 hospitals in both public and private sectors operate in the country. There are 146197 hospital beds, out of which 54660 are located in hospitals owned by the government. There are over 101000 registered physicians and around 20000 registered nurses who staff these public health facilities. The "maturing" of the health care system in the country is illustrated by improved doctor-population ratio which more than doubled over the last 25 years.

These advances in the public and private health sectors in Bangladesh have plausibly been responsible for historic improvements in the reproductive health status of women of the country as reflected through the trend in selected reproductive health indicators over a period of 25 years beginning 1993. The gains in reproductive health status of women in Bangladesh are remarkable given that it started its journey as one of the poorest countries of the world but has transformed itself into a developing country. In this paper we document the progress in the reproductive health status of women in Bangladesh as revealed through eight rounds of Demographic and Health Survey (DHS) conducted in the country during the period 1993-2018. No precise cause and effect can be shown for the links to the outcomes, but it is useful to juxtapose the two and be attentive to the clear proximate determinants from the outcomes back to direct services provided by the health sector. This follows on an earlier, similar analysis of the trend in India for reproductive health advances (Ross, 2022). The progress is documented from two perspectives. The first is the trend in selected reproductive health indicators related to women and the second is the analysis of the equity in reproductive health of women across different income groups. We have found that, although, Bangladesh has made remarkable progress in meeting the reproductive health needs of its women, yet there are areas of concern that have emerged from the analysis presented in this paper. There are few studies that have assessed the reproductive health situation in Bangladesh (Begum, 1999; El-Saharty et al, 2014). The present study analyses how the reproductive health scenario has changed over time in the country. The 25-year period examined in this paper falls just prior to the Covid-19 Pandemic. As such, the present analysis the past record against which the impact of the Covid-19 Pandemic can be gauged in subsequent surveys.

The paper is organised as follows. The next section of the paper describes the data sources and outlines the methods used for analysing the progress. We have followed the indicator-based approach of analysing progress in reproductive health. On the other hand, odds ratios have been calculated to analyse the trend in the rich-poor gap in selected indicators of reproductive health. Progress in selected reproductive health indicators has been described and discussed in section three of the paper while section four presents findings of the equity analysis. The last section of the paper summarises the findings of the analysis and discusses their policy implications.

Data and Methods

The present paper is primarily based on the analysis of the data available through the eight Demographic and Health Surveys (DHS) conducted in Bangladesh during the period 1993-2018. The first DHS was conducted in Bangladesh in 1993-94 (Mitra et al, 1994)

which was followed by DHS in 1996-97 (Mitra et al, 1997), 1999-2000 (NIPORT, 2001), 2004 (NIPORT, 2005), 2007 (NIPORT, 2009), 2011 (NIPORT, 2013), 2014 (NIPORT, 2016), and 2017-18 (NIPORT, 2020). The methodology adopted in different rounds of DHS has remained more or less the same which allows comparing the reproductive health situation as revealed through different rounds. We have used the open source STATcompiler tool (ICF, 2015) to generate a set of reproductive health indicators for the present analysis. The reproductive health indicators set generated from the data available from different rounds of DHS are given in the appendix table for the period 1993-2018. The focus of the analysis is women aged 15-49 years, either married or in union, although some indicators such as the total fertility rate (TFR) and age-specific fertility rates, pertain to all women aged 15-49 years. Data available from DHS have been supplemented by data drawn from United Nations Population Division, World Bank, and other international agencies.

We assume that the change between two successive rounds DHS is linear. Under this assumption, the annual per cent change between two successive rounds of DHS can be calculated as

$$APC = \frac{1}{t_2 - t_1} \times \left(\frac{x_2 - x_1}{x_1}\right) \times 100$$

where t_1 is the year of the first survey, t_2 is the year of second survey, x_1 is the value of the reproductive health indicator in the first survey, and t_2 is the value of the reproductive health indicator in the second survey. The change between different rounds of DHS may be different so that APC in different time segments may not be the same. We combine APC in different time segments into the average annual per cent change (AAPC) during the entire reference period as follows:

$$AAPC = \sum_i w_i \times APC_i$$

where w_i is the proportionate length of the time segment i relative to the total reference period. The *AAPC* reflects the trend in a more appropriate manner than the conventional way of calculating the change by considering only the beginning and end of the reporting period (Clegg et al, 2009). *AAPC* takes into consideration the different pace of change in different time segments of the reference period.

On the other hand, the equity analysis has been carried out by calculating the inequality in reproductive health indicators across wealth index quintiles groups with the richest wealth index quintiles group serving as the reference. The index of inequality across the five wealth index quintiles groups has been calculated as

$$I = \frac{1}{x_{ir}} \times \sqrt{\frac{\sum\left(x_{ij} - x_{ir}\right)^2}{5}}$$

where x_{ij} is the value of the indicator i in the wealth index quintiles group j and x_{ir} is the value of the indicator i in the richest wealth index quintiles group or the reference group. The index I is zero when the value of the indicator is the same in all wealth index quintiles groups whereas the higher the index I the higher the inequality.

Progress in Reproductive Health

Table 1 gives annual per cent change (APC) in different time segments of the period 1993-2018 in different reproductive health indicators along with the average annual per cent change (AAPC) in the entire reference period which gives an idea about the change in the reproductive health indicator during the 25-years time horizon from 1993 through 2018. The table gives the snapshot of the progress in reproductive health of women of the country over a period of 25 years. The progress is different with reference to different reproductive health indicators. However, the overall improvement in the reproductive health status of the women of the country is very much evident from the table. To be more specific, we have discussed in the following pages the progress in different dimensions of reproductive health of women.

Time of Marriage and Time of First Birth. Women in Bangladesh generally get married at a very young age. The median age of marriage of females in the country is the fourth lowest in the world and the lowest first in Asia (United Nations, 2018). The good sign, however, is that the age at marriage of females in the country is increasing. The median age at marriage of women aged 20-24 years increased from 15.3 years in 1993 to 17.3 years in 2018, a rise of 13 per cent. A more telling measure is the proportion of women marrying by exact age 15 years, 18 years, and 20 years as shown in figure 1. The proportion of women who got married by 15 years of age decreased sharply from 47.2 per cent to less than 20 per cent between 1993 and 2018. The decrease in women who got married by 18 years of age and by 20 years of age has been comparatively less, but the decrease is very much evident from the figure.

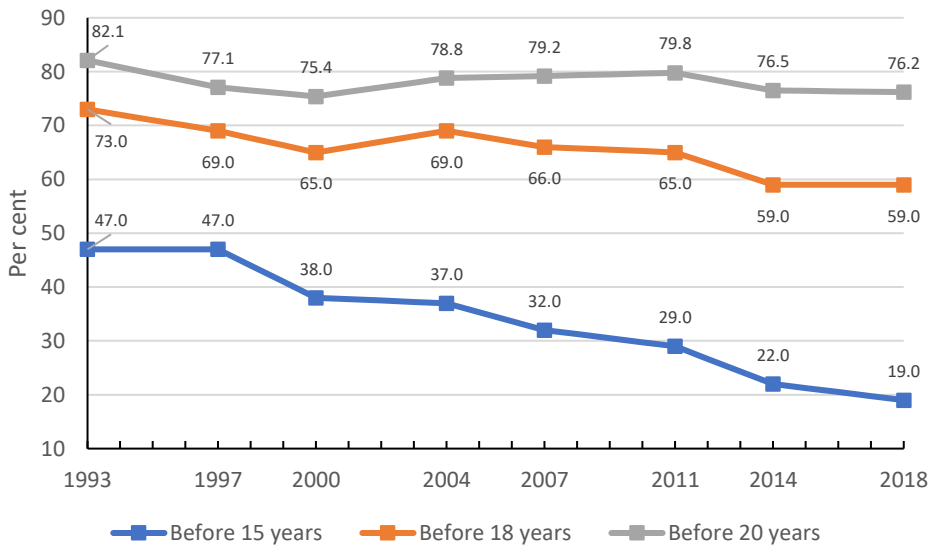

Figure 1: Proportion of women aged 20-24 years who got married before reaching 15 years, 18 years, and 20 years of age in Bangladesh, 1994-2017.
Source: Authors based on data from different rounds of DHS.

The median age at marriage of females in Bangladesh increased by an AAPC of around 0.5 per cent per year from 15.3 years in 1993 to 17.3 years in 2018. The increase in the median age at marriage of females was the most rapid during 1997-2000. The median age at marriage of females also increased very rapidly during 2011-2014. On the other hand, there has been virtually no change in the median age at marriage of females during 1993-1997 whereas it decreased, instead increased, 2000-2004 according to DHS. It may be seen from the table that most of the increase in the median age at marriage of females was confined to the time segments 1997-2000 and 2011-2014. Data available from DHS suggests that in other time segments, there has been only a marginal increase in the median age at marriage of women.

The proportion of women aged 20-24 years who got married before reaching 15 years of age decreased annually by more than 3 per cent per year during the 25 years period under reference. The decrease in this proportion was the most rapid during 2011-2014 when this proportion decreased by more than 8 per cent per year. However, the decrease in this proportion has slowed down considerably during 2014-2018. On the other hand, the proportion of women aged 20-24 years who got married before reaching 18 years of age decreased by just around 0.8 per cent per year during 1993-2018. The decrease in this proportion was very rapid during 2011-2014 but there has been no change in this proportion during 2014-2018. By comparison, the decrease in the proportion of women aged 20-24 years who got married before reaching 20 years of age was only marginal, from around 82 per cent in 1993 to around 76 per cent in 2018. The decrease in this proportion also nearly stagnated during the period 2014-2018. This proportion increased, instead decreased, during the period 2000-2011, but the decrease was quite rapid during the period 2011-2014.

When the age at marriage of females increases, the age at first birth also increases. Figure 2 shows the trend in the proportion of women aged 20-24 years who had their first birth before reaching 15 years of age; before reaching 18 years of age; and before reaching 20 years of age. In 1993, around 15 per cent married women aged 20-24 years had their first birth before 15 years of age. This proportion decreased to less than 6 per cent in 2018, the decrease has been the most rapid during 2014-2018. On the other hand, the proportion of women aged 20-24 years who had their first birth before 18 years of age decreased at around 1.4 per cent per year during the last 25 years and most of the decrease was confined to the period 2011-2018. By comparison, the decrease in the proportion of married women aged 20-24 years who had their first birth before 20 years of age decreased only marginally at around 0.4 per cent per year on average. The decrease in this proportion was very rapid during 2011-2014 but it slowed down considerable during 2014-2018.

In Bangladesh, the age at marriage of females signals the beginning of socially acceptable reproductive life, the lower the age at marriage the longer the reproductive life of the female. Female age at marriage also has implications for the education of women. The female age at marriage and the associated age at first birth has a telling impact on the level of fertility. The evidence available from different rounds of DHS suggests that although there has been improvement in the marriage dimension of the reproductive health of women in Bangladesh, the slowdown in the increase in the female age at marriage and in the age at first birth is a matter of concern from the policy perspective.

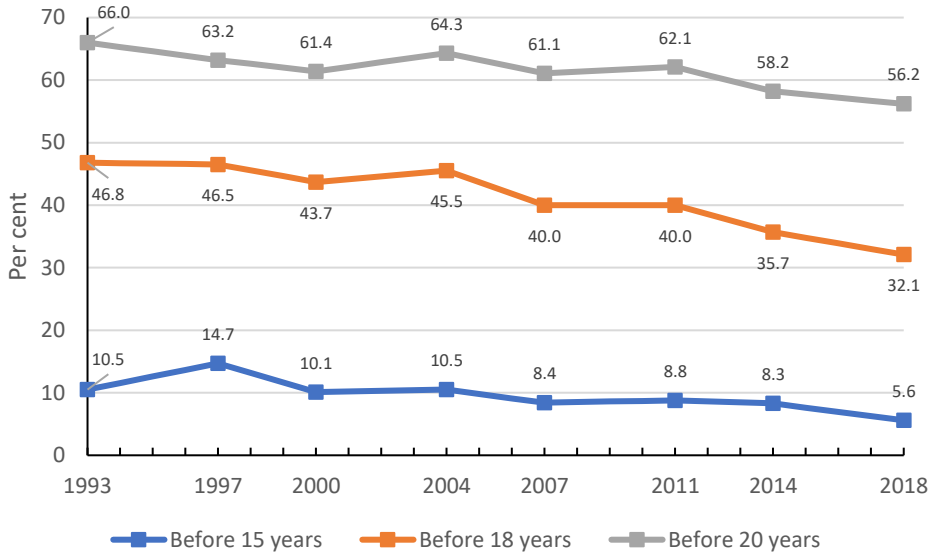

Figure 2: Proportion of women aged 20-24 years who delivered first birth before reaching 15 years of age; before reaching 18 years of age; and before reaching 20 years of age in Bangladesh, 1994-2018.
Source: Authors based on data from different rounds of DHS.

The delay in the time of marriage and the postponement of the first birth contribute not only to the improvement in the reproductive health status of women but also to the reduction in fertility. The total fertility rate (TFR) in Bangladesh decreased by about one-third from 3.4 births per woman of reproductive age in 1993 to 2.3 births per women of reproductive age in 2018. Nearly all the decrease in the fertility of Bangladesh has been confined to the period 2000-2011 when the TFR decreased from 3.3 to 2.3 births per woman of reproductive age. TFR in Bangladesh is still above the replacement fertility of 2.1 births per woman of reproductive age which has emerged as a matter of serious concern to Bangladesh.

Antenatal, Natal, and Postnatal Care. For health care services surrounding pregnancy and childbirth, available indicators show remarkable upward trend from 2004 onwards (Figure 3). The latest round of DHS suggests that more than 80 per cent of the pregnant women in Bangladesh had received at least one antenatal visit by a trained health care services provider in 2018, and nearly half of them had received at least four visits by "any" health care services provider – trained or untrained. Majority of the services providers during pregnancy and at the time of the delivery are either doctors or nurses/midwives. Similarly, the proportion of the deliveries which were assisted by a skilled provider increased from less than 10 per cent in 1993 to almost 54 per cent in 2018. On the other hand, the proportion of women who received a postnatal visit within two days of the delivery increased from less than 20 per cent in 2004 to more than 50 per cent in 2018. Although, these trends are remarkable, yet they leave sufficient scope for the realisation of universal access to antenatal, natal and postnatal care in the country.

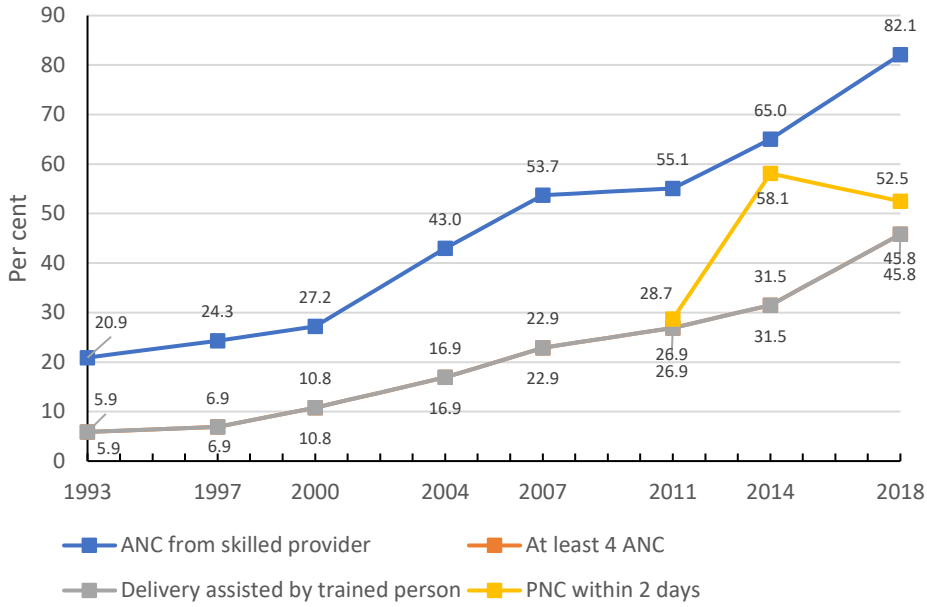

Figure 3: Trends in selected indicators of antenatal, natal and postnatal care in Bangladesh, 1993-2018.
Source: Authors, based on data from different rounds of DHS.

Birth Interval. When births occur at short birth intervals, the health risks to the mother and the child are elevated. The reduction in the proportion of births with a short birth interval (less than 36 months) is, therefore, an important indicator of the reproductive health status of women. The median birth interval in Bangladesh increased sharply from 34.7 months in 1993 to more than 55 months in 2018 at an AAPC of almost 2 per cent per year. The increase in the median birth interval reflects the rise in the use of contraceptive methods, especially for birth spacing. The increase in the median birth interval may be attributed mainly to both decrease in the proportion of births with a birth interval of less than 36 months and increase in the proportion of births with birth interval of at least 60 months (Figure 4). The proportion of births with a birth interval of less than 36 months in Bangladesh decreased by more than 50 per cent from almost 54 per cent in 1993 to just around 25 per cent in 2018 which implies that this proportion decreased at an AAPC of almost 2.9 per cent per year. On the other hand, the proportion of births with a birth interval of at least 60 months increased from just around 12 per cent in 1993 to around 45 per cent in 2018 which implies that this proportion increased at an AAPC of almost 5.9 per cent per year during the 25 years under reference. These improvements are impressive and have implications to the health of both mothers and children. However, the increase in the proportion of births with a birth interval of at least 60 months slowed down considerably during 2014. The APC in this proportion during 2014-2018 was the lowest among different time segments of the period 1993-2018 as may be seen from table 1. There is a need to explore reasons for the slowdown in the increase in the proportion of births with a birth interval of at least 60 months.

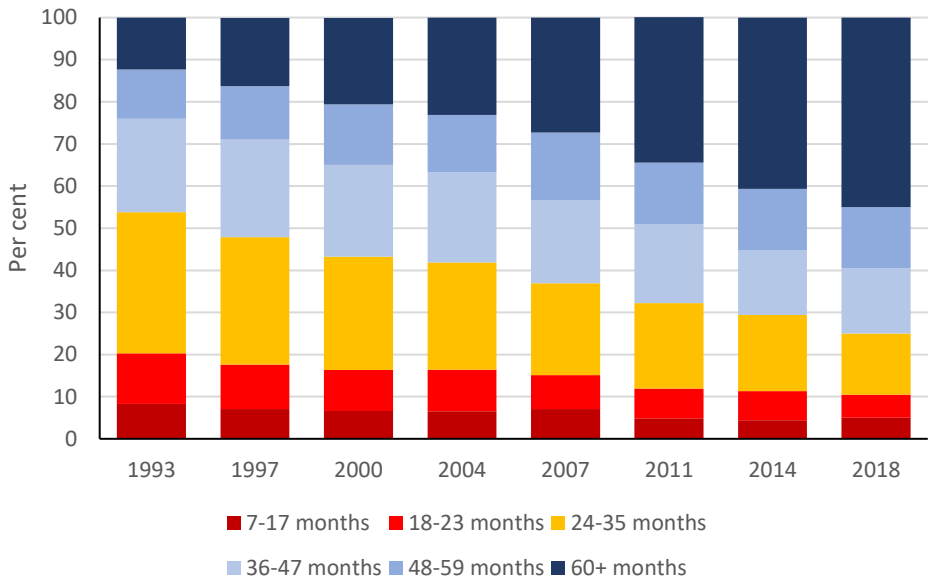

Figure 4: Distribution of births by birth interval in Bangladesh, 1993-2018.
Source: Authors based on data from different rounds of DHS.

Family Planning. The contraceptive prevalence rate in Bangladesh has increased from around 45 per cent in 1993 to more than 61 per cent in 2011. On the other hand, the prevalence of modern methods of family planning increased from 37 per cent in 1993 to around 54 per cent in 2014 but decreased sharply to less than 52 per cent in 2018 (Figure 5). This means that the prevalence of traditional family planning methods increased from around 8 per cent in 1993 to 9 per cent in 2018 which is an area of concern. Similarly, a matter of serious concern is that the prevalence of contraception in the country has almost stagnated since 2011 whereas there is a clear indication of the decrease in the prevalence of modern methods of family planning. The stagnation in the contraceptive prevalence rate and the decrease in the prevalence of modern methods of family planning appear to be a factor in the stagnation of TFR in the country at around 2.3 births per woman of reproductive age after 2011.

The unmet need of family planning in the country decreased from about 22 per cent to around 12 per cent but there has been no decrease in the unmet need for family planning since 2014. The unmet need of family planning for limiting or stopping births has decreased but the unmet need of family planning for birth spacing has virtually stagnated since 2011 which is also a matter of concern in the context of the reproductive health status of women of the country. Combining the contraceptive prevalence rate and the unmet need for family planning, the total demand for family planning in the country increased only marginally from 67 per cent in 1993 to less than 74 per cent in 2018. The demand for family planning in the country remains low by international standards. The total demand for family planning in the country recorded an increase during 1993-2011 but demand for family planning has decreased continuously since 2011 which is also a matter of concern.

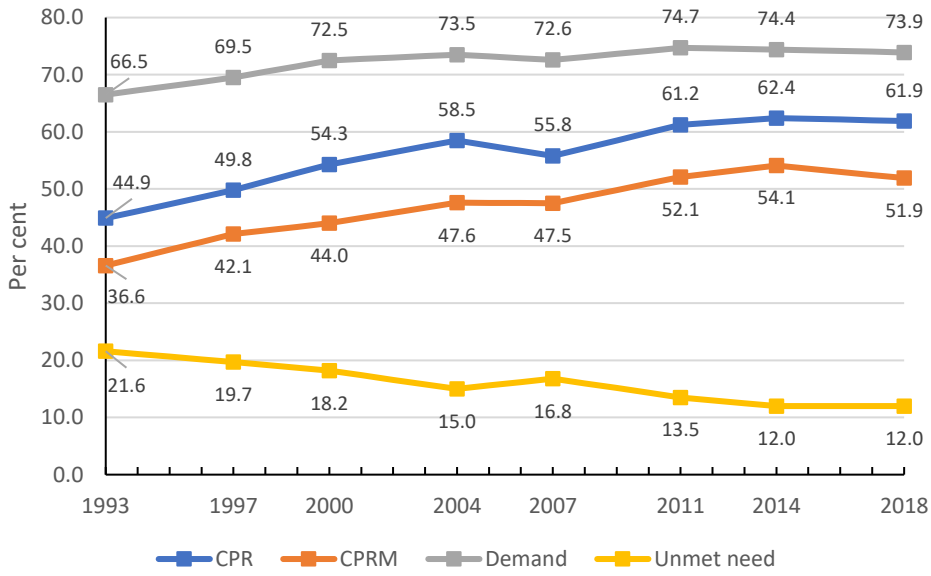

Figure 5: Demand for family planning and indicators of family planning use in Bangladesh, 1993-2018.
Source: Authors based on data from different rounds of DHS.

A similar trend can also be observed in case of the proportion of women who wanted either to postpone or to stop the next birth at the time of the survey. This proportion increased from almost 58 per cent in 1993 to almost 65 per cent in 2011 but has decreased after 2011. In 2018, less than 60 per cent of the married women wanted to postpone or to stop their next child. This observation, in conjunction with the observation that the demand for contraception has decreased after 2011 indicates that there has been an unwelcome change in the reproductive behaviour of the people of the country. Reasons for this change in the reproductive behaviour of the people of the country need to be explored. In any case, this change in the reproductive behaviour has implications for the reproductive health of women.

The observation that a substantial proportion of women in Bangladesh want to either delay or stop the next birth indicates that a sizeable proportion of unwanted pregnancies in Bangladesh would have undoubtedly been aborted. Estimates of the incidence of abortion are not available in Bangladesh. However, menstrual regulation is commonly used in Bangladesh to avoid unwanted pregnancies. According to the latest round of DHS, more than 70 per cent of the ever-married women knew of menstrual regulation as a method to avoid pregnancy, although only 7 per cent of them had practised this method. The method appears to be more common among old as compared to young women as almost 11 per cent of the ever-married women aged 40-44 years reported that they had used the method. A study based on the data from the 2014 round of DHS has revealed that more than 12 per cent of the ever-married women had used this method for avoiding the pregnancy (Rana et al, 2019).

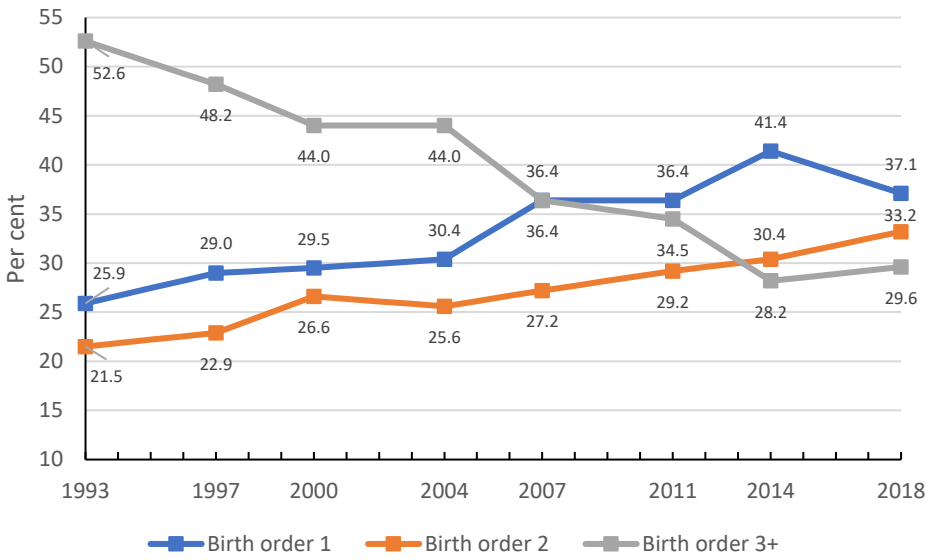

Figure 6: Distribution of births by birth order Bangladesh, 1993-2018.
Source: Authors based on data from different rounds of DHS.

There has also been a very significant decrease in the proportion of higher order births in the country during the 25 years period under reference. The proportion of third and higher order births in the country decreased from 53 per cent in 1993 to 28 per cent in 2014. However, this proportion increased after 2014 as may be seen from the figure 6. The increase in the proportion of third and higher order births has been associated with the decrease in the proportion of first order births. However, the proportion of 2nd order births in the country increased from around 21 per cent to almost 30 per cent during the 25 years under reference.

Maternal, Infant, and Child Mortality. Estimates of maternal mortality ratio and the life time risk of a maternal death are not available from the DHS. However, the World Health Organization, in collaboration with its sister agencies, has prepared estimates the maternal mortality ratio and life time risk of a maternal death for its member countries, for the period 2000-2020 (WHO, 2023). These estimates suggest that Bangladesh has experienced a major decrease in the maternal mortality ratio from an estimated 441 maternal deaths for every 100 thousand live births in 2000 to 123 maternal deaths for every 100 thousand live births in 202020. On the other hand, it is estimated that one in every 390 women in the country face the life time risk of a maternal death. Although, the risk of death associated with the complications of pregnancy and child birth has decreased quite rapidly in Bangladesh during 2000-2020, yet this risk remains very high by international standards. One reason, probably and so obviously, is that the proportion of deliveries assisted by a skilled provider remains quite low. According to the latest DHS, less than 55 per cent of the deliveries in the country were assisted by a skilled services provider in 2018. Improving skilled assistance at delivery may contribute significantly towards reducing the risk of death due to complications of pregnancy and child birth in the country.

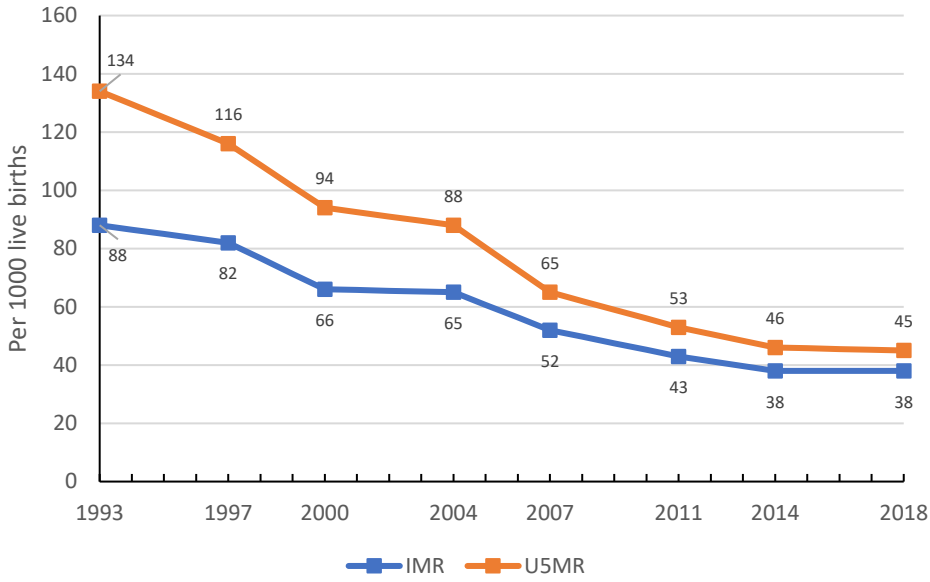

Figure 6: Infant mortality rate and under-five mortality rate in Bangladesh, 1993-2018. Source: Different rounds of DHS.

As regards the risk of death in the first five years of life, Bangladesh has recorded a sharp decline in the risk of death in the first five years of life (U5MR) during the 25 years under reference, from 134 under-five deaths to 45 under-five deaths for every 1000 live births between 1993 and 2018 (Figure 7). However, the decrease in this risk almost stagnated after 2014 as the U5MR decreased from 46 to 45 under-five deaths for every 1000 live births between 2014 and 2018. The decrease in U5MR in the country was the most rapid during 1993-2000 when it decreased from 134 to 94 under-five deaths for every 1000 live births in a period of seven years only. The decreased slowed down considerably during 2000-2004. However, the decrease decelerated continuously after 2004 despite high levels of U5MR.

Compared to the decrease in the risk of death in the first five years of life, the decrease in the risk of death in the first year of life has been slower during the period under reference as the infant mortality rate (IMR) decreased from 88 infant deaths for every 1000 live births to 38 infant deaths for every 1000 live births between 1993 and 2018 and the decrease in IMR virtually stagnated during 2014-2018 at an unacceptably high level. Like the decrease in U5MR, most of the decrease in IMR was also confined to the period 1993-2000 when IMR decreased from 88 to 66 infant deaths for every 1000 live births in a period of seven years. However, the decrease in IMR nearly stagnated during 2000-2004 and, like U5MR, the decrease in IMR also decelerated continuously after 2004. The near stagnation in the decrease in the risk of death in the first five years of life in Bangladesh after 2014 is a matter of serious concern as the prevailing risk of death during childhood in the country remains high by international standards and well above the targets set under the United Nations Sustainable Development Agenda.

Table 1: Trend in selected reproductive health indicators in Bangladesh, 1993-2018.

Reproductive health indicator	Annual per cent change (APC)							Average annual per cent change 1993-2018
	1993-1997	1997-2000	2000-2004	2004-2007	2007-2011	2011-2014	2014-2018	
Time of marriage and first birth								
Median age at marriage	0.000	1.743	-0.155	0.833	0.305	1.205	0.145	0.501
Women aged 20-24 years married before 15 years of age	0.000	-6.383	-0.658	-4.505	-2.344	-8.046	-3.409	-3.298
Women aged 20-24 years married before 18 years of age	-1.370	-1.932	1.538	-1.449	-0.379	-3.077	0.000	-0.809
Women aged 20-24 years married before 20 years of age	-1.523	-0.735	1.127	0.169	0.189	-1.378	-0.098	-0.282
Women aged 20-24 years who had first by 15 years of age	10.000	-10.431	0.990	-6.667	1.190	-1.894	-8.133	-1.631
Women aged 20-24 years who had first by 18 years of age	-0.160	-2.007	1.030	-4.029	0.000	-3.583	-2.521	-1.419
Women aged 20-24 years who had first by 20 years of age	-1.061	-6.224	6.274	-1.659	0.409	-2.093	-0.859	-0.435
Fertility								
Total fertility rate	-0.735	0.000	-2.273	-3.333	-3.704	0.000	0.000	-1.474
Fertility of women 15-19 years	1.250	-0.680	-1.215	-2.676	-1.587	-1.412	-1.106	-0.998
Fertility of women 20-24 years	-0.510	-0.694	0.399	-3.141	-2.890	-2.179	0.000	-1.202
Fertility of women 25-29 years	-1.266	3.333	-4.848	-1.504	-3.937	0.935	0.909	-1.131
Fertility of women 30-34 years	-2.143	1.042	-4.040	-5.221	-5.000	0.595	1.754	-1.939
Fertility of women 35-39 years	-5.357	0.000	-1.136	-6.349	-9.559	4.762	-6.250	-3.759
Fertility of women 40-44 years	-1.316	0.000	-1.389	-13.725	-10.000	-11.111	6.250	-4.013
Fertility of women 45-49 years	-14.286	-16.667	-8.333	-16.667	50.000	22.222	-20.000	-0.152
Proportion of third and higher order births	-2.091	-2.905	0.000	-5.758	-1.305	-6.087	1.241	-2.115
Total wanted fertility rate	-1.136	1.587	-3.409	0.000	-3.947	2.083	0.000	-0.918

Reproductive health indicator	Annual per cent change (APC)							Average annual per cent change 1993-2018
	1993-1997	1997-2000	2000-2004	2004-2007	2007-2011	2011-2014	2014-2018	
Family planning								
Total demand for family planning	1.128	1.439	0.345	-0.408	0.723	-0.134	-0.168	0.432
Contraceptive prevalence rate	2.728	3.012	1.934	-1.538	2.419	0.654	-0.200	1.356
Prevalence of modern family planning methods	3.757	1.504	2.045	-0.070	2.421	1.280	-1.017	1.479
Unmet need of family planning	-2.199	-2.538	-4.396	4.000	-4.911	-3.704	0.000	-2.110
Unmet need for spacing	-2.336	-4.124	-5.294	0.000	-4.851	-0.617	0.472	-2.490
Unmet need for limiting	-2.064	-1.000	-3.608	7.229	-4.950	-5.761	-0.373	-1.703
Women wanting to delay or stop next birth	0.389	0.680	0.042	1.331	0.960	-1.233	-1.040	0.149
Birth interval								
Median birth interval	1.441	1.907	0.322	3.647	2.179	3.024	1.934	1.970
Births with birth interval less than 36 months	-2.695	-3.333	-0.752	-3.978	-3.252	-2.804	-3.741	-2.884
Births with birth interval at least 60 months	7.927	8.848	3.171	6.061	6.593	5.990	2.641	5.761
Child mortality								
Infant mortality rate	-1.705	-6.504	-0.379	-6.667	-4.327	-3.876	0.000	-3.071
Under-five mortality rate	-3.358	-6.322	-1.596	-8.712	-4.615	-4.403	-0.543	-3.950
Antenatal, natal and postnatal care								
Antenatal care from a skilled provider	4.067	3.978	14.522	8.295	0.652	5.989	6.577	6.322
Antenatal visits for pregnancy: 4+ visits	4.237	18.841	14.120	11.834	4.367	5.700	11.349	9.817
Assistance during delivery from a skilled provider	-1.359	16.475	4.808	15.699	11.075	11.550	5.418	8.437
Mother first postnatal checkup within two days after birth	na	na	na	na	na	34.146	-2.410	13.257

Source: Authors' calculations based on the data available from different rounds of DHS in Bangladesh.
na Not available.

Reproductive Health Inequality

It is well-known that with the improvements in reproductive health, inequality across population sub-groups at different standards of living reduces and reproductive health status across population sub-groups converges. Information about selected reproductive health indicators by wealth index quintiles groups – poorest, poor, average, rich and richest – are available from DHS with roughly 20 per cent of the households in each wealth index quintiles group. Selected reproductive health indicators across five wealth index quintiles groups in Bangladesh are given in the appendix table 2 for different rounds of DHS. The table reflects the inequality in reproductive health across five wealth index quantiles groups and the change in this inequality over time. The table suggests that, although there has been a decrease over time, there still exists a substantial degree of inequality in reproductive health status of women across different wealth index quintiles groups in the country.

Table 2 presents estimates of the index of inequality in different reproductive health indicators across wealth index quintiles groups for different years of the period 1993-2018. The trend in the index of inequality reflects the progress towards equity in reproductive health status of women in the country. The table reflects that there has been, in general, progress towards reproductive health equity in the country during the period under reference as reflected in the decrease in the index of inequality in most of the reproductive health indicators during the 25 years under reference. There are, however, some disturbing trends as the index of inequality has increased in recent years with respect to some indicators related to fertility and family planning. Although, the inequality in the level of fertility across wealth index quintiles groups has decreased consistently from 0.485 in 2004 to 0.177 in 2018, yet the inequality in the fertility of women aged 15-19 years has increased in 2018 relative to 2014. There has also been an increase in the inequality across wealth index quintiles groups in recent years in most of the indicators related to family planning. The inequality in the demand for family planning across different wealth index quintiles groups has increased because of the increase in the inequality across wealth index quantiles groups in both contraceptive prevalence rate and prevalence of modern methods of contraception. Similarly, there has been an increase in the inequality across wealth index quantiles groups in terms of the unmet need of family planning for birth spacing, although the inequality across wealth index quintiles groups in terms of the unmet of family planning for birth limitation has decreased consistently during the period under reference. There has also been an increase in recent years in the inequality across wealth index quintiles groups in the proportion of women who wanted either to delay or stop their next birth. Similarly, the inequality across wealth index quintiles groups in the proportion of women who had their first birth respectively by the age of 15 years, 18 years, and 20 years has also increased in recent years. The index of inequality across different wealth index quantiles groups has also increased between 2014 and 2018 in terms of the proportion of women who had undergone a health check-up within 2 days of the delivery as reflected through the increase in the index of inequality. It appears that, in recent years, there has been a diverging trend in the reproductive behaviour of women of different wealth index quantiles groups. Reasons behind the observed diverging trend in recent years are not known at present, but they need an examination from the policy perspective.

Table 2: Index of inequality across wealth index quintiles groups in Bangladesh, 1993-2018.

Reproductive health indicator	Year							
	1993	1997	2000	2004	2007	2011	2014	2018
Time of marriage and first birth								
Median age at marriage	na	na	ma	0.136	0.125	0.100	0.089	0.073
Women aged 20-24 years married before 15 years of age	0.641	0.850	0.850	0.721	0.783	0.746	0.659	0.639
Women aged 20-24 years married before 18 years of age	0.204	0.278	0.343	0.301	0.306	0.274	0.259	0.235
Women aged 20-24 years married before 20 years of age	0.103	0.104	0.123	0.116	0.128	0.101	0.123	0.096
Women aged 20-24 years who had first by 15 years of age	0.465	1.063	0.954	1.290	1.778	1.237	1.268	1.778
Women aged 20-24 years who had first by 18 years of age	0.413	0.469	0.690	0.551	0.628	0.593	0.587	0.696
Women aged 20-24 years who had first by 20 years of age	0.220	0.278	0.364	0.278	0.317	0.299	0.318	0.337
Fertility								
Total fertility rate	na	na	na	0.485	0.298	0.327	0.206	0.177
Fertility of women 15-19 years	na	na	na	0.785	0.815	0.580	0.276	0.530
Fertility of women 20-24 years	na	na	na	0.406	0.204	0.339	0.231	0.115
Fertility of women 25-29 years	na	na	na	0.218	0.125	0.155	0.136	0.094
Fertility of women 30-34 years	na	na	na	na	na	na	na	na
Fertility of women 35-39 years	na	na	na	na	na	na	na	na
Fertility of women 40-44 years	na	na	na	na	na	na	na	na
Fertility of women 45-49 years	na	na	na	na	na	na	na	na
Proportion of third and higher order births	0.249	0.477	0.391	0.440	0.445	0.652	0.879	0.478
Total wanted fertility rate	na	na	na	0.325	0.205	0.112	0.063	0.037

Reproductive health indicator	Year							
	1993	1997	2000	2004	2007	2011	2014	2018
Family planning								
Total demand for family planning	0.104	0.070	0.068	0.040	0.037	0.020	0.011	0.036
Contraceptive prevalence rate	0.183	0.167	0.155	0.081	0.078	0.019	0.013	0.057
Prevalence of modern family planning methods	0.157	0.152	0.149	0.059	0.045	0.030	0.030	0.088
Unmet need of family planning	0.135	0.303	0.312	0.169	0.132	0.103	0.107	0.099
Unmet need for spacing	0.127	0.264	0.382	0.255	0.121	0.165	0.108	0.156
Unmet need for limiting	0.161	0.376	0.265	0.139	0.236	0.088	0.133	0.071
Women wanting to delay or stop next birth	0.043	0.068	0.019	0.073	0.081	0.088	0.107	0.141
Birth interval								
Median birth interval	0.080	0.109	0.168	0.130	0.125	0.176	0.125	0.076
Births with birth interval less than 36 months	0.180	0.230	0.206	0.187	0.210	0.388	0.378	0.276
Births with birth interval at least 60 months	0.383	0.352	0.385	0.258	0.278	0.279	0.173	0.118
Child mortality								
Infant mortality rate	na	na	na	na	na	na	na	na
Under-five mortality rate	na	na	na	na	na	na	na	na
Antenatal, natal and postnatal care								
Antenatal care from a skilled provider	0.613	0.632	0.613	0.486	0.442	0.431	0.344	0.195
Antenatal visits for pregnancy: 4+ visits	0.824	0.782	0.769	0.692	0.626	0.578	0.508	0.421
Assistance during delivery from a skilled provider	0.731	0.761	0.732	0.712	0.685	0.558	0.482	0.414
Mother first postnatal checkup within two days after birth	na	na	na	na	na	0.582	0.328	0.421

Source: Authors' calculations based on the data available from different rounds of DHS in Bangladesh.
na Not available.

Another way of analysing the reproductive health inequality is to compare reproductive health indicators in a wealth index quintiles group with the reproductive health indicator in the richest wealth index quintiles group. This can be done by calculating the odds ratio. The odds ratio is one if the value of the reproductive health indicator in a wealth index quintiles group is the same as in the richest wealth quintiles group. A deviation from 1 in the odds ratio signals the inequality. The odds ratio converges to 1 when the rich-poor gap diminishes, and that depends upon how the paths of the poor and the rich move relative to each other. Often the improvement in different wealth index quintiles groups comes closer to the richest wealth index quintiles group, and this may happen while the reproductive health status is improving in all wealth index quantiles groups. This is the "ideal" result, even if the final levels of the indicator may still leave much to be achieved. It may, however, be noted that odds ratios can be calculated in case of proportions only.

The odds ratios are presented in table 3. The movement towards equity has been different in different reproductive health indicators. In some, there is evidence of rich-poor convergence whereas in other, there appears a divergence over time. For example, the rich poor gap in the female marriage behaviour has narrowed in Bangladesh. In 1993, the poorest women aged 20-24 years were more than 3 times more likely to get married before 15 years of age compared to their richest counterparts. This ratio decreased to less than 2.5 times in 2018. There has, however, been little change in the rich-poor odds ratio in women aged 20-24 years marrying by 18 years of age and by 20 years of age. On the other hand, the gap between the richest and the poorest women in terms of the proportion giving first birth by 15 years; 18 years; and 20 years of age has decreased over time.

The richest-poorest gap in family planning has, however, increased over time, especially in recent years. Similarly, the riches-poorest gap in the proportion of women wanting to delay or stop the next birth has also increased. Similarly, the richest-poorest gap in the proportion of third and higher order births has also increased with time. The diverging trend in the reproductive behaviour of the rich and the poor people in the country is an area of concern. On the other hand, there is virtually little change in the richest-poorest gap in the proportion of births with birth interval less than 36 months.

The trend in the richest-poorest gap in antenatal, natal and postnatal care services has been mixed. The richest-poorest gap in the proportion of women who received antenatal care from a skilled service provider has increased over time but the gap in terms of the proportion of women receiving at least four antenatal visits during the antenatal period has decreased. On the other hand, the richest-poorest gap in the proportion of women who were assisted by a skilled provider at the time of the delivery decreased during the period 1993 through 2014 but this gap increased quite rapidly after 2014. Similarly, the richest-poorest gap in the proportion of women who had a health check-up within two days after the delivery has been higher in 2014 and 2018 as compared to the richest-poorest gap observed in 2011, although this gap appears to have decreased between 2014 and 2018. These observations indicate a mixed trend in the progress towards equity in reproductive health in the country. There has been remarkable progress towards equity in some dimensions of reproductive health of women, but the progress towards equity appears to have reversed, particularly, in recent years in other dimensions of the reproductive health of women.

Table 3: Odds ratios of different wealth index quintiles groups in selected reproductive health indicators in Bangladesh, 1993-2018.

Indicator and year	Wealth index quintiles group				
	Poorest	Poor	Middle	Rich	Richest (Reference group)
Proportion of women aged 20-24 years married by 15 years of age					
1993	3.093	2.970	2.154	1.621	1
1997	4.056	3.734	2.303	1.958	1
2000	3.144	3.545	2.267	1.448	1
2004	3.431	2.808	1.860	1.231	1
2007	3.407	2.349	2.154	1.405	1
2011	3.037	2.244	1.952	1.519	1
2014	2.791	1.889	1.598	1.329	1
2018	2.475	1.888	1.779	1.181	1
Proportion of women aged 20-24 years married by 18 years of age					
1993	2.306	2.306	1.839	1.364	1
1997	2.455	2.455	1.909	1.661	1
2000	2.571	2.571	2.226	1.632	1
2004	3.273	2.455	1.909	1.588	1
2007	2.969	2.398	2.069	1.330	1
2011	2.808	2.069	1.721	1.387	1
2014	2.676	1.628	1.437	1.325	1
2018	2.333	1.632	1.564	1.222	1
Proportion of women aged 20-24 years married by 20 years of age					
1993	1.864	1.894	1.574	1.521	1
1997	1.687	1.635	1.548	1.311	1
2000	1.686	1.811	1.548	1.360	1
2004	2.027	1.650	1.569	1.503	1
2007	2.224	1.853	1.756	1.320	1
2011	1.907	1.825	1.424	1.286	1
2014	2.064	1.649	1.572	1.316	1
2018	1.772	1.385	1.441	1.325	1
Proportion of women aged 20-24 giving first birth by 15 years of age					
1993	4.368	3.108	2.642	1.606	1
1997	4.016	1.941	1.813	1.535	1
2000	3.663	2.661	1.668	1.180	1
2004	4.208	3.192	2.741	2.370	1
2007	3.660	2.813	2.030	1.407	1
2011	2.105	2.767	2.190	1.446	1
2014	3.327	2.594	1.866	1.382	1
2018	1.833	1.785	1.232	1.232	1

Indicator and year	Wealth index quintiles group				
	Poorest	Poor	Middle	Rich	Richest (Reference group)
Proportion of women aged 20-24 giving first birth by 18 years of age					
1993	3.296	2.240	1.822	1.252	1
1997	3.156	1.931	1.773	1.300	1
2000	3.120	2.282	1.854	1.361	1
2004	3.062	2.568	1.870	1.453	1
2007	3.299	2.508	1.755	1.343	1
2011	2.639	3.318	2.426	1.478	1
2014	2.592	2.430	1.633	1.469	1
2018	2.350	2.275	1.541	1.427	1
Proportion of women aged 20-24 giving first birth by 20 years of age					
1993	2.774	1.959	1.758	1.319	1
1997	2.452	2.144	1.747	1.418	1
2000	2.839	2.094	1.631	1.415	1
2004	2.370	2.337	1.919	1.436	1
2007	2.579	2.077	1.826	1.450	1
2011	2.231	2.465	2.241	1.725	1
2014	2.057	2.313	1.677	1.649	1
2018	1.989	2.197	1.562	1.376	1
Proportion of births of birth order 3 and above					
1993	1.908	1.916	1.341	1.143	1
1997	2.333	2.428	1.748	1.820	1
2000	2.144	2.205	1.311	1.449	1
2004	2.983	1.796	1.471	1.248	1
2007	2.763	1.658	1.484	0.848	1
2011	3.846	1.785	1.340	1.347	1
2014	3.398	2.556	2.174	1.243	1
2018	2.460	1.820	1.336	1.216	1
Contraceptive prevalence rate					
1993	0.584	0.632	0.650	0.729	1
1997	0.544	0.676	0.751	0.668	1
2000	0.511	0.661	0.770	0.737	1
2004	0.701	0.832	0.835	0.842	1
2007	0.812	0.808	0.789	0.825	1
2011	1.030	1.093	1.026	0.947	1
2014	0.991	1.017	0.996	0.930	1
2018	1.323	1.170	0.975	1.056	1

Indicator and year	Wealth index quintiles group				
	Poorest	Poor	Middle	Rich	Richest (Reference group)
Prevalence of modern spacing methods					
1993	0.707	0.745	0.735	0.729	1
1997	0.673	0.732	0.824	0.673	1
2000	0.593	0.770	0.805	0.764	1
2004	0.822	0.931	0.883	0.901	1
2007	0.905	0.916	0.876	0.930	1
2011	1.075	1.114	1.041	0.980	1
2014	1.093	1.097	1.066	0.996	1
2018	1.402	1.164	1.058	1.105	1
Proportion of women who want to delay or stop next birth					
1993	0.818	0.992	0.955	0.888	1
1997	1.173	1.297	1.154	1.089	1
2000	1.038	1.064	1.069	1.025	1
2004	1.262	1.267	1.127	1.160	1
2007	1.514	1.215	1.092	0.996	1
2011	1.476	1.309	1.246	1.056	1
2014	1.584	1.419	1.162	1.017	1
2018	1.652	1.475	1.304	1.157	1
Proportion of births with birth interval: <36 months					
1993	1.587	1.510	1.222	1.263	1
1997	2.077	1.536	1.359	1.279	1
2000	1.978	1.753	1.463	1.285	1
2004	1.389	1.371	1.485	1.242	1
2007	1.683	1.226	1.267	1.147	1
2011	1.527	1.374	1.352	1.386	1
2014	1.454	1.640	1.633	1.248	1
2018	1.482	1.417	1.464	1.423	1
Proportion of women received antenatal care from a skilled provider					
1993	0.047	0.091	0.149	0.288	1
1997	0.056	0.142	0.176	0.338	1
2000	0.054	0.093	0.173	0.302	1
2004	0.068	0.086	0.138	0.295	1
2007	0.082	0.124	0.192	0.349	1
2011	0.077	0.101	0.157	0.268	1
2014	0.088	0.103	0.167	0.262	1
2018	0.097	0.143	0.247	0.335	1

Indicator and year	Wealth index quintiles group				
	Poorest	Poor	Middle	Rich	Richest (Reference group)
Proportion of women having at least 4 visits during antenatal period					
1993	0.147	0.196	0.301	0.412	1
1997	0.150	0.195	0.305	0.426	1
2000	0.106	0.141	0.214	0.440	1
2004	0.090	0.119	0.170	0.408	1
2007	0.056	0.080	0.184	0.256	1
2011	0.036	0.064	0.095	0.172	1
2014	0.056	0.038	0.074	0.247	1
2018	0.006	0.030	0.086	0.127	1
Proportion of women assisted by a skilled provider at the time of delivery					
1993	0.081	0.148	0.221	0.374	1
1997	0.076	0.146	0.236	0.379	1
2000	0.071	0.131	0.229	0.437	1
2004	0.053	0.052	0.129	0.279	1
2007	0.053	0.044	0.142	0.326	1
2011	0.058	0.088	0.114	0.215	1
2014	0.040	0.075	0.097	0.256	1
2018	0.088	0.107	0.115	0.262	1
Proportion of women who had first postnatal checkup in first two days after birth					
1993	na	na	na	na	na
1997	na	na	na	na	na
2000	na	na	na	na	na
2004	na	na	na	na	na
2007	na	na	na	na	na
2011	0.068	0.139	0.223	0.444	1
2014	0.158	0.229	0.284	0.455	1
2018	0.084	0.150	0.221	0.356	1

Source: Authors' calculations based on the data available from different rounds of DHS.
na Not available.

Discussion and Conclusion

During the 25 years between 1993 and 2018, Bangladesh has undergone an economic and social transformation, from severe poverty levels that made such a transformation implausible and surprising. The GDP (gross domestic product) grew over 7 times, and over 6 times per capita. Bangladesh graduated into lower-middle-income status in 2015 and is on track to become an upper-middle-income country by 2031 and a developed country by 2041. The human development index (HDI) almost doubled from 0.394 in 1990 to 0.632 in 2019 (UNDP, 2022). Both fertility and mortality have declined during this period so that average annual population growth rate decreased from around 3 per cent to 1.1 per cent in this period. Educational enrolment increased and there was

improvement in gender parity in education. Similarly, all indicators of the health and nutritional status of the population increased, and the life expectancy rose.

The favourable trends reported here for most measures of reproductive health are encouraging, though some continue to fall short of the goals in the national plans and in such international guides as the SDGs. The impact of the Covid 19 pandemic upon the trends is as yet unclear, pending the results of the 2022 survey. Most indicators show no sign of plateauing. However, there are the important exceptions of contraceptive use, the total fertility rate (TFR), and possibly infant and child mortality. Those are areas of serious concern among policymakers as well as the main development partners, the NGOs and collaborating international agencies.

Notwithstanding that Bangladeshi women still remain a disadvantaged group, their status has improved remarkably over the years. They are now more educated than in the past; they have greater freedom of movement, and a more enhanced role in household decision making. Especially, they have greater freedom from unwanted pregnancies and births. Measures of empowerment and autonomy have improved, and more women are employed in the labour force, with more control over their own earnings.

Government initiatives to advance the past advances are well underway; however, more efforts are needed to address the issues where they need more attention such as stalling in fertility decline and near stagnation in contraceptive prevalence rate. They are the primary driver of reproductive health services for women across the country, along with the private sector. Together these constitute the infrastructure that women depend upon. They interact with the less direct influences of better empowerment for women and socio-economic advances. The next national survey will clarify the extent to which all of these remarkable changes continue.

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Appendix Table 1: Indicators of reproductive health status of women in Bangladesh, 1993-2018.

Reproductive health Indicator	Year							
	1993	1997	2000	2004	2007	2011	2014	2018
Time of marriage and first birth								
Median age at marriage	15.3	15.3	16.1	16.0	16.4	16.6	17.2	17.3
Proportion of women aged 20-24 years								
Married before reaching 15 years of age	47.0	47.0	38.0	37.0	32.0	29.0	22.0	19.0
Married before reaching 18 years of age	73.0	69.0	65.0	69.0	66.0	65.0	59.0	59.0
Married before reaching 20 years of age	82.1	77.1	75.4	78.8	79.2	79.8	76.5	76.2
Who had first birth before 15 years of age	10.5	14.7	10.1	10.5	8.4	8.8	8.3	5.6
Who had first birth before 18 years of age	46.8	46.5	43.7	45.5	40.0	40.0	35.7	32.1
Who had first birth before 20 years of age	66.0	63.2	51.4	64.3	61.1	62.1	58.2	56.2
Fertility								
Total fertility rate	3.4	3.3	3.3	3.0	2.7	2.3	2.3	2.3
Fertility of women 15-19 years	140	147	144	137	126	118	113	108
Fertility of women 20-24 years	196	192	188	191	173	153	143	143
Fertility of women 25-29 years	158	150	165	133	127	107	110	114
Fertility of women 30-34 years	105	96	99	83	70	56	57	61
Fertility of women 35-39 years	56	44	44	42	34	21	24	18
Fertility of women 40-44 years	19	18	18	17	10	6	4	5
Fertility of women 45-49 years	14	6	3	2	1	3	5	1
Proportion of third and higher order births	52.6	48.2	44	44	36.4	34.5	28.2	29.6
Total wanted fertility rate	2.2	2.1	2.2	1.9	1.9	1.6	1.7	1.7
Family planning								
Total demand for family planning	66.5	69.5	72.5	73.5	72.6	74.7	74.4	73.9
Contraceptive prevalence rate	44.9	49.8	54.3	58.5	55.8	61.2	62.4	61.9
Prevalence of modern family planning methods	36.6	42.1	44.0	47.6	47.5	52.1	54.1	51.9
Unmet need of family planning	21.6	19.7	18.2	15.0	16.8	13.5	12.0	12.0
Unmet need for spacing	10.7	9.7	8.5	6.7	6.7	5.4	5.3	5.4
Unmet for limiting	10.9	10.0	9.7	8.3	10.1	8.1	6.7	6.6
Proportion of women wanting to delay or stop next birth	57.9	58.8	60.0	60.1	62.5	64.9	62.5	59.9

Reproductive health Indicator	Year							
	1993	1997	2000	2004	2007	2011	2014	2018
Birth interval								
Median birth interval	34.7	36.7	38.8	39.3	43.6	47.4	51.7	55.7
Proportion of births with birth interval <36 months	53.8	48.0	43.2	41.9	36.9	32.1	29.4	25.0
Proportion of births with birth interval ≥60 months	12.3	16.2	20.5	23.1	27.3	34.5	40.7	45.0
Child mortality								
Infant mortality rate	88	82	66	65	52	43	38	38
Under-five mortality rate	134	116	94	88	65	53	46	45
Antenatal, natal, postnatal care								
Antenatal care from a skilled provider	20.9	24.3	27.2	43.0	53.7	55.1	65.0	82.1
Antenatal visits for pregnancy: 4+ visits	5.9	6.9	10.8	16.9	22.9	26.9	31.5	45.8
Assistance during delivery from a skilled provider	9.2	8.7	13.0	15.5	22.8	32.9	44.3	53.9
Mother's first postnatal checkup in the first two days after birth	na	na	na	na	na	28.7	58.1	52.5

Source: Authors' calculations based on different rounds of DHS.
na Not available.

Appendix Table 2: Variation in reproductive health indicators by wealth index quintiles groups in Bangladesh, 1993-2018

Indicator and year	Total	Wealth index quintiles group				
		Lowest	Second	Middle	Fourth	Highest
Median age at first marriage						
1993	15.3	na	na	na	na	na
1997	15.3	na	na	na	na	na
2000	16.1	na	na	na	na	na
2004	16.0	14.5	15.0	16.0	16.9	18.2
2007	16.4	15.0	15.6	16.0	17.2	18.4
2011	16.6	15.5	15.9	16.5	17.1	18.2
2014	17.2	15.7	16.9	17.0	17.6	18.5
2018	17.3	16.2	16.9	17.2	17.7	18.4
Women aged 20-24 years who got married before 15 years of age						
1993	47.0	57.0	56.0	48.0	41.0	30.0
1997	47.0	60.0	58.0	46.0	42.0	27.0
2000	38.0	47.0	50.0	39.0	29.0	22.0
2004	37.0	52.0	47.0	37.0	28.0	24.0
2007	32.0	46.0	37.0	35.0	26.0	20.0
2011	29.0	40.0	33.0	30.0	25.0	18.0
2014	22.0	33.0	25.0	22.0	19.0	15.0
2018	19.0	27.0	22.0	21.0	15.0	13.0
Women aged 20-24 years who got married before 18 years of age						
1993	73.0	79.0	79.0	75.0	69.0	62.0
1997	69.0	75.0	75.0	70.0	67.0	55.0
2000	65.0	72.0	72.0	69.0	62.0	50.0
2004	69.0	80.0	75.0	70.0	66.0	55.0
2007	66.0	77.0	73.0	70.0	60.0	53.0
2011	65.0	76.0	70.0	66.0	61.0	53.0
2014	59.0	72.0	61.0	58.0	56.0	49.0
2018	59.0	70.0	62.0	61.0	55.0	50.0
Women aged 20-24 years who got married before 20 years of age						
1993	82.1	84.9	85.1	82.6	82.1	75.1
1997	77.1	80.2	79.7	78.8	75.9	70.6
2000	75.4	78.1	79.3	76.6	74.2	67.9
2004	78.8	83.7	80.7	79.9	79.2	71.7
2007	79.2	84.8	82.3	81.5	76.8	71.5
2011	79.8	84.1	83.5	79.8	78.1	73.5
2014	76.5	82.4	78.9	78.1	74.9	69.4
2018	76.2	80.9	76.8	77.5	76.0	70.5
Women aged 20-24 years who had their first birth before 15 years of age						
1993	10.5	13.1	12.8	9.2	9.2	7.6
1997	14.7	22.2	18.2	13.8	10.6	7.9
2000	10.1	11.1	14.1	11.5	7.9	5.6
2004	10.5	17.0	13.6	10.2	7.3	5.3
2007	8.4	12.9	10.1	8.8	7.7	3.4
2011	8.8	15.3	11.6	7.6	5.5	4.7
2014	8.3	15.6	8.2	7.7	6.6	4.4
2018	5.6	9.7	7.1	6.1	3.8	2.4

Indicator and year	Total	Wealth index quintiles group				
		Lowest	Second	Middle	Fourth	Highest
Women aged 20-24 years who had their first birth before 18 years of age						
1993	46.8	55.2	54.4	44.7	42.8	34.4
1997	46.5	56.3	54.7	44.8	42.2	33.2
2000	43.7	49.9	55.6	47.8	35.8	27.4
2004	45.5	60.6	53.9	45.0	38.5	31.8
2007	40.0	52.6	48.2	40.4	34.5	26.6
2011	40.0	53.7	45.9	40.8	33.6	27.1
2014	35.7	51.0	38.9	36.9	30.0	24.8
2018	32.1	47.0	37.6	32.9	25.2	21.2
Women aged 20-24 years who had their first birth before 20 years of age						
1993	66.0	71.1	73.1	65.9	63.0	55.3
1997	63.2	67.9	70.4	63.3	62.9	50.7
2000	61.4	65.8	68.0	65.9	59.8	46.3
2004	64.3	73.8	69.4	66.6	61.3	52.2
2007	61.1	68.8	68.5	64.1	57.2	48.2
2011	62.1	73.8	67.5	61.8	58.4	49.8
2014	58.2	67.8	64.8	60.0	54.9	46.2
2018	56.2	68.9	61.0	58.4	51.3	44.4
Total fertility rate						
1993	3.4	na	na	na	na	na
1997	3.2	na	na	na	na	na
2000	3.3	na	na	na	na	na
2004	3.0	4.1	3.2	3.2	2.5	2.2
2007	2.7	3.2	3.1	2.7	2.5	2.2
2011	2.3	3.1	2.5	2.2	2.1	1.9
2014	2.3	2.8	2.4	2.2	2.1	2.0
2017	2.3	2.6	2.5	2.1	2.1	2.0
Age specific fertility rate 15-19						
1993	140.0	na	na	na	na	na
1997	147.0	na	na	na	na	na
2000	144.0	na	na	na	na	na
2004	137.0	190.0	158.0	153.0	121.0	85.0
2007	126.0	170.0	154.0	131.0	124.0	77.0
2011	118.0	171.0	135.0	123.0	98.0	84.0
2014	113.0	146.0	119.0	117.0	102.0	96.0
2018	108.0	140.0	127.0	101.0	104.0	76.0
Age specific fertility rate 20-24						
1993	196.0	na	na	na	na	na
1997	192.0	na	na	na	na	na
2000	188.0	na	na	na	na	na
2004	191.0	258.0	185.0	208.0	164.0	147.0
2007	173.0	184.0	198.0	167.0	175.0	149.0
2011	153.0	181.0	174.0	155.0	140.0	120.0
2014	143.0	172.0	158.0	132.0	141.0	123.0
2018	143.0	165.0	155.0	134.0	132.0	136.0

Indicator and year	Total	Wealth index quintiles group				
		Lowest	Second	Middle	Fourth	Highest
Age specific fertility rate 25-29						
1993	158.0	na	na	na	na	na
1997	150.0	na	na	na	na	na
2000	165.0	na	na	na	na	na
2004	133.0	155.0	130.0	151.0	118.0	115.0
2007	127.0	141.0	134.0	136.0	105.0	120.0
2011	107.0	133.0	96.0	96.0	109.0	100.0
2014	110.0	133.0	99.0	111.0	103.0	103.0
2018	114.0	124.0	118.0	110.0	110.0	106.0
Age specific fertility rate 30-34						
1993	105.0	na	na	na	na	na
1997	96.0	na	na	na	na	na
2000	99.0	na	na	na	na	na
2004	83.0	114.0	87.0	79.0	60.0	73.0
2007	70.0	78.0	72.0	65.0	60.0	72.0
2011	56.0	77.0	56.0	45.0	48.0	56.0
2014	57.0	59.0	67.0	57.0	53.0	53.0
2018	61.0	62.0	65.0	62.0	57.0	61.0
Age specific fertility rate 35-39						
1993	56.0	na	na	na	na	na
1997	44.0	na	na	na	na	na
2000	44.0	na	na	na	na	na
2004	42.0	63.0	41.0	48.0	36.0	24.0
2007	34.0	42.0	50.0	30.0	24.0	26.0
2011	21.0	45.0	16.0	17.0	18.0	15.0
2014	24.0	41.0	29.0	17.0	21.0	17.0
2018	18.0	19.0	22.0	16.0	14.0	20.0
Age specific fertility rate 40-44						
1993	19.0	na	na	na	na	na
1997	18.0	na	na	na	na	na
2000	18.0	na	na	na	na	na
2004	17.0	37.0	36.0	9.0	4.0	4.0
2007	10.0	24.0	6.0	16.0	5.0	2.0
2011	6.0	14.0	8.0	5.0	2.0	2.0
2014	4.0	5.0	3.0	7.0	4.0	2.0
2018	5.0	6.0	7.0	3.0	5.0	3.0
Age specific fertility rate 45-49						
1993	14.0	na	na	na	na	na
1997	6.0	na	na	na	na	na
2000	3.0	na	na	na	na	na
2004	2.0	3.0	7.0	0.0	0.0	0.0
2007	1.0	4.0	0.0	1.0	0.0	0.0
2011	3.0	4.0	6.0	3.0	2.0	0.0
2014	5.0	7.0	1.0	5.0	0.0	10.0
2018	1.0	0.0	2.0	0.0	0.0	1.0

Indicator and year	Total	Wealth index quintiles group				
		Lowest	Second	Middle	Fourth	Highest
Proportion of third and higher order births						
1993	52.6	59.3	59.4	50.6	46.6	43.3
1997	48.2	53.8	54.8	46.6	47.6	33.3
2000	44.0	50.8	51.5	38.7	41.1	32.5
2004	44.0	58.4	45.8	40.9	37.0	32.0
2007	36.4	51.8	39.2	36.6	24.8	28.0
2011	34.5	53.6	34.9	28.7	28.8	23.1
2014	28.2	40.0	33.4	29.9	19.6	16.4
2018	29.6	40.4	33.4	26.9	25.1	21.6
Total wanted fertility rate						
1993	na	na	na	na	na	na
1997	na	na	na	na	na	na
2000	na	na	na	na	na	na
2004	1.9	2.6	1.9	2.1	1.7	1.6
2007	1.9	2.1	2.0	1.9	1.8	1.6
2011	1.6	1.8	1.7	1.6	1.5	1.5
2014	1.7	1.8	1.7	1.6	1.6	1.6
2018	1.7	1.8	1.8	1.7	1.7	1.7
Women wanted to delay or stop next birth						
1993	57.9	54.8	59.5	58.6	56.8	59.7
1997	58.8	59.5	61.9	59.1	57.7	55.6
2000	60.0	60.0	60.6	60.7	59.7	59.1
2004	60.1	62.2	62.3	59.5	60.2	56.6
2007	62.5	68.9	64.0	61.5	59.3	59.4
2011	64.9	69.6	67.0	65.9	62.1	60.8
2014	62.5	68.8	66.4	61.8	58.6	58.2
2018	59.9	65.8	63.2	60.3	57.4	53.8
Total demand for family planning						
1993	66.5	61.0	65.6	65.1	68.4	73.1
1997	69.5	65.2	70.1	69.2	69.0	73.8
2000	72.5	68.1	71.1	74.2	72.3	76.8
2004	73.5	70.1	73.1	73.8	74.5	75.8
2007	72.6	71.9	72.9	70.9	72.1	75.0
2011	74.7	75.3	75.3	74.8	74.6	73.4
2014	74.4	75.7	73.8	74.8	74.1	74.1
2018	73.9	76.2	75.0	72.0	74.4	71.9
Contraceptive prevalence rate						
1993	44.9	40.4	42.3	43.0	45.8	53.7
1997	49.8	43.1	48.5	51.1	48.2	58.2
2000	54.3	45.8	52.2	56.0	54.9	62.3
2004	58.5	54.1	58.3	58.4	58.6	62.7
2007	55.8	54.8	54.7	54.1	55.2	59.9
2011	61.2	61.5	62.9	61.4	59.5	60.8
2014	62.4	62.6	63.2	62.7	61.1	62.8
2018	61.9	66.3	63.5	59.2	61.1	59.8

Indicator and year	Total	Wealth index quintiles group				
		Lowest	Second	Middle	Fourth	Highest
Prevalence of modern contraceptive methods						
1993	36.6	34.5	35.7	35.4	35.2	42.7
1997	42.1	38.8	40.8	43.7	38.8	48.5
2000	44.0	37.4	43.7	44.8	43.5	50.2
2004	47.6	45.2	48.3	47.0	47.5	50.1
2007	47.5	46.9	47.2	46.1	47.6	49.4
2011	52.1	52.9	53.8	52.1	50.6	51.1
2014	54.1	55.1	55.2	54.5	52.8	52.9
2018	51.9	57.2	52.6	50.2	51.3	48.8
Unmet need of family planning for birth spacing						
1993	10.7	11.2	11.1	10.4	11.0	9.6
1997	9.7	11.6	10.0	8.7	10.2	8.0
2000	8.5	10.3	8.5	8.9	8.4	6.4
2004	6.7	6.6	6.5	7.3	7.6	5.5
2007	6.7	6.2	7.2	5.5	7.8	6.6
2011	5.4	5.2	5.4	5.4	6.3	4.8
2014	5.3	5.3	4.5	5.9	5.8	5.1
2018	5.4	4.0	5.0	6.3	6.1	5.3
Unmet need of family planning for birth limiting						
1993	10.9	9.4	12.2	11.6	11.6	9.8
1997	10.0	10.5	11.7	9.4	10.6	7.5
2000	9.7	12.0	10.5	9.2	9.0	8.1
2004	8.3	9.4	8.4	8.1	8.3	7.5
2007	10.1	11.0	11.0	11.2	9.1	8.5
2011	8.1	8.6	7.0	8.1	8.8	7.8
2014	6.7	7.8	6.1	6.2	7.1	6.2
2018	6.6	5.9	6.5	6.5	7.2	6.8
Total unmet need of family planning						
1993	21.6	20.6	23.3	22.1	22.6	19.4
1997	19.7	22.1	21.6	18.1	20.8	15.6
2000	18.2	22.3	18.9	18.2	17.4	14.5
2004	15.0	16.0	14.8	15.4	15.9	13.1
2007	16.8	17.1	18.2	16.8	16.9	15.1
2011	13.5	13.8	12.4	13.4	15.1	12.6
2014	12.0	13.1	10.6	12.1	13.0	11.3
2018	12.0	9.9	11.5	12.8	13.3	12.1
Median birth interval						
1993	34.7	34.0	34.2	34.3	34.4	37.6
1997	36.7	36.4	35.2	35.4	37.8	41.1
2000	38.8	37.3	38.6	38.4	38.5	47.0
2004	39.3	36.5	39.1	39.5	41.3	45.5
2007	43.6	41.9	42.1	41.1	44.7	49.2
2011	47.4	41.0	45.4	48.4	52.7	57.3
2014	51.7	45.6	52.3	51.9	54.2	58.5
2018	55.7	50.5	54.8	59.4	58.9	59.4

Indicator and year	Total	Wealth index quintiles group				
		Lowest	Second	Middle	Fourth	Highest
Proportion of births with birth interval less than 36 months						
1993	53.8	55.7	54.6	55.4	54.7	45.9
1997	48.0	48.6	51.6	51.5	44.8	39.4
2000	43.2	46.2	43.6	43.2	43.8	36.0
2004	41.9	48.3	40.5	41.3	38.9	35.7
2007	36.9	38.2	37.9	39.8	35.6	30.8
2011	32.1	37.8	35.0	31.0	28.3	23.5
2014	29.4	36.8	30.1	27.6	26.4	21.9
2018	25.0	28.4	27.4	23.4	24.0	20.0
Proportion of births with birth interval at least 60 months						
1993	12.3	10.1	10.7	11.3	12.7	19.5
1997	16.2	14.0	13.9	14.4	17.9	24.6
2000	20.5	15.2	17.6	21.7	22.1	33.1
2004	23.1	16.8	22.6	23.7	27.6	30.6
2007	27.3	22.1	26.9	25.5	29.3	37.2
2011	34.5	24.1	32.1	35.5	42.2	46.4
2014	40.7	32.5	41.9	41.3	44.0	48.1
2018	45.0	37.9	43.3	49.3	48.2	49.4
Antenatal care by skilled service provider						
1993	20.9	8.4	11.9	18.9	24.0	48.5
1997	24.3	11.4	13.0	19.6	27.6	59.3
2000	27.2	12.7	16.0	22.8	33.5	65.3
2004	43.0	22.7	30.8	40.8	55.6	78.2
2007	53.7	32.0	37.5	48.9	67.2	87.4
2011	55.1	28.4	40.6	55.9	68.9	88.0
2014	65.0	36.5	59.2	64.3	77.6	91.1
2018	82.1	63.1	76.6	84.3	91.2	97.3
At least four ANC visits during pregnancy						
1993	5.9	0.2	1.0	2.8	4.1	25.2
1997	6.9	1.9	1.3	2.5	7.9	25.8
2000	10.8	2.4	4.2	6.1	10.5	40.5
2004	16.9	4.9	6.8	14.4	19.0	47.8
2007	22.9	8.8	11.3	15.4	30.4	51.7
2011	26.9	11.7	15.0	21.1	35.5	55.6
2014	31.5	16.6	20.6	28.9	36.2	57.1
2018	45.8	28.0	34.2	44.4	52.2	72.6
Delivery assisted by skilled person						
1993	9.2	3.4	4.1	4.4	9.5	28.6
1997	8.7	1.7	3.1	4.0	9.9	30.0
2000	13.0	4.1	6.1	7.8	13.7	42.5
2004	15.5	4.3	3.6	10.7	21.6	45.8
2007	22.8	7.2	7.1	15.8	28.9	59.3
2011	32.9	11.5	19.4	29.7	44.6	64.8
2014	44.3	19.5	31.8	43.0	54.8	76.2
2018	53.9	28.7	42.4	52.4	65.1	83.3

Indicator and year	Total	Wealth index quintiles group				
		Lowest	Second	Middle	Fourth	Highest
Health checkup of women within two days of delivery						
1993	na	na	na	na	na	na
1997	na	na	na	na	na	na
2000	na	na	na	na	na	na
2004	na	na	na	na	na	na
2007	na	na	na	na	na	na
2011	28.7	9.0	16.8	24.5	39.3	59.3
2014	58.1	40.6	49.7	55.1	66.3	81.2
2018	52.5	28.3	41.2	50.9	62.5	82.4

Source: Authors' calculations based on different rounds of DHS.
na Not available.

INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 3(2), July 2023: 275-296

Citizenship Acquisition of Immigrants in Canada: Trends and Determinants

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Abstract

This paper analyses citizenship acquisition of immigrants in Canada, using census data during the 35-year period from 1981 to 2016. The paper examines individual characteristics of immigrants and variation in their countries of origin. The paper investigates trends in citizenship acquisition in two ways: decomposition of rates for overall changes and multivariate analysis of trends after considering individual characteristics and variation in their country of origin. Both individual characteristics and origin-country variables are found to be important determinants of Canadian citizenship acquisition.

Introduction

Compared to the vast research literature on the socioeconomic advancement of immigrants in receiving countries, studies of naturalization or citizenship acquisition are relatively limited. Citizenship acquisition among immigrants, however, influences a wide range of social and economic outcomes. Citizenship rates are connected in most immigrant-receiving countries to the right to vote, which has important political consequences. Most immigrant-receiving countries have visa categories for the sponsorship of family and relatives that depend upon citizenship status. Citizenship gives immigrants the right to obtain and use passports of their destination country. Countries often restrict social programs and employment, such as work in government agencies, to its citizens.

This paper examines citizenship acquisition in Canada during the 35-year period from 1981 to 2016 using data from population censuses that collect information from immigrants every five years. It analyses data for trends over 35 years and provides multivariate analysis of census microdata samples of individual immigrants, with linked information about their origin countries.

The plan of this paper is as follows. The next section provides a brief description of the conceptual framework for the study, including discussion of previous studies of citizenship acquisition in Canada. The following section reviews data on citizenship acquisition for immigrants in Canada and describes explanatory variables for the study. This section also describes the multivariate analysis that is used to study the determinants of citizenship acquisition. Next, the paper analyses the trend in citizenship acquisition, including decomposition of two factors affecting overall changes. The following section

presents statistical results from the analysis of individual characteristics and origin-country contextual variables. Lastly, there is a section that summarises and discusses the findings of the analysis.

Conceptual Framework

The conceptual model used in this paper recognizes three types of variables: (1) personal characteristics of the immigrant that reflect a commitment to the destination country, (2) personal characteristics that indicate the benefits of citizenship acquisition for the immigrant, and (3) features of the country or region of origin that may affect citizenship acquisition in the destination country. The first two variables are based on individual characteristics that are available in microdata samples from Canada's population censuses. The third type of variable requires separate collection of contextual data on the immigrant's country or region of origin from other sources. These variables are discussed below.

Variables related to an immigrant's commitment to their destination country involve direct and indirect measures such as knowledge of the official language(s) of the destination country, marital status, and duration of years since arrival in the destination country (Bernard, 1936; Chiswick, 1978; Kelley and McAllist, 1982; Evans, 1988; and Yang, 1994 and 2002; Bloemraad, 2017; and Edmonston, 2021). The presence of children in the household can also be included as an indication of stronger attachment to the destination country.

There are several variables that relate to benefits that immigrants might obtain by acquiring citizenship in their destination country. A review of the literature by Devoretz (2013) found that some groups of immigrants received higher earnings and better employment opportunities by obtaining citizenship. Immigrants with higher education are more likely to seek citizenship to widen their employment opportunities. Likewise, immigrants living in metropolitan areas where there is a greater variety of possible employment may be more willing to pursue citizenship than immigrants living in rural areas or small towns where citizenship does not create better employment prospects. Previous research has also noted the potential influence of visa category for citizenship acquisition (Jasso and Rosenzweig, 1986; Portes and Curtis, 1987). Immigrants with employment-related visas are more likely to seek citizenship because of the benefits of citizenship lead to a greater variety of employment opportunities. Information about visa category of immigrants, however, is seldom collected in censuses and, therefore, this variable is not included in this study.

Jasso and Rosenzweig (1986) was one of the earlier studies to include variables on the origin-country of the immigrants. They argued that contextual variables are important for immigrant decisions about citizenship acquisition because they reflect the comparison of the features of the origin and destination countries. If the characteristics of the destination country are more attractive than the origin country in terms of social, economic, and political conditions, immigrants would be more likely to seek citizenship. Various contextual variables about the origin-country have been included in prior research. This study includes four variables that are particularly related to citizenship acquisition in

Canada. These include permission by the origin-country for dual citizenship, mandatory military service, per capita income, and whether the origin country has a democratic or an autocratic government.

There are many empirical studies that have analysed factors associated with the citizenship acquisition of immigrants in Canada. Mata (1999) carried out an exploratory data analysis to isolate the relative contribution of economic and non-economic forces in determining rates of citizenship and concluded that there is no economic evidence to support immigrant naturalization and that non-economic forces are more significant. His analysis has not been confirmed, however, by empirical studies in other countries nor by other studies in Canada.

Bloemraad (2004; 2006) addressed the question of Canadian immigrant naturalization and highlighted the importance of the dual citizenship option open to some immigrants, which significantly affected naturalization rates. The conclusion to be drawn from this body of literature is that citizenship acquisition, when researched in isolation from other factors, leaves a minor role for economic determinants. When contrasted with other empirical studies, it demonstrates the need for more comprehensive model construction with the inclusion of more important individual and contextual variables.

Devoretz and Pivnenko (2005; 2008) examined the economic costs and benefits derived from immigrant citizenship acquisition. They found sizeable economic benefits of citizenship, and interpreted the results as evidence that more productive immigrants self-select economic benefits through citizenship. They argued that immigrants in either the United States or Canada earned an income premium after citizenship acquisition.

Picot and Hou (2011) examined Canada and United States data in a comparative analysis of key determinants for citizenship acquisition. Their study also included discussion of the economic benefits of citizenship for immigrants in both countries.

Bloemraad (2017) offered a comprehensive review of factors related to citizenship acquisition, with citations of Canada and other countries by discussing the link between different categories of immigrants, and motivations for citizenship acquisition. Her review, however, does not include empirical analysis for citizenship acquisition in Canada.

Hou and Picot (2019) examined trends in the citizenship rate. The citizenship rate among recent immigrants aged 18 and over peaked in 1996 and declined continuously to 2016. Most of this decline occurred after 2006. The citizenship rate declined the most among immigrants with low family income, poor official language skills, and lower levels of education. There was also significant variation in the decline among immigrants from different source regions, with the decline being the largest among Chinese immigrants. Their study was limited to recent immigrants and should be confirmed with studies of all immigrants.

The present paper adds to the existing research in three ways. First, it updates previous work with the most recently available census data. Second, unlike prior research that are cross-sectional studies, this study provides multivariate analysis of trend data for the period 1981-2016. Finally, the analysis includes both individual characteristics and selected contextual variables that influence the decision to obtain citizenship.

Data and Methods

Two broad types of variables are considered in the multivariate analysis: individual characteristics and contextual factors related to the countries of origin of the immigrants. The contextual factors are linked to individuals for the multivariate analysis.

Individual Characteristics

Canadian citizenship of immigrants is the key variable for this study. It is a binary variable that takes the value of 1 if the immigrant has acquired Canadian citizenship and 0 otherwise. The independent variables for the analysis include age and sex of the immigrant, duration of residence since immigration, educational attainment, knowledge of English or French or both languages, whether the immigrant is residing in a metropolitan area or not, and family structure. These variables have been selected based on the available literature. Previous research has found that the relationship of the immigrant's sex and citizenship varies, with some research finding higher rates for females in United States of America (Chiswick and Miller, 2009) and in European countries (Dronkers and Vink, 2012) while others reporting higher rates for males in Canada (Hou and Picot, 2019). We expect age to have a positive relationship with citizenship acquisition. The duration of residence since immigration is expected to be strongly and positively related to citizenship acquisition. We do not expect duration of residence to be linearly related to citizenship acquisition, so we have included a categorical variable with five-year categories of the duration of residence.

Educational attainment is an important variable for citizenship acquisition. We assume that immigrants with higher education are more likely to seek citizenship. Moreover, immigrants with higher education may feel more comfortable taking the citizenship test that is required for Canadian citizenship. Knowledge or English, French, or both languages is included as a measure of language proficiency. Immigrants with greater language proficiency are likely to be more at ease with applying and completing the citizenship process. Similarly, immigrants living in metropolitan areas are assumed to be more familiar with the citizenship application process and find it easier to complete the process than immigrants living in rural areas and small towns. Finally, family structure is included to take into account differences in immigrants who live in a married or consensual union rather than living alone, as a single parent, with other relatives, or with non-family persons. Immigrants who live in a family with a married or consensual partner are expected to have a greater attachment to Canadian society and are more likely to seek Canadian citizenship. We have included a separate variable for immigrants living in a households with children because we expect them to be more likely to acquire Canadian citizenship.

Country of Origin Variables

We have also included four contextual variables related to the country of origin in the analysis. The first variable is whether the immigrant's country of origin permits dual citizenship, which has benefits and disadvantages. We expect that immigrants from countries that permit dual citizenship will be more likely to acquire Canadian citizenship. The second contextual variable is whether military service is mandatory in the country of origin or not. Mandatory military service may be a strong motivation for some young adults to emigrate and seek citizenship in other countries. We expect that immigrants from

countries having mandatory military service for its citizens are more likely to seek Canadian citizenship to avoid military service in their country of origin. The third contextual variable is per capita income coded in four categories following the World Bank classification – low income, lower-middle income, upper-middle income, and high income (World Bank, 2023). We expect that there is a negative relationship between the income of the origin country and the likelihood of acquiring Canadian citizenship. The last contextual variable is the polity indicator which codes countries in three categories by the predominant type of government. The polity indicator is based on a composite "polity score" that ranges from -10 for autocracy to +10 for democracy (Marshall and Gurr, 2020). The polity score is collapsed into three categories: +6 to +10 for democracy; -5 to +5 for anocracy or semi-democracy; and -10 to -5 for autocracy. We expect that immigrants from countries with semi-democratic or autocratic governments are more likely to seek Canadian citizenship.

Statistical Analysis

The binary logit model has been used in the analysis. Since the model is nonlinear, the magnitude of change in the outcome probability associated with change in one explanatory variable depends upon the level of all other explanatory variables. The logit model considers binary outcomes in terms of the odds of observing the positive outcome against the negative outcome, as follows:

$$\Omega = \frac{Pr(y=1)}{\Pr(y=0)} = \frac{Pr(y=1)}{1-\Pr(y=1)} \quad (1)$$

The log of the odds is called the logit, and the logit model is linear in the logits. The log odds are a linear combination of the explanatory variables, x, and the estimated coefficients, β. A logit model with two explanatory variables is:

$$\ln\left\{\frac{Pr(y=1):x}{1-Pr(y=1):x}\right\} = \ln\Omega(x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 \quad (2)$$

Equation (2) indicates that a unit change in x_1 results in a change in the logit by β_1, holding all other variables constant. The challenge in interpreting the estimated coefficients is that a change of β_k has little substantive meaning. A common approach is to interpret the exponential of β as the change in odds ratio. For example, if $\exp(\beta_k)=2$, the change in the odds of the outcome variable is 2 times larger, holding all other variables constant.

There is, however, a serious problem in interpreting the odds ratio in social science research because outcome variables typically have values greater than the small likelihoods observed in epidemiology and related medical research. Table 1 shows result of doubling the original odds ratio and the resulting probabilities for different odds ratios. When the original odds ratio is small, such as less than 2/100, doubling of the odds ratio results in roughly a doubling of the resulting probabilities. However, when the original odds ratio is close to 1/1, or an implied probability of 0.500, the doubling of the odds ratio results in probabilities that vary greatly, depending upon the original odds ratio. When the original odds ratios is between 1/2 and 2/1, there is no understandable interpretation for a coefficient that "doubles the odds ratio" because the differences in the resulting probabilities depend upon the original odds ratio. Finally, when the original odds ratios is greater than 100/1, the doubling of the odds ratio yields little substantive change in the resulting probabilities.

Table 1: Results of the constant factor change in the odds ratio and the resulting change in the probability.

Original odds ratio	Implied original probability	2×odds ratio	Resulting probability	Ratio of resulting to original probability
1/1000	0.001	2/1000	0.002	1.998
1/100	0.010	2/100	0.020	1.980
2/100	0.020	4/100	0.038	1.962
1/2	0.333	2/2	0.500	1.500
1/1	0.500	2/1	0.667	1.333
2/1	0.667	4/1	0.800	1.200
100/1	0.990	200/1	0.995	1.005
200/1	0.995	400/1	0.998	1.002
1000/1	0.999	2000/1	1.000	1.000

Source: Author

The outcome or the study variable in the present study has probabilities that typically range from 0.5 to 0.9, depending upon the explanatory variables used in the analysis. This is in contrast to the medical and epidemiological research which generally focusses upon rare events so that the probabilities are small. As such and, with reference to table 1, it is not useful to interpret regression coefficients of the logit model in terms of the odds ratio. Instead, an alternative but more meaningful approach is to interpret regression coefficients in the logit model in terms of the predicted probabilities. The predicted probabilities for categorical explanatory variables can be estimated for the fixed values of categorical explanatory variables. For the continuous explanatory variables, on the other hand, predicted probabilities can be calculated for selected fixed values of the continuous explanatory variables holding all other explanatory variables constant (Long and Freese, 2014).

There is also a question whether determinants of male and female citizenship rate should be analysed separately or as a group by including a binary variables for sex or an interaction term for sex with other explanatory variables should be included in the analysis. We investigated this question by comparing the predicted values of citizenship rate with two explanatory variables - duration of residence (coded as a categorical variable) and sex (coded as a binary variable), using the merged data from different population census between 1981-2016. The results of the analysis are presented in figures 1 and 2 which suggest that male citizenship rate exceed female citizenship rate by around 1.3 percentage points. Moreover, the predicted values of male and female citizenship rates closely fit the observed rates for all categories of the duration of residence. We also analysed whether a logit equation that includes an interaction term for sex and duration of residence is statistically significant or not and found that the interaction term is not statistically significant. Chiswick and Miller (2009) have also observed in their study that the interaction term is weak in predicting the citizenship rate, As such we have decided to analyse determinants of citizenship rates using the pooled data for male and female immigrants with binary explanatory variable sex of the immigrant as an explanatory variable.

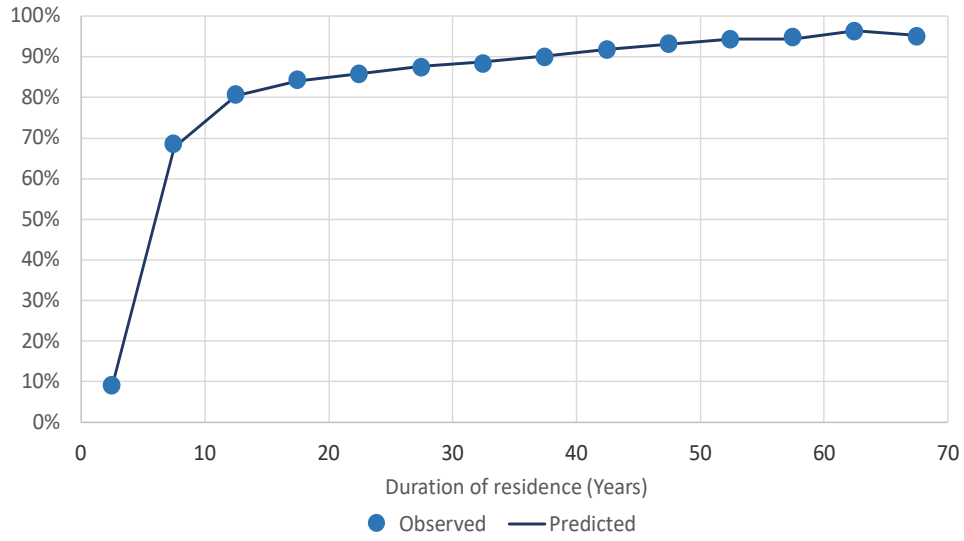

Figure 1: Observed and predicted citizenship rates among female immigrants by duration of residence in Canada, 1981-2016.
Source: Author

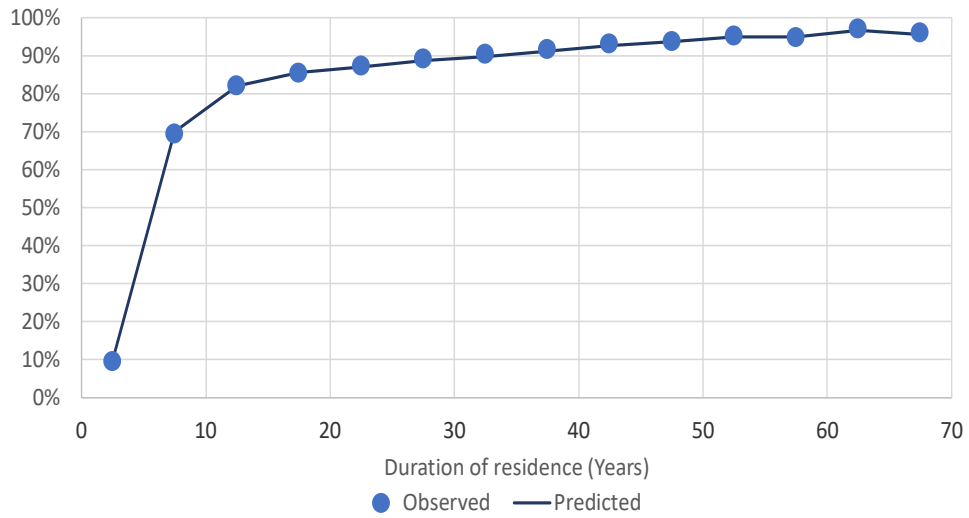

Figure 2: Observed and predicted citizenship rates among male immigrants by duration of residence in Canada, 1981-2016.
Source: Author.

Trend in Citizenship Rate

Immigrants to Canada have relatively high rates of citizenship acquisition compared to other western countries (Picot and Hou, 2011). Since 1981, the proportion of the foreign-born who reported Canadian citizenship has generally increased with modest fluctuations (Figure 3). In 1981, 69.1 per cent of immigrants reported that they had acquired Canadian citizenship. Except for decreases in during 1991-1996, the Canadian citizenship rate among immigrants increased to 77.3 per cent in 2006. Although the proportion reporting Canadian citizenship decreased after 2006 to 75.1 per cent in 2016, yet there has been an overall gain of 6.0 percentage points since 1981.

Changes in the proportion of the foreign-born reporting Canadian citizenship is affected by several factors. First, requirements for Canadian citizenship have varied because of changes in Canada's *Citizenship Act*, which stipulates the legal requirements for Canadian citizenship. Currently, there are five mandatory requirements for citizenship: (1) be a permanent resident, (2) have lived in Canada for 3 out of the last 5 years, (3) filed taxes if required, (4) pass a test on knowledge of Canada and the rights and responsibilities of citizens, and (5) demonstrate language skills in either English or French. These requirements have varied in the past. For example, in previous years applicants needed to reside in Canada for five years, which was changed to a requirement of three years, and then to a requirement of four out of the previous six years. Changes in federal requirements affect the timing of citizenship applications even if they did not have a major influence on the level of Canadian citizenship acquisition over a person's lifetime.

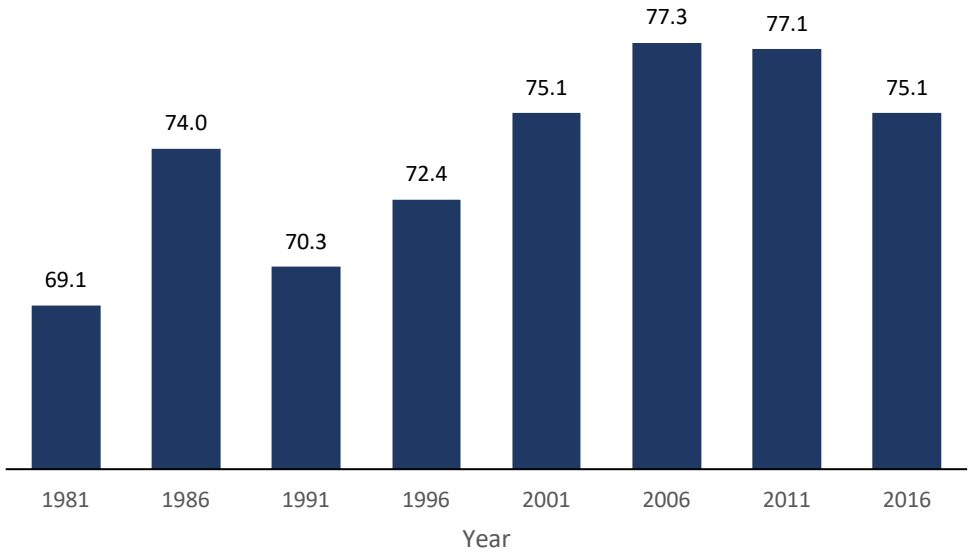

Figure 3: Trend in citizenship rate of immigrants in Canada, 1981-2016.
Source: Author

Second, citizenship rates are influenced by changes in the background of immigrants and timing of their arrival. The two most important factors affecting the citizenship rate are: (1) duration of residence since arrival in Canada and (2) country of birth. The duration of residence is important because immigrants cannot apply for Canadian citizenship until they have resided in Canada for several years. The proportion reporting Canadian citizenship for the foreign-born population increases markedly in the first 20 years after arrival (Figure 4). For immigrants residing in Canada for more than 20 years, there are steady but small gains. A large increase in the volume of immigration creates an immigrant population with fewer years of residence, which tends to reduce the citizenship rate. Likewise, if fewer immigrants arrive in Canada, the proportion of the foreign-born population with longer durations of residence increases, which tends to increase citizenship rate.

The other factor affecting citizenship rate is the country of birth. Some immigrants come from countries in which they are more likely to seek Canadian citizenship, perhaps because they do not plan to return or want to travel with Canadian passport. On the other hand, some immigrants do not see any reason to seek Canadian citizenship, perhaps because they prefer to retain citizenship in their country of origin. Figure 5 illustrates the variations citizenship rate for four regions of origin, for immigrants who have resided in Canada for at least 20 years to control the variation in the duration of residence. Immigrants from Europe have the highest citizenship rate. Immigrants from Asia or from other countries report lower levels of citizenship rate. Immigrants from the United States report relatively low levels of citizenship rate. These results indicate that overall levels of citizenship rate are likely to be affected by shifts in the countries of origin of immigrants, as well as changes in the duration of residence.

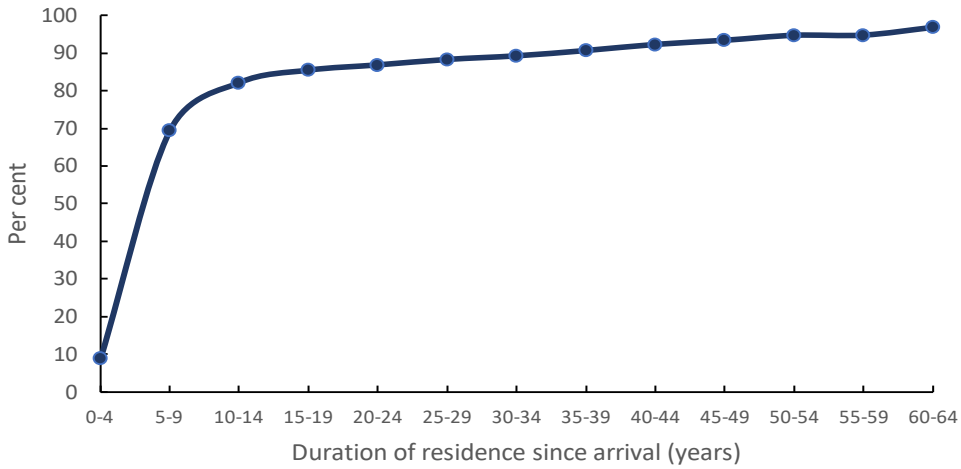

Figure 4: Citizenship rates by duration of residence in Canada among immigrants with at least 20 years of residence.
Source: Author

If we want to compare the change in the citizenship rate between 1981 and 2016, we need a method that contrasts the effects of changes in the composition as well as changes in the cell-specific rates of citizenship. There are different statistical methods available for decomposing the difference between two rates. One approach, proposed by Das Gupta (1991), involves the effect of differences in cell-specific rates. This approach is particularly useful for analysis of citizenship rates that involves factors that account for the differences in cell-specific citizenship rates for two points in time. If the cross-classification of citizenship status in 1981 and 2016, for example, involves one factor, such as duration of residence, then the decomposition generates two additive effects: the duration of residence-effect and the rate-effect. The duration of residence-effect indicates the influence of differences in the duration of residence composition between 1981 and 2016. The rate-effect measures the influence of differences in duration of residence-specific citizenship rates on the overall citizenship rate.

Suppose there are k sub-groups of immigrants and r_i is the citizenship rate for the sub-group i. Then, the citizenship rate of all immigrants combined, r, can be expressed as

$$r = \sum_{i=1}^{k} p_i x_i \tag{3}$$

where p_i is the proportion of immigrants in the sub-group i. If superscript a is used to denote the year 1981 and superscript b is used to denote the year 2016, then the difference between r^a and r^b can be decomposed as

$$r^b - r^a = \sum_i \frac{\left(p_i^b + p_i^a\right)\left(r_i^b - r_i^a\right)}{2} + \sum_i \frac{\left(p_i^b - p_i^a\right)\left(r_i^b + r_i^a\right)}{2} \tag{4}$$

The first factor on the right of equation (4) is the contribution of the change in rate while the second is the contribution of the change in the composition. In the present study, the two factors are region/country of origin (x_1) and duration of residence (x_2). Therefore, their contribution to the difference between r^a and r^b $C(x_1)$ and $C(x_2)$ can be calculated as:

$$\begin{cases} C(x_1) = \sum_i \frac{(p_1^b + p_1^a)(r_1^b - r_1^a)}{2} + \sum_i \frac{(p_1^b - p_1^a)(r_1^b + r_1^a)}{2} \\ C(x_2) = \sum_i \frac{(p_2^b + p_2^a)(r_2^a - r_2^b)}{2} + \sum_i \frac{(p_2^b - p_2^a)(r_2^b + r_2^a)}{2} \end{cases} \tag{5}$$

Intuitively, the contribution of a factor lies in its conditional effect on the mean values of the other factor. The relative contribution of x_1 is therefore $C(x_1)/\{C(x_1) + C(x_2)\}$, while that of x_2 is $C(x_2)/\{C(x_1) + C(x_2)\}$. This approach is straightforward when there are two factors. Calculations, however, become cumbersome when there are more than two factors. We have used the *rdecompose* Stata command (Li, 2017) for the decomposition. The duration of residence has been categorised into 9 categories (0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-39 and 40 or more years) while region/country of origin has been categorised into 13 categories.

Table 2 shows the decomposition results. The citizenship rate among immigrants increased by 6.0 percentage points between 1981 and 2016 in Canada. The change in the country/region of origin accounts for a change of 3.2 percentage points. The contribution of the change in rates is, however, 5.1 percentage points but the contribution of the change in composition is -1.9 percentage points because the country of origin of immigrants shifted

from countries like United Kingdom and Italy that have relatively high citizenship rates to countries like China, India, and the Philippines that have comparatively low citizenship rates. The contribution of the rate change was positive for all county/region of origin categories, except for Germany. Much of the contribution of the change in rates was due to relatively large gains in citizenship rates among immigrants from Latin America and the Caribbean, (22 percentage points) and Asia (11 percentage points).

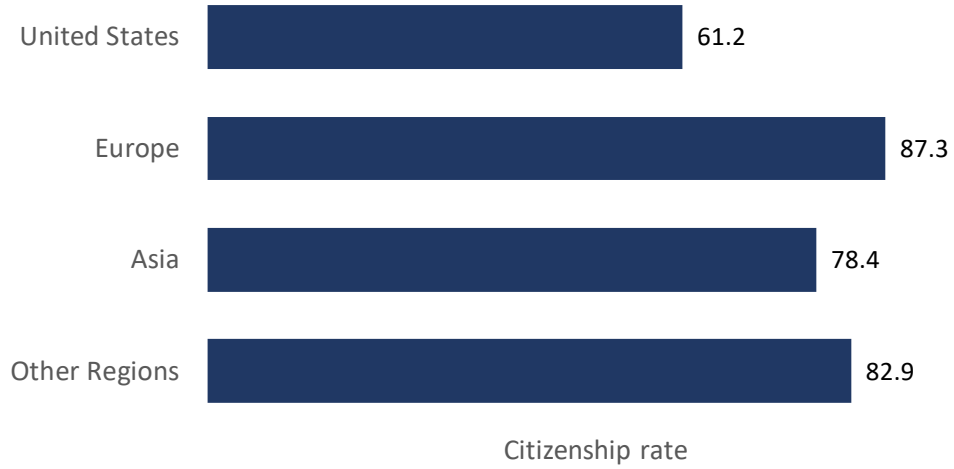

Figure 5: Citizenship rates by region of origin among immigrants with at least 20 years of residence in Canada.
Source: Author

Table 2: Decomposition of the change in citizenship rate among immigrants 1981-2016.

Particulars	Citizenship rate among immigrants		Difference		
	1981	2016	Total	Composition	Rate
	69.1	75.1	6.0		
Difference due to country of origin			3.2	-1.9	5.1
Difference due to duration of residence			2.8	0.6	2.2
Difference due to both factors			6.0	-1.3	7.3

Source: Author.

The contribution of the change in the duration of residence accounts for an increase of 2.8 percentage points in the citizenship rate. Most of this increase stems from 2.2 percentage points increase due to increase in rates while contribution of compositional change accounts for an increase of 0.6 percentage points. Citizenship rates increased for all categories of five or more years. For example, immigrants residing in Canada for 20-24 years reported citizenship rates of 82.4 percent in 1981 and 93.0 percent in 2016. The only exception is in the category 0-4 years in which the citizenship rate decreased because of

the changes in Canada's *Citizenship Act*. In 1986, recent immigrants reported higher Canadian citizenship rates because they were eligible for citizenship acquisition after three years of residence in the early 1980s. Moreover, citizenship applications were processed relatively quickly at that time whereas, in recent years, it normally takes longer to process citizenship applications and current immigrants are required to have resided in Canada for five years and establish that they have resided in Canada for three of those five years. Although some immigrants reported citizenship in 1981 within five years of arrival, no immigrants reported citizenship within five years of arrival in 2016. On the other hand, the contribution of the changes in composition was negative among immigrants with 15 or fewer years of residence in Canada but positive among immigrants with 35 or more years of residence. Because more recent immigrants tend to have lower citizenship rates than immigrants with longer residence, the net effect of these shifts in the composition of immigrants by duration of residence are higher citizenship rates. Table 2 also suggests that the contribution of the change in the region/country of origin had a slightly larger effect on citizenship rates than the contribution of the change in the duration of residence. A larger proportion of immigrants from all countries have acquired citizenship in 2016 than in 1981, but this important change has been slightly counterbalanced by shifts from a predominately European-origin to heavily Asian-origin immigrants, which has tended to reduce the overall citizenship rate. Duration of residence has been affected by the change in the volume of immigration. Increases in immigration initially decrease the proportion of immigrants with longer duration of residence and hence contribute to lower citizenship rates. As a larger volume of immigration continues, however, the duration of residence increases which leads to increases in the citizenship rate.

Factors Influencing Citizenship Acquisition

The citizenship rate has been found to be influenced by both individual and contextual characterises of immigrants as may be seen from table 3. This table is based on microdata samples of the eight population censuses conducted at every five years in Canada during the period 1981 through 2016 and comprises of 43,429,729 foreign-born individuals. The sampling fraction of the microdata sample varies from 2-3 per cent in different population census. Some census microdata variables are grouped in order to maintain the confidentiality of individual responses. For this reason, country of birth is grouped into broader categories for countries in which there are relatively few individuals, such as collapsing immigrants from all countries in East Africa into a single category.

Table 3 suggests that the mean rate of citizenship among the foreign-born in Canada, averaged 72.3 per cent during 1981-2016: 72.9 per cent for males and 71.7 per cent for females. Canadian citizenship rates are generally lower for females, in contrast to the United States where female citizenship rates are noticeably higher. Citizenship rates are positively related to age because age is associated with the duration of residence since arriving in Canada. Citizenship rates are less than 10 per cent for the youngest immigrants and increase to almost 90 per cent for immigrants aged 75 years and older. Younger immigrants have usually arrived in Canada within the past decade and have limited time to seek citizenship. Most elderly immigrants have resided in Canada for at least 40 years and

have a longer time to acquire citizenship. Except for ages 5-14 years, males are more likely to acquire citizenship than females.

One of the most consistent relationships found in studies of citizenship acquisition is the influence of duration of residence since arrival. As shown in table 3, immigrants lack Canadian citizenship upon arrival and begin to acquire citizenship shortly after the arrival. Some immigrants were able to acquire citizenship within 0-4 years after arrival because immigrants could apply for citizenship 3 years after arrival until 2014. Currently, immigrants need to reside in Canada for a minimum of 3 out of the previous 5 years for acquiring citizenship. Citizenship rates increase steadily after 5 years of residence, reaching 90 per cent among immigrants with 35-39 years of residence. Smaller increases continue for even longer duration of residence. It is noticeable that the male-female difference is consistent, with males reporting higher citizenship rates for all durations of residence.

Although educational attainment is generally found to be positively related to the citizenship rate, table 3 fails to reveal this relationship as citizenship rates are higher for less educated immigrants than highly educated immigrants. Cross-tabulated data for all population censuses during 1981-2016, however, need to be interpreted with caution. Less educated immigrants were more usual in the 1980s but, in the 2010s, highly educated immigrants became more common. The educational attainment of immigrants has shifted markedly from the 1950s when European immigrants arrived seeking better employment in Canada to the 1990s when Canadian immigration was selective in preferring highly educated immigrants from a wider range of countries. Immigrants with a high school education or less show lower citizenship rates for males as compared to females, while in immigrants with at least college level education, male citizenship rate is higher than that in females. Multivariate analysis below takes these variations into account.

Language proficiency is an important factor in acquiring Canadian citizenship. The citizenship rate for immigrants knowing either English or French or both is 73.5 per cent compared to 54.1 per cent in immigrants who do not know either English or French. The pattern is the same for males and females. Lower citizenship rates for immigrants lacking knowledge of English or French are probably associated with the language requirements for citizenship and possibly with the shorter duration of residence in Canada among immigrants with limited language skills. Males lacking language skills have lower citizenship rates than females, which is a pattern that does not have an obvious explanation.

The citizenship rate is found to be higher among married immigrants (defined as having a spouse or partner present in the household) as compared to unmarried immigrants. Among married immigrants, the citizenship rate is higher in males as compared to females but, among unmarried immigrants, the citizenship rate is found to be higher in females as compared to males and the difference is quite pronounced. On the other hand, it is generally expected that the presence of children in the household is associated with greater social commitment of the immigrants to their new destination and, therefore, the citizenship rates among immigrants with children should be higher than citizenship rate among immigrants without children. This expectation, however, has not been found to be true. The citizenship rate among immigrants with children is found to be lower than the citizenship rate for immigrants without children. Males have higher citizenship rates than females regardless of the presence of children.

Table 3: Variation in the citizenship rates among immigrants to Canada during 1981-2016 by selected individual and contextual characteristics of immigrants.

Individual and contextual factors	Citizenship rate			Total immigrants	
	Female	Male	All	Number	%
Age (years)					
0-4	7.9	8.5	8.2	331,193	0.8
5-9	34.8	33.1	33.9	859,718	2.0
10-14	50.1	49.0	49.6	1,323,043	3.1
15-19	57.3	57.7	57.5	1,772,907	4.1
20-24	56.5	59.6	58.0	2,240,167	5.2
25-29	53.5	58.0	55.6	2,842,166	6.6
30-34	58.4	60.3	59.3	3,587,778	8.3
35-39	66.3	66.6	66.4	3,992,931	9.2
40-44	72.5	73.7	73.1	4,120,447	9.5
45-49	77.7	78.1	77.9	4,001,393	9.3
50-54	80.4	82.1	81.2	3,717,101	8.6
55-59	82.9	85.0	83.9	3,333,169	7.7
60-64	83.9	86.4	85.1	2,966,827	6.9
65-69	85.0	87.6	86.2	2,565,853	5.9
70-74	85.5	88.1	86.7	2,097,644	4.9
75-79	87.2	89.4	88.2	1,635,385	3.8
80-84	88.1	90.2	89.0	1,079,429	2.5
85 and older	87.7	90.3	88.7	764,073	1.8
All Ages	71.7	72.9	72.3	43,231,224	100.0
Duration of residence					
0-4	9.0	9.4	9.2	5,748,108	14.0
5-9	68.4	69.4	68.9	5,684,695	13.8
10-14	80.5	82.0	81.2	5,024,788	12.2
15-19	84.2	85.5	84.8	4,240,108	10.3
20-24	85.7	87.3	86.5	4,141,528	10.1
25-29	87.4	89.1	88.2	3,364,372	8.2
30-34	88.3	90.4	89.3	3,809,607	9.3
35-39	89.9	91.6	90.7	2,504,970	6.1
40-44	91.6	93.0	92.3	2,568,679	6.3
45-49	93.0	93.8	93.4	1,829,064	4.5
50-54	94.2	95.1	94.6	1,080,541	2.6
55-59	94.6	94.8	94.7	361,093	0.9
60-64	96.2	97.1	96.6	504,868	1.2
65-69	94.9	96.0	95.5	216,450	0.5
All Durations	73.6	74.9	74.2	41,078,871	100.0
Educational attainment					
Less than High School	74.6	74.5	74.6	11,781,257	29.1
High School	73.9	73.6	73.8	6,885,380	17.0
Trade Certificate or 1-2 Years College	75.2	79.0	77.4	5,397,169	13.3
2-4 Years College	75.9	78.2	76.9	4,973,297	12.3
Bachelor's Degree	71.0	74.2	72.6	8,563,860	21.2
Post-Graduate or Professional Degree	67.2	71.8	70.0	2,882,553	7.1
All Immigrants	73.6	75.2	74.3	40,483,516	100.0

Individual and contextual factors	Citizenship rate			Total immigrants	
	Female	Male	All	Number	%
Language proficiency					
Knows English, French, or Both	73.0	74.0	73.5	40,607,151	93.6
Does not Know English or French	56.1	50.7	54.1	2,786,651	6.4
All Immigrants	71.7	72.8	72.3	43,393,802	100.0
Marital status					
Married	72.9	77.0	75.0	27,684,919	63.7
Not Married	69.8	64.5	67.5	15,743,811	36.3
All Immigrants	71.6	72.9	72.2	43,428,730	100.0
Presence of children					
Children Present	71.4	73.6	72.5	22,868,920	67.6
Children Not Present	75.2	77.5	76.3	10,982,804	32.4
All Immigrants	72.6	74.9	73.7	33,851,724	100.0
Residence					
Metropolitan Resident	71.5	72.4	71.9	37,270,315	85.8
Not Metropolitan Resident	72.6	75.7	74.1	6,159,414	14.2
All Immigrants	71.6	72.9	72.2	43,429,729	100.0
Year of immigration					
1981	67.7	70.6	69.1	3,833,300	8.8
1986	72.5	75.5	74.0	3,918,450	9.0
1991	66.1	67.7	66.9	4,523,079	10.4
1996	69.1	71.0	70.0	5,115,636	11.8
2001	72.2	72.7	72.4	5,634,927	13.0
2006	74.7	75.6	75.1	6,011,427	13.8
2011	72.8	73.4	73.1	6,907,070	15.9
2016	74.3	74.7	74.5	7,485,840	17.2
All Years	71.6	72.9	72.2	43,429,729	100.0
Dual citizenship in country of origin					
Permitted	73.3	74.3	73.8	31,956,779	74.8
Not Permitted	66.5	68.4	67.4	10,789,175	25.2
All Countries	71.6	72.8	72.2	42,745,954	100.0
Military services in country of origin					
Mandatory	69.6	71.7	70.6	518,993	1.2
Not Mandatory	71.6	72.9	72.2	42,226,961	98.8
All Countries	71.6	72.8	72.2	42,745,954	100.0
Income group of country of origin					
High	75.1	77.2	76.1	20,832,760	48.7
High-Middle	70.0	69.8	69.9	13,173,960	30.8
Low-Middle	64.9	66.9	65.8	6,955,203	16.3
Low	68.4	67.7	68.0	1,784,031	4.2
All Countries	71.6	72.8	72.2	42,745,954	100.0
Polity status in country of origin					
Democratic	72.9	74.5	73.7	32,284,648	75.5
Semi-Democratic	67.5	68.5	68.0	5,346,550	12.5
Autocracy	67.4	67.2	67.3	5,114,756	12.0
All Countries	71.6	72.8	72.2	42,745,954	100.0

Source: Author

Similarly, contrary to expectations, the citizenship rate is found to be higher for immigrants living in non-metropolitan areas compared to those in metropolitan areas. This relationship may reflect the fact that immigrants living in non-metropolitan areas have lived in Canada for longer durations than immigrants in metropolitan areas. The male-female difference in citizenship rate exists for both immigrants living in metropolitan and immigrants living in non-metropolitan areas with a higher citizenship rate for males than females.

The relationship of citizenship rates with the year of the population census has already been examined in the preceding section. The male-female difference in citizenship rates was highest in the earlier years, but the difference has decreased substantially with time, which suggests that the 2021 and later population censuses may find negligible difference in male and female citizenship rates.

The citizenship rate for immigrants from countries that permit dual citizenship is found to be higher than the citizenship rate for immigrants from countries that do not permit dual citizenship. This is expected as it does not preclude them from continuing to maintain citizenship in their country of origin. Once again, the citizenship rate is higher for males compared to females.

Table 3 does not support the expectation that the citizenship rate among immigrants from countries with mandatory military service will be higher as compared to countries with no mandatory military service. Mandatory military service in the country of origin does not appear to be a strong motivation for acquiring Canadian citizenship. On the other hand, there is no monotonic relationship between the income status of the country of origin and the citizenship rate. There is also no clear pattern for the male-female difference in the citizenship rate by the level of income group of the country of origin. Similar is the case with the type of the government in the country of origin.

Multivariate Analysis

The results of the multivariate analysis are presented in table 4. The logit model has a statistically significant log likelihood ratio that is statistically significant for a sample size of 1,145,478 observations. Because of the large sample size, almost all regression coefficients are statistically significant. In such a situation, interpretations should focus on substantive interest rather than on the statistical significance of the regression coefficient.

The individual characteristics, as a group, are statistically significantly related to the citizenship rate. The F-test for their joint contribution in the logit model has a test statistic of 9532.43. Omitting the four contextual variables reduces the adjusted R^2 from 0.3252 to 0.3085, which shows that individual characteristics are more important than contextual variables in influencing the citizenship rate.

Results presented in table 4 largely conform to expectations. The predicted probability of citizenship for males, holding all other explanatory variables constant, is 86.3 per cent but 85.1 per cent for females. On the other hand, the predicted probability increases steadily with age (Figure 6). The predicted probability for the duration of

residence, however, is nonlinear, rising sharply in the first 20 years of residence to about 90 per cent, and then slowing down gradually. This relationship is consistent with the interpretation that immigrants apply for citizenship shortly after they are eligible, and most immigrants acquire citizenship within the first 15 years of eligibility.

The predicted probability of citizenship is higher among better educated immigrants compared to immigrants who have not completed high school, but the difference is not large. The predicted probability of citizenship is substantially higher among immigrants having proficiency in English, French or in both languages compared to the predictive probability among immigrants who lack proficiency in either English or French. Immigrants lacking knowledge of official languages are likely to have limited access or familiarity with the citizenship process or may be unable to fulfil the language requirements of the citizenship test itself.

Family structure variables have only modest effects on the predictive probability of citizenship. Similarly, the presence of children also has a modest effect. The predictive probability of citizenship among immigrants living in metropolitan areas is higher than immigrants residing in non-metropolitan areas. This is expected as immigrants living in the metropolitan areas have better access to immigrant support groups and are more familiar with the citizenship application process. It is also possible that the type of employment available in the metropolitan areas offers better opportunities for immigrants with Canadian citizenship than employment opportunities typically found in rural areas and small towns.

Results presented in table 4 support previous results in this paper on the trend analysis of citizenship rates. The decomposition analysis showed that the rate component is more important than the composition component in the change in citizenship rates. The multivariate analysis finds that the predicted probability of citizenship rose from 81.0 percent in 1981 to 85.7 percent in 2016, a gain of 4.7 percentage points, compared to the observed increase of 6.0 percentage points. This means that controlling for the explanatory variables accounts for some, but not all of the increases in citizenship rate.

The four contextual variables have also been found to be statistically significantly associated with the citizenship rate as a group or individually. They are, however, less important than individual characteristics as determinants of citizenship rate. Immigrants from countries that permit dual citizenship are more likely than immigrants from countries that do not permit dual citizenship to acquire Canadian citizenship, but the effect is small. This finding is similar to that in the United States (Chiswick and Miller, 2009). Similarly, immigrants from countries that have mandatory military service have higher citizenship rates than immigrants from countries where military service is not mandatory, although the number of immigrants from countries with mandatory military service is very small. On the other hand, citizenship rate is found to be directly related to the income level of the country of origin, the higher the income, the higher the citizenship rate. This finding differs from the study in the United States (Chiswick and Miller, 2009), which found a negative relationship. One reason is that Canada receives fewer immigrants from low-income countries than the United States, and this may also be a reason for the positive relationship observed in the present study. There may also be differences in the composition of immigrants from low-income countries to Canada than to the United States. In any case, this conflicting observation needs further investigation.

Table 4: Logit estimates for citizenship acquisition of immigrants in Canada, 1981-2016.

Explanatory variable and categories	Coefficient	SE	z	p	Predicted probability
Sex					
Female	®				0.8510
Male	0.1083	0.0073	14.89	0.0000	0.8633
Age (years)	0.0035	0.0003	11.53	0.0000	[b]
Duration of residence (years)					
5-9	®				0.6770
10-14	0.8164	0.0110	74.48	0.0000	0.8219
15-19	1.1428	0.0126	90.69	0.0000	0.8638
20-24	1.3107	0.0135	97.01	0.0000	0.8820
25-29	1.3500	0.0148	91.17	0.0000	0.8859
30-34	1.6097	0.0154	104.40	0.0000	0.9092
35-39	1.5604	0.0189	82.64	0.0000	0.9052
40-44	1.8962	0.0210	90.38	0.0000	0.9300
45-49	2.1135	0.0248	85.14	0.0000	0.9427
50-54	2.1365	0.0367	58.16	0.0000	0.9439
55-59	2.3987	0.0635	37.80	0.0000	0.9562
60-64	2.6108	0.0617	42.32	0.0000	0.9642
65-69	2.5929	0.0903	28.71	0.0000	0.9636
Educational attainment					
Less than High School	®				0.8382
High School Diploma	0.0488	0.0112	4.38	0.0000	0.8442
Trade School or 1-2 Years College	0.0977	0.0120	8.12	0.0000	0.8501
3-4 Years College	0.2177	0.0131	16.58	0.0000	0.8637
Bachelor's Degree	0.4111	0.0113	36.31	0.0000	0.8836
Master's, Doctorate, or Professional Degree	0.3972	0.0166	23.89	0.0000	0.8823
Language proficiency					
Knows English or French	®				0.8628
Does not know English or French	-0.6995	0.0147	-47.66	0.0000	0.7675
Presence of kids					
Kids Present	®				0.8583
No Kids Present	-0.0388	0.0080	-4.83	0.0000	0.8539
Metropolitan residence					
Metropolitan Residence	®				0.8642
Not Metropolitan Residence	-0.4705	0.0106	-44.56	0.0000	0.8050
Year of immigration					
1981	®				0.8097
1986	-0.0181	0.0148	-1.22	0.2230	0.8071
1996	0.3853	0.0147	26.30	0.0000	0.8587
2001	0.4573	0.0145	31.50	0.0000	0.8667
2006	0.5796	0.0149	38.99	0.0000	0.8794
2011	0.6034	0.0150	40.13	0.0000	0.8817
2016	0.3725	0.0144	25.95	0.0000	0.8573

Explanatory variable and categories	Coefficient	SE	z	p	Predicted probability
Dual citizenship permitted					
No	®				0.8508
Yes	0.1975	0.0087	22.82	0.0000	0.8725
Mandatory military service					
No	®				0.8568
Yes	0.0988	0.0324	3.05	0.0020	0.8677
Income level of country of origin					
Low income	®				0.7975
Low-middle income	0.9251	0.0096	96.06	0.0000	0.9008
High-middle income	0.8438	0.0117	72.11	0.0000	0.8939
High income	1.3404	0.0251	53.45	0.0000	0.9304
Governance in country of origin					
Democracy	®				0.8371
Semi-democracy	0.8567	0.0135	63.38	0.0000	0.9190
Autocracy	0.6583	0.0127	51.73	0.0000	0.9041
Constant	0.2247	0.0172	13.07	0.0000	
Summary Statistics					
Number of Observations	1,145,478				
LR chi-squared (df=3)	45,519.71				
Probability of chi-squared	0.0000				
Pseudo R^2	0.3242				
Log likelihood Ratio	-256,177.28				

Footnotes: ® reference category
[b] See text for discussion
Source: Author

Finally, the governance in the country of origin is found to be associated statistically significantly with the citizenship rate. The predicted probability of citizenship for immigrants from semi-democratic and autocratic countries is found to be markedly higher than that of immigrants from democratic countries. The percentage point difference in the citizenship rate of immigrants from countries with limited political rights, such as North Korea or Eritrea, and that from countries with greater civil liberty, such as Switzerland or New Zealand, is noteworthy. These findings are similar to those reported by a study that examined civil liberties and political rights in the country of origin of immigrants and found a high correlation between limited political rights and civil liberties in the country of origin with the citizenship rate of immigrants (Chiswick and Miller, 2009).

Discussion and Conclusion

Canada, like other major immigrant-receiving countries, offers and promotes Canadian citizenship for immigrants. Factors in the destination country influence citizenship acquisition because citizenship may provide benefits for work permits, health care, education, voting rights, ability to run for political office, owning property, and travel freedom to other countries. On the other hand, destination countries often institute rules

for citizenship such as requiring several years of residence; knowledge of the official language(s); knowledge of social, political, and economic institutions; readiness to do military service; and sometimes renouncing citizenship in other countries. Individual differences in language competence, years of residence, age, and education are found to be important predictors of citizenship rate in this study. Factors specific to the country of origin of immigration such as political instability and prohibition of dual citizenship have also been found to affect citizenship rate among immigrants. These findings suggest that research on naturalisation in Canada and other countries should not be limited to institutional conditions in the country of destination but should also consider factors specific to the country of origin and individual characteristics of immigrants.

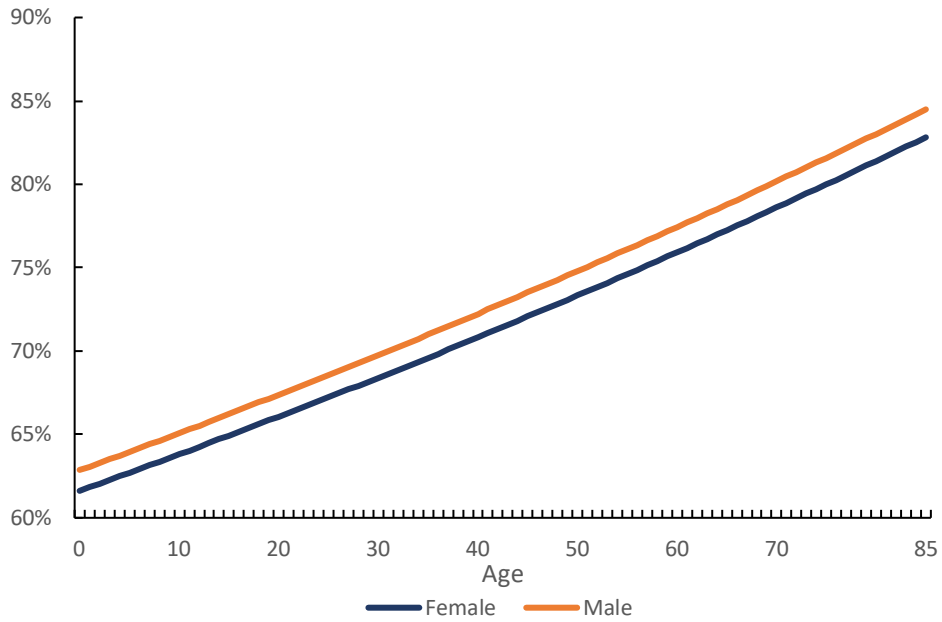

Figure 6: Predicted probability of citizenship rate by age, 1981-2016.
Source: Author.

The findings of this study have implications for immigration policy in Canada. To the extent that Canada wants immigrants who successfully integrate into Canadian society and become citizens, the immigration policy should encourage immigration of persons with higher education, proficiency in English or French, who immigrate with their family, and who are expected to remain primarily in Canada for longer periods. Much of current immigration policy is consistent with these recommendations. The findings of this study offer empirical support for its continuation. Public programmes that encourage and support citizenship acquisition need to be promoted. Classes for immigrants that help to improve language skills are a fundamental first step for immigrants with limited knowledge of English or French. Additional language training would help immigrants to gain competence

and improve their language skills. This will increase the likelihood of citizenship acquisition and will offer important social and economic benefits to immigrants. In general, programmes that offer classes in Canadian civics, history, government, and culture can enhance the likelihood of citizenship acquisition. Finally, public programmes that offer advice and assistance with the citizenship application process can be useful, especially for immigrants with weak language skills or less education.

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INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 3(2), July 2023: 297-318

Review of the Civil Registration System in Madhya Pradesh, India

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Abstract

This paper carries out an analytical review of the civil registration system in Madhya Pradesh based on the births, deaths and infant deaths registered under the system. The analysis highlights the inconsistencies in the registration of births, deaths, and infant deaths in Madhya Pradesh and in its constituent districts as reflected through birth rate, death rate and infant mortality rate derived from the births, deaths and infant deaths registered under the system. There appears to be under registration of births and infant deaths under the system but there are indications of over registration of deaths. The analysis also reveals a high degree of rural-urban and male-female misclassification in the births and deaths registered under the system. The analysis calls for a thorough introspection and a comprehensive reinvigoration of the civil registration system in the state to make the system relevant to the demographic data system.

Background

The organisation of the civil registration activities in Madhya Pradesh is guided by the Birth and Death Registration Act 1969 of the Government of India (Government of India, 1969). This Act lays down an elaborate administrative and structure at different levels of the public administration system in the country and lays down the processes required to ensure that all births and deaths in the country are registered under the civil registration system. The Act mandates that it is the duty of the persons specified in the Act to give or cause to be given, either orally or in writing, according to the best of their knowledge and belief, information related to births and deaths to the competent authority responsible for registering births and deaths within the prescribed time so that this information can be entered in the forms prescribed and maintained for the purpose. The Act envisions that all births and all deaths in the country will be registered under the civil registration system in the due course of time. The Act has been amended recently (Government of India, 2023). At the national level, the responsibility of the implementation of the Act has been entrusted to the Registrar General of India. Establishing the civil registration system and organising the birth and death registration activities under the Act, have, however, been entrusted to the government of the constituent states and Union Territories of the country. The Registrar General of India publishes annual report on the vital statistics of India based on the births and deaths registered under the civil registration system (Government of India, 2022).

In compliance with the Birth and Death Registration Act, 1969, the civil registration activities are organised in Madhya Pradesh under the Madhya Pradesh Birth and Death Registration Rules, 1999 (Government of Madhya Pradesh, 2001). These Rules provide the implementation framework for the registration of live births and deaths. The implementation framework comprises of informants and registrars and sub-registrars. The informants are supposed to provide information about live births, still births and deaths that come to their knowledge to the concerned registrar or sub-registrar while the responsibility of the registrar or the sub-registrar is to register the information according to the formats provided under the rules and issue a certificate of registration of live birth or still birth or death in the prescribed format. The format in which the information about live birth, still birth and death is recorded is in two parts – the legal part and the statistical part. The two parts of the information about live births, still births and deaths serve two essential functions of the civil registration system. The first is the documentation of the family or the household organisation which is also known as the legal function of the civil registration system. The exclusive purpose of the legal function of the civil registration system is to produce official, full, and permanent proof of the occurrence of a live birth or still birth and death, so that the occurrence of the live birth or still birth or death may be easily validated at any time. The statistical part, on the other hand, is directed towards producing vital statistics, which are part of demographic statistics in conjunction with the population census. The registrar or the sub-registrar is also responsible for maintaining a register of all live births, still births and deaths that have occurred in her or his jurisdiction and for the preparation of annual report on vital statistics of the area based on the number of live births, still births and deaths registered.

The Rules framed for the organisation of birth and death registration activities in Madhya Pradesh have been amended and supplemented time to time by the executive orders issued by the Government of Madhya Pradesh. The Government of India has also introduced an online system to facilitate real time registration of live births, still births and deaths in the country in an attempt to improve the efficiency of the civil registration system in the country. In Madhya Pradesh, the online registration of births and deaths has been in operation since 2015. During the year 2020, almost 96 per cent of the births and almost 99 per cent of the deaths registered under the civil registration system in the state were registered through the online system in the state (Government of India, 2022) which means that offline registration of births and deaths in Madhya Pradesh constitute an insignificant proportion of all births and deaths registered in the state.

There has never been a review of the civil registration system in Madhya Pradesh in the context of its performance in terms of its legal function and statistical function. There is only one study in which the quality of civil registration system data in Madhya Pradesh was assessed along with the states of Gujarat, Haryana, Himachal Pradesh, Karnataka, and Maharashtra (James et al, 2014). A review of the civil registration system, specific to Madhya Pradesh, has, however, never been carried out. In the past, Government of India used to provide estimates of the completeness of the registration of births and deaths in different states and Union Territories of the country, but this exercise has been discontinued since 2020. As such, there is now little idea about the performance of the civil registration system in Madhya Pradesh even in terms of the completeness of the registration of births and deaths.

In this paper, we carry out an analytical review of the functioning of the civil registration system in Madhya Pradesh, one of the constituent states of India. The review focusses on both the legal function and the statistical function of the civil registration system in the state. The civil registration system is the only source in Madhya Pradesh which provides data to generate vital statistics at the district level. The Government of India had launched the Annual Health Survey Programme in the past to generate estimates of key vital rates at the district level in the state (Government of India, 2013). This programme has, however, been discontinued after 2013 and the only source of data to calculate vital rates at the district level is the civil registration system. It is in this context, review of the civil registration system in the state important. It may be noted that such a review has never been carried out in the state.

The review of the civil registration system in Madhya Pradesh is, however, hampered by the paucity of the necessary information available through the civil registration system, although collection of statistical information related to every birth or death registered under the system is mandatory under the Birth and Death Registration Act of 1969 of the Government of India and Madhya Pradesh Birth and Death Registration Rules, 1999. The report on the vital statistics of India based on the civil registration system released by the Registrar General of India every year provides information about the number of live births, deaths, infant deaths and still births registered under the system for four mutually exclusive population sub-groups – rural male, rural female, urban male, and urban female (Government of India, 2022). The report also provides the distribution of deaths registered by age, but this information is available for the state but not for districts. We compare state level estimates of birth rate, death rate and infant mortality rate derived from the births and deaths registered under the civil registration system with the corresponding rates available from the sample registration system. At the district level such a comparison is not possible as estimates of birth rate, death rate, and infant mortality rate for the districts are not available from any other source.

The paper is organised as follows. The next section of the paper outlines the analytical framework. State level analysis of the vital statistics data available from the civil registration system is carried out in section. Section four focusses on district level analysis which highlights inter-district variation in the functioning of the civil registration system. Findings of the analytical review are discussed in section five while the last section summarises the findings of the review and puts forward a set of recommendations for strengthening the system.

Analytical Framework

We have calculated the following vital rates based on the number of live births, deaths, infant deaths and still births registered under the civil registration system:

1. Registered birth rate (*Reg*BR) or number of registered live births per 1000 population.
2. Registered death rate (*Reg*DR) or number of registered deaths every 1000 population.

3. Registered infant mortality rate (*Reg*IR) or number of registered infant deaths for every 1000 registered live births.
4. Registered still birth rate (*Reg*SR) or number of registered still births for every 1000 registered births.

The completeness of the events registered under the civil registration system may be measured from the completeness index (CI) which is defined as

$$CI = \frac{Rge\text{VR}}{\text{VR}} \times 100$$

where *Reg*VR is the vital rate – birth rate, death rate, infant mortality rate, and still birth rate – from the civil registration data and VR is the vital rate available from the sample registration system. If the index CI=100 for a given vital event, then the registration of that vital event is complete under the civil registration system. If CI<100, there is under registration which means that a number of vital events have not been registered under the system. On the other hand, if CI>100, there is over registration which implies that there is either duplication in the registration of the vital event or there is error of misclassification during the registration process.

In addition, it is also possible to calculate the sex ratio of registered live births and still births, and mortality sex ratio and infant mortality sex ratio derived from the civil registration system to analyse sex bias, if any, in the registration of births and deaths under the civil registration system by calculating the following indicators:

1. Sex ratio of registered live births is calculated as the number of male live births registered for every 100 female live births registered.
2. Mortality sex ratio is calculated as the ratio of the male death rate derived from the civil registration data to the female death rate derived from the civil registration data.
3. Infant mortality sex ratio is calculated as the ratio of male infant mortality rate derived from the civil registration data to the female infant mortality rate derived from the civil registration data.
4. Still birth sex ratio is calculated as the ratio of male still birth rate derived from the civil registration data to the female still birth rate derived from the civil registration data.
5. Urban-rural ratio of the birth rate as the ratio of the urban birth rate derived from the civil registration data to the rural birth rate derived from the civil registration data.
6. Urban-rural ratio of the death rate as the ratio of the urban death rate derived from the civil registration data to the rural death rate derived from the civil registration data.
7. Urban-rural ratio of the infant mortality rate as the ratio of the urban infant mortality rate derived from the civil registration data to the rural infant mortality rate derived from the civil registration data.
8. Urban-rural ratio of the still birth rate as the ratio of the urban still birth rate derived from the civil registration data to the rural still birth rate derived from the civil registration data.

Estimation of birth and death rates from the civil registration data requires estimate of the population of the state and districts. In the absence of 2021 population census, we have used the population of the state projected by the Government of India (Government of India, 2020). The projected population of the state is available for the total and urban population separately for males and females from which the projected rural population is estimated. However, population of the districts of the state has not been projected by the Government of India. We have, therefore, used population forecast for the districts prepared by Chaurasia (2023). These forecasts are available for male and female population but not for rural and urban population of the district. The forecast is available for 50 districts of the state as they existed at the time of the 2011 population census. After the 2011 population census, the erstwhile district of Shajapur has been divided into existing Agar Malwa and Shajapur districts. We have, therefore, calculated birth and death rates for the erstwhile district of Shajapur and assumed that these rates apply to existing Agar Malwa and Shajapur districts. Estimates of infant mortality rate and still birth rate can be calculated from the registered number of live births, infant deaths and still births four mutually exclusive population sub-groups – rural male, rural female, urban male, and urban female - for each district. Similarly, the sex ratio of registered births, deaths, infant deaths, and still births has been calculated all districts.

It may, however, be pointed out that assessment of the completeness in the registration of births and deaths is possible at the state level only as estimates of birth rate, death rate and infant mortality rate for the districts are not available from the sample registration system. There is no alternative source of data for the estimation of vital rates at the district level to serve the reference for assessing the completeness of the registration of births and deaths at the district level. The health management information system (HMIS) launched by the Government of India under the National Health Mission reports number of live births, number of still births and number of infant deaths in each district but not the number of deaths. Estimates of birth rate and infant mortality rate estimated from HMIS data, however, reveal that these estimates based are substantially lower than estimates from the sample registration system. The only way to assess the completeness of the registration of births and deaths in the districts is, therefore, judgemental, based on the plausibility or implausibility of the estimates.

Data Source

Data for the present analysis have been taken from the database maintained by the Registrar General of India about the number of live births, deaths, infant deaths and still births registered under the civil registration system. This database is available up to the year 2020 only. The present analysis, therefore, is confined to the analysis of the situation that prevailed in Madhya Pradesh during the period 2016-2020. On the other hand, the analysis of the situation in the districts of the state has been carried out for the year 2020 only. District level data about the registration of live births, death, still births and infant deaths is, however, available under the civil registration system for the period 2016-2020.

Under the provisions of both the Birth and Death Registration Act, 1969 (Government of India, 1969) and Madhya Pradesh Birth and Death Registration Rules, 1999

(Government of Madhya Pradesh, 2000), detailed statistical information is also collected for every birth and death registered under the civil registration system. In case of live birth registered, information is collected on 13 points specific to the live birth. These include residence of the mother; religion of the family; level of education of the father and the mother of the newborn; current age of the mother and the age of the mother at the time of marriage; number of children born alive to the mother; type of attention at the time of delivery; method of delivery; birth weight of the newborn; and the duration of pregnancy. Similarly, for each death registered, information on 11 points specific to the death is to be collected under the civil registration system. These include residence and religion of the deceased; occupation of the deceased; type of medical attention received before death; medical certification of the cause of death; name of the disease or the actual cause of death; in case of female death, whether the death was a maternal death (death during pregnancy, at the time of delivery or within 6 weeks after the end of the pregnancy); whether the deceased was habitual smoker or habitual tobacco chewer or habitual chewer of arecanut including pan masala and, if yes, the duration of addition in each case. On the other hand, information on 6 points is collected for each still birth registered under the civil registration system. These include residence, age, and educational status of the mother; type of attention at delivery; duration of pregnancy and cause of foetal death (Government of India, 2012). However, the statistical information associated with each live birth, death and still birth collected at the time of registration is not entered in the relevant registers maintained at the registration units and, therefore, is not reported and analysed. The statistical information that is collected for every live birth, death and still birth registered under the civil registration system can give useful insight into the demographic dynamics that prevails in the state and in the districts of the state. However, this statistical information has not been made available by the Registrar General of India to carry out a deeper analysis of the civil registration data, especially at the local level so that the data available from the civil registration system do not permit analysis of the demographic situation that prevails at the local level. Because of this limitation of the data available from the civil registration system, the present analytical review of the civil registration system in Madhya Pradesh is limited to the analysis of the number of live births, deaths, infant deaths, and sill births registered under the civil registration system in the state.

Table 1 gives the information about the number of live births, deaths, infant deaths, and still births registered under the civil registration system in Madhya Pradesh during the period 2016 through 2020 classified by the place of residence and sex of the vital event. Using data contained in table 1, state level analysis has been carried out for the period 2016 through 2020 to get an idea about the function of the civil registration system in Madhya Pradesh during the period 2016-2020. Data on the number of live births, deaths, infant deaths, and still births are also available for each of the 50 districts of the state as they existed as the time of 2011 population census bur are not presented here. The district level analysis has, however, been carried out for the year 2020 only and not for the previous years as it is the current state of the functioning of the civil registration system at the district level that matters for strengthening the civil registration system at the district level. Improving the functioning of the civil registration system in the district, it may be emphasised, is necessary for improving the functioning of the civil registration system in the state.

Table 1: Number of live births, deaths and infant deaths registered under the civil registration system in Madhya Pradesh, 2016-2020.

Population		Year				
		2020	2019	2018	2017	2016
		Live births registered				
Rural	Male	321190	290500	251926	235960	231727
	Female	288530	250210	225904	218086	209248
	Person	609720	540710	477830	454046	440975
Urban	Male	546548	557358	530170	533788	535898
	Female	497361	503975	478794	480357	488906
	Person	1043909	1061333	1008964	1014145	1024804
Total	Male	867738	847858	782096	769748	767625
	Female	785891	754185	704698	698443	698154
	Person	1653629	1602043	1486794	1468191	1465779
		Deaths registered				
Rural	Male	206715	204602	162458	124340	106925
	Female	123420	114953	94562	80727	74120
	Person	330135	319555	257020	205067	181045
Urban	Male	120200	105117	100533	99160	92849
	Female	74119	68656	66704	66311	64693
	Person	194319	173773	167237	165471	157542
Total	Male	326915	309719	262991	223500	199774
	Female	197539	183609	161266	147038	138813
	Person	524454	493328	424257	370538	338587
		Infant deaths registered				
Rural	Male	1055	949	797	585	939
	Female	878	783	774	538	829
	Person	1933	1732	1571	1123	1768
Urban	Male	5532	5117	5215	5498	4802
	Female	4120	3839	3943	4738	3944
	Person	9652	8956	9158	10236	8746
Total	Male	6587	6066	6012	6083	5741
	Female	4998	4622	4717	5276	4773
	Person	11585	10688	10729	11359	10514
		Still births registered				
Rural	Male	2942	1395	1672	1455	1145
	Female	2518	1246	1373	1250	1184
	Person	5460	2641	3045	2705	2629
Urban	Male	2408	4347	3709	4999	4610
	Female	2149	9728	2974	4048	3939
	Person	4557	6683	6683	9047	6549
Total	Male	5350	4347	4347	6454	6055
	Female	4667	9728	9728	5298	5123
	Person	10017	7294	9728	11752	11178

Source: Government of India (2022).

Vital Rates Based on Civil Registration System

Table 2 gives estimates of birth rate, death rate, infant mortality rate, and still birth rate in Madhya Pradesh derived from the registered births and deaths along with estimates of birth rate, death rate and infant mortality rate obtained from the sample registration system. Estimates of the still birth rate are not available from the sample registration system. The birth rate derived from registered live births (*Reg*BR) is consistently lower than SRS birth rate which indicates under registration of live births in the civil registration system. In 2020, the birth rate derived from the civil registration system was almost 18 per cent lower than the birth rate obtained from SRS. Although, there has been some improvement in the registration of live births in recent years, yet there is a substantial degree of under registration of live births in the civil registration system.

An intriguing observation of table 2 is that the registered birth rate for the urban population is substantially higher than the corresponding birth rate from SRS. Similarly, the registered birth rate for the rural population is substantially lower than the corresponding SRS birth rate. The table also shows that the birth rate in the urban population derived from the civil registration data is substantially higher than the birth rate in the rural population derived from the civil registration data. Under the Birth and Death Registration Act of 1969, all vital events are registered at the place of occurrence or the *de facto* place of residence whereas are based on *de jure* place of residence. The Birth and Death Registration Act, 1969, however, makes no distinction between the *de facto* and *de-jure* place of residence. Because of this reason, the registered birth rate is contrastingly different from SRS birth rate.

A similar situation exists in case of death rate, although the difference between the registered death rate and SRS death rate is not as wide as in case of birth rate. Like the registration of birth, the death is also at the *de-facto* place of residence and not at the *de-jure* place of residence and, therefore, registered death rate reflects higher risk of death in the urban population as compared to that in the rural population. To address this anomaly, it is important that both births and deaths are registered according to the *de-jure* place of residence in addition to the *de-facto* place of residence to obtain meaningful estimates of birth and the death rates from the civil registration system.

Table 2 also indicates that the registered male death rate is higher than the male death rate from the SRS whereas registered female death rate is lower than the female death rate from SRS both rural and urban and hence in total population. This observation indicates that there is either sex-bias in the registration of deaths or a substantial proportion of female deaths is registered as male deaths.

The situation appears to be precarious in case of the registration of infant deaths under. The registered infant mortality rate is incomprehensible when compared with the estimate of infant mortality rate obtained from the sample registration system. It is obvious from table 2 that a large proportion of infant deaths are not being registered under the civil registration system and there appears to be little improvement over time. Interestingly, the registered still birth rate in the state is very similar to the registered infant mortality rate. It appears that a substantial proportion of live births are registered as still births which lowers the registered infant mortality rate.

Table 2: Estimates of birth rate, death rate and infant mortality rate based on civil registration system and sample registration system in Madhya Pradesh, 2016-2020.

Population		Estimates based on civil registration system					Estimates based on sample registration system				
		2020	2019	2018	2017	2016	2020	2019	2018	2017	2016
						Birth rate					
						Number of live births registered per 1000 population					
Rural		10.3	9.2	8.2	7.9	7.8	26.0	26.4	26.6	26.8	27.1
Urban		43.7	45.2	43.8	44.8	46.1	18.8	19.0	19.1	19.4	19.5
Total		19.8	19.5	18.3	18.4	18.6	24.1	24.5	24.6	24.8	25.1
						Death rate					
						Number of deaths registered per 1000 population					
Rural	Male	6.8	6.8	5.4	4.2	3.7	7.4	7.6	7.7	8.0	8.4
	Female	4.3	4.0	3.4	2.9	2.7	6.1	6.3	6.4	6.5	6.8
	Person	5.6	5.4	4.4	3.6	3.2	6.8	7.0	7.1	7.3	7.6
Urban	Male	9.6	8.6	8.4	8.4	8.0	6.4	6.0	5.8	5.9	6.1
	Female	6.5	6.1	6.0	6.1	6.1	5.8	5.1	5.2	5.1	5.4
	Person	8.1	7.4	7.3	7.3	7.1	5.6	5.6	5.5	5.5	5.7
Total	Male	7.6	7.3	6.3	5.4	4.9	7.2	7.8	7.2	7.5	7.8
	Female	4.9	4.6	4.1	3.8	3.6	5.8	6.0	6.1	6.1	6.4
	Person	6.3	6.0	5.2	4.6	4.3	6.5	6.6	6.7	6.8	7.1
						Infant mortality rate					
						Number of infant deaths registered per 1000 live births registered					
Rural	Male	3.3	3.3	3.2	2.5	4.1	47	52	54	52	53
	Female	3.0	3.1	3.4	2.5	4.0	46	47	49	49	47
	Person	3.2	3.2	3.3	2.5	4.0	47	50	52	51	50
Urban	Male	10.1	9.2	9.8	10.3	9.0	30	34	37	34	34
	Female	8.3	7.6	8.2	9.9	8.1	29	30	35	29	31
	Person	9.2	8.4	9.1	10.1	8.5	30	32	36	32	33
Total	Male	7.6	7.2	7.7	7.9	7.5	44	49	51	48	49
	Female	6.4	6.1	6.7	7.6	6.8	43	43	46	45	44
	Person	7.0	6.7	7.2	7.7	7.2	43	46	48	47	47
						Still birth rate					
						Number of still births registered per 1000 births registered					
Rural	Male	9.1	4.8	6.6	6.1	4.9	na	na	na	na	na
	Female	8.7	5.0	6.0	5.7	5.6	na	na	na	na	na
	Person	8.9	4.9	6.3	5.9	5.9	na	na	na	na	na

Population		Estimates based on civil registration system					Estimates based on sample registration system				
		2020	2019	2018	2017	2016	2020	2019	2018	2017	2016
Urban	Male	4.4	7.7	6.9	9.3	8.5	na	na	na	na	na
	Female	4.3	18.9	6.2	8.4	8.0	na	na	na	na	na
	Person	4.3	6.3	6.6	8.8	6.3	na	na	na	na	na
Total	Male	6.1	5.1	5.5	8.3	7.8	na	na	na	na	na
	Female	5.9	12.7	13.6	7.5	7.3	na	na	na	na	na
	Person	6.0	4.5	6.5	7.9	7.6	na	na	na	na	na

Source: Author based on table 1 and Government of India (2017; 2019a; 2020b; 2021a; 2022a).
Remarks: Estimates of still birth rate are not available from the sample registration system.

Table 4: Birth rate and death rate derived from the births and deaths registered under the civil registration system in districts of Madhya Pradesh, 2020.

District		Birth rate (0/00)	Death rate (0/00)		
			Person	Male	Female
1	Alirajpur	37.4	6.0	8.0	3.7
2	Annuppur	4.8	2.2	2.4	1.9
3	Ashoknagar	12.8	2.6	3.3	1.8
4	Balaghat	13.1	6.6	7.1	6.0
5	Barwani	75.2	10.1	13.1	6.8
6	Betul	14.8	5.8	6.7	4.7
7	Bhind	20.2	6.9	8.9	4.7
8	Bhopal	34.9	10.0	12.1	7.5
9	Burhanpur	17.1	5.0	5.8	4.1
10	Chhatarpur	14.9	4.1	5.1	2.9
11	Chhindwara	29.5	10.5	12.2	8.7
12	Damoh	10.6	3.6	4.4	2.7
13	Datia	5.3	1.9	2.3	1.5
14	Dewas	36.1	13.0	15.8	9.9
15	Dhar	41.2	15.3	19.3	11.0
16	Dindori	11.5	4.2	4.9	3.5
17	Guna	18.0	4.2	5.0	3.3
18	Gwalior	26.3	7.4	9.5	5.2
19	Harda	6.3	2.0	2.4	1.6
20	Hoshangabad	12.4	4.7	5.6	3.6
21	Indore	24.5	12.2	14.8	9.5
22	Jabalpur	10.9	6.3	7.4	5.1
23	Jhabua	20.9	2.9	3.8	2.0
24	Katni	27.1	5.7	6.8	4.7
25	Khandwa	14.5	4.9	5.9	3.8
26	Khargone	20.5	7.4	9.1	5.6
27	Mandla	7.8	3.4	3.7	3.0
28	Mandsaur	15.1	6.4	7.4	5.2
29	Morena	26.5	7.4	9.4	5.3
30	Narsimhapur	12.7	4.3	5.2	3.3
31	Neemuch	20.2	9.1	10.6	7.5
32	Panna	15.5	4.4	5.3	3.4
33	Raisen	15.4	4.7	5.8	3.4
34	Rajgarh	10.2	3.5	4.0	3.0
35	Ratlam	30.4	8.9	10.5	7.2
36	Rewa	61.7	18.5	19.8	17.3
37	Sagar	39.3	14.2	18.0	10.4
38	Satna	20.0	6.0	7.4	4.5
39	Sehore	18.6	4.4	5.3	3.5
40	Seoni	12.5	5.6	6.7	4.6
41	Shahdol	16.4	4.9	5.7	3.9
42	Shajapur	30.8	10.5	12.2	8.6
43	Sheopur	9.7	2.5	3.1	1.8
44	Shivpuri	42.3	12.7	17.1	8.2
45	Sidhi	21.9	4.9	6.1	3.6
46	Singroli	23.1	3.9	4.7	3.0
47	Tikamgarh	26.3	7.4	9.7	5.1
48	Ujjain	45.4	18.6	22.8	14.5
49	Umariya	8.2	2.6	3.0	2.1
50	Vidisha	32.8	9.6	12.1	7.1

Source: Author's calculations.

Table 5: Infant mortality rate (per 1000 live births) in the districts of Madhya Pradesh derived from the births and deaths registered under the civil registration system, 2020.

SN	District	Rural			Urban			Total		
		Male	Female	Person	Male	Female	Person	Male	Female	Person
1	Aagar Malwa	0.00	4.69	2.13	1.88	1.33	1.62	1.73	1.58	1.66
2	Alirajpur	0.91	0.62	0.77	0.00	0.51	0.25	0.79	0.60	0.70
3	Annuppur	2.28	6.17	4.22	8.65	6.96	7.82	5.23	6.53	5.88
4	Ashoknagar	0.00	0.00	0.00	9.43	7.55	8.55	4.71	3.79	4.28
5	Balaghat	3.56	3.19	3.38	19.44	15.79	17.63	12.33	10.25	11.31
6	Barwani	0.66	0.99	0.82	0.26	1.58	0.88	0.58	1.12	0.83
7	Betul	1.90	1.75	1.83	1.53	1.79	1.65	1.70	1.77	1.74
8	Bhind	0.00	0.92	0.38	0.00	0.18	0.08	0.00	0.38	0.17
9	Bhopal	1.20	3.79	2.47	3.74	2.90	3.34	3.63	2.94	3.30
10	Burhanpur	1.04	1.43	1.22	1.30	1.31	1.31	1.19	1.36	1.27
11	Chhatarpur	0.62	0.69	0.65	1.12	0.65	0.89	0.97	0.66	0.82
12	Chhindwara	10.06	7.53	8.81	11.40	11.42	11.41	10.91	9.99	10.46
13	Damoh	25.80	21.45	23.74	15.21	11.85	13.59	19.95	16.08	18.10
14	Datia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Dewas	2.12	2.34	2.23	2.63	1.63	2.14	2.51	1.79	2.16
16	Dhar	15.94	14.67	15.34	22.94	16.10	19.65	19.61	15.43	17.62
17	Dindori	2.20	3.78	2.98	0.00	0.69	0.34	1.85	3.28	2.55
18	Guna	6.53	6.86	6.68	1.18	0.96	1.08	2.05	1.84	1.95
19	Gwalior	0.71	0.73	0.72	33.15	29.13	31.35	27.78	24.83	26.48
20	Harda	2.18	1.51	1.83	5.99	6.34	6.16	4.79	4.59	4.69
21	Hoshangabad	0.47	0.49	0.48	10.18	10.68	10.42	8.45	8.79	8.61
22	Indore	1.53	0.85	1.21	21.63	17.24	19.50	20.06	16.01	18.09
23	Jabalpur	0.00	0.00	0.00	11.93	9.20	10.61	11.45	8.90	10.22
24	Jhabua	0.00	0.31	0.14	0.00	0.34	0.16	0.00	0.32	0.15
25	Katni	0.18	0.75	0.43	0.24	0.00	0.13	0.20	0.49	0.33
26	Khandwa	0.64	2.48	1.51	3.00	1.57	2.34	1.96	1.98	1.97
27	Khargone	2.02	1.29	1.67	21.34	18.36	19.91	11.43	9.66	10.59
28	Mandla	2.04	1.45	1.75	22.23	15.19	18.79	9.60	6.66	8.18
29	Mandsaur	1.90	3.24	2.55	0.70	0.88	0.79	1.07	1.59	1.32
30	Morena	0.29	0.54	0.40	0.06	0.07	0.07	0.13	0.21	0.17
31	Narsimhapur	2.12	2.59	2.35	8.56	8.19	8.38	6.80	6.64	6.72
32	Neemuch	4.77	4.38	4.59	1.19	2.57	1.85	1.82	2.89	2.33
33	Panna	0.33	0.00	0.18	20.28	17.94	19.15	10.10	8.97	9.56
34	Raisen	1.75	1.61	1.68	1.47	2.28	1.86	1.56	2.06	1.80
35	Rajgarh	0.00	0.00	0.00	3.85	2.21	3.04	3.04	1.78	2.43
36	Ratlam	1.10	0.80	0.96	25.90	16.57	21.35	15.72	10.22	13.05
37	Rewa	13.22	13.22	13.22	5.73	6.16	5.93	8.22	8.58	8.38
38	Sagar	3.57	4.16	3.86	18.39	16.49	17.49	14.56	13.22	13.92
39	Satna	1.70	0.97	1.36	13.79	12.04	12.96	9.91	8.56	9.28
40	Sehore	0.65	0.98	0.80	0.19	0.10	0.15	0.33	0.36	0.34
41	Seoni	0.00	0.00	0.00	39.72	18.93	29.49	18.30	8.81	13.65
42	Shahdol	0.00	0.00	0.00	9.12	6.55	7.88	7.62	5.41	6.55
43	Shajapur	0.40	0.91	0.63	0.56	0.30	0.43	0.52	0.45	0.48
44	Sheopur	0.81	0.92	0.86	3.06	3.19	3.12	2.19	2.31	2.25
45	Shivpuri	0.49	0.72	0.60	1.12	3.67	2.32	0.92	2.74	1.78
46	Sidhi	0.81	0.65	0.73	0.35	0.19	0.27	0.64	0.48	0.57
47	Singroli	13.99	9.43	11.82	13.93	11.94	13.01	13.98	9.99	12.09
48	Tikamgarh	1.40	0.83	1.14	12.14	9.26	10.75	9.45	7.29	8.42
49	Ujjain	5.77	4.88	5.34	17.44	13.79	15.68	14.98	11.90	13.49
50	Umariya	1.93	0.00	1.00	0.00	0.77	0.37	1.09	0.33	0.72
51	Vidisha	3.75	2.22	3.01	8.14	7.46	7.82	6.74	5.73	6.26

Source: Author's calculations.

Table 6: Still birth rate (per 1000 births) in the districts of Madhya Pradesh derived from the births and deaths registered under the civil registration system, 2020.

SN	District	Rural			Urban			Total		
		Male	Female	Person	Male	Female	Person	Male	Female	Person
1	Aagar Malwa	0.00	0.00	0.00	11.99	9.95	11.02	11.03	9.21	10.17
2	Alirajpur	0.14	0.15	0.15	0.00	0.00	0.00	0.12	0.13	0.13
3	Annuppur	0.33	0.65	0.49	0.00	0.00	0.00	0.17	0.35	0.26
4	Ashoknagar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	Balaghat	1.91	1.30	1.62	5.63	5.20	5.42	3.97	3.49	3.73
6	Barwani	0.03	0.04	0.04	0.00	0.00	0.00	0.03	0.03	0.03
7	Betul	0.68	1.35	1.01	0.00	0.00	0.00	0.32	0.66	0.48
8	Bhind	214.07	242.02	225.94	4.25	4.29	4.27	82.35	84.01	83.10
9	Bhopal	8.36	4.40	6.43	1.26	2.42	1.82	1.57	2.51	2.02
10	Burhanpur	5.98	4.99	5.52	0.00	0.19	0.09	2.64	2.30	2.48
11	Chhatarpur	0.47	0.69	0.57	0.00	0.00	0.00	0.14	0.20	0.17
12	Chhindwara	2.97	2.29	2.64	13.91	12.24	13.10	9.95	8.59	9.29
13	Damoh	0.76	0.68	0.72	6.63	7.01	6.81	4.01	4.23	4.12
14	Datia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	Dewas	9.60	7.30	8.51	0.00	0.19	0.09	2.23	1.79	2.01
16	Dhar	11.24	11.27	11.26	14.26	17.48	15.81	12.83	14.58	13.67
17	Dindori	0.78	0.67	0.73	0.00	0.00	0.00	0.65	0.56	0.61
18	Guna	7.24	6.36	6.84	0.96	0.88	0.92	1.98	1.70	1.85
19	Gwalior	0.53	0.73	0.61	0.00	0.00	0.00	0.09	0.11	0.10
20	Harda	19.75	16.38	18.00	0.00	0.00	0.00	6.30	6.02	6.16
21	Hoshangabad	0.47	0.00	0.24	12.15	8.92	10.62	10.09	7.28	8.75
22	Indore	63.35	59.71	61.63	0.13	0.10	0.12	5.38	4.84	5.12
23	Jabalpur	0.00	0.00	0.00	0.63	0.72	0.67	0.60	0.70	0.65
24	Jhabua	4.06	4.48	4.26	0.00	0.00	0.00	2.47	2.68	2.57
25	Katni	6.98	7.40	7.16	6.22	6.38	6.29	6.73	7.03	6.87
26	Khandwa	1.59	0.53	1.09	0.00	0.00	0.00	0.70	0.24	0.48
27	Khargone	19.36	19.41	19.39	0.00	0.00	0.00	10.02	9.98	10.00
28	Mandla	1.63	2.32	1.96	29.50	30.39	29.93	12.25	13.15	12.69
29	Mandsaur	3.52	4.11	3.81	0.12	0.00	0.06	1.15	1.23	1.19
30	Morena	4.08	6.24	5.05	0.00	0.00	0.00	1.24	1.82	1.51
31	Narsimhapur	3.03	1.29	2.19	12.62	10.93	11.81	10.01	8.28	9.18
32	Neemuch	4.75	1.75	3.33	2.03	1.47	1.76	2.51	1.52	2.04
33	Panna	12.97	12.72	12.85	27.47	20.14	23.96	20.13	16.44	18.38
34	Raisen	4.48	2.41	3.48	0.00	0.13	0.06	1.48	0.89	1.20
35	Rajgarh	0.00	0.00	0.00	10.84	8.85	9.86	8.58	7.14	7.88
36	Ratlam	2.20	2.12	2.16	17.80	15.87	16.86	11.46	10.38	10.93
37	Rewa	1.80	4.90	3.25	0.56	1.55	1.01	0.97	2.71	1.77
38	Sagar	3.71	2.99	3.36	1.03	0.84	0.94	1.72	1.41	1.57
39	Satna	0.00	0.00	0.00	6.14	7.84	6.94	4.18	5.39	4.75
40	Sehore	0.22	0.98	0.57	2.06	1.40	1.74	1.50	1.28	1.39
41	Seoni	10.83	9.50	10.19	18.36	15.02	16.72	14.31	12.08	13.22
42	Shahdol	0.00	0.00	0.00	8.12	5.52	6.87	6.80	4.57	5.71
43	Shajapur	1.58	0.45	1.06	0.00	0.00	0.00	0.41	0.11	0.27
44	Sheopur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
45	Shivpuri	1.31	0.54	0.94	0.00	0.00	0.00	0.41	0.17	0.30
46	Sidhi	0.30	0.43	0.37	0.00	0.00	0.00	0.19	0.28	0.23
47	Singroli	0.50	0.39	0.45	0.00	0.00	0.00	0.39	0.31	0.35
48	Tikamgarh	8.56	10.91	9.64	17.65	17.05	17.36	15.40	15.62	15.50
49	Ujjain	0.92	1.22	1.07	7.62	8.92	8.25	6.22	7.30	6.74
50	Umariya	8.47	5.27	6.93	0.00	0.00	0.00	4.78	2.99	3.92
51	Vidisha	3.94	5.74	4.81	9.62	9.13	9.39	7.81	8.01	7.91

Source: Author's calculations.

Estimation of birth and death rates for the districts of the state based on the births and deaths registered requires estimates of district population for the year 2020 which are not available. We have, therefore, used district population forecast for the year 2020 produced by Chaurasia (2023) to estimate birth rate and death rate for the districts of the registered births and deaths. The population forecast produced by Chaurasia (2023) are, however, available for 50 districts of the state as they existed at the time of 2011 population census. After the 2011 population census, the erstwhile district of Shajapur of the state has been divided into two districts - district Agar Malwa and district Shajapur. For the present analysis, we have merged the births and deaths registered in district Agar Malwa and in district Shajapur to obtain birth and death rates for the erstwhile district of Shajapur as population forecast of district Agar Malwa and district Shajapur for the year 2020 are not available. The birth rate for the districts has been estimated for the total population whereas the death rate has been estimated for the total population and for male and female populations separately. On the other hand, infant mortality rate and the still birth rate has been estimated for all the four mutually exclusive population sub-groups – rural male, rural female, urban male, and urban female - as estimation of the infant mortality rate and the still birth rate does not require estimate of the population of different population sub-groups.

Table 4 presents estimates of registered birth rate (*Reg*BR) and registered death rate (*Reg*DR) for the districts of the state, derived from the civil registration data. The most revealing feature of table 4 is that both registered birth rate and registered death rate vary widely across the districts of the state. For example, in the year 2020, the registered birth rate estimated from the civil registration data varies from an unacceptably high level of more than 75 registered live births for every 1000 population in district Barwani to an unacceptably low level of less than 5 registered live births for every 1000 population in district Anuppur. In district Rewa also, the registered birth rate derived from the civil registration data is estimated to be more than 60 registered live births for every 1000 population whereas in districts Shivpuri and Ujjain, it is estimated to be around 45 registered live births for every 1000 population. These birth rates are exceptionally high and indicative of a substantial degree of duplication in the registration of live births under the civil registration system. On the other hand, there are 28 districts in the state where the registered birth rate is estimated to be less than 20 registered live births for every 1000 population which shows that there is gross under registration of live births under the civil registration system in these districts. In six districts of the state - Anuppur, Datia, Harda, Mandla, Sheopur and Umaria – the registered birth rate is estimated to be less than 10 registered live births for every 1000 population which suggests that there is gross under-registration of live births in these districts.

Similarly, the death rate derived from the civil registration data also varies widely across districts from an unacceptably low level of less than 2 registered deaths for every 1000 population in district Datia to an unacceptably high level of almost 19 registered deaths for every 1000 population in district Ujjain. In 22 districts of the state, the death rate, derived from the deaths registered under the civil registration system is estimated to be less than 5 registered deaths for every 1000 population which shows that there is gross under registration of deaths under the civil registration system in these districts. On the other hand, there are 11 districts where the death rate based on the deaths registered under the civil registration system is estimated to be more than 10 registered deaths for every 1000 population which is exceptionally high by all standards. These districts are Barwani, Bhopal, Chhindwara, Dewas, Dhar, Indore, Rewa, Sagar, Shajapur, Shivpuri and Ujjain. In Neemuch, Ratlam and Vidisha districts also, the death rate derived from the number of deaths registered under the civil registration system is found to be very high. An exceptionally high registered death rate is an indication of the duplication in the registration of deaths under the civil registration system.

In case of infant mortality rate, there is no district in the state where the registered infant mortality rate derived from the civil registration data is more than 30 infant deaths for every 1000 registered live births (Table 5). District Gwalior is the only district in the state where the infant mortality rate derived from the civil registration data is estimated to be around 26 registered infant deaths for every 1000 registered live births. On the other hand, in districts Datia, no infant death was registered under the civil registration system during the entire year 2020 so that the infant mortality rate based on the civil registration system data in this district is zero which is nearly impossible. There are only 13 districts in the state where the registered infant mortality rate derived from the civil registration data is estimated to be more than 10 registered infant deaths for every 1000 registered live births. According to the sample registration system, the infant mortality rate in Madhya Pradesh is the highest among the states and Union Territories of the country. However, the data from the civil registration system depicts an entirely different picture of the risk of death in the first years of life in all districts of the state.

The inter-district variation in the still birth rate is even more revealing (Table 6). In 16 districts of the state, the still birth rate derived from the civil registration data is higher than the corresponding infant mortality rate. The most astonishing case is that of district Bhind where the still birth rate is estimated to be more than 83 still births for every 1000 live births. In the rural population of district Bhind, the still birth rate derived from the civil registration data is almost 226 still births for every 1000 live births whereas, in the urban areas of the district, the still birth rate derived from the civil registration data is less than 5 still births for every 1000 live births. In districts Agar Malwa and Panna also, the still birth rate based on the civil registration data is found to be markedly higher than the infant mortality rate estimated from the civil registration data. It appears that a substantial proportion of live births, in these districts, is registered as a still births under the civil registration system and this misclassification at the time of registration appears to be very high in the rural areas of district Bhind. This misclassification reflects the poor competency of the staff engaged in the registration of births and deaths in the state.

Completeness of Registration

The index of completess showing the level of registration of different vital events under the civil registration system is presented in table 7. The level of completeness of is different for different vital events and in different population sub-groups. Similarly, the improvement in the level of completeness has also been different for different vital events. Interestingly, compared to the improvement in the level of registration of births, the improvement in the registraion of deaths appears to be relatively more marked in the state. By contrast, there has only a marginal improvement in the registration of infant deaths under the civil registration system in the state. However, the level of completeness is radically different in different sub-groups of the population. For example, the index of completeness of birth registration is more than 200 per cent in the urban areas of the state but less than 40 per cent in the rural areas. On the other hand, while the index of completeness of birth registration has improved in the rural areas, it has virtually remained unchanged in the urban areas.

Table 7: Index of completeness of registration of different vital events under the civil registration system in Madhya Pradesh, 2016-2020.

Population		2020	2019	2018	2017	2016
				Births		
Rural		39.62	34.85	30.83	29.48	28.78
Urban		232.45	237.89	229.32	230.93	236.41
Total		82.16	79.59	74.39	74.19	74.10
				Deaths		
Rural	Male	91.89	89.47	70.13	52.50	44.05
	Female	70.49	63.49	53.13	44.62	39.71
	Total	82.35	77.14	61.97	49.32	42.11
Urban	Male	150.00	143.33	144.83	142.37	131.15
	Female	112.07	119.61	115.38	119.61	112.96
	Total	144.64	132.14	132.73	132.73	124.56
Total	Male	105.56	93.59	87.50	72.00	62.82
	Female	84.48	76.67	67.21	62.30	56.25
	Total	96.92	90.91	77.61	67.65	60.56
				Infant deaths		
Rural	Male	7.02	6.35	5.93	4.81	7.74
	Female	6.52	6.60	6.94	5.10	8.51
	Total	6.81	6.40	6.35	4.90	8.00
Urban	Male	33.67	27.06	26.49	30.29	26.47
	Female	28.62	25.33	23.43	34.14	26.13
	Total	30.67	26.25	25.28	31.56	25.76
Total	Male	17.27	14.69	15.10	16.46	15.31
	Female	14.88	14.19	14.57	16.89	15.45
	Total	16.28	14.57	15.00	16.38	15.32

Source: Author, based on table 1.

Like the index of completeness in birth registration, the index of completeness in death registration is also well above 100 per cent in the state for both male and female deaths. On the other hand, the improvement in the index of completeness of registration of deaths has been faster in case of male deaths as compared to female deaths. The improvement in the index of completeness of death registration in the urban areas of the state has been entirely due to the improvement in the registration of male deaths as the index of completeness of female death registration in the urban areas of the state has virtually remained the same over the last five years. In the rural areas of the state also, the improvement in the index of completeness of registration of male deaths has been relatively faster than the improvement in the index of completeness in the registration of female deaths.

In case of the completeness of the registration of infant deaths, the situation in the state is very poor as may be seen from the index of completeness. For the total population, the index of completeness of registration of infant deaths has virtually remained unchanged since 2016 while the index of completeness of registration of female infant deaths appears to have decreased, instead increased. In the rural areas of the state, the index of completeness of the registration of infant deaths under the vital registration system has always been less than 10 per cent and there is hardly any indication that the index of completeness has improved in the recent past, either in the registration of male infant deaths or in the registration of female infant deaths. A similar situation prevails in the urban areas of the state also, although the index of completeness of the registration of infant deaths in the urban areas is comparatively higher than the in the rural areas.

Table 7 highlights the contrasting difference in the completeness of the registration of vital events in different mutually exclusive population sub-groups within the state. The index of completeness of the registration of both births and deaths in the urban areas is estimated to be more than 100 per cent. This may be because, both births and deaths are registered by *de-facto* pace of residence whereas the population is counted by the *de-jure* place of residence. On the other hand, the index of completeness of the registration of vital events under the civil registration system has been found to be always lower for females than for males. This suggests that there is under registration of female vital events under the civil registration system.

Sex Bias in Civil Registration

The reports released by the Registrar General of India also permits calculation of the sex ratio (males per 100 females) of the births, deaths and infant deaths registered under the civil registration system. This sex ratio reflects the male or female bias in the registration of births, deaths, and infant deaths under the civil registration system. The sex ratio of births registered under the civil registration system is an estimate of the sex ratio at birth and can be compared with the sex ratio at birth estimated from the sample registration system. On the other hand, mortality sex ratio based on registered deaths and infant mortality sex ratio based on registered infant deaths indicates sex bias, in the registration of deaths and infant deaths under the civil registration system.

Table 6 and figure 5 shows the sex ratio of registered births, mortality sex ratio and infant mortality sex ratio based on registered deaths and infant deaths respectively in Madhya Pradesh for the period 2016-2020. The sex ratio of registered births was 110 registered male births for every 100 registered female births with only a marginal difference between rural and urban areas. Another important observation of table 6 is that the sex ratio of the registered births in the state has remained more or less unchanged since 2016. Although, the sex ratio of registered births in Madhya Pradesh is higher than the globally accepted sex ratio at birth of 105 male births for every 100 female births, yet it is nearly the same as the sex ratio at birth reported by the sample registration system for Madhya Pradesh (Government of India, 2022a). As such, it appears that there is no sex bias in the registration of births under the civil registration system in the state.

In case of the mortality sex ratio and infant mortality sex ratio, the situation is strikingly different. Table 8 reveals that mortality sex ratio based on registered deaths is very highly favourable to males as compared to females. This implies that there is gross under registration of female deaths as compared to the registration of male deaths. An even more disturbing observation of table 8 is that the male biasedness in the registration of deaths has increased over time. In 2016, the mortality sex ratio based on registered deaths was 136 registered male deaths for every 100 registered female deaths. This ratio increased to 159 in 2019. Although the mortality sex ratio based on registered deaths decreased marginally to 155 in 2020, yet it was

well above the mortality sex ratio in 2016. By comparison, the mortality sex ratio obtained from the sample registration system is always lower than that derived from the civil registration data. The sample registration system also suggests that the mortality sex ratio has largely remained unchanged in the state during 3016-2020. This shows that a large number of female deaths are not registered under the civil registration system in the state.

A similar situation may be observed in case of the infant mortality sex ratio based on registered infant deaths which has increased over time whereas the infant mortality sex ratio estimated from the sample registration system appears to have decreased in the state. The infant mortality sex ratio based on registered infant deaths was 119 registered male infant deaths for every 100 registered female infant deaths in the year 2020 whereas it was only 110 in 2016. By contrast, the infant mortality sex ratio estimated from the sample registration system was 102 in 2020 compared to 111 in 2016. A similar trend may also be seen in the rural and urban areas of the state. This shows that like the male biasedness in the registration of deaths, the male biasedness in the registration of infant deaths has also increased in the state. This male biasedness may be due to both duplicate registration of male deaths and under registration of female deaths.

The exceptionally high mortality sex ratio and infant mortality sex ratio in the state also implies that once the mortality sex ratio and the infant mortality sex ratio based on registered deaths are adjusted for the male biasedness, the death rate implied by the deaths registered under the civil registration system in the state will become higher than the death rate estimated from the sample registration system. This observation is also supported by the observation that there is gross under registration of infant deaths in the state and there is significant male bias in the registration of infant deaths which has increased over time. It is obvious that if the under-registration of infant deaths is taken into consideration, then the number of registered deaths will also increase, and this will lead to even further increase in the registered death rate, well above the death rate obtained from the sample registration system.

Table 8: Sex ratio (males per 100 females) at birth, mortality sex ratio and infant mortality sex ratio in Madhya Pradesh derived from the civil registration system and obtained from the sample registration system.

Population	Derived from civil registration data					Obtained from sample registration system				
	2020	2019	2018	2017	2016	2020	2019	2018	2017	2016
					Sex ratio at birth					
Total	110	112	111	110	110	Na	109	108	108	109
Rural	111	116	112	108	111	Na	110	109	109	110
urban	110	111	111	111	110	na	104	103	103	105
					Mortality sex ratio					
Total	158	170	159	145	137	121	121	120	123	124
Rural	148	141	140	138	131	110	118	112	116	113
Urban	155	159	154	142	136	124	130	118	123	122
					Infant mortality sex ratio					
Total	110	106	94	100	103	102	111	110	106	113
Rural	122	121	120	104	111	103	113	106	117	110
Urban	119	118	115	104	110	102	114	111	107	111

Source: Author's calculations based on the data given in table 1.

The sex ratio at birth, mortality sex ratio and infant mortality sex ratio obtained from the civil registration data for the districts are presented in table 9. The sex ratio of registered births varies from a low of 101 registered male births for every 100 registered female births in district Anuppur to a high of 126 registered male births for every 100 registered female births in district Gwalior. There are six districts – Anuppur, Balaghat, Betul, Chhindwara, Dindori and Seoni – where sex ratio of registered births is estimated to be less than 105 male births for every 100 female births. In these districts, there appears to be under registration of male deaths relative to female deaths. On the other hand, sex ratio of registered births is estimated to be more than 120 registered male births for every 100 registered female births in three districts - Bhind, Gwalior, and Katni. In these districts, there appears to be substantial under registration of female deaths relative to male deaths. At the state level, the sex ratio of the registered births is very similar to the sex ratio at birth obtained from the civil registration system, but the sex ratio of registered births varies widely across the districts. In some districts, there appears gross under registration of male births while in other districts, there appears to be gross under registration of male births under the civil registration system.

Table 8: Sex ratio (male per 100 female) of births, deaths and infant deaths registered under the civil registration system in the districts of Madhya Pradesh, 2022.

District		Sex ratio at birth			Infant mortality sex ratio				Still birth sex ratio		
		Rural	Urban	Total	Total	Rural	Urban	Total	Rural	Urban	Total
1	Aagar Malwa	120	111	112	142	na	142	109	na	121	120
2	Alirajpur	111	106	110	216	147	na	131	90	na	91
3	Annuppur	100	103	101	126	37	124	80	50	na	49
4	Ashoknagar	113	112	113	184	na	125	124	na	na	na
5	Balaghat	106	102	104	118	112	123	120	147	108	114
6	Barwani	109	111	110	194	67	16	52	91	na	91
7	Betul	99	109	104	142	109	85	96	50	na	48
8	Bhind	140	115	122	190	na	na	na	88	99	98
9	Bhopal	105	110	110	161	32	129	123	190	52	62
10	Burhanpur	115	115	115	143	72	100	87	120	na	115
11	Chhatarpur	110	109	110	176	91	173	147	68	na	68
12	Chhindwara	103	105	104	141	134	100	109	130	114	116
13	Damoh	111	108	109	164	120	128	124	113	95	95
14	Datia	123	111	115	159	na	na	na	na	na	na
15	Dewas	110	106	107	159	91	161	140	131	na	125
16	Dhar	111	108	109	176	109	142	127	100	82	88
17	Dindori	104	103	104	137	58	na	56	115	na	116
18	Guna	119	108	110	151	95	123	111	114	109	117
19	Gwalior	138	124	126	181	97	114	112	72	na	79
20	Harda	93	115	107	151	144	94	105	121	na	105
21	Hoshangabad	106	112	111	155	94	95	96	na	136	139
22	Indore	111	106	106	156	181	125	125	106	126	111
23	Jabalpur	134	107	108	145	na	130	129	na	87	87
24	Jhabua	112	107	110	192	na	na	na	91	na	92
25	Katni	128	113	123	144	23	na	41	94	98	96
26	Khandwa	111	114	113	156	26	191	99	299	na	295
27	Khargone	110	109	110	163	157	116	118	100	na	100
28	Mandla	107	105	106	122	140	146	144	70	97	93
29	Mandsaur	108	107	108	144	59	80	67	86	na	93
30	Morena	123	116	118	178	54	86	64	65	na	68
31	Narsimhapur	107	109	108	155	82	104	102	234	115	121

District		Sex ratio at birth				Infant mortality sex ratio			Still birth sex ratio		
		Rural	Urban	Total	Total	Rural	Urban	Total	Rural	Urban	Total
32	Neemuch	110	108	109	141	109	46	63	271	139	166
33	Panna	112	108	110	154	na	113	113	102	136	122
34	Raisen	107	109	109	169	109	65	76	186	na	166
35	Rajgarh	113	103	105	135	na	174	171	na	122	120
36	Ratlam	108	105	106	146	139	156	154	104	112	110
37	Rewa	115	121	119	115	100	93	96	37	36	36
38	Sagar	107	111	110	173	86	111	110	124	122	122
39	Satna	115	111	112	163	175	115	116	na	78	78
40	Sehore	113	107	109	151	66	187	92	22	147	117
41	Seoni	105	103	104	145	na	210	208	114	122	118
42	Shahdol	100	107	105	145	na	139	141	na	147	149
43	Shajapur	115	107	109	142	44	187	115	348	na	368
44	Sheopur	113	114	113	167	89	96	95	na	na	na
45	Shivpuri	110	112	111	207	68	30	34	241	na	239
46	Sidhi	106	109	107	171	126	183	133	71	na	70
47	Singroli	110	116	111	156	148	117	140	127	na	126
48	Tikamgarh	118	108	111	191	169	131	130	78	104	99
49	Ujjain	106	107	107	158	118	126	126	76	85	85
50	Umariya	107	108	108	144	na	na	326	161	na	160
51	Vidisha	107	112	110	172	169	109	118	69	105	97

Source: Author's calculations.
Remarks: na not available

Unlike the sex ratio of registered births, the mortality sex ratio based on registered deaths is very highly biased towards males and varies from a low of around 114 registered male deaths for every 100 registered female deaths in district Mandla to a high of 240 registered male deaths for every 100 registered female deaths in district Alirajpur. There are only three districts – Balaghat, Mandla and Rewa – where the mortality sex ratio based on registered deaths is less than 140. On the other hand, mortality sex ratio based on registered deaths is exceptionally high in five districts - Alirajpur, Ashoknagar, Barwani, Bhind, and Shivpuri. In these districts, mortality sex ratio based on registered deaths is at least 200 registered male deaths for every 100 registered female deaths which indicates that a large proportion of female deaths in these districts are not registered. Similarly, a high degree of male bias in registered infant deaths is also evident in majority of the districts of the state, although there are 12 districts where infant mortality sex ratio based on registered infant deaths is found to be favourable to females. In Bhind, Datia and Jhabua districts, infant mortality sex ratio based on registered infant deaths could not be calculated as there was either no male infant death or no female infant death registered in these districts in 2020. In district Shivpuri, infant mortality sex ratio based on registered infant deaths was only 38 which is highly improbable in all respect. Similarly, infant mortality sex ratio based on registered infant deaths is estimated to be 350 in district Umaria which is also next to improbable. It may, however, be noted that the number of infant deaths registered under the civil registration system in most of the districts of the state is very small which may be a reason behind the high volatility in infant mortality sex ratio based on registered infant deaths.

The inter-district volatility in the sex ratio of registered still births is even higher. In some districts, there appears very high degree of under registration of female still births whereas in other districts, there is high degree of under registration of male still births. The number of still births registered under the civil registration system, however, is very small in all districts of the state.

Discussion and Conclusions

The civil registration system serves two essential functions – documentation of the family organisation which is termed as the legal function and collection of statistical information which is termed as the statistical function. The exclusive purpose of the legal function of the civil registration system is to produce official, proof of the occurrence of birth or death that is complete and permanent, so that it can be validated at any time. The purpose of the statistical function, on the other hand, is to produce vital statistics, which are part of demographic statistics in conjunction with the population census. The civil registration system, therefore, is internationally recognised as an important component of the demographic data system of any country. The legal and the statistical functions of the civil registration system are closely related as they refer to the same vital event – birth or death. In pursuance of its legal function, civil registration system records the occurrence of events related to the civil status of the persons which, in statistical terminology, are termed as vital events and then collects additional data for the processing of the corresponding vital statistics. The system also serves as the mechanism for effective operation of such institutions as social security, voter registration, personal identification, and social assistance services. It is, therefore, imperative that civil registration system is fully developed and fulfils its own basic legal and statistical functions.

The review of the civil registration system in Madhya Pradesh, however, reflects a sorry state of affairs which requires thorough introspection and serious reinvigoration. The civil registration system in the state contributes little to improving the understanding of the demographic dynamics in the state and is of little help in the operation of welfare institutions, especially, the social protection institutions. Estimates of key vital rates derived from births and deaths registered under the system are of little relevance in analysing the demographic dynamics either at state or district levels. The relevance of the civil registration system is rooted in the fact that it is the only system that can generate basic vital data even up to the grass roots level which is critical for development planning and programming. Viewed from this perspective, the civil registration system in the state remains largely irrelevant.

The present analysis is limited to the analysis of selected outputs of the civil registration system. It does not dwell upon the inputs and processes of the system that ultimately have an impact on system outputs. For a deeper understanding of the malice that plagues the civil registration system in the state, it is pertinent to analyse the inputs and processes of registering births and deaths and linking inputs and processes with system outputs. It is ultimately the outputs that infuse the sense of confidence in the civil registration system

and ensure its relevance to a range of welfare and development institutions. The poor state of the civil registration system implies that Madhya Pradesh continues groping for a black cat in a dark forest that may or may not be there. In the absence of an efficient and effective civil registration system, targeting of welfare and development efforts remains seriously compromised with the result that the poorest and the most marginalised sections of the community suffer the most.

It is not possible, at this stage, to pin point the problems of the civil registration system in the state. The problems that civil registration systems commonly face can be grouped into three broad categories: 1) relatively intractable problems that are due to factors which are exogenous to the system; 2) endogenous problems of the system that can be addressed only through additional technical and financial inputs; and 3) endogenous problems of the system that that be addressed by reorganisation and reorientation of the system with little additional technical and financial resources. The first category of problems can be addressed only through long-range social and economic development efforts. These problems are outside the scope of the changes that the civil registration system itself can bring about. The exogenous factors that have an impact on the working of the civil registration system are many. One important factor is the perception of the people about birth and death registration. People may be lacking the motivation for getting births and deaths registered, may fail to comply with the laws or even be aware of them, or may delay reporting of births and deaths as they may not see any value in registering them. There may even be cultural and political factors that may instigate resistance to registration, and even falsification of the reported information.

The second category of problems are endogenous to the system and can be addressed through additional technical and financial inputs. There is a long list of such problems. These include inadequate staff, lack of proper training and orientation, availability and distribution of essential forms and supplies and other infrastructure facilities, transport for supervisory or training staff, office space, modern record storage, document reproduction equipment, data processing facilities, printing facilities, so on and so forth. A major problem that ails the civil registration system in India is that there is no dedicated staff for civil registration activities. The staff and officials of different government departments have been designated as informants and registrars/sub-registrars in addition to their routine responsibilities. This arrangement poses challenge of motivation and coordination. Addressing these issues are intricate, especially at the local level.

The third category of problems is related to the internal processes of the system. There is currently hardly any system of monitoring civil registration activities at the local level, the interface with the people. Analysis of the civil registration data at the district level can provide directions for improving the system. This and similar other innovations may be incorporated with little additional technical and financial resources but may contribute significantly towards improving civil registration.

There is a need to crystallise the three categories of the problems and to search for operationally feasible interventions to address them. It is expected that the findings of the present analysis may serve as the basis for initiating a process of discussion and debate among different stakeholders to secure lasting improvements in the civil registration system of the state. This is important as a reliable and effective civil registration system is the foremost requirement to ensure that no one is left behind.

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INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 3(2), July 2023: 319-336

Review of the Quality of Population Estimates and Projections at Subnational Level in India Using Principles of Applied Demography

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Abstract

The projected population based on the 2011 census published by Ministry of Health and Family Welfare (MoHFW), Government of India (2020) has been used as the basic input data for generating the projections of population for districts by Dhar (2022) ; Esri India (2022)) and studying the long-term population growth scenarios for large states by Kulkarni (2021a, 2023). It is, therefore, necessary to review the quality of the latest population projections by the Government of India. The goal of this paper is to review the quality of the MoHFW population projections as follows: (1) describe the principles of applied demography, (2) apply these principles to review the quality of the technical report for the population and urban population projections for States, Union Territories and India, 2011-2036, (3) describe the tasks for updating the existing population projections by the technical committee of the population projection and applied demographers to serve the needs of clients for better quality of population projections, and (4) discuss the feasibility for developing population projections for districts in India using the cohort component method. This paper presents some weaknesses in the existing projected population by MoHFW (2020), which have affected the quality of district wise population projection by Dhar (2022) and Esri, India (2022). In addition, it is found that the projected numbers by MoHFW (2020) are not comparable to other sets of projections developed by United Nations, Population Division (2022), United states Census Bureau (2023), Kulkarni (2021a) and Chaurasia (2023) for India over the periods 2021-2025, 2026-2030, 2031-2036. In order to provide better quality of data for users, the existing population projection by the Government of India (2020) needs to be updated based on the population projection by United Nations (2022). Further work on the development of district wise population projection using the cohort-component method is suggested in the paper.

Introduction

India does not publish annual population estimates after the year of the population census year as is the practice in countries like United States of America, Canada, United Kingdom, Australia, and New Zealand. The reason is that there is a high level of incompleteness in the registration of births and deaths under the civil registration system. Although, it is mandatory under the Registration of Births and Deaths Registration Act of

1969 that every birth and every death is registered under the civil registration system, yet the deficiencies of the civil registration system in India are well-known. For example, births and deaths registered under the civil registration system in the year 2019 have been published 2021 only (Government of India, 2021).

The Government of India, however, has been producing population projections by age and sex for India and for its constituent States and Union Territories for 25 years, since 1958 after every population census. The latest of these projections have been carried out by the Registrar General of India based on the data available through the 2011 population census and published by the National Commission on Population (Government of India, 2020). These projections provide annual projected population of the country and its constituent States and Union Territories for the period 2011 through 2036, although they were published in 2020, almost 9 years after the 2011 population census (Government of India, 2020). The Government of India, however, makes no attempt to project the population of the districts of the country.

Dhar (2022) has carried out projections of the population of 640 districts of the country as they existed at the time of the 2011 population census by sex and age for the period 2011 through 2031 using the population projections prepared by the Government of India. He has used the ratio method to project the population of the district based on the projected population of the State/Union Territory to which the district belongs. This is a top-down method which does not take into consideration the district-level variation in population growth. The limitation of this method is that the projected population of the district is controlled by the projected population of the concerned State/Union Territory prepared by the Government of India.

Chaurasia (2023), on the other hand, has forecasted the population of each of the 640 districts of the country by modelling the population growth pattern in the district during the period 1951-2011 as revealed through the decennial population census since 1951. He has modelled the population growth in a district by fitting the logistic growth curve. Based on the forecasted population of each district, population forecast of different States and Union Territories and population forecast of the country has been obtained by simply summing the population forecast of the districts within the State/Union Territory. In this approach, the forecasted population of the district and hence States and Union Territories is not controlled by the population projected by the Government of India.

The ESRI India has also produced district-wise population projections for the period 2011-2036 by calculating a factor of projected population of a state for the year (t+K) and the base year (t). These factors are calculated for the period 2012-2036 and then they are multiplied to the population of the district enumerated at the 2011 population census (ESRI India, 2022). These projections, however, are not available in the public domain. They are available for the registered users of ArcGIS software only.

Kulkarni (2021a; 2021b; 2023) has projected the population of the country and its large states up to the year 2100 based on certain assumptions on future changes in demographic parameters using the country level population projections prepared by the United Nations Population Division (United Nations, 2022). He has, however, made no attempt to project the population of the districts of the country.

The population projections prepared by the Government of India are the basic input data for projecting district population by Dhar (2022) and by ESRI India (2022) and for studying the long-term population growth scenarios for large states of the country by Kulkarni (2021; 2023). In this context, it is important to review the quality of the population projections prepared by the Government of India. It is in this perspective that the present paper aims at (1) describing some principles of applied demography that may be used to analyse the quality of projections; (2) using these principles to review the quality of the population projections prepared by different researchers and agencies; (3) describing the task of updating the current population projections prepared by the Government of India; and (4) discussing the feasibility of projecting district population using the cohort component method. The paper also reviews the projections prepared by Chaurasia (2023), Dhar (2022), ESRI India (2022) and Kulkarni (2021a; 2023).

The paper is organised as follows. The next section of the paper outlines the basic principles of applied demography that may be used to analyse the quality of population projections. The third section of the paper reviews the population projection prepared by the Registrar General of India from the applied demography lens. Section four of the paper discusses the factors that may influence the quality of population projections. Section five reviews the district level population projections prepared by Dhar (2022), ESRI India (3022) and Chaurasia (2023).

Method

This paper uses the principles of applied demography to review the population projections prepared by the Registrar General of India and projections and forecasts prepared by Chaurasia (2023), Dhar (2022), ESRI India (2022) and Kulkarni (2021a; 2023). Applied demography is intrinsically distinct from basic demography. Applied demography exhibits the value-orientation and empirical characteristics of a decision-making science whereas basic demography exhibits the value-orientation and empirical hallmarks of a basic science (Swanson et al, 1996). Applied demography is based on the context and, therefore, its substantive problems are largely exogenously defined. By contrast, the substantive problems of basic demography are largely endogenously defined. Basic demography primarily offers explanations of demographic phenomena whereas applied demography focusses on what is necessary to support practical decision-making while minimising time and resources. There are nine principles of applied demography (Swanson and Tayman, 2012):

1. Need of estimates and projections
2. Time
3. Resources
4. Method(s)
5. Input data quality
6. Developing estimates and projection scenarios
7. Error assessment
8. Review process
9. Transparency

Projections Prepared by the Government of India

The population projections of the Government of India (2022) are prepared by a Technical Committee comprising of 19 experts including senior demographers from India: technical staff of the Office of the Registrar General, India and representative of the Ministry of Health and Family Welfare, the nodal ministry of the Government of India for population related matters. The Technical Committee includes only Indian experts whereas technical committees constituted by many western countries include international experts. For example, Statistics Canada has two advisory committees for different subject matters. The advisory Committee on Demography and the Federal-Provincial Statistical Advisory Committee are responsible to evaluate the quality of demographic products such as population estimates and projections for Canada, provinces and territories and sub provincial areas. The demography committee includes experts from other countries. The United States Bureau of Census also has similar committees. Similarly, the Office of National Statistics (ONS) of the United Kingdom collaborates with many international and national experts to determine the methods, data and assumptions which underpin population estimates and projections. (United Kingdom, 2021). There is, however, no doubt that the report prepared by the Technical Committee has taken care of the issues related to methods of projection and adjustment of input data quality for all states and union territories. The projections prepared by the Technical Committee for 25 years (2011 to 2036) appear to be more accurate than 50- and 100-years projection prepared by the United Nations (United Nations, 2022).

The technical Committee uses the cohort component method for projecting the population of the country. However, the Committee has followed different methods for projecting population of the States and Union Territories because of data constraints. It has used the cohort component mothed for some States and Union Territories of Chandigarh and National Capital Territory of Delhi. For the northeastern states of the country the population projections prepared by the Committee are based on the cohort component method and the ratio method. For the Union Territories and Goa, the Committee has used the exponential rate of growth for projecting the population. This is quite in contrast to the western countries which adopt consistent approach of projecting the population at all administrative levels. It is also not clear from the Technical Committee report how has the projected population of northeaster states, Goa and Union Territories has been distributed by age and sex.

There are ambiguities in the input data and their quality used by the Technical Committee also. For example, it is not clear how the conventional five-year age specific fertility rates are split into single-year age specific fertility rates. The Statistics Canada uses the Pearson Type III curve has been used to convert the five-year age specific fertility rates into single year of age specific fertility rates (Verma and Loh, 1996; 2008). Similarly, it is not clear how five-year age specific probability of death has been converted into single-year age specific probability of death necessary for the application of the cohort component method of population projection.

The Technical Committee has assumed for the purpose of projection that the international migration in zero. This assumption is questionable as the emigration from India to other countries is quite substantial. At the same time, there is immigration to India

also, although the immigration is small compared to emigration. This means that there is net emigration from the country. The Technical Committee should have at least discussed the size of immigration and emigration and may then have assumed that the international migration, is zero. The technical Committee has also assumed that within country, net inter-state migration during the period 2011-2036 is the same as the net inter-state migration during the period 2001-2011 as revealed through the 2011 population census. This assumption is also questionable and would have affected the population projected for the period 2011-2036. It may also be pointed out that there has been very significant decline in inter-state migration because of the Covid-19 pandemic so that the assumption that inter-state migration will remain constant during the period 2011-2036 is contentious.

The Covid-19 pandemic during the period 2019-2021 has also influenced the pace of fertility and mortality transition at the national level as well at state/Union Territory level. For example, Chaurasia (2023) has observed that the pandemic has resulted in a loss of almost 3.7 years in the life expectancy at birth and accounted for at least 4 million excess deaths in the country. The loss in the life expectancy at birth in India associated with the pandemic has been amongst the highest across countries for which estimates are prepared by the United Nations Population Division. Moreover, there have been more male that female excess deaths due to the pandemic. The Population Reference Bureau (2001) has observed that" incorrect assumptions about fertility and mortality have a greater effect at older and younger ages". The Technical Committee has also not adjusted the population enumerated at the 2011 population census for under coverage. At the national level, the post-enumeration check after the 2011 population census has revealed the under enumeration of 20 per 1000 population and this error is different in different states and Union Territories of the country. This is a big source of the difference across the projected population of the country carried out by different organisations. Population Reference Bureau (2001) has stressed that "In short-term projections, inaccuracies in the population count at the beginning of the projection period are the most important sources of error whereas in the long-term projections, assumptions about the future trends in fertility, mortality, and migration matters the most."

The Government of India released the report of the Technical Committee in the year 2020 only, almost 9 years after the 2011 population census without any note about the inordinate delay in the release of the report. This is in contrast to the projection report based on the 2001 population census which was released in 2006 in which it was clearly mentioned that the report was delayed because the migration data of the 2001 population census could be released in 2005 only (Government of India, 2006).

The official population projections released by the Government of India are associated with the caution that the projected population may be wrong in the future. There is, however, no analysis that how the projections carried out for the period 2011-2026 differ from the projections for the same period based on the 2001 population census and what are the sources of the difference. It would have been useful if the Technical Committee would have provided the error of closure between the projected population and the enumerated population from 1961 census onward.

The population projections prepared by the Technical Committee are limited to one scenario only whereas the United Nations produces population projections under

different scenarios. Traditionally, United Nations projects population under three scenarios – low, medium, and high – depending upon the pace of fertility decline whereas the pace of mortality decline is assumed to be the same in all the three scenarios and the medium variant is assumed to be the most likely scenario. It would have been more appropriate if the Technical Committee would have produced population projections under alternative scenarios of the future trend in fertility, mortality, and migration.

Table 1: Population (000) of India projected by different agencies and authors, 2011-2036.

Year	Government of India		United Nations 2022	US Census Bureau 2023	Kulkarni 2021	Chaurasia 2023
	2011	2001				
2011	1210855	1192506	1257621	1236352	1211000	1324262
2012	1226901	1208116	1274487	1251839		1338635
2013	1242942	1223581	1291132	1267220		1352419
2014	1258985	1238887	1307247	1282483		1365617
2015	1275030	1254019	1322867	1297588		1378235
2016	1291074	1268961	1338636	1312486	1292000	1390280
2017	1305463	1283600	1354196	1327127		1401761
2018	1319844	1298041	1369003	1341471		1412690
2019	1334235	1312240	1383112	1355597		1423079
2020	1348616	1326155	1396387	1369541		1432944
2021	1363006	1339741	1407564	1380722	1368000	1442298
2022	1375586	1352695	1417173	1389637		1451159
2023	1388163	1365302	1428628	1399180		1459543
2024	1400744	1377442	1441720	1409128		1467467
2025	1413324	1388994	1454607	1419317		1474950
2026	1425908	1399838	1467231	1429700	1437000	1482009
2027	1436478		1479579	1440259		1488662
2028	1447051		1491671	1450913		1494928
2029	1457628		1503471	1461595		1500825
2030	1468194		1514994	1472251		1506369
2031	1478775		1526209	1482896	1496000	1511579
2032	1487471		1537108	1493392		1516472
2033	1496175		1547690	1503552		1521064
2034	1504878		1557920	1513365		1525372
2035	1513578		1567802	1522819		1529410
2036	1522288		1577303	1531918	1544000	1533194

Source: Government of India (2006; 2020); United Nations (2022); United States Census Bureau (2023); Kulkarni (2021a); Chaurasia (2023).

The report of the Technical Committee has not been externally reviewed by independent experts either within or outside the country as is the practice in western countries. The review by external independent experts and agencies provides credibility to the projections prepared by the Technical Committee. Such a review also helps in improving the quality and hence relevance of the projected population. An attempt, therefore, has

been made in this paper to compare the population projected by the Government of India based on the 2001 population census (Government of India, 2006) with the population projected by the Government of India based on the 2011 population census (Government of India, 2020) for the period 2011-2026. In addition, we have also compared population projections prepared by the Government of India based on 2011 population census with the population projections prepared by the United Nations (2022), United States Census Bureau (2023), Kulkarni (2021a) and Chaurasia (2023).

Table 1 gives data on projected population of India prepared by the Technical Committee based on 2011 population census for different years of the period 2011-2036 along with the population projected by United Nations (2022), United States Census Bureau (2023), Kulkarni (2021a) and Chaurasia (2023). The population projected by the Government of India based on 2011 population census is consistently higher than the population projected by the Government of India based on the 2001 population census and one reason is that the population enumerated at the 2011 population census was higher than the population projected for the year 2011 based on the population enumerated at the 2001 population census. On the other hand, population projected by the United Nations (2022), United States Census Bureau (2023), Kulkarni (2021a), and Chaurasia (2023) is consistently higher than the population projected by the Government of India based on the 2011 population census throughout the period 2011-2036, although the difference is not large.

The difference in the population of India projected by different agencies and authors may be attributed to different methods used for projection. Three of the five projections, except Government of India (2020) and Chaurasia (2023), are based on the estimated population of the country as on July 1, 2021. The projections by the Government of India (2020) are based on the population enumerated at the 2011 Census. Chaurasia (2023), on the other hand, has prepared population projections for India and states based on population projections for 640 districts, using the logistic growth model. All projections, except by Chaurasia (2023) are based on the cohort component method. but assumptions about projected trend in the components of population growth (fertility, mortality, and migration) are different. The United Nations and United States Census Bureau have also adjusted the base population for census undercount and net international migration.

Despite differences in methodology, population projected by different agencies and authors for the year 2036 is at the comparable level ranging from 1520 million (Government of India, 2020) to 1577 million (United Nations, 2022). The population projected by United Nations, United States Census Bureau and Chaurasia are higher by 2 to 4 per cent over the population projected by the Government of India whereas the population projected by Kulkarni is lower than that projected by the Government of India for the years 2021 and 2026 but higher by about 3 per cent for the year 2036. United Nations (2022) has projected the total fertility rates using the Bayesian probabilistic approach whereas the United States Census Bureau (2023) has projected the total fertility rate by modelling the trend in total fertility rate in 240 countries through the logistic curve. The Government of India (2020) has used the Gompertz Curve. United Nations and United States Census Bureau have estimated net international migration rates using the residual method. Untied Nations (2022), United States Census Bureau (2023, and Kulkarni (2021a) have projected that the total fertility rate will decline from 2.4 during 2011-2015 to 1.9 children

per woman in during 2031-2036 whereas the Government of India (2020) has projected that the total fertility rate will decline to 1.77 children per woman by the period 2031-2036. On the other hand, Kulkarni (2021) has projected lower life expectancy at birth as compared to that projected by the Government of India (2020). The United States Census Bureau has also projected lower life expectancy at birth for 2021-2025, 2026-2030 and 2031-2036 whereas United Nations (2022) has projected the life expectancy at birth which is similar to that by the Government of India. Chaurasia (2023) has derived the projected population for India based on the population projections for 640 districts using the logistic curve fitted to the population enumerated at the previous seven census years by inflating the parameter K, (maximum population size) of the model by 10 per cent. Modelling population growth by logistic curve is less affected by the problem of census undercount. Kulkarni (2021a) has produced the population projection for three scenarios (high, medium, and low). The projected population under medium scenario is lower than that projected by United Nations (2020) for all years but marginally higher than that prepared by the Government of India (2020). Kulkarni has not adjusted the base population for the census undercount and has assumed that the net international is zero. There is also a difference in the base population between Kulkarni and Government of India (2020).

We have also calculated the error of closure, mean absolute per cent error (MAPE), and the relative difference in the projected and the enumerated population for the year 2011. The error of closure is defined as the difference between the projected and the enumerated population divided by the enumerated population. If the projected population is less than the enumerated population, then the error of closure is negative, otherwise positive. The higher the error of closure, the higher the inaccuracy in the projection exercise.

The error of closure between the projected population for the year 2011 based on the 2001 population census and the population enumerated at the 2011 census is estimated to be -1.5 per cent for India. The projected population by age and sex for the year 2011 was obtained by the cohort-component method with the population at the 2001 census as the base. The net international migration was assumed to be zero over the projection period. The uncertainty in the assumptions about assumed changes in the components of population growth during 2001-2011 explains major share of the error of closure (Table 2). The difference between the projected total fertility rate and the total fertility rate obtained from the official Sample Registration System was 1.0 and 1.1 respectively during the period 2001-05 and 2006-10. Similarly, the projected life expectancy at birth was consistently higher than the life expectancy at birth obtained from the Sample Registration System for both males and females. Other factors may also lead to the discrepancy between projected and enumerated population for the year 2011. These include effect of HIV/AIDs, quality of the population data from 2001 and 2011 census, and net international migration. While projecting the population for the year 2011, the data available from the 2001 population census were not adjusted for undercount and the net international migration was assumed to be zero. On the other hand, the impact of HIV/AIDS on the projected population was published in the technical report based on the 2001 census during the period 2001-2026 (Government of India, 2006). HIV/AIDS is estimated to have reduced the projected population in 2011 from 1193. million to 1188 million so that the error of closure increased to -1.9 per cent.

Table 2: Error of closure in India and states, 2011.

India, States and Union Territories	Projected population as of March 2011 (000)	Census count 2011 (000)	Difference (000)	Error of closure (%)
India				
1.1 Projected population without HIV/AIDS	1192516	1210855	-18,339	-1.5
1.2 Projected population with HIV/AIDs	1187533	1210855	-23,322	-1.9
1.3 Projected population with net international migration and HIV/AIDS	1182251	1210855	-28,604	-2.4
1.4 Difference in undercount in 2001 and 2011 census	45404	42527	2,877	
1.5 Adjusted projected population and census count for 2011	1182251	1253382	-25,727	-2.1
States and Union Territories (Projected population is without adjustment)				
Andhra Pradesh and Telangana	84735	84581	286	0.3
Assam	30508	31206	-698	-2.2
Bihar	97720	104099	-6,379	-6.1
Chhattisgarh	24258	25547	-1,289	-5.0
Delhi	18451	16788	1,663	9.9
Gujarat	59020	60440	-1,420	-2.3
Haryana	25439	25351	88	0.3
Himachal Pradesh	6728	6865	-137	-2.0
Jammu & Kashmir including Ladakh	11718	12541	-823	-6.6
Jharkhand	31472	32988	-1,516	-4.6
Karnataka	59419	61095	-1,676	-2.7
Kerala	34563	33406	1,157	3.5
Madhya Pradesh	72200	72627	-427	-0.6
Maharashtra	112660	112374	286	0.3
Odisha	40750	41974	-1,224	-2.9
Punjab	27678	27743	-65	-0.2
Rajasthan	67830	68548	-718	-1.0
Tamil Nadu	67944	72147	-4,203	-5.8
Uttar Pradesh	200764	199812	952	0.5
Uttarakhand	9943	10086	-143	-1.4
West Bengal	89499	91276	-1,777	-1.9
Other states, and Union Territories	18196	18196	82	0.5
Total	1191495	1209690	-17,981	-1.5
Mean absolute per cent error (MAPE)				2.8
Number of states with higher projected population over 2011 census count				6

Source: Author's calculations. Projected population for 2011 is from Government of India (2006). Census count for 2011 is from Government of India (2020).

According to the United Nations (2022), about 5.282 million Indians emigrated to other countries during the period 2001-2011. This means that the projected population of India in 2011 decreased from 1,187,533 million (with HIV/AIDs) to 1,182,251 million when the net international out migration is considered, and the error of closure increased to -2.4 per cent. On the other hand, the figures about the census undercount are derived by taking the difference from the population estimated by the United Nations for 2001 and 2011 from

the difference in the population enumerated in 2001 and 2011 population census. As the result of this difference, the error of closure decreased marginally to -2.1 per cent. Although, this error of closure is higher than the error of closure of -1.50 per cent obtained without making any corrections due to HIV/AIDS, net international out migration, and the difference in the undercount in 2001 and 2011 population census, yet it is quite small and suggests that the quality of the population projection prepared by the Technical Committee constituted by the Government of India is acceptable.

Among different states and Union Territories of the country, the population projected by the Government of India is lower than the population enumerated at the 2011 population census in all but 6 states - Andhra Pradesh (including Telangana), Delhi, Haryana, Kerala, Maharashtra, and Uttar Pradesh (Table 2). The mean absolute per cent error (MAPE) across all states and Union Territories between the projected population for the year 2011 and the population enumerated at the 2011 census is estimated to be 2.8 per cent which is comparable to MAPE for states in the United States of America (Swanson and Tayman, 2012). The table also shows that the error of closure varies across the states and Union Territories of the country. The error of closure is based on the projected population for the year 2011 which does not consider the extent of international migration from states, impact of HIV/AIDS and the difference in the undercount of population at 2001 and 2011 population census.

As discussed earlier, different methods have been used by the Technical Committee of the Government of India for projecting the population of different states and Union Territories. For states for which relevant information about fertility and mortality is available through the official Sample Registration System, the cohort component method has been used for projecting the population. In these states, the error of closure is mainly due to the difference in the projected and the observed trend in fertility and mortality (Tables 3 and 4). In Delhi, Bihar and Tamil Nadu, the error of closure for the year 2011 is estimated to be more than 5 per cent. The error of closure in Delhi is positive and close to 10 per cent, the highest in all states and Union Territories of the country. This means that the projected population of Delhi in 2011, based on the 2001 population census was higher than the population enumerated at the 2011 population census. The positive error of closure for Delhi may be attributed to higher net in-migration rate assumed in the projection exercise.

On the other hand, the error of closure in Bihar and Tamil Nadu is found to be negative. The large negative error of closure in Bihar may be attributed to the fact that the decrease in both fertility and mortality in the state was slower than the projected one, In Tamil Nadu, the large negative error of closure may be attributed to the relatively slower decrease in mortality compared to the decrease in mortality assumed in the projection exercise and the assumption about the migration out of the state. In other states and Union Territories of the country, the error of closure is not large. There are only 6 states and Union Territories where the population projected based on the 2001 population census by the Government of India is found to be larger than the population enumerated at the 2011 population census. In other states and Union Territories, population projected for the year 2011 based on 2001 population census is smaller than the population enumerated at the 2011 population census.

Table 3: Projected and estimated total fertility rate (TFR) in India and states.

India/States	Projected TFR		Estimated TFR		Difference between projected and estimated TFR	
	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10
India	2.9	2.6	3.0	2.6	-0.1	0.0
Andhra Pradesh and Telangana	2.1	1.9	2.3	1.8	-0.2	1.0
Assam	2.9	2.6	2.9	2.6	0.0	0.0
Bihar	3.9	3.3	4.2	3.9	-0.3	-0.6
Chhattisgarh	3.3	2.9	3.1	3.0	0.2	-0.1
Delhi	2.0	1.8	2.1	2.0	-0.1	-0.2
Gujarat	2.6	2.3	2.8	2.5	-0.2	-0.2
Haryana	2.8	2.4	3.0	2.5	-0.2	-0.1
Himachal Pradesh	2.1	1.9	2.1	1.9	0.0	0.0
Jammu & Kashmir	2.8	2.4	2.4	2.2	0.4	0.2
Jharkhand	3.3	2.8	3.5	3.2	-0.2	-0.4
Karnataka	2.2	2.0	2.3	2.0	-0.1	0.0
Kerala	1.8	1.8	1.8	1.7	0.0	0.1
Madhya Pradesh	3.7	3.2	3.8	3.8	-0.1	-0.6
Maharashtra	2.4	2.2	2.3	2.0	0.1	0.2
Odisha	2.5	2.2	2.6	2.4	-0.1	-0.2
Punjab	2.3	2.1	2.3	1.9	0.0	0.2
Rajasthan	3.6	3.1	3.8	3.3	-0.2	-0.2
Tamil Nadu	1.9	1.9	1.9	1.7	0.0	0.2
Uttar Pradesh	4.4	4.0	4.4	3.8	0.0	0.2
Uttarakhand	3.2	2.8	2.3	2.5	0.9	0.3
West Bengal	2.2	1.9	2.3	1.9	-0.1	0.0
Northeastern states	2.2	2.0	na	na	na	na

Source: Projected values are from Government of India (2006). Estimated values are from Government of India (2013).

Population Projection at the District Level

There are few attempts to project district population in India (UNFPA, 2016; Sinha et al, 2009). These are based on the 2001 census. The is a need for district population projections based on 2011 census for planning and assessing progress towards Sustainable Development Goals. Dhar (2022) has argued that cancer registration authorities in India indispensably require annual estimate of district population. Chaurasia (2023) has also argued that updating and forecasting district population is the need of the time as they are required for many purposes including district development planning and programming, provision of welfare services such as health and education services, infrastructure development, and making decisions about investments in the district, and assessing the future development and welfare needs of the people.

Table 4: Projected and estimated life expectancy at birth in India and states.

India/ Major Large States	Life expectancy at birth by sex								Difference between projected and estimated life expectancy at birth			
	Projected				Estimated							
	Male		Female		Male		Female		Male		Female	
	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10	2001-05	2006-10
India	63.8	65.8	66.1	68.1	63.1	64.6	65.6	67.7	0.7	1.2	0.5	0.4
Andhra Pradesh & Telangana	63.4	65.4	67.9	69.4	62.8	63.5	67.5	68.2	0.6	1.9	0.4	1.2
Assam	59.6	61.6	60.8	62.8	58.4	61.0	60.3	63.2	1.2	0.6	0.5	-0.4
Bihar	65.6	67.1	64.7	66.7	64.2	65.5	64.1	66.2	1.4	1.6	0.6	0.5
Chhattisgarh	58.5	61.0	62.0	64.0	na	na	na	na				
Delhi	70.6	71.4	73.8	74.8	na	na	na	na				
Gujarat	64.9	67.2	69.0	71.0	63.7	64.9	67.8	69.0	1.2	2.3	1.2	2.0
Haryana	66.4	67.9	68.3	69.8	65.0	64.9	68.2	69.5	1.4	3	0.1	0.3
Himachal Pradesh	68.8	69.8	72.1	73.3	na	na	na	na				
Jammu & Kashmir	63.0	65.8	64.5	67.0	na	na	na	na				
Jharkhand	64.0	66.0	62.0	64.0	na	na	na	na				
Karnataka	64.0	66.5	69.6	71.1	63.9	64.9	68.5	69.7	0.1	1.6	1.1	1.4
Kerala	70.8	72.0	76.0	76.8	70.5	71.5	76.7	76.9	0.3	0.5	-0.7	-0.1
Madhya Pradesh	60.5	62.5	61.3	63.3	58.9	61.1	60.5	63.8	1.6	1.4	0.8	-0.5
Maharashtra	66.4	67.9	69.8	71.3	66.3	67.9	69.7	71.9	0.1	0.0	0.1	-0.6
Odisha	60.3	62.3	62.3	64.8	59.6	62.2	62.1	63.9	0.7	0.1	0.2	0.9
Punjab	67.7	68.7	70.4	71.6	67.5	67.4	70.2	71.6	0.2	1.3	0.2	0.0
Rajasthan	64.1	66.1	67.2	69.2	63.0	64.7	66.0	68.3	1.1	1.4	1.2	0.9
Tamil Nadu	66.1	67.6	69.1	70.6	65.7	67.1	65.7	70.9	0.4	0.5	3.4	-0.3
Uttar Pradesh	62.0	64.0	61.9	64.4	60.6	61.8	61.1	63.7	1.4	2.2	0.8	0.7
Uttarakhand	62.0	64.0	66.0	68.0	na	na	na	na				
West Bengal	66.7	68.2	69.4	70.9	65.7	67.4	68.9	71.0	1.0	0.8	0.5	-0.1

Source: Projected life expectancy at birth is from Government of India (2006). Estimated life expectancy at birth is from Government of India (2013).

Recently, Dhar (2022), ESRI India (2023) and Chaurasia (2023) have prepared district level population projections using different methods. Dhar (2022) has used the ratio method, ESRI India (2023) has used the ratio of population change and Chaurasia (2023) has used the logistic curve to project district population. This section discusses, in brief, the approach adopted by the authors for projecting district population.

The ESRI India (2023) has projected district population by calculating a factor based on the projected population and the base year population of the state. Subsequently, this factor is calculated for each year using the projected values provided by the Government of India. It is; however, not clear which derived values are being compared. The methodology needs to be elaborated further. This approach is a top-down approach which does not considers the variation in population change due to internal migration among districts within a particular state. It is suggested to generate the projected population for districts for the year 2011 using the factor based on the population projections for India, States and Territories from 2001 to 2026 and to compare the projected population for each district for the year 2011 with the population enumerated at the 2011 population census. Such analysis would provide the error of closure for each district and would give an estimate of the accuracy of the projection.

Dhar (2022) has used the ratio method for projecting district population based on the population projected by the Government of India (2022) for the states and Union Territories of the country. This approach is also a top-down approach and district projection is contingent upon the population projected at the state/Union Territory level. This method also does not consider the district level variation in population growth while projecting population. The author has observed that the method is more accurate than other methods in majority of districts by calculating the accuracy of the method relative to other methods using data from 1991 and 2001 population census for those districts which did not have boundary changes during 1991-2011.

Chaurasia (2023) has produced population projection by sex for 640 districts of India from 2011 to 2041 using the logistic model of population growth. For each district, the model was fitted to the population of the district enumerated in 1951, 1961, 1971, 1981, 199, 2001, and 2011 population census. Unlike the approaches used by ESRI India (2022) and Dhar (2022), the approach adopted by Chaurasia (2023) is the bottom-up approach in which the project population of the state/Union Territory and the country is contingent upon the projected population of districts of the state/Union Territory or country. The model provided good fit to population growth during 1951-2011 in all but 12 districts which are flagged as outliers. Two measures of the goodness of the fit – mean absolute per cent error (MAPE) and R^2 are used. About 90 per cent districts had MAPE under 0.05 per cent for males and females. Similarly, in more than 95 percent districts, the R^2 is estimated to be at least 0.90 for both males and females. The fitted logistic curve has been used for projecting population for 30 to 40 years based on the assumption that growth curve of the population follows an exponential path for 30-40 years only. Consequently, when it comes to projecting population for a longer period, a provision for population stabilisation is required exogenously (Mahmood and Kundu, 2001). Chaurasia (2023) has estimated population at stabilisation in each district by inflating the parameter *K* of the logistic growth curve by 10 per cent. This has not affected the projected population from

2011 to 2036 which are considered in this paper. Chaurasia (2023) has, however, not estimated the closure error for the districts. The approach adopted by Chaurasia (2023) for projecting district population is recommended as they are based on historical data on population growth in the district. The logistic curve provides relatively more accurate population projection for the country, states, and small areas. However, the projected population for districts based on the logistic curve is not available by age. This may be done by multiplying the projected population by their percentage distribution by age using the ratio method.

All the existing district population projections do not provide any information about the future tend in the components of population growth. It is therefore not possible to explain the growth of population in the district. There is, therefore, a need to project the population of the district using the cohort-component method to explain the determinants of population growth. This issue will be discussed in the following section of the paper.

Projection of the Urban Population

The Government of India (2020) has used the urban rural growth difference (URGD) approach proposed by the United Nations to project the urban population in the country and in its states/Union Territories. The URGD for the period 2001-2011 has been assumed to be the same up to the year 2036. This exercise suggests that the urban population in the country will increase from about 31 per cent in 2011 to around 39 per cent in 2036. The same method has been used by the United Nations (United Nations, 2018). According to the United Nations, more than 43 per cent population of India will be living in the urban areas by the year 2035. This proportion is substantially higher than that projected by the Government of India and the difference may be due to the use of population adjusted for census undercount as base population for projecting the population. It is, however, well-known that the URGD method over projects the urban population, especially, in the developing countries (Bocquier 2005). Alternative to URGD method includes the polynomial method (Bocquier, 2005). Application of the polynomial method suggests that the URGD method may overestimate the urban population in the world for the year 2030 by almost one billion. The overestimation will be more pronounced in the developing countries and may exceed 30 per cent in Africa, India, and Oceania. The logistic growth model has also been used to project the population of metropolitan cities in India (Dey et al, 2021) for the period 2011-2051.

Updating the Projections of Government of India

The terms of reference for the Technical Committee on Population Projections constituted by the Government of India clearly states that the Committee may give guidance to adjust the existing population projections based on 2011 population census to meet the requirements relating to use of population projections in the intervening period, both before and after the release of the data from the 2011 population census. It has also been

mentioned that the group may also give guidance for similar adjustments in population projections of intervening periods, when results of the 2021 population census become available. (Government of India, 2020). It is in the above context that the following recommendations are put forward to address the weaknesses in the existing projections:

(a) Following the tradition followed by the United Nations, projections may be prepared under three scenarios – high, medium, and low – depending upon the future trend in fertility.

(b) The distribution of the projected population across states/Union Territories may be obtained and this distribution may be applied to the projections to provide the updated projected population for subnational level in India.

(c) Generate the distribution of projected population by age and use this distribution to update the population by age and sex for the states/Union Territories.

District Level Projections Using Cohort-component Method

Projecting district population using cohort-component method is required to understand the determinants of district population growth. This responsibility may be undertaken by 18 Population Research Centers in the country and the activity may be coordinated by the International Institute for Population Sciences. The Hamilton -Perry method, which requires only population data by age for males and females separately from two points of time may be used for the purpose (Hamilton and Perry, 1962). This method is based on cohort change ratios which combine the effects of mortality and migration and using the child-woman ratio to estimate the youngest age group. This method has been recommended for small areas which lack the input data necessary for cohort-component method (Swanson and Tayman, 2012). The district level census data by age may be adjusted for digit preference.

Concluding Remarks

Some reasons for the low representation of applied demography work (estimating and projecting) population for small areas in India in comparison to the western countries are discussed in this paper. The first and the most important reason is that the civil registration system of the country still suffers from high level of incompleteness and lack of timeliness at the district level. Moreover, users are not aware of the weaknesses in the existing population projections produced by the Government of India. There has not been any publication by any external reviewer with respect to quality of the latest population projection based on the 2011 population census. The review of the latest population projections produced by the Government of India based on the principles of applied demography has outlined some weaknesses that need to be addressed by making alternative sets of projections for planning and for making business decisions. The Technical Committee on Population Projections constituted by the Government of India is mandated

to update current population projections and report any updated projections to the National Commission on Population. As regards projecting the district population, we recommend the projections prepared by Chaurasia (2023) based on the population growth modelling approach. These projections are based on the historical data on population growth in each of the 640 districts that existed at the time of the 2011 population census. For each district, these projections are available for males and females separately. These projections may serve the basis for projecting district population by age following the ratio method or by using other appropriate methods. An applied demographer can carry out this task and update population projections for the country and for its constituent states and Union Territories. This is the need of the time as the Government of India has placed the emphasis on decentralised district level planning, programming, and monitoring and evaluation of development and welfare activities. At the same time, the Population Research Centers of the country, under the stewardship of the International Institute for Population Sciences, may bear the challenging responsibility of projecting district population using the cohort-component method.

Acknowledgements

Appreciation is acknowledged to the anonymous reviewer and the chief editor of this journal for providing valuable suggestions for improving the first draft of the paper. I am also grateful to Professor PM Kulkarni for providing some projected data on special request, and to Professor Murli Dhar for providing the modified Table 6 of his report on district wise population projections in India.

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INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 3(2), July 2023: 337-356

Migration and Employment in Mumbai, India

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Abstract

This paper examines the migration and employment situation in Mumbai city, the commercial capital of India. Using the latest available information from the National Sample Survey and the decennial population census, the paper provides information on changing pattern of employment and workforce in the city during the last 20 years. The differences in the industrial and occupational profile of workers in terms of sex, age and migration status have also been analysed. The analysis reveals that the share of the manufacturing sector in the workforce has decreased while that of the trade and commerce sector has increased. Another major change has been the increase in self-employed workers. The data available from the decennial population census reveals decrease in male work participation rate but increase in female work participation rate. The proportion of non-agricultural establishments has increased but employment in non-agricultural establishments has decreased.

Introduction

The city of Mumbai is popularly known as the commercial capital of India as it is the main centre of finance, trade, and entertainment of the country. At the 2011 population census, the population of the city was enumerated to be 12.4 million. There was no decennial population census in the country in 1921 because of the COVID-19 pandemic so the official estimates of the population of the city for the recent date are not available. It is, however, estimated that the population of the city has now increased to more than 24 million, making it the seventh largest city of the world (United Nations, 2019). In India, Mumbai is the second largest city, next to the national capital of Delhi. It is projected that the population of the city will increase to more than 28 million by the year 2030 (United Nations, 2019).

The growth of the population of Mumbai has largely been due to in-migration from the hinterland in search of better livelihood opportunities. Before the 18th century, Mumbai was a small locality on seven small islands on the Arabian sea inhabited mostly by fishermen. In the late 18th and early 19th centuries, development

activities in terms of the railway network and port city put Mumbai on the road of national and international map. In the early 19th century, the city was known as the Manchester of India because of the flourishing textile industry which was ruined by trade union strike in the 1980s. The textile industry which was once the main source of livelihood to thousands of workers coming from all over the country now lies in shambles. In the early eighties, the decline of manufacturing industries, especially downfall of textile industry, led to the emergence of various territory sector activities including real estate and service-oriented industries. The demand for housing in the city is now so high that many textile industries have now turned into housing and commercial centres. The globalisation and the liberalisation policy of the Government of India in the early nineties also contributed to the change in the profile of Mumbai city from manufacturing focussed activities to tertiary sector activities.

The aim of this paper is to analyse the historical and emerging trend in migration and employment in Mumbai and the contribution of Mumbai to the economy of the state of Maharashtra. The paper also analyses differences in the employment pattern of migrants and non-migrants to inform the policy makers and development planners to enhance the vision about the future of Mumbai and to prepare for the migration and employment scenario of the city that is likely to emerge at least in the near future. Such an analysis is important as Mumbai continues to be the rapidly growing cities of India because of its potential of providing employment and generating income.

Data Source

The paper uses data from decennial population censuses from 1961 through 2011 and different rounds of the national sample survey during 1987-2010. The decennial population census in India has been conducted at every ten years since 1881. The place of birth and place of enumeration data available from the census is the only data source in India to establish patterns of population movement within the country. The national sample survey (NSS) also provides data about the type of work, days of work, wages earned by regular and casual workers and related information which may be used to examine the difference between migrant and non-migrant population in terms of type of work classified by industrial categories and occupational patterns. The 2021 population census could not be carried out in India because of the COVID-19 pandemic. It is not clear till to date when the next round of the population census in the country will be conducted. Moreover, some of the migration tables of the 2011 population census such as industrial classification and occupational classification tables known as D8 and D-9 have not been released. We have, therefore, relied on data from the 64th round of NSS for analysisng occupational and industrial difference between migrants and non-migrants in Mumbai.

Population of Mumbai and Its Migration component

According to the 2011 population census, the population of Mumbai was enumerated as 12,442,373 persons, roughly about 1 per cent of the population of the country. From the administrative perspective, the city is divided into two administrative districts - Mumbai and Suburban Mumbai districts – but is governed by one civic body – Municipal Corporation of Greater Mumbai – which is responsible for the welfare of its citizens in term of providing all basic amenities and collecting revenues from city population.

The population of Mumbai has been growing faster than any other city in the country except the decade 2001-2011. In the last fifty years, the population of the city has been increasing, on average, by nearly 2000 thousand persons every 10 years (Table 1). The city is spread over an area of 437.71 square kilometres and is locked by the Arabian sea from three sides. Because of its limited geographical area, the city faces several problems related to housing, infrastructure, civic facilities and so on. Since 1980 the city planners have developed new areas in the adjoining district of Thane to decongest Mumbai and the efforts have been successful in providing housing and other facilities to the ever-increasing population of the city. One of the central ironies of this most prosperous city of India is that more than half of the population of the city (54 per cent) lives in slums which are highly congested and lack basic amenities and civic services.

Migration has always played a significant role in the increase in the population of the city. In the early decades of the 19th century, the population of the city increased mainly because of in-migration of working population (Table 1). The natural increase component of population growth was almost negligible until 1941. During 1951-61, the growth in population due to migration and due to natural increase was nearly the same but the contribution of migration to city population growth started decreasing since 1961 and decreased to around 39 per cent during 1991-2001 because many migrants settled with family in the city and children born to these families were classified as non-migrants. Since 1980 adjoining areas of the city started growing faster in terms of industrial activities and the proximity of these areas to the city resulted in the movement of the population to these newly emerged satellite towns. During 1991-2001, nearly 650 thousand persons moved out of the city to the adjoining Thane district while only 20 thousand moved from Thane to Mumbai district. This movement of the population resulted in weakening of the population pressure in the city. During 2001-2011, the contribution of migration to city population growth is found to be negative, which may again be due to the substantial out-migration of the city population to the adjoining Thane. The data available through the 2011 population census suggest that 11.9 lakh persons from the city migrated out to the Thane district while only about 1.2 lakh persons migrated to the city from the Thane district during the period 2001-2011.

Table 1: Population growth in Mumbai 1901-2011 and components of population growth.

Year	Population (000)	Increase in population (000)			Share of	
		Total	Natural increase	Net migration	Natural increase	Migration
1901						
1911		221	-129	350	-58.37	158.37
1921		231	-168	399	-72.73	172.73
1931		18	-58	76	-322.22	422.22
1941		402	4	398	1.00	99.00
1951		1194	243	951	20.35	79.65
1961	4152	1158	558	600	48.19	51.81
1971	5971	1818	947	871	50.50	49.50
1981	8243	2274	1203	1071	60.42	39.58
1991	9926	1682	1400	282	83.23	16.77
2001	11978	2053	1254	799	61.08	38.92
2011	12442	464	950	-486	205.00	-105.00

Source: Singh (2007). For the period 2001-2011, migration estimates are based on registered births and deaths.

Table 2 shows the distribution of migrants by their place of origin. During the last 60 years, the proportion of lifetime migrants in the city population has decreased from 64 per cent to 43 per cent. The proportion of international migrants decreased consistently during this period. percentage shows a consistent decline from nearly 3 per cent to less than one per cent. The most notable feature of migration in Mumbai is the decrease in the proportion of lifetime migrants from other districts of Maharashtra but the increase in the lifetime migrants from other states of the country. At the 2011 population census, nearly two-third of lifetime migrants in the city were born outside Maharashtra (63.4 per cent) while around one-third (35.2 per cent) were born within the state of Maharashtra.

Table 2: Distribution of lifetime migrants in Mumbai by place of origin 1961-2011.

Type of Migrants	Year					
	1961	1971	1981	1991	2001	2011
Lifetime migrants (000)	2667	3372	4229	3703	5185	5445
Migrants from within Maharashtra	26.75	23.48	21.67	15.34	16.19	15.35
Migrants from other states	34.09	30.70	28.13	21.11	26.48	27.66
International migrants	3.37	2.3	1.51	0.79	0.62	0.62

Source: Singh (2007). Migrants are based on place of birth concept.

Migration in India is mostly due to economic and social reasons. This has been the case in Mumbai also. Nearly 62 per cent of male lifetime migrants in Mumbai reported that came to the city for employment and for business-related activities

while nearly 80 per cent female migrants moved to the city as family member. Employment as the reason for migration was higher among migrants from the rural areas. Similarly, employment was the main factor of migration to the city for the people from other states of the country as compared to people migrated from within the state. The employment opportunities available in the city and in its outgrowth, has always been the main pull factor for the movement of the people from different parts of the country to the city. for migrants from all over the country.

Employment Scenario

Census of India defines work as participation in any economically productive activity with or without compensation, wages, or profit. Since 1981, workers in the population census in India are divided into main workers, marginal workers and non-workers based on the duration they had worked during the year prior to the census. Main workers are workers who had worked for at least 6 months during the year prior to the census. Marginal workers are those who worked for less than 6 months during the year prior to the census. Finally, non-workers are those who had not worked for even a day during the year prior to the census. Non-workers include, among others, students, persons engaged in household chores like cooking, looking after children, aged, pensioners after retirement and not engaged in any economic activity, beggars, vagrants, and prostitutes. Population aged below 5 years is treated as non-workers. The ratio of the workers to the total population is termed as the work participation rate which measures the extent of participation in productive activities.

The data available from the 2011 population census suggest that the male work participation rate in Mumbai was nearly 56 per cent whereas the female work participation rate was around 16 per cent. Over the years, the female work participation rate increased from 9 per cent in 1961 to nearly 16 per cent in 2011 but the male work participation rate decreased from around 62 per cent to 56 per cent during 1961-2011 (Table 3). The increase in the female work participation rate may be attributed to the increase in the employment opportunities in the tertiary sector such as banking and commerce activities which are more women friendly. As the result, the workers sex ratio in Mumbai increased consistently from around 9 female workers for every 100 male workers in 1961 to more than 26 female workers for every 100 male workers in 2011. Recent data about the work participation rate in the city are not available as the decennial population census scheduled for 2021 could not be carried out. In any case, despite the increase in the workers sex ratio for more than 50 years, the workforce in Mumbai remains heavily biased towards males. There is also little difference in the work participation rate in the slum and non-slum population of the city according to the 2011 population census - 56.3 per cent and 57.4 per cent for male population and 11.4 per cent and 14.9 per cent respectively for female

population – although the proportion of marginal workers to total workers is found to be relatively higher in the slum population as compared to non-slum population of the city.

The national sample survey (NSS) also provides data on workers based on three approaches of work status - usual, weekly, and daily. The usual work status is measured into two parts - principal and subsidiary – depending upon the duration of engagement in economic activity during the reference period of 365 days. Table 4 provides the employment rate by principal and subsidiary status in the last 20 years along with the corresponding figures for urban India available from different rounds of NSS. The employment rate in Mumbai is marginally better than that in urban India rates for both males and females. However, in the early 1990s the employment rate in in Mumbai was marginally lower than that in urban India.

Table 3: Work participation rate in Mumbai, 1961-2011.

Year	Number of workers			Work participation rate		
	Male	Female	Total	Male	Female	Total
1961	1540861	145807	1686668	61.73	8.81	40.62
1971	2005728	192370	2198098	57.66	7.72	36.82
1981	2579978	322221	2902199	55.45	8.97	35.21
1991	3007332	492010	3499342	55.08	11.02	35.25
2001	3764550	699698	4464248	56.87	13.06	37.27
2011	3965331	1054086	5019417	56.39	16.38	37.98

Source: Census of India, 1961 to 2011.

Table 4: Number of persons usually employed per 1000 persons aged 15 years and above according to principal and subsidiary status by sex during 1987-88 to 2006-07.

Year	Male		Female	
	Mumbai	Urban India	Mumbai	Urban India
64th	797	761	203	185
61st	786	763	267	227
55th	753	752	174	197
50th	773	768	221	223
43rd	733	769	188	225

Source: Author's calculations based on different rounds of NSS.

Workers, in NSS, are categorised into self-employed, regular salary/wage employees and casual labourers. Self-employed persons are those who are engaged in household enterprise including own account worker, employer, and unpaid family members. Table 5 gives the distribution of workers in three categories. Nearly 60 per cent of the male workers in Mumbai were categorised as regular salaried/wage workers while around one third were self-employed. Among female workers, the proportion of regular/salaried workers was relatively higher than that of males. It may

also be seen from the table that opportunities for regular/salaried employment in Mumbai has been relatively better than in urban India. However, the share of the casual labour in the work force has increased sharply in Mumbai after 2000. This may be due to the increase in real estate activities which demand more casual than regular labour.

Table 5: Proportion usually employed for every 1000 population aged 15 years and above by status of employment in Mumbai and in urban India.

Year	Male			Female		
	Self-employed	Regular Salaried	Casual Labour	Self-employed	Regular Salaried	Casual Labour
			Mumbai			
64th	336	589	75	242	663	95
61st	403	517	80	292	689	19
55th	292	679	31	259	690	52
50th	352	654	21	276	692	32
43rd	324	628	48	305	631	64
			Urban India			
64th	425	424	152	355	436	209
61st	449	407	144	471	361	167
55th	415	418	166	452	335	213
50th	415	425	160	446	293	261
43rd	415	439	146	467	280	253

Source: Computed by the author from data from different rounds of NSS.

It is possible to estimate the extent of under-employment as the difference in the employment rate based on the weekly status and the employment rate based on the daily status. This exercise using the data available from NSS suggests that the under-employment rate in Mumbai has varied between 5 to 10 per thousand population aged 15 years and above for males and 4 to 14 per thousand population aged 15 years and above for females. The data available from different rounds of NSS also suggest that the under-employment rate in Mumbai has always been lower than the under- employment rate in other class I cities of the country since 1987-88,

Unemployment Situation

The NSS defines the unemployment rate as the number of persons/person-days unemployed per 1000 persons/person-days in the labour force (which includes both the employed and unemployed). Unemployment rate is computed based on three work status criteria – usual (principal or subsidiary) status, weekly status, and daily status. According to the 64th round of NSS, the unemployment rate in India was 81 per thousand population aged 15 years and above based on the daily status; 42 per

1000 population aged 15 years and above; and 22 per 1000 population based on usual status (Government of India, 2010). According to the daily status approach, the unemployment rate in urban areas of the country was 74 per 1000 population aged 15 years and above compared to 84 per 1000 population aged 15 years and above in the rural areas. In Mumbai, the unemployment rate has been found to be lower than that in India (Table 6). The unemployment rate has decreased for the male population after 2000 but the trend in the unemployment rate in females is mixed. Moreover, female unemployment rate is higher than that in females in Mumbai as well as in urban India.

Table 6: Unemployment rate in Mumbai and in urban India according to usual, weekly, and current daily status.

Year	Male			Female		
	Usual (adjusted)	Current Weekly	Current Daily	Usual (adjusted)	Current Weekly	Current Daily
			Mumbai			
64th	25	41	62	83	121	116
61st	31	65	75	53	66	69
55th	68	77	85	117	124	136
50th	53	57	60	71	83	93
43rd	81	93	98	96	119	126
			Urban India			
64th	37	41	68	53	54	95
61st	38	52	74	70	91	117
55th	44	56	73	57	72	92
50th	40	52	68	63	87	109
43rd	51	66	87	63	93	124

Source: Computed by the author from data from different rounds of NSS. Usual rate is adjusted for principal and subsidiary activity.

Occupational Distribution of Workers

The occupational distribution of workers in Mumbai shows a clear shift from the manufacturing sector to the trade and commerce sector during the last five decades (Table 4). The share of workers in the manufacturing sector started decreasing whereas the share of workers in trade and commerce sector started increasing after 1981. Similarly, the share of workers in the construction sector increased by nearly 2 times since 1981. On the other hand, there has been only a marginal change in the proportion of workers in transport and storage sector and workers in other industrial sectors. Despite the decrease in its share, the manufacturing sector still remains the main sector providing work opportunities to the population aged 15 years and above in Mumbai.

Table 7: Occupational distribution of workers in Mumbai, 1961 to 2001.

Industrial activity	1961	1971	1981	1991	2001	2011
1. Agricultural	1.89	1.26	1.38	0.84	1.12	1.28
2. Manufacturing - HH industry	1.36	1.33	2.49	1.48	3.12	2.25
3. Manufacturing - other than HH industry	39.46	40.96	38.91	35.31	25.67	21.71
4. Construction	2.66	3.05	3.35	4.24	6.41	6.65
5. Trade and Commerce	18.01	22.36	21.80	24.90	32.9	27.07
6. Transport and storage	11.22	10.78	10.04	11.32	12.11	10.02
7. Other services	25.39	20.27	22.02	21.91	18.65	31.01

Source: Computed by the author from data from different rounds of NSS.
Remarks: Trade and commerce include wholesale-retail trade, hotel-restaurants, and financial-real estate activities

Migration and Employment

Table 8 gives the distribution of migrant and non-migrant population by employment status. Employment rate in male migrants is higher than that in non-migrants but the employment rate in female non-migrants is higher than that in female migrants. Male migrants come to the city purposely for work and, therefore, they agree to take up any available work while non-migrants start working only after acquiring better education and skills for work. Female migrants usually accompany the male migrants and therefore are not inclined to work. They are usually dependent upon their male counterpart.

Table 8: Employment status of migrant and non-migrant population in Mumbai.

Year	Migrant population				Non-Migrant			
	Employed	Unemployed	Non-Workers	Total	Employed	Unemployed	Non-Workers	Total
				Male				
2007-08	87.5	0.9	11.6	100.0	72.4	3.2	24.4	100.0
1999-00	84.5	2.5	13.0	100.0	65.7	8.8	25.5	100.0
1987-88	84.0	2.7	13.3	100.0	62.8	10.2	27.0	100.0
				Female				
2007-08	15.5	0.7	83.9	100.0	24.0	2.7	73.3	100.0
1999-00	12.5	0.6	86.9	100.0	21.5	4.0	74.5	100.0
1987-88	12.8	0.5	86.7	100.0	17.9	3.4	78.6	100.0

Source: Author's calculations based on data from different rounds of NSS.

The occupational distribution of migrant and non-migrant population of the city is presented in table 9 separately for males and females. Nearly one-fourth of male migrants in the city are self-employed compared to less than 13 per cent male non-migrants. On the other hand, the proportion of both male and female non-migrants as self-employed employer and unpaid family worker is higher than migrants

as self-employed employer and unpaid family worker. The proportion of male migrants as regular salaried and wage employees is also higher compared to non-migrants. By contrast the proportion of non-migrants attending educational institutions and looking for job is higher than male migrants. Among female regular employees, the percentage exceeds that of migrants' women as well as attending educational institutions whereas the proportion of migrant women involved in domestic work is found be higher compared to non-migrants.

Table 9: Occupational classification of migrant and non-migrant population aged 15 years and above in Mumbai.

Nature of employment	Male			Female		
	Migrant	Non-migrant	Total	Migrant	Non-migrant	Total
Self-employed - working in household enterprise as own account worker	22.66	12.59	17.44	2.83	2.92	2.88
Self-employed - employer	4.79	6.50	5.68	0.32	0.74	0.56
Self-employed - working as helper in household enterprise - unpaid worker	1.39	5.33	3.44	0.75	0.54	0.63
Working as regular salaried/wage employee	49.91	43.30	46.48	6.90	14.38	11.15
Regular employees in other types of work	8.63	3.39	5.91	1.53	1.65	1.60
Seeking work or available for work	0.92	4.12	2.58	0.79	3.48	2.32
Attending educational institution	3.13	18.10	10.89	2.06	15.71	9.81
Attending domestic duties and other free collection of goods	0.25	0.38	0.32	80.56	56.61	66.94
Rentiers, pensioners, remittance recipients etc.	5.81	3.58	4.65	0.55	1.72	1.21
Not able to work due to disability	0.59	0.45	0.52	0.75	0.16	0.42
Others including begging, prostitution, etc	1.92	2.26	2.10	2.96	2.11	2.48
Total	100	100	100	100	100	100

Source: Author's calculations based on data from 2007-2008 round of NSS.

Industrial Classification and Migration Status

Table 10 gives the distribution of migrant and non-migrant workers aged 15 years and above by industrial classification as revealed through the 2001 population census. There is little difference in the distribution of migrant and non-migrant workers by industrial classification. The proportion of non-migrant workers in financial, real estate and business activities is higher than the proportion of migrant workers. Data from NSS 2007-2008 round also suggests that the distribution of migrant and non-migrant workers by industrial classification is nearly the same. The distribution of migrant and non-migrant workers by industrial classification is not available from the 2011 population census.

Table 10: Distribution of migrant and non-migrant workers aged 15 years and above by industrial classification.

Classification	NSS (2007-2008)				Census (2001)			
	Male		Female		Male		Female	
	Migrant	Non-Migrant	Migrant	Non-Migrant	Migrant	Non-Migrant	Migrant	Non-Migrant
Agriculture and mining - A-B-C	0.2	0.2	1.4	0.0	0.98	1.23	1.54	1.19
Manufacturing - D	28.7	21.5	12.3	21.9	31.89	27.25	21.16	22.18
Electricity-Gas-Water- E					0.48	0.58	0.17	0.21
Construction - F	6.4	4.9	7.7	1.8	8.14	5.31	5.24	1.35
Wholesale and retail - G	18.5	21.1	13.9	8.4	19.66	21.71	9.63	8.85
Hotels and restaurants - H	4.1	3.3	5.8	2.8	4.12	2.55	1.31	1.01
Transport, storage, communication - I	19.6	17.3	2.5	9.6	13.74	13.31	3.58	4.71
Financial intermediation - J	2.0	5.7	0.5	6.2	8.08	13.85	10.94	18.5
Real estate, business - K	4.6	13.2	2.6	14.1				
Public administration - L	5.4	5.3	3.8	1.1	12.9	14.22	46.43	42.0
Education - M	1.0	1.7	4.5	13.3				
Health and social work - N	0.9	1.3	7.4	7.2				
Other community activities - O	5.6	3.2	0.9	4.7				
HH with employed persons - P	3.0	1.3	36.8	9.0				
Total	100	100	100	100				

Source: Author's calculations.

Remarks: Census figures are based on total population. The population census does not provide age data for migrants. Migration data by industrial classification from the 2011 population census have not been released till date.

Tables 11 presents the distribution of male and female migrant and non-migrant workers by industrial classification over time. There has been marked decrease in the share of both male and female migrant and non-migrant workers in manufacturing activities over time whereas the share of main migrant workers in construction activities has increased markedly during 1999-2000 compared to that in 1987-1988. Similarly, the share of female migrant workers in wholesale and retail trade and hotels activities has increased sharply in 1999-2000 compared to that in 1987-1988 according to the national sample survey. table shows that there has been little change in the distribution over time. On the other hand, there has been a noticeable decrease in the share of both migrant and non-migrant workers in community, social and personal services over time.

Occupational Distribution of Main Workers

According to the 2011 population census, around 49 lakh persons in Mumbai were classified as main workers excluding cultivators and agricultural labourers. Table 12 presents the occupational distribution of main workers in the city. Nearly 15 per cent of the main workers were engaged in service, shops, and market sales activities.

Similarly, 16 per cent of the main workers excluding agriculturists and agricultural labourers were engaged in craft and related trade activities. On the other hand, the share of female main workers in elementary occupation including street vendors, domestic helpers, messengers, labourers in manufacturing, construction and transport activities were higher than that of male main workers. The proportion of female main workers is also high in professional-technical and clerical and related services, but their actual number is less than that of male main workers.

Table 11: Industrial Classification of Male Workers aged 15 years and above based on Usual Principal Activity among migrants and non-migrants.

Industrial Classification	1999-2000		1987-1988		1983	
	Migrant	Non-Migrant	Migrant	Non-Migrant	Migrant	Non-Migrant
			Male			
Agriculture and mining	0.1	3.0	0.2	1.1	1.4	0.5
Manufacturing	28.1	23.8	37.1	35.8	38.5	34.6
Electricity, gas, and water	0.4	0.3	0.4	0.5	0.4	1.2
Construction	9.2	4.4	2.9	4.8	3.7	3.7
Wholesale and retail trade and hotels	26.6	27.5	22.8	20.3	20.5	22.9
Transport, storage, communication	12.7	14.5	12.0	11.7	14.1	13.2
Financial and business services	6.6	11.7	4.1	8.5	4.3	7.2
Community, social and personal services	16.3	14.9	20.4	17.5	17.1	16.7
			Female			
Agriculture and mining		1.6		0.9	0.4	1.1
Manufacturing	17.8	16.2	17.3	22.1	30.1	22.5
Electricity, gas, and water				0.6		1.9
Construction	2.7	1.6	0.3	2.5	4.9	0.7
Wholesale and retail trade and hotels	25.4	14.2	18.5	7.5	9.6	11.6
Transport, storage, communication	4.1	4.4	.3	5.4	3.9	4.0
Financial and business services	2.9	12.5	1.0	9.7	1.1	12.7
Community, social and personal services	47.1	49.4	62.7	51.3	49.9	45.6

Source: Author's calculations based on data from different rounds of NSS.

The occupational distribution of main migrant and non-migrant workers excluding cultivators and agricultural labourers is presented separately for males and females in table 13 for the period 2007-2008. A relatively higher proportion of males, non-migrant main workers were engaged as professional, technicians-associate professionals and clerical and related activities in comparison to male migrant main workers whereas the proportion of male migrant main workers was high in craft-related trade activities and activities related to plant and machine operations. Similarly, half of the female non-migrant main workers were engaged in professional and clerical and related activities while the share of female migrant main workers was high in elementary occupations and in trade and market related activities. The occupational distribution clearly shows that migrant main workers are absorbed in service-related activities, while non-migrants' main workers are in white-collar jobs.

Table 12: Distribution of main workers excluding cultivators and agricultural labourers in Mumbai, 2001 and 2011.

Occupational classification	2001			2011		
	Total	Male	Female	Total	Male	Female
Legislators, senior official, managers	5.34	5.61	3.82	10.17	10.83	7.50
Professionals	5.98	5.08	11.13	7.55	6.50	11.80
Technicians and associated professionals	6.69	5.49	13.59	7.53	6.22	12.84
Clerical and related activities	6.93	5.66	14.22	8.77	7.54	13.76
Service workers, shops, and market sales	19.73	21.16	11.52	15.32	16.27	11.52
Skilled agricultural and fishery workers	0.79	0.81	0.69	0.43	0.45	0.35
Crafts and related trades workers	20.99	23.04	9.21	16.04	18.42	6.44
Plant and machine operators	12.86	14.53	3.25	9.87	11.76	2.22
Elementary occupations	18.08	16.32	28.18	17.15	16.16	21.15
Workers not classified by occupation	2.60	2.29	4.39	7.16	5.86	12.43

Source: Author's calculations based on data from 2001 and 2011 population census.

Wages and Days of Work

Average wages during a week in Mumbai are higher than that in other cities of India and Maharashtra for both regular salaried/wage employees and casual wage labourers (Table 14). A study done by Lakdawala et al. (1963) has highlighted the difference in the wages of migrants and non-migrants' workers in Mumbai. Another interesting observation that can be made from table 14 is that male migrant workers receive comparatively higher wages than non-migrant workers in Mumbai as well as in urban India while the same is not true for female migrant workers. In some occupations wages of female migrant workers is higher than that of female non-migrant workers.

Table 13: Occupational Distribution of Migrants and Non-migrants based on usual principal activity aged 15 years and above, Mumbai: NSS 2007-08

Occupational classification	Male			Female		
	Migrant	Non-Migrant	All	Migrant	Non-Migrant	All
Legislators, senior official, managers	2.54	4.02	3.23	2.48	6.24	5.05
Professionals	24.31	30.01	26.97	33.34	23.89	26.88
Technicians and associated professionals	3.27	7.72	5.34	4.76	14.45	11.38
Clerical and related activities	6.43	11.42	8.76	4.08	21.35	15.89
Service, shop, market trade	15.37	15.62	15.48	16.78	10.36	12.39
Craft and related trade workers	19.86	9.97	15.24	9.72	4.41	6.09
Plant and machine operators	17.43	11.30	14.57		1.95	1.33
Elementary Occupation	10.80	9.94	10.40	28.84	17.35	20.99
Total	100.00	100.00	100.00	100.00	100.00	100.00

Source: Computed by the author from raw data from 2007-08 round of NSS.

Table 14: Average wages of and average number of days work for regular salaried/wage employees and casual labourer, Mumbai 2007-08.

Type of employee	Sex	Migrant/Non-migrant	Average wages per day (Rupees)			Average number of days worked in a week		
			Mumbai	Thane Urban	Urban India	Mumbai	Thane Urban	Urban India
Regular salaried/ wage employee	Male	Migrant	465	331	310	6.7	6.8	6.7
		Non-Migrant	316	347	244	6.9	6.9	6.8
		Total	394	335	273	6.8	6.8	6.8
	Female	Migrant	197	306	221	7.0	7.0	6.7
		Non-Migrant	262	290	200	7.0	6.6	6.8
		Total	245	298	211	7.0	6.8	6.7
	Total	Migrant	441	328	292	6.8	6.8	6.7
		Non-Migrant	303	331	237	7.0	6.8	6.8
		Total	369	329	262	6.9	6.8	6.8
Casual wage labour	Male	Migrant	142	126	114	5.8	5.0	5.9
		Non-Migrant	109	134	102	5.1	6.3	5.7
		Total	132	127	105	5.5	5.1	5.7
	Female	Migrant	74	78	60	4.3	5.0	5.3
		Non-Migrant	53	88	59	5.5	3.9	5.3
		Total	61	79	60	5.1	4.8	5.3
	Total	Migrant	130	112	93	5.5	5.0	5.7
		Non-Migrant	85	121	96	5.2	5.6	5.6
		Total	112	113	95	5.4	5.0	5.6
Total	Male	Migrant	425	316	279	6.6	6.7	6.6
		Non-Migrant	302	339	200	6.8	6.9	6.6
		Total	368	321	231	6.7	6.8	6.6
	Female	Migrant	169	257	169	6.1	6.1	5.9
		Non-Migrant	232	282	158	6.6	6.2	6.1
		Total	214	268	164	6.4	6.2	6.0
	Total	Migrant	399	309	253	6.5	6.6	6.4
		Non-Migrant	284	324	193	6.8	6.7	6.5
		Total	341	313	218	6.7	6.6	6.5

Source: Computed by the Author from raw data from 2007-08 round of NSS.

Table 14 also shows that there is difference between regular salaried/wage employees and casual wage labours in terms of the average number of working days in a week. The average number of working days for casual wage labours is nearly 5.5 days per week while that for regular salaried/ wage employees is 6.9 days per week. The regular salaried/wage employees usually get a day or two as compensatory off in a week. As the result, the average wage per day of the regular salaried/wage employees is higher than that of casual wage labours.

Income and per capita income

Mumbai and the adjoining district Thane have always been a major contributor to the economy of Maharashtra. The two districts account for nearly one-third of state income. The contribution of Mumbai in the state income was much higher than other districts of the state, although the share of Mumbai in state income decreased marginally from 24 per cent during 1993-1994 to 21.5 per cent during 2008-2009. Per capita income in Mumbai has been 1.6 to 2 two times higher than that in the state of Maharashtra, but the growth in the net domestic product per capita (NDDP) in Mumbai has been slower than that in Maharashtra during this period. This may be because of rapid economic growth in the adjoining district of Thane and in Nashik and Pune districts. The relatively slow growth of per capita income in Mumbai may also be attributed to government policies of dispersal of industries to other regions of the state of Maharashtra and the decrease in the traditional textile and manufacturing industries in Mumbai. The near saturated infrastructure and space in the city may also be a factor that may be responsible for the slower growth of the economy of the city.

Table 15: Net district domestic product (NDDP) and per capita NDDP in Mumbai and Maharashtra at current prices.

Year	Total NDDP		Per Capita NDDP		Contribution of Mumbai to State Income	Ratio of Mumbai NDDP to Maharashtra
	Mumbai	Maharashtra	Mumbai	Maharashtra		
	Rupees In lakh		Rupees	Rupees	%	%
1993-94	2516237	10349187	24012	12390	24.31	1.94
1994-95	2834059	11843034	26476	13880	23.93	1.91
1995-96	3460671	14256492	31661	16363	24.27	1.93
1996-97	3803220	16285771	34090	18313	23.35	1.86
1997-98	4377596	17720226	38460	19531	24.70	1.97
1998-99	4780675	19267006	41189	20825	24.81	1.98
1999-2000	4827597	22030412	41907	23340	21.91	1.80
2000-01	4750427	22110904	40105	22992	21.48	1.74
2001-02	5279394	23943170	43369	24450	22.05	1.77
2002-03	5927865	26528972	47575	26697	22.34	1.78
2003-04	6891971	30057582	53960	29770	22.93	1.81
2004-05	7892898	33825401	60304	32979	23.33	1.83
2005-06	8798965	38624067	65625	37081	22.78	1.77
2006-07	8976400	43505500	65382	41444	20.63	1.58
2007-08	10842200	52650000	77145	49058	20.59	1.57
2008-09	12851100	59754200	89343	54867	21.51	1.63

Source: Government of Maharashtra.

It may be emphasised here that the economy of Mumbai may probably much larger than the reported one because of a large population commutes daily to Mumbai from the adjoining areas for work. The economic contribution of these daily commuters is added to the economy of the district of their origin because of the way the size of the economy is estimated. At the same time, there is also evidence of reverse flow of workers from Mumbai to adjoining districts that compensates for some underestimation, but it is not at an equal level.

Sectoral Shifts, 1993-94 to 2005-06

The sectoral shift in the economy of Mumbai is confined to the secondary and tertiary sector as Mumbai is a totally urban areas and the share of the primary sector accounts for only around 1-2 per cent of the economy of the city. Table 16 shows that the share of the tertiary sector in the economy of the city increased from around 62 per cent during 1993-1994 almost 74 per cent during 2005-2006 so that the share of the secondary sector in the state economy decreased from around 36 per cent to around 25 per cent during this period. The share of the primary sector, although very small has also decreased during this period. The primary sector accounted for less than 1 per cent of the net district domestic product of Mumbai during the period 2005-2006 as compared to more than 2 per cent during the period 1996-1997. The economy of Mumbai is now almost entirely dependent upon the tertiary sector of the economy.

Table 16: Share of the primary, secondary, and tertiary sector in the economy of Mumbai, 1993-94 to 2005-06.

Years	Primary	Secondary	Tertiary	Total	NDDP Rupees in lakh
1993-94	1.25	36.12	62.64	100.00	2516237
1994-95	1.29	33.62	65.09	100.00	2834059
1995-96	1.46	33.54	64.99	100.00	3460671
1996-97	2.07	33.65	64.28	100.00	3803220
1997-98	1.83	34.54	63.62	100.00	4377597
1998-99	1.78	31.51	66.70	100.00	4780675
1999-2000	1.87	31.46	66.67	100.00	4827597
2000-01	1.88	25.85	72.27	100.00	4750427
2001-02	1.63	26.13	72.23	100.00	5279394
2002-03	1.56	26.47	71.97	100.00	5927865
2003-04	1.35	28.59	70.06	100.00	6891971
2004-05	1.49	26.61	71.90	100.00	7892898
2005-06	0.88	25.30	73.82	100.00	8798965

Source: Government of Maharashtra

Industrial Set-up

The economy of Mumbai is almost entirely based on non-agricultural activities so that the city provides employment opportunities in the non-agricultural sector only. The economic census, 2012 indicates that 99.6 per cent of total economic establishments in Mumbai were non-agricultural establishments as against 74 per cent in Maharashtra. The share of Mumbai in the economic establishments in Maharashtra decreased considerably between 1990 and 2014 in terms of both all establishments and non-agricultural establishments as may be seen from table 17. Non-agricultural economic establishments almost doubled in Mumbai between 1990 and 2014 but the increase in Maharashtra was even more rapid, especially during 2005-2014.

Table 17: Number of establishments and non-agricultural establishment in Mumbai and Maharashtra, 1990-2014.

Year	All establishments		Mumbai as proportion to Maharashtra	Non-agricultural establishments		Mumbai as proportion to Maharashtra
	Mumbai	Maharashtra		Mumbai	Maharashtra (Urban)	
1990	423419	2623594	16.14	421437	1293421	32.58
1998	485492	3234022	15.01	484252	1591830	30.42
2005	572198	4225312	17.69	571309	2091094	27.32
2014	726675	6137342	11.84	723504	4545581	15.92

Source: Government of Maharashtra (1990; 2000; 2008; 2016).

The own account economic establishments account for almost 40 per cent of the total non-agricultural economic establishments in Mumbai (Table 18). Own account economic establishments are establishments without any hired worker on a regular basis. They are generally run by members of the household. Since own account economic establishments hire workers on an irregular basis and that too casually, the number of workers engaged in the own account economic establishments constitute only a small proportion of total workers in the city.

Table 18: Number of Non-Agricultural Establishments and Own Account enterprises and Employment, Mumbai 1990-2005.

Year	Non- agricultural establishments		Workers usually employed in non-agricultural establishments		
	With hired labour	Own account	With hired labour	Own account	Total workers
1990	253759	167678	2165107	250021	2415128
1998	234348	249904	2283697	335293	2618990
2005	335890	235419	1963611	281816	2245427
2014	391030	332474	2274512	424056	2698568

Source: Government of Maharashtra (1990; 2000; 2008; 2016).

Employment size in Non-Agricultural Establishment

There has been a significant increase in the number of small non-agricultural economic establishment, establishments with at the most 5 workers, in both Mumbai and urban Maharashtra (Table 19). The probable reason is that many large size establishments in the city have closed while no large new establishment could be setup in the city because of space and other infrastructure constraints. After 1980, many large manufacturing establishments, especially, textiles industries in the city have been closed while others changed their setup in the real estate business. At the same time, many heavy industries shifted their base out of the city because of cheap land availability and better infrastructure facilities. The shift in the non-agricultural economic establishment by the number of workers hired may be seen in this perspective.

Table 19: Distribution of non-agricultural economic establishment in Mumbai and urban Maharashtra by the number of workers hired.

Number of workers	Mumbai			Maharashtra		
hired	1990	1998	2005	1990	1998	2005
1-5	70.64	72.83	81.74	72.26	75.73	83.57
6-9	16.06	13.40	13.36	13.80	11.64	11.28
10-14	5.80	5.69	1.59	5.68	5.17	1.71
15-19	2.41	2.43	0.93	2.67	2.16	0.99
20-24	1.25	1.41	0.54	1.40	1.31	0.56
25-49	2.19	2.21	0.34	2.41	2.37	0.36
50-99	0.92	1.14	1.08	0.99	0.92	1.17
100-199	0.39	0.45	0.20	0.44	0.37	0.20
200-499	0.23	0.28	0.13	0.23	0.22	0.12
500+	0.11	0.16	0.08	0.11	0.11	0.05
Total	100.00	100.00	100.00	100.00	100.00	100.00
Number of workers	253759	234348	335890	596772	647837	1030996

Source: Government of Maharashtra (1990; 1998; 2008).

Conclusions

The present paper has attempted to analyse the employment situation in Mumbai during the 20 years between 1990 and 2010 using data from the national sample survey and population census. The population of Mumbai has grown more rapidly as compared to other cities of India. The reason is that Mumbai city and its outgrowth provide ample economic opportunities. Mumbai remains the city of hope and aspiration to the job seekers in all parts of the country. As a result, migrants from different parts of the country constitute a large proportion of the population of the

population of the city. However, non-migrants are generally engaged in regular jobs in the city while migrants are largely engaged in casual jobs in trade and services activities.

The present paper also shows that there has been a decrease in the number of non-agricultural economic establishments and hence in generating employment opportunities in the city since the 1990s. This is a matter of concern for the economy of the city which has an important place in the economy of Maharashtra, the state where the city of Mumbai is located. There is little space and many infrastructure constraints that inhibit new economic establishments in the city which, in turn, has affected the employment generating potential of the city. On the other hand, old economic establishments of the city are moving out which has also dented the employment generating potential of the city. There is a need to introduce innovative approaches for creating additional opportunities of employment in the city considering the space limitation and infrastructure constraints that Mumbai is facing. This is a major challenge to city planners and city administrators. Mumbai has always remained the economic capital of India. Innovative approaches are needed to ensure that Mumbai remains the economic capital of the country in the coming years too.

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INDIAN JOURNAL OF POPULATION AND DEVELOPMENT
ISSN: 2583-4827; Volume 3(2), July 2023: 357-378

Multi-dimensional Composite Health Indices in India: A Review of literature

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Abstract

Composite indices are widely used in different fields to measure and quantify a variety of multi-dimensional concepts into a single construct. While many multi-dimensional composite health indices are produced and applied in developed countries, there are relatively few studies for developing countries, and even considerably less in Asia. However, the indicators of health relevant in high-income countries will not be suitable for use in developing countries such as India due to differences in health system characteristics, differences in disease patterns, and data availability and quality. Therefore, it is important to consider the specific context and characteristics of a country when developing a composite health index to ensure its relevance and usefulness for policy and decision-making. In this paper, we review published studies on the multi-dimensional composite health indices in India, specifically focussing on the purpose of the index, the indicators chosen to represent population health, methods used in the calculation of the indices, geographical level of aggregation, sources of data, the application and validation of index. While doing so, we also assessed the policy or practical relevance of such indices.

Introduction

Health is a complex, multidimensional construct, and any attempt to create a health index needs to capture the multidimensional nature of health. Various indicators have been used globally to measure health and they vary from single indicators to multiple indicators. Traditionally, health has been measured using single indicators such as mortality rates, life expectancy, and health-adjusted life expectancy. The main advantage of using these indicators is the availability of data. However, these measures have analytical limitations (McDowell, et al. 2004). Additionally, due to changing health problems (such as increase in the prevalence of chronic diseases), their usefulness is also limited in measuring a concept as complex as health. The recent developments in measuring population health status and disease burden include multi-dimensional composite health indices which use several mortality and morbidity/disease indicators into a single index. Such multi-dimensional composite health indices (CHIs) are useful to make comparisons of health risks

within and across populations in different geographical regions (Ashraf et al, 2019; Costa et al, 2019), to track progress over time, to monitor effectiveness of health interventions (Costa et al, 2019; Yap et al, 2020) and serve as tool to assist in allocating resources (Ashraf et al, 2019).

While many CHIs are produced and applied in the developed countries, there are relatively few such attempts for developing countries, and even considerably less in Asia (Kaltenthaler et al, 2004; WHO, 2018; Ashraf et al, 2019). However, health indicators that are relevant to the developed countries are not be suitable for use in developing countries, like India, because of differences in health system characteristics, differences in disease patterns, and data availability and quality. Applying CHIs designed for the developed countries to the developing countries may run the 'risk of exporting failure' because of different social and cultural context of health and health care between developed and developing countries (Miranda and Zaman 2010). It has been argued that for such an index to be useful to health makers, it is essential that it should be suitable for needs assessment at the community or the national level and for monitoring and evaluating changes in health (Kaltenthaler et al, 2004). Therefore, it is important to consider the specific context and characteristics of a country or sub-national geographical region when developing a composite health index to ensure its relevance and usefulness for policy and decision-making.

In India, there have been some efforts to develop composite health indexes using different perspectives. In this paper, we present a review of these indexes with the aim of describing the context, development, use and validation of the multi-dimensional composite health indices that have been developed in India. India has made a significant progress in improving the health of the population over the last four decades as reflected through the reduction in infant mortality rate (IMR), crude death rate (CDR), crude birth rate (CBR), maternal mortality ratio (MMR) and through improvement in the life expectancy at birth (Government of India, 2022). However, there are significant regional, geographical, and socioeconomic inequalities in health across multiple axes of caste, class, and gender that are quite pervasive and persistent (Bango and Ghosh, 2022). Given the large and diverse population of the country, with marked variation in the levels of health outcomes across regions and population groups, greater focus on composite health indices which are sensitive to the diversity in India is needed to identify and address health inequalities. As suggested in the literature (Ashraf et al, 2019; Kaltenthaler et al, 2004) the paper focusses on the purpose of the index, conceptual basis of constructing the index, indicators chosen to reflect the state of health, methods used in the construction of the index, sources of data and their geographical level aggregation, application of the index and the validation of the index. We have also attempted to discuss the policy or practical relevance as and where possible.

Methodology

We had searched four databases (PubMed, EMBASE and Web of Science, and Google Scholar), and government sites up to January 2023, to isolate composite health indexes developed and used in the Indian context. The following search terms and

truncations were used as the search criteria - India and health index or indices or indicator, or child health, or maternal health, or health coverage, or health service, or Sustainable Development Goals (SDGs). Only those studies were retained for the review which were related to health outcomes, hence indexes such as development index, deprivation index or nutrition indicators were excluded. We also searched the references of the selected articles to find additional studies that could not be retrieved in the initial search. We did not place any restriction on the time of the publication of the study. We, however, did put restrictions regarding the language of publication. The search was restricted to only these studies which were published in English only.

Findings

Table 1 presents summary statistics of different composite health indices developed by different authors and agencies to measure and monitor health of the people in India. One of the early attempts of constructing a composite health index for India was undertaken in 1991 (Sekhar et al, 1991). The authors proposed an index that, they argued, reflected the need for health resources. The index was not meant to measure and monitor the health status of the Indian people. The rationale put forward by the authors for creating the composite index was that there was huge inequality in the allocation of health resources within the country, across states and Union Territories. It was, therefore, deemed important to create and use a composite index of health resources so as to monitor the allocation of resources to meet the health needs of the people. The indicators that they used in the construction of the index were restricted by their availability, and even the selected set of seven indicators used by the authors was available for 17 of the 22 states of the country. The data for the construction of the index for the country and for its selected states were taken from different resources including police records, Sample Registration System (SRS), State Medical Council data on registered doctors, 1981 Census of India, and other government records. The selection of the indicators for the construction of the index, however, lacked a solid conceptual framework. Factor analysis technique was used to derive standardized indices which helped to compare quantitatively the health needs of the people of different States. The factor analysis revealed that the seven indicators could be grouped into two factors. The first factor, comprising of four indicators, explained 67 per cent of the total variation in the dataset and was termed the 'proximate determinants' factor, The second factor comprised of three indicators described 16 per cent of the total variation and was termed as the 'socio-medical background' factor. The authors acknowledged the need of creating a composite index for health resources at the district level but constructed the index at the state level only because of the paucity of data at the district level. The authors acknowledged and discussed the need for including other indicators such as morbidity measures, life expectancy at birth, neonatal and post-neonatal mortality in the construction of the index. The authors also planned for collecting longitudinal data to allow for a better assessment of the need of health resources and to assess the validity of the index, but this was not pursued. The authors, however, emphasised that their index could trigger the examination of the causes behind the poor ranking of states and to help to determine the corrective steps in resource allocation, health services, and awareness about States lagging in health status.

Table 1: Summary of different composite health indexes.

Reference	Index	Indicators Used	Method of Aggregation	Data Source
Sekhar et al, 1991	Composite Health Index	No conceptual framework is specified. Homicides per 100 000 population, Crude death rate, Infant mortality rate, Crude birth rate, Doctors per 1000 population, Percentage of literates based 1981 census, Hospital beds per 1000 population.	Factor analysis was carried out to group seven indicators into two factors. The factor scores of the two factors were combined using the proportion of variation explained by each factor.	Secondary data sources included police records for the number of homicides, the Sample Registration System (SRS), the State Medical Councils, the 1981 national census, the hospitals, health centres and nursing homes registered with the government.
Satyanarayana et al, 1995	Index of Child Mortality	No conceptual framework is specified. UFMR, IMR, NMR, perinatal mortality rate and still birth rate.	Factor analysis of data on five indicators of child mortality was used, two factors that together explained most variation were combined.	Secondary data sources included SRS reports of the Registrar General of India; State.
Antony and Rao, 2007	Composite Index to explain variations in Poverty, Health, Nutritional Status	No conceptual framework is specified. Demographic: Male and Female life expectancy at birth; birth rate, death rate, MMR, IMR, UFMR, Socio-economic status (per capita GDP, percentage below poverty line, male and female school enrolment ratio, male and female literacy, government	Factor Analysis was applied on five sets of indicators.	Secondary data sources included Indian Government publications on economic and health surveys, The Health Monitor and Economic Survey of 1998.

Reference	Index	Indicators Used	Method of Aggregation	Data Source
		expenditure on education, Health status: Availability of proper sanitation facilities, drinking water, underweight in under five year children, contraceptive use), Food intake (per consumption unit/day in grams): cereals, pulses, roots, fruits, milk, etc. Nutrient intake: Total fat, calories, and proteins, along with indices to measure poverty, human development, and standard of living.		
Government of India, 2014	Composite Index (CI)	No conceptual framework is specified. 16 indicators covering four stages of lifecycle, pre-pregnancy/reproductive age: Post-partum sterilization, Male sterilization, all family planning methods, pregnancy care: total ANC registration, 3 ANC check-ups to total ANC registration, Pregnant women given 100 IFA, Obstetric Complications, Pregnant women receiving TT2 or Booster, childbirth/delivery:	Arithmetic mean of standardized indicators. States have been classified into four levels based on quartile of CI score, and coded as Red – depict very low performance, Pink – Low performing, Yellow - promising and Green – good performance.	Secondary data from HMIS.

Reference	Index	Indicators Used	Method of Aggregation	Data Source
		Skilled Birth Attendant attended home deliveries, Institutional deliveries, C-Section, post-natal and maternal and new-born care: Newborns breast fed within 1 hour, Women discharged under 48 h, Newborns weighing less than 2.5 kg, Newborns visited within 24h of home delivery , Infants who received Measles.		
Anand, 2014	Composite Indices of Health Status and Health Services	No conceptual framework is specified. Health status indicator: Crude birth rate, Total fertility rate, Institutional deliveries, Crude death rate, IMR, UFMR, Health infrastructure indicator: Number of hospitals per lakh population, Number of Primary Health Care facilities per lakh population, Number of doctors per lakh populations, Number of beds per lakh populations, Number of	Maher's normalization technique and principal component analysis. Based on these indices, districts have been classified into five levels of development, very high, high, average, very low and low.	Secondary data from Annual Health Survey (2011) and Statistical Diary (2011), *Shankhikya Patrika* (2010-2011), Uttar Pradesh Planning Commission and Bihar Statistical Handbook (2010-2011).

Reference	Index	Indicators Used	Method of Aggregation	Data Source
		nurses/paramedical staff per lakh populations.		
Meher et al, 2014	Composite Health Development Index (CHDI)	No conceptual framework is specified. IMR, birth rate, death rate, MMR, total fertility rate of female in the reproductive age group and life expectancy at birth of both males and females.	Arithmetic mean of standardized indicators, deprivation method was followed to compute the index. The Index values of the 17 states were compared for three time periods 1998–99, 2004–05 and 2009–10.	Secondary data published by the Government of India, National family health survey (NFHS-II, 1998–99 & NFHS-III, 2005–06), and Office of Registrar General, India, Special bulletin on maternal mortality in India 2007–09, Abridged life tables 2002–06, Sample registration system (SRS reports different years), Statistical report 2005 & 2008.
Chauhan et al, 2017	Composite Index	No conceptual framework has been specified. In all twenty six health-related indicators related to demographics: share of slum population to urban population, population density, population growth rate, total literacy rate, female literacy rate, population sex ratio, child sex ratio, dependency ratio, total fertility rate , crude birth rate , crude	Standardized indicators were aggregated into an index by statistical method proposed by (Prem et al., 2007).	Secondary data published by the Ministry of Health and Family Welfare, Government of India, and other official sources.

Reference	Index	Indicators Used	Method of Aggregation	Data Source
		death rate and infant mortality rate, family planning: contraceptive method, maternal health care % Tetanus expectant mothers, IFA full course, % of institutional delivery, immunization of children: including TT 10 year, prophylaxis against blindness (below 1 year and under 5 years), and health and other infrastructure facilities: Share of primary health care (PHC) working 24 × 7, share of latrine facility within premises of houses.		
Prinja et al, 2017	Composite Universal Health care Coverage Index (CUHCI)	Used Universal Health Care framework. Maternal and Child Health Iron and folic Acid, TT (2 injection), ≥ 3 Antenatal check-up, Institutional delivery, Postnatal care, Full immunization, ORS use rate, Family Planning Contraceptive prevalence rate,	The index was generated by standardized values of the ten indicators. Three approaches were used for aggregation of indicators by geometric mean, principal component analysis, and regression models.	Primary data collection, cross section survey of 51656 households across all districts of the state.

Reference	Index	Indicators Used	Method of Aggregation	Data Source
		Curative Care Overall met need for any illness, Met need for non-communicable diseases, financial risk protection Pre-payment poverty headcount, post-payment poverty headcount, Catastrophic Hospitalization Expenditure. Quality of care Full effective ANC, Care from qualified provider		
Doke, 2018	Comprehensive Health Index	No specific framework has been specified. Health outcome: IMR, Birth rate, Sickle cell carrier rate, Annual parasite incidence of malaria. Health System: Doctor population ratio, Nurse population ratio, Bed population ratio, other health determinants), use of latrine (by subtracting the proportion of open-air defecation), use of clean fuel for cooking. Health-care utilization: Institutional deliveries.	Each block was scored relative to the highest value of each indicator. The ten indicators were integrated into one score using Principal Component Analysis.	Secondary data sources included Census, Survey of Cause of Death scheme, Health Management Information System, Directorate of Economics and Statistics, and Maharashtra Medical Council largely from 2013-14 or prior years. Management Information System of Women and Child Development Department (malnutrition in children). Special survey was conducted (preferred health-care provider, drug addiction). Interactions with key

Reference	Index	Indicators Used	Method of Aggregation	Data Source
				informants (morbidity and mortality experiences, functioning of public and private health sectors, and traditions and cultural factors in seeking health care).
Sharma et al, 2019	Health system performance index (HSPI).	Conceptual framework has been specified, it included health system outputs and outcomes. Health system outputs: Primary care coverage; Curative care utilization; Equity in health financing; Efficiency and equity in service delivery. Health system outcomes: Morbidity rates; Mortality rates; Financial risk protection.	Value of indicators was normalized and aggregated using geometric mean approach, to generate domain-specific and overall index. The index was generated by three different statistical approaches.	Primary data was collected through a community-based survey and Secondary data from HMIS.
Government of India, 2022	State Health Index	No conceptual framework has been specified. Up to 24 indicators grouped in the domains of health outcomes: NMR, UFMR, Sex Ratio at Birth, MMR, Modern Contraceptive Prevalence Rate, Full immunization coverage,	Weighted average of standardized indicators was used to compute the index. Weights were determined by technical experts.	Secondary data sources included State Department of Health, Health Management Information System (HMIS), National Tuberculosis Control Programme (RNTCP), National Family Health Survey (NFHS), Centre NHM Finance Data, Reserve Bank of

Reference	Index	Indicators Used	Method of Aggregation	Data Source
		Proportion of ANCs registered, Proportion of pregnant women who received 4 or more ANCs, Proportion of institutional deliveries, Total case notification of tuberculosis and Treatment Success Rate, Proportion of people living with HIV on antiretroviral therapy ; Governance and information: Institutional deliveries, ANC registered within first trimester, Average occupancy of an officer at State level for last three years , Average occupancy of a full-time officer (in months) for all the districts in last three years , Number of days taken for transfer of Central NHM fund from State Treasury to implementation agency, Proportion of State Government Health Expenditure to Total State Expenditure), and key inputs and processes: Proportion of shortfall of health		India (RBI) Reports, reports of Ministry of Health & Family Welfare (MoHFW)-Government of India, Civil Registration System, Integrated Disease Surveillance Project (IDSP).

Reference	Index	Indicators Used	Method of Aggregation	Data Source
		care providers, Proportion of total staff covered under a functional IT enabled integrated Human Resources Management Information System, Proportion of specified type of facilities functioning b. Proportion of public health facilities with Kayakalp score >70%, Proportion of functional Health and Wellness Centres, Proportion of district hospitals with functional Critical Care Units , Completeness of Integrated Disease Surveillance Programme (IDSP), Proportion of public health facilities with accreditation certificates, Proportion of labour rooms and proportion of Maternity OTs certified under LaQshya.		

With the objective of measuring and monitoring the health status of children over time, another composite index was proposed in 1994 which was termed as the index of child mortality (Satyanarayana et al, 1995) has developed a comprehensive index, the Index of Child Mortality. The index was based on five indicators - under-five mortality rate (U5MR), infant mortality rate (IMR), neonatal mortality rate (NMR), perinatal mortality rate (PEMR), and stillbirth rate (SBR). No conceptual framework was, however, underpinned in the selection of indicators. The index was constructed using the data from the Sample Registration System of the country. The study also used the factor analysis technique to construct the composite index. The study found that the five indicators can be grouped into two factors, first factors include three indicators – NMR, IMR, and U5MR – while the second factor comprised of SBR and PEMR. The study also examined the relationship between the trend in the composite index and the trend in U5MR. It was a good initiative for across state comparison across states and for longitudinal monitoring of child health status. However, tedious statistical computations prohibited widespread use of this index.

In 2006, an attempt was made to construct a composite index to explain variation in poverty, health, nutritional status, and standard of living across states (Antony and Rao, 2007). This composite index used five sets of indicators namely demographic situation, (male and female life expectancy at birth and at 5 years); socio-economic status (per capita gross domestic product; proportion of population below the poverty line); health status (prevalence of contraception, availability of sanitation, health services and safe drinking water, proportion of severe and moderate underweight children below 4 years of age); food intake (per consumption unit/day in grams); and nutrient intake (per consumption unit/day and total fat, total calories, total protein). The authors have also used indices to measure poverty, human development, and standard of living. However, indicator selection by the authors was not guided by any conceptual framework. The index was calculated for 14 large states of the country. Discriminant function analysis and factor analysis were used to assess state ranking based on health inequality and standard of living. The first component which included the intake of cereals, male educational status, infant mortality rate, total fat intake, income, life expectancy at birth, and availability of sanitation facilities accounted for 60 per cent of the total variation. The second component included intake of fruits and explained 15 per cent of the total variation. Human Development Index (HDI) was used for the purpose of validation. Cohen's Kappa statistics were calculated for validation and Bland and Altman plot was used to find agreement between the two methods. Primary data from an urban and rural site was used to validate the index. This composite index gives better indication of development and standard of living rather that health. The construction of the index uses only four health related indicators, but these indicators do not represent different stages of life, difference in morbidity, accessibility, and quality of health services, that are associated with health status.

Health Management Information System (HMIS) score card is one of the first attempts made by the Government of India to capture the disparity in the state of reproductive, maternal, newborn, child and adolescent health across states, districts, sub-districts or blocks in in the country (Government of India, 2014). The main purpose was to strengthen the health care delivery system to achieve the goals of RMNCHA strategy. The score card is based on 16 reproductive, maternal, newborn, child, and adolescent health indicators covering four stages of the lifecycle: pre-pregnancy/reproductive age, pregnancy

care, childbirth/delivery, post-natal, maternal, and newborn care. However, the conceptual framework was notably absent in the choice of indicators. The normalized index values of each of the 16 indicators are combined by using the arithmetic mean as the aggregation function to arrive at the overall composite index. One of the advantages of this index is the availability of data from the health management information system. However, evidence suggests that data from HMIS suffer from poor quality, incompleteness of records and a tendency to over report outputs and outcomes (Verma and Prinja, 2007; Pandey et al, 2010, Sharma; et al, 2016).

Anand (2014) has constructed composite indices to measure the extent of inequality in health status and health care services in the two most populous states of India, Uttar Pradesh, and Bihar in an attempt to define inter-regional and inter-district variation for appropriate policy prescription. The data from the Annual Health Survey, 2011 (Government of India, 2011) and Statistical Diary (2011) pertaining to 6 health status indicators and 5 health infrastructure indicators were used to compute the index. Health status indicators included crude birth rate, total fertility rate, institutional deliveries, infant mortality rate, and under five-mortality rate. The health infrastructure indicators included number of hospitals per one hundred thousand population, number of doctors per one hundred thousand population, number of beds per one hundred thousand population, number of nurses/paramedical staff per hundred thousand population. Selection of the indicators was not guided by any conceptual framework. The author has used Maher's normalisation technique and principal component analysis to develop weights for the indicators. The author also used inequality measures such as co-efficient of variation to measure disparities between states for overall performance in health attainment. The main advantage of this health index was the use of routinely available data at the district level. Many important indicators in terms of achieving better health status and health infrastructure such as maternal mortality rate and life expectancy at birth were not used in the construction of the index. There is also data comparability issue as data from different sources have been used in the study.

Meher and Patro (2014) have created composite health development index to highlight the trend and level of disparities in health status of the population at state level. Using data from different sources, the authors analysed health status of people, health development programmes and public health services in 17 major states of India for three different time periods 1998–99, 2005-06, 2009-10. The indicators used in the construction of the index included infant mortality rate, crude birth rate, crude death rate, maternal mortality ratio, total fertility rate, and life expectancy at birth for both males and females. There was no conceptual framework to serve as the base for the construction of the index. The index was constructed using the deprivation method as followed in the Human Development Report (United Nations, 1990). The states were classified into five groups ranging from highly developed to backward to highlight differences in health status. Since, the index was computed for three time periods, a trend assessment has also been undertaken. One major strength of this index is to reflect the persistence of disparity across states. However, no validation of the index has been carried out.

Another attempt to construct a composite health index first analyses inter-state variation in health-related indicators (Chauhan et al, 2017). The aim of the index was to

improve the performance of the health sector to have a 'uniform efficiency level' throughout the country, thereby to accelerate the progress towards "health for all." The index is based on 26 health-related push and pull indicators covering demographic situation (12 indicators), family planning (1 indicator), maternal health care (3 indicators), immunisation of children (8 indicators), and health and other infrastructure facilities (2 indicators). The selection of indicators lacked a conceptual framework. The statistical procedure used to construct the index is similar to that used by Sharma and colleagues (Sharma et al, 2007). The index is designed to range between 0 and 1, the lower the index the better the performance. The index covered many indicators related to health, but no rationale is given for including the indicators. The statistical methodology used for the construction of the index has also not been described.

Another composite index attempts to measure progress towards universal health coverage at the district level (Prinja et al, 2017). The index aims at ranking districts by the availability of affordable health care services to all. Unlike other indexes, this index is based on primary data collected from all districts of Haryana, India during 2012-2013. The index is based on the universal health care framework of the World Health Organisation (Prinja et al, 2017). The focus of the index is to develop methodology to measure and compare preventive and curative services which could be delivered at all levels of the health system. Methods used for constructing the index include geometric mean aggregation, standardising the values of indicators, principal component analysis and regression methods. The index is validated using a variety of sensitivity and scenario analyses. The index has many strengths including coverage of indicators based on the list outlined by Government of India and using the conceptual framework proposed by the World Health Organization. However, it falls short of measuring the health status of the population. Universal health coverage is an important determinant of health, but there are many other indicators which are not included in the construction of the index. For example, many social determinants of health are not included. The authors have also acknowledged the limitations of their measures of quality of care and financial risk protection measurements.

Doke (2018) has attempted to assess community health status at the block level in Gadchiroli district of Maharashtra in terms of a comprehensive health index. The primary purpose of the index is to compare health status and financial allocation at the block level. The index is based on a variety of indicators related to different dimensions of health including infant mortality rate, crude birth rate, sickle cell carrier rate, annual parasite incidence of malaria (API), doctor population ratio, nurse population ratio, bed population ratio, use of latrine, use of clean fuel for cooking, and institutional deliveries. However, construction of the index lacks a conceptual framework. The principal component analysis is used to combine different indicators into the composite index and the index has been correlated with degree of urbanization for validating the index-based ranking. The assessment of the health status based on the index is, however, restricted due to limited coverage of indicators representing community health. Moreover, the authors gave different weightings to different groups and subgroups.

There has also been an attempt to construct a health system performance index following the conceptual framework of the World Health Organization (Sharma et al, 2019). The World Health Organization (WHO) identifies six core components or "building blocks"

of the health systems: (i) service delivery; (ii) health workforce; (iii) health information systems; (iv) access to essential medicines; (v) financing; and (vi) leadership/governance. The index is based on 70 input and process indicators grouped into 20 sub-domains. The indicators were normalised and aggregated to generate domain-specific and overall health system performance index by using a preference-weighted approach which gives equal weight to each indicator, each subdomain, and each domain of the health system. The aggregation was done using geometric mean. The validation of the index was done using different methods of aggregation and through sensitivity analyses to assess the robustness. Data pertaining to many indicators used in the construction of the index requires primary survey which makes it challenging to repeat and replicate the index.

The NITI Aayog, the think tank of the Government of India has also constructed a state health index based on 24 indicators grouped into domains of health outcomes, governance and information, and key inputs and processes for the large states, 19 indicators for small states, and 16 indicators for Union Territories (Government of India, 2022). Each domain has been assigned weight based on its importance. The weights used for aggregation are, however, based on expert opinion so that weighting can introduce self-selection bias in the construction of the index (Chowdhury and Squire, 2006). Within a domain or sub- domain, the weight is equally distributed among the indicators in the domain or sub- domain. The index is not comparable across large states, small states, and Union Territories because the number of indicators used in the construction of the index is different. The ranking of the states based on the index has also not been validated.

Discussion

This paper has attempted to provide an overview of the attempts made to develop a composite health index to reflect the state of health in India. The paper reveals that different composite health indexes developed and used in India are directed towards different purposes from measuring and monitoring health resources (Sekhar et al, 1991) to measuring and monitoring child health (Satyanarayana et al, 1995); to explain variation in poverty, health, nutritional status and standard of living (Antony and Rao, 2007); to make block-level comparison in financial allocation (Doke 2018) or to measure and monitor the inequity in the coverage of health services (Prinja et al, 2017). There has also been attempt to develop a composite index that reflects the overall health of the population (Sekhar et al, 1991). The Government of India has also constructed composite indexes for specific domains (Government of India, 2014; 2022), Attempts have also been made to develop composite indexes for health system outputs and health system outcomes (Sharma et al, 2019) and for health status and health services (Anand, 2014). However, none of the composite indexes reviewed in this paper gives a complete picture of the health of the population.

In general, the composite indexes have used secondary data from different sources barring a few exceptions (Prinja et al, 2017; Doke, 2018; Sharma et al, 2019). Most of the indexes have been calculated at the state level and, therefore, have scale limitations. There are only a few attempts to apply the composite index at district level (Anand, 2014;

Government of India, 2014; Sharma et al, 2019) while there is only one study that used composite index to measure health at the block level (Doke 2018).

Availability of the data has been found to be a major obstacle in the construction of composite health index that fully reflects the state of health of the people (Sekhar et al, 1991; Satyanarayana et al, 1995; Prinja et al, 2017). Different approaches have been adopted to address the data constraints. Some researchers have modified the geographical area (Antony and Rao, 2007); others limited the scope of the Index (Sekhar et al, 1991) or carried out special surveys to fill data gaps (Doke 2018; Prinja et al, 2017). There is a need of measuring health at lower administrative units such as district or block as studies have acknowledged the importance of local geography for public policy (Kim et al, 2019). This is also consistent with the evidence that magnitude and persistence of health inequalities is large when smaller geographical areas are considered as compared to when the larger areas are considered (Krieger et al, 2002). Data constraints, however, inhibit any attempt to measure the health of the people at the local level in India.

There has also been variation in the way health has been conceptualised in the construction of different composite indexes. Mortality indicators such as infant mortality have commonly been used to reflect the state of health. If a composite index is to serve as an effective tool to monitor the progress in health and to give an overall reflection of the health of the people, other indicators, which address the complex notion of health, need to be incorporated in the composite index. The central idea underpinning the construction of multi-dimensional composite health index is based on measuring and monitoring population health which is reflected in terms of health outcomes which are shaped by the determinants of health. Health determinants also serve as predictors for future health outcomes. The composite health indexes developed in the Indian context have primarily focused on indicators related to health outcomes, health inputs, health processes, health outputs, and health impact. It may, however, be emphasised that health outcomes and health impact do not depend upon the health care delivery system alone. They are also influenced by a host of social, cultural, economic and environment factors that are exogenous to the health system. As such, a composite health index that considers only the health outcome and health impact has limited relevance in measuring the performance of the health system. The importance of the social determinants of health on the health of the people has been repeatedly and extensively emphasised (WHO, 2018). However, only one study (Antony and Rao, 2007) has included indicators related to the social determinants of health in the construction of the composite index.

There has also been little discussion about the choice of indicators in the construction of the composite index in all the studies reviewed. Indicators used in the construction of the composite index appears to have been arbitrarily chosen, mainly depending upon the availability of the data and without any justification or rationale about the selection of the indicator for the construction of the composite index. In addition, some of the indicators have not been used in the construction of the composite index because either these indicators were available for only some of the administrative areas or were not required at the national level. The lack of publicly available data has been a major hindrance in the selection of indicators for the construction of the composite index in most of the studies.

A crucial consideration in the construction of the composite index involves examining the multicollinearity among the indicators for the construction of the composite index as strongly correlated indicators reflect similar characteristics. The present review suggests that many studies have used statistical tools like factor analysis, discriminant analysis or principal component analysis to address the multicollinearity among the indicators used in the construction of the composite index. The review also suggests that some studies have explicitly examined the correlation among the indicators used for the construction of the composite index (Sekhar et al, 1991; Satyanarayana et al, 1995; Antony et al, 2007).

All composite indices use an aggregation function to combine indicators reflecting different dimensions of health. These aggregation functions range from simple one-dimensional aggregation function such as arithmetic mean of standardized indicators or geometric mean (e.g., composite index (CI) by Government of India (2014), composite health development index (CHDI) by Meher and others (Meher et al, 2014), health system performance index (HSPI) by Sharma and colleagues (Sharma et al, 2019), state health index (Government of India, 2022) to multi-dimensional aggregation function such as factor analysis or principal component analysis (e.g., composite health index by Sekhar and others (Sekhar et al, 1991), index of child mortality by Satyanarayana and others (Satyanarayana et al, 1995), and comprehensive health index by Doke (2018). It is important to underscore that all indices we have reviewed are relative in nature, meaning they are dependent on the underlying data. If the data undergo changes, the ranking based on these indices will also change. This naturally prompts concerns about the comparability of the indices, and it constrains their utility for their intended purpose and the indicators they encompass.

There is also wide variation in the way weights were assigned to different indicators while combining them into an overall index. Some studies did not give information on weighting, few indexes had weights assigned through expert judgement (Government of India, 2022), other studies have used a variety of methods to assign weights to the health indicators. For example, index of child health (Satyanarayana et al, 1995), and composite health index for states of India (Antony and Rao, 2007) have used factor analysis, others have used principal component analysis (Prinja et al, 2017).

Only few studies have validated the indices. In one of the recent studies, multiple approaches have been adopted for computing the index and the internal validity of ranks has been based on different indices produced by different approaches (Prinja et al, 2017). While NITI Aayog has validated the indicators used in the index through independent validation agencies but has not validated the index (Government of India, 2022). Another study has validated the index with the Human Development Index (Antony and Rao, 2007). Additionally, except Prinja and others (Prinja et al, 2017) and Sharma and others (Sharma et al, 2019), there has been a lack of use of theory or conceptual framework in the selection of health indicators which shows that the studies have mainly used the health indices as a statistical tool rather than test out theories of disease or how to promote wellbeing. However, a theoretical or conceptual framework provides a structure to select the independent indicators representing health, defines the analytical approach, and serve as the guide to discuss the findings (Nilsen, 2015). In fact, a theoretical or conceptual framework should precede the selection of indicators (McDowell et al, 2004). Despite the

significance of a conceptual framework in creating a health index, only 7 out of 27 studies in a scoping review of population health indices had a conceptual foundation guiding the choice of indicators (Ashraf et al, 2019). Given lack of consensus on the common criteria used to measure health, the usage of conceptual framework in the selection of indicators gains added significance.

In general, attempts to construct a composite health index are not based on any explicit theory or conceptual framework. This means that, most of the cases, the composite index is developed mainly as a statistical tool to combine different indicators, rather than testing out the theories of disease or how to promote well-being. A theoretical or conceptual framework provides a structure to select the independent indicators representing health, defines the analytical approach, and serve as guide to discuss the findings (Nilsen, 2015). In fact, a theoretical or conceptual framework should precede the selection of indicators (McDowell et al, 2004). Despite the significance of a conceptual framework in creating a composite health index, only 7 out of 27 studies in a scoping review of population health indices have been found to have a conceptual foundation guiding the choice of indicators (Ashraf et al, 2019). Given the lack of consensus on the common criteria used to measure health of the people, the specification of the conceptual framework in the selection of indicators gains added significance.

The paper has some limitations. First, we might have omitted some papers because of our specific focus on health. Secondly, we did not include in our review indexes using only one dimension such as India Hunger Index. However, our review of the composite health indexes in the Indian context highlights areas of improvement. We recommend selecting theory-based indicators to measure health, using data from small areas such as district to acknowledge local geography for public policy and using routinely collected data at uniform intervals to track progress over time to monitor effectiveness of health interventions. We also recommend examining the validity of composite indices by examining their association with health outcomes or with health inequality measures.

The present review highlights the unavailability of quality data at lower administrative level such as district. As data are the main determinant of the accuracy and for the validation of the composite health index, we recommend to policy makers to fund health data collection on both processes (data related to health systems), determinants of health (including both protective and risk factors affecting health), representing different life stages (childhood, adult, and elderly) and health outcome (morbidity and mortality measures). Future research should focus not only on constructing composite indexes based on data of high quality but should also examine the use of composite health indexes in developing better understanding of the progress towards health.

Conclusions

The complexity of measuring and monitoring public health arises from the multidimensional nature of the health construct. Measuring and monitoring the health of the people, therefore, is quite complex. There is no single indicator that can measure and

monitor the health of the people in its totality. As such, composite indexes that capture different dimensions of the health of the people are proposed to measure and monitor health of the people. The review of different composite health indexes proposed to measure and monitor health of the people in India suggests that none of the proposed composite indexes captures different dimensions of the health of the people in their entirety and a more nuanced approach is needed to develop a composite index to measure and monitor the health of the people of the country. We suggest selecting indicators grounded in theory including both determinants of health (e.g., factors representing health care deliver and different social, economic, cultural, and environmental dimensions of health) and health outcome measures encompassing diverse domains. Additionally, we propose using data from small areas, such as district, to account for local geography. Each domain may then be represented by a set of indicators which may then be combined first into sub-domain-specific composite indexes and then into overall composite index that reflects the state of health of the people. There are different approaches available for combining different indicators into one composite index and these methods have their own advantages and disadvantages. Statistical methods and tools are commonly preferred over other methods for the construction of the composite index. Lastly, we recommend that future research should explore the role of health indices in monitoring progress towards health.

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