
Estimating Life Expectancy at Birth by Sex in Bombay Presidency during the Colonial Period (1891-1939) using Census of British India and Sanitary Commissioner's Annual Reports

**Chander Shekhar, T.V. Sekher, F. Ram, Mihoko Takahama Daigo,
Mili Dutta and Osamu Saito**



**INTERNATIONAL INSTITUTE FOR POPULATION SCIENCES
Mumbai, India**
Website: www.iipsindia.ac.in

December, 2021

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Suggested Citation: Shekhar Chander, Sekher T.V., Ram F., Daigo M.T., Dutta M. and Saito O. (2021). "Estimating Life Expectancy at Birth by Sex in Bombay Presidency during the Colonial Period (1891-1939) using Census of British India and Sanitary Commissioner's Annual Reports", Working Paper No. 23, International Institute for Population Sciences, Mumbai.

IIPS Working Paper No. 23

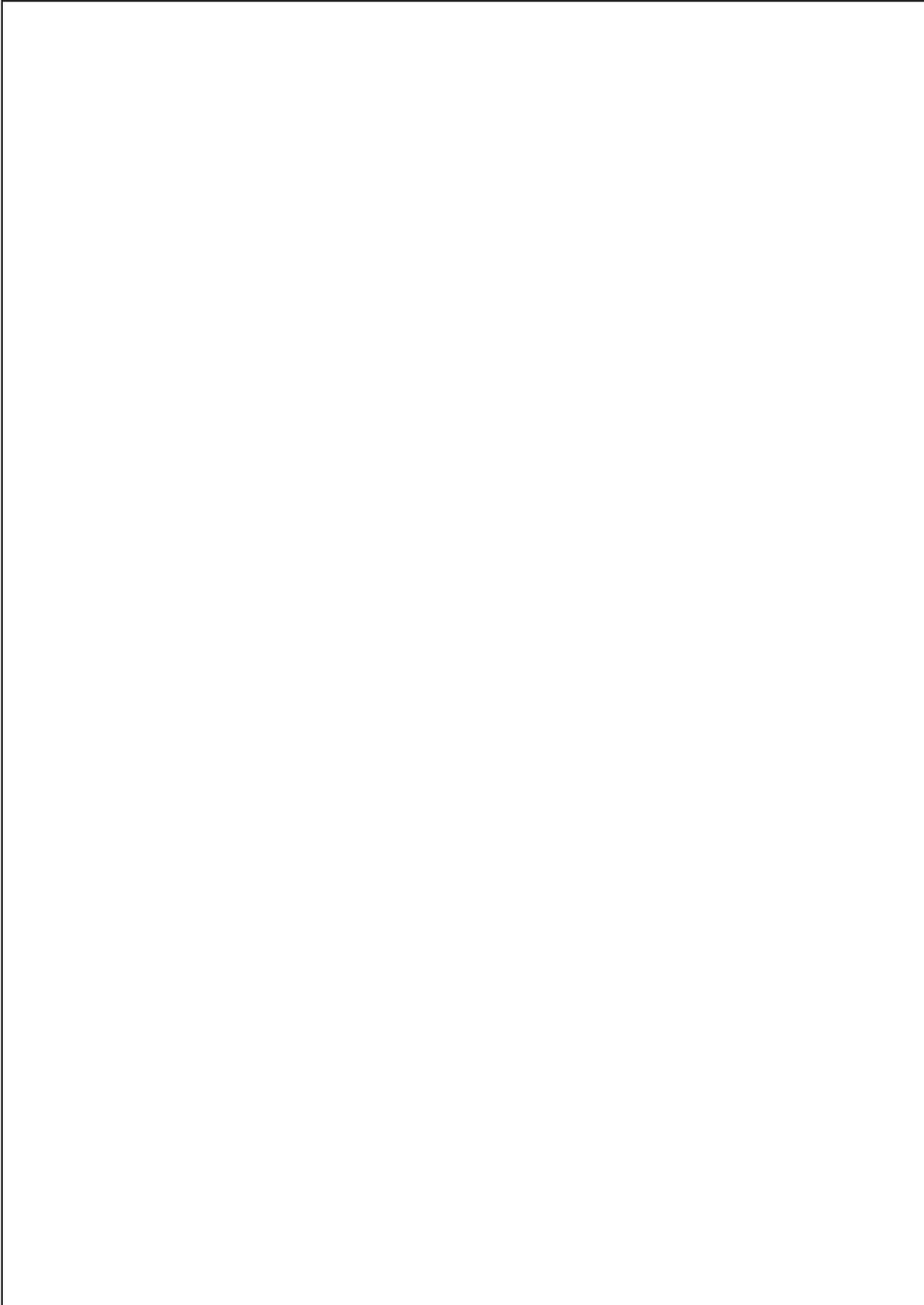
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Abstract

Looking into the history of human life span and exposure risks from widespread diseases, natural disasters, and wars can help protect the human race in the future. Estimating life expectancy at birth with limited and scanty data has always been of keen interest, especially in the community of demographers. There are only few studies in the area of historical mortality estimates in the Indian context, but most of them do not provide sex-specific estimates of life expectancy at birth. The mortality situation was more dynamic than the birth rate transition from low to high population growth rates. This paper aims to estimate life expectancy at birth (e_0^0) for the population of Bombay Presidency by sex from the period 1891 to 1939. Data from the British Census of India and the Sanitary Commissioner's Reports have been used for the study. Brass's Indirect technique (United Nations, 1983) is employed to estimate life expectancy. The results indicate the deteriorating mortality until the year 1920 in the erstwhile Bombay Presidency. The second decade of the twentieth century (1911-1920) witnessed lower levels of life expectancy at birth. However, the period after 1920 had given a clear indication of improvement in life expectancy in the erstwhile Bombay Presidency, which was under direct British rule. The decadal estimates of life expectancy at birth between 1891 and 1940 suggested that females were at a slightly advantageous position as compared to the males till the decade 1901-1910; thereafter life expectancy at birth for males remained higher than that of females. The maximum difference between male and female life expectancy, more than one year, was estimated for the decade 1921-1930. The year-wise life expectancy at birth for both the sexes was estimated to be at a very low level in 1900 and 1918.

Keywords: Life expectancy at birth, Bombay Presidency, Colonial Period, Sanitary Commissioner Reports

Introduction

Carrying a demographic analysis systematically and scientifically could only be possible after the year 1871 when the census was taken for the first time in India though the reports of Sanitary Commissioner of Bombay Presidency, available from the year 1864. According to the studies of population, the history of population growth can be categorised into two contrasting periods (Navaneetham and Krishnakumar 2011). The pre-1921 is characterised as a period of slow and fluctuating growth, whereas the post-1921 period was a period of accelerating growth.

The annual growth rate of the population was below 1 percent during the period 1921-1931, while it had increased to about 2 percent by 1951 (Guha 1991). These fluctuations were mostly due to incidences of epidemics and famines. It is also known that three main determining factors—death rate, birth rate, and net migration are critical to any population growth. The death rate was a more dynamic factor, whereas the birth rate was relatively static during the low-to-high population growth rate. Further, the death rate is determined by two factors: short-term factors, which include epidemics such as cholera, plague, smallpox, influenza, and malaria. The other includes long-term environmental factors (Bhadani 2016). During the pre-1921 period, mortality was strikingly high in India. The average life expectancy was only around 25 years for males during the period 1881-1920 and 25.6 years for females during 1901-1911, indicating high mortality in the late 19th and early 20th centuries in India. The level of infant mortality rate (IMR) was more than 200 infant deaths per thousand live births in the country, with high fluctuations. According to Bhat (1989), mortality was high mainly due to heavy adult mortality during the late 19th century and early 20th century.

A pioneering work by Bhat (1989) characterized the age pattern of mortality as high mortality among adults compared to the heavy mortality in the younger ages. He showed that the higher life expectancy at birth and somewhat lower fertility levels were measured during the 1881-1951 period and a few subsequent years. Also, Clark, in her research work, had come across the regional demographic variations by sex for the United Provinces in the north (now Uttar Pradesh), Bombay Presidency in the west (now Maharashtra and Gujarat), and Madras a state in the far south (now Andhra Pradesh and Tamil Nadu), during the period 1881-1931. She also explained the lower level of life expectancy in the United Provinces than in Madras as the former area was more prone to endemic malaria and harvest failure than the latter one (Clark 1989). In his study of Berar utilizing vital registration data, Dyson estimated birth and death rates and found an inverse relationship between the two. He emphasized that vital registration data be included for calculating the vital historical rates and also mentioned the limitations of the data availability of the vital registration (Dyson 1989a and 1989b).

Various other studies marked the impact of famines, epidemics, and pandemics on the mortality level in India. In his study of the British India, Arnold focused on the history of cholera (Arnold 1986). Mills addressed the influenza pandemic, which resulted in massive mortality during the 1918-19 period. He showed that the ‘mysterious’ disease spread from Bombay, and the mortality caused by this pandemic was much more severe in the north and the west than in the east and the south. He found that nine percent of the female population died and almost 20 percent of the marriages dissolved due to the death of one of the spouses (Mills 1986). The few months of influenza in 1918 resulted in more deaths than nearly 20 years of plague in many Indian provinces. The epidemic struck India at a time when the country was least prepared to cope with the calamity. The total failure of the monsoon, scarcity of food supply, and inadequate medical facilities created

a miserable situation in many parts of India (Sekher 2007). Guz (1989), in his study in Hisar, Punjab in 1896-97 and 1899-1900, found a very low level of life expectancy for the decade 1891-1900. Famine was identified as the major reason for such a low level of life expectancy at birth in the years 1896-97 and 1899-1900. He also observed that the rise in food prices during the famine increased death which occurred during the famine and subsequent years (McAlpin, 1983). However, Guz (1989) observed an unusual fact that sex differentials in mortality were in favour of men in Hisar against most studies done in western and south India, which found women were relatively better protected than men. He argued that this unusual finding was consistent with the cultural discriminatory practices against women in the allocation of resources in normal times.

The present study demonstrates the mortality situation in the then Bombay Presidency and aims to estimate the life expectancy of its residents by sex during the period 1881-1939.

Data Source and Methodology

Data from Censuses of India and Annual Sanitary Commissioner Reports have been used for this study for the period 1881-1939. Between 1881 and 1939, there had been considerable boundary changes in the different districts of the Bombay Presidency. To avoid confusion, the proper Bombay Presidency has been taken to include the districts Khandesh, Nashik, Ahmadnagar, Poona, Satara, Sholapur, Belgaum, Dharwar, Kaladgi, Kanara, Ratnagiri, Kolaba, Bombay, Tanna, Surat, Broach, Kaira, Punch Mahals, Ahmedabad, Kurrachee, Haidarabad, Thar and Parkar, Shikarpur excluding the native states and Aden. Geographical steadiness is the reason for choosing these districts.

The annual reports of the Sanitary Commissioner for the Government of Bombay are currently available from 1865 to 1946 with the British Council Library, London. Recently, the South Asia Open Archives made these reports available for 1882-1919 through the online JSTOR digital library. These reports were annually published by the Education Society's Press, Byculla, till early 1871 and later the Government Central Press, Bombay, started publishing these reports. These reports contained the comprehensive health statistics (diseases and mortality) of the general population, the European and native troops, and the prisoners. These reports provide data of the presidency and district levels; the prevalence of diseases, causes of death statistics, birth and death rates, the number of deaths and death rate in broad age groups and by sex, rural-urban differentials, and comparison of births and deaths over calendar months for the previous and current year. Despite the limited resources and computational facilities in that era, these reports give a comprehensive analysis of the health status and sanitary conditions.

In 1864, on the recommendations of the Royal Commission of 1859, a sanitary police force and sanitary boards were formulated to improve hygiene and sanitation conditions among the troops and civil society, respectively. The office of the Sanitary Commissioner in Bombay was responsible for the collection, maintenance, analysis and publishing of vital statistics annually (Mushtaq, 2009).

The major barrier to get age-pattern of mortality was the unavailability of age distribution of deaths. Most of the annual reports of the Sanitary Commissioner provide distribution of deaths as under 1 year, 1-20 years, 20-30 years...., 60+ years age groups. Therefore, deaths reported beyond 1 year of age were converted into five-year age groups by applying a four-degree polynomial estimation. The detailed procedure of polynomial estimation for male is given below as an illustration. We have used different polynomials for males and females (Females not shown here).

Interpolation of Number of Deaths using a Four-degree Polynomial:

The estimated number of deaths in five-year age groups from the 10-year age group using a fourth-order polynomial equation is described below for 1891.

$$Y = 509.88*x^4 - 4830*x^3 + 15014*x^2 - 15928*x + 24742$$

Where Y is the estimated number of deaths in 10-year age intervals starting from age 20 years (20-29, 30-39, 40-49, 50-59 and 60+) for given sex and year, x is taken as 1,2,3,4 and 5 respectively. The parameters (coefficients and the error term) used in the equation have been obtained by fitting a straight line through the least square method using the LINEST function in MS-Excel. Table 2 (a) and Table 2 (b) in the appendix show values of different parameters used in fittings. Appendix Table 1 shows the outcome of fitted polynomials carrying 10-year age-group based mortality rates and estimated number of deaths by quinquennial age groups. The estimated number of deaths in quinquennial age groups have been interpolated using mid-values of x, e.g., 1.5, 2.5,...4.5.

After calculating the age-specific death rates for both sexes, one must find which mortality pattern would suit this data. This could be done using Brass' relational model, also called the "logit system" of life table (Brass and colleagues 1971). This system can accommodate the smoothing of mortality patterns for a broader spectrum of developing and developed countries. Accordingly, one can find an appropriate standard life table for a given l_x^k and chose which pattern fits well from the available Coale-Demeny model life tables. Once the pattern and level are picked from the set, the estimation of life expectancy at birth is straightforward by using interpolation technique on person-years survived.

Estimation of life expectancy at birth (e_0^0):

Brass' Indirect technique (United Nations 1983) is used to estimate life expectancy at birth, and its details are given below (Saito et al. 2005). Brass has developed a two-parameter life table system, also referred to as the logit model life table system. The mathematical formulation of the method is given below.

$$STD(l_x^s) = \frac{\sum_{k=t}^{t+a} Logit(l_x^k)}{a+1} = \frac{\sum_{k=t}^{t+a} \left[0.5 \ln \frac{(1-l_x^k)}{l_x^k} \right]}{a+1}$$

Where t represents the starting year, t+a the end year, and l_x^k is the population survived to age x in year k.

An appropriate standard has been chosen using the *Coale and Demeny Model Life Table* to construct an original standard, which would most closely depict the mortality pattern of the region (Saito et al. 2005). The Coale and Demeny Model Life Table North Level 10 for both males and females are found to exhibit the best fit to the mortality age pattern of the erstwhile Bombay Presidency. The period (years) used to determine the mortality patterns are 1925-46 and 1931-46 for males and females, respectively. These years were taken based on the data as no or least mortality shocks were observed during these particular years for the respective sex.

All the estimation and calculation were done using MS-Excel Standard 2019.

Results and Discussion

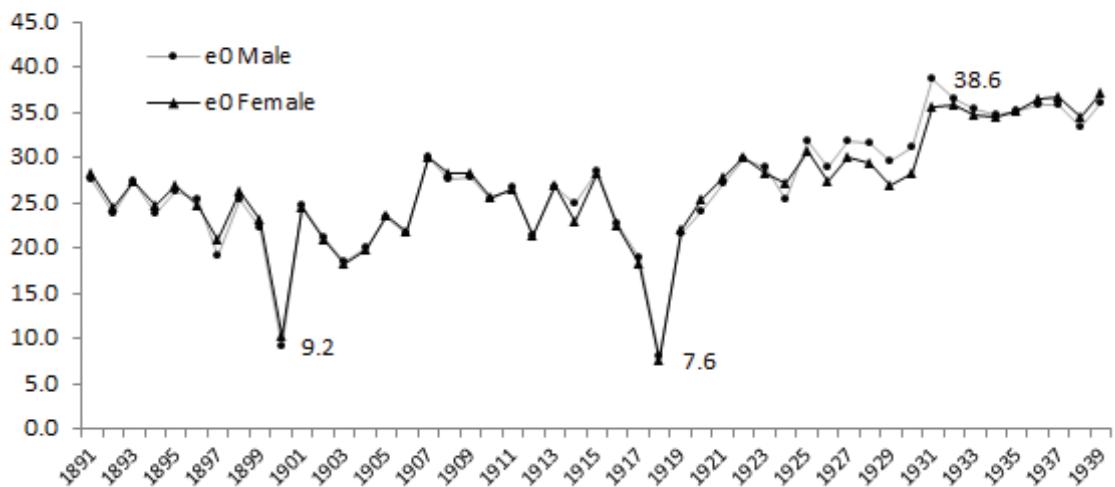
The estimated life expectancy at birth (e_0^0) for males and females between 1891 and 1940 for the Bombay Presidency are shown in Table 1, and the same has been plotted in Graph 1. The trends shown in Table 1 illustrates that life expectancy at birth for the erstwhile Bombay Presidency remained relatively low for both males and females in the late nineteenth and at the beginning of the twentieth century. Its value for males and females was estimated at 27.6 years and 28.3 years, respectively, in 1891. By the end of 1939, the respective values for average life expectancy at birth had risen to 36.1 years for males and 37.2 years for females. Males gained 8.5 years and females, 8.9 years between 1891 and 1939. Bombay's levels during the period before 1920 were noticeably lower than in Berar and Madras, for which we have comparable estimates, though slightly higher than in Punjab.

On the other hand, volatility in Bombay's annual series tended to be less marked than in the other three regions (see Figure 1 in Saito et al. 2005). In the pre-1920 period, the Bombay Presidency saw only two mortality crises. In 1900 and 1918, the life expectancy for males and females was estimated to be dramatically low. The much lower life expectancy level at birth could be due to the plague in the year 1900 and the influenza pandemic in 1918. The first outbreak of an epidemic of bubonic plague broke out in Bombay in 1896 (Mushtaq 2009). In the first year, the disease was confined to the Bombay Presidency with small occurrences in other parts of the country. In the later years, the disease spread to other provinces and cities. In 1899, the whole of India was under this epidemic. By the end of 1903, it had caused around 2 million deaths (Lamb 1908).

Not much variation was noticed in the life expectancy of males and females throughout the period. This meant that the mortality conditions for both sexes were not significantly different in the Bombay Presidency during the colonial period under consideration (Graph 1). However, an interesting trend was noticed; the life expectancy at birth for males was considerably higher than their female

counterparts during the second half of the decade 1921-1930. The gap between male and female life expectancy at birth, favouring males, was estimated at 2.8 years in 1929 and 1930. In the next decade, life expectancy at birth improved for both sexes, but the improvement was much faster for females. As a result, the life expectancy at birth for females surpassed the life expectancy at birth for males by 1.1 years in 1939. This could have been due to the improvements in the healthcare system in the erstwhile Bombay Presidency and the status of women.

Graph 1: Annual Life Expectancy at Birth in Bombay Presidency, 1891-1939



This study also estimated the life expectancy at birth for both sexes in the erstwhile Bombay Presidency. During the period 1891-1900 to 1901-1910, there was a slight increase in the life expectancy for both males and females, although again a decline in life expectancy was witnessed between 1901-1910 and 1911-1920. In the decade 1911-1920 onwards, a sharp increase was noticed in the life expectancy of both the sexes.

This study also provides decadal estimates of the life expectancy at birth for males and females in the erstwhile Bombay Presidency during the colonial period 1891-1939 (Table 2). In 1891-1910, the life expectancy at birth remained low, slightly favourable towards females (23.7 years) than males (23.0 years). In the next decade, 1901-1910, there were some improvements, relatively lower for females, and crossed on average (e_0^0) 24 years for both sexes. This finding confirms the previous study estimates (Ortega 2001).

In the second decade of the twentieth century (1911-1920), life expectancy at birth plunged to its lowest level for both sexes and was estimated at 22.0 years for males and 22.2 years for females. This decade had witnessed the influenza pandemic (Spanish Flu) worldwide and higher incidences

of tuberculosis. Tuberculosis was also recognised as a major public health issue in the Bombay Presidency around 1912 (Ramanna 2012). The decadal estimates of life expectancy at birth during 1921-31 indicate the significant improvements in mortality conditions for both sexes in the erstwhile Bombay Presidency. It reached 29.6 years for males and 28.6 for females. The progress in the life expectancy at birth continued in the next decade (1931-1940) too, as the average life expectancy at birth was 35.7 years for males and 35.1 years for females. The advancement in life expectancy after the year 1920 could be due to the improvement in the situation of plague in the Bombay Presidency. Several measures were taken to improve the healthcare system and combat the epidemics and pandemics during the period by governmental and non-governmental bodies. Such initiatives included the foundation of the Bombay Sanitary Association in 1903, the Bombay Medical Congress in 1909, the Anti-Tuberculosis League in 1912 and the League for Combating Venereal Diseases in 1916 to provide both treatment and to spread awareness about hygiene and sanitation. These initiatives led to improvement in the healthcare system in the erstwhile Bombay Presidency (Ramanna 2004). Colonial authorities were instrumental in sowing the seeds of public health machinery that helped develop an administrative structure for delivering public health services. This is more evident in the cities of the British Presidencies such as Bombay, Madras, and Calcutta (Sekher 2018).

The amelioration of female life expectancy at birth was more than males during 1925-35. It could also be due to a reduction in female mortality given that for the first time voluntary birth control methods were introduced exclusively for women's health and not for the reduction in the birth rate during that decade (Visaria and Chari 1998). It might have impacted women's survival more positively provided all other mortality circumstances remained the same for both males and females in the erstwhile Bombay Presidency during 1931-40.

Limitations of the study:

Age misreporting is observed in the historical Indian data (Bhat 1995; Saito et al. 2005). Therefore, there are chances of age misreporting which may cause upward bias in the life expectancy for both males and females. Also, the population was assumed closed to migration which might not be the case in reality. Future research in this direction can gain a lot from Clark's work (1989) who has adjusted the population by age for migration.

Acknowledgments:

This paper is part of a joint study undertaken by the International Institute for Population Sciences (IIPS) and Institute of Economic Research, Hitotsubashi University, Tokyo. We are also thankful to the support extended by the IIPS Library and the British Council Library, UK. We sincerely thanks both the reviewers for their comments and suggestions on the earlier draft of this paper.

References

- Arnold, D. (1986). Cholera and Colonialism in British India. *Past & Present*, (113), 118-151.
- Bhadani, P. (2016). Population Growth in United India Since 1881 to 1941. *International Journal of Information Research and Review*, 1757-1761.
- Bhat, P. N. M. (1989). Mortality and Fertility in India, 1881–1961: A Reassessment. In T. Dyson (Ed.), *India's Historical Demography: Studies in Famine, Disease and Society* (pp.73-118), Curzon Press, London.
- Bhat, P. N. M. (1995). Age Misreporting and its Impact on Adult Mortality Estimates in South Asia. *Demography India*, 24 (1), 59-80.
- Brass, W. 1971. "On the scale of mortality". In *Biological Aspects of Demography*, Edited by: Brass, William. New York: Barnes & Noble Inc.
- Clark, A. W. (1989). Mortality, Fertility, and the Status of Women in India, 1881–1931. In T. Dyson (Ed.), *India's Historical Demography: Studies in Famine, Disease and Society* (pp.119-149), Curzon Press, London.
- Dyson, Tim. (1989a). Indian Historical Demography: Developments and Prospects. In T. Dyson (Eds.), *India's Historical Demography. Studies in Famine, Disease and Society* (pp.1-16), Curzon Press, London.
- Dyson, Tim. (1989b). The Historical Demography of Berar, 1881-1980. In T. Dyson (Eds.), *India's Historical Demography: Studies in Famine, Disease and Society* (pp.150-196), Curzon Press, London.
- Guz, D. (1989). Population Dynamics of Famine in Nineteenth Century Punjab, 1896-97 and 1899-1900. In T. Dyson (Ed.), *India's Historical Demography: Studies in Famine, Disease and Society* (pp.197-221), Curzon Press, London.
- Guha, S. (1991). Mortality Decline in Early Twentieth Century India: A preliminary enquiry. *The Indian Economic & Social History Review*, 28 (4), 371-391.
- Davis, Kingsley (1951). *The Population of India and Pakistan*. Princeton University Press, Princeton, New Jersey.
- Lamb, George (1908). *The Etiology and Epidemiology of Plague: A summary of the work of the Plague Commission; issued under the authority of the Government of India by the*

Sanitary Commissioner with the Government of India, Shimla. Superintendent of Government Printing, India.

McAlpin, M. B. (1983). Famines, Epidemics, and Population Growth: The Case of India. *The Journal of Interdisciplinary History*, 14 (2), 351-366.

Mills, I. D. (1986). The 1918-1919 Influenza Pandemic—The Indian experience. *The Indian Economic & Social History Review*, 23 (1), 1-40.

Mushtaq, M. U. (2009). Public Health in British India: A Brief Account of the History of Medical Services and Disease Prevention in Colonial India. *Indian Journal of Community Medicine*, 34 (1), 6.

Navaneetham, K. & Krishnakumar, C.S. (2011). Mortality Trends and Patterns in India: Historical and Contemporary Perspectives. In D. Narayana and R. Mahadevan (Eds.), *Shaping India: Economic Change in Historical Perspective* (pp. 264-295). Routledge, Delhi.

Ortega, Osona. J. A. (2001). The Attenuation of Mortality Fluctuations in British Punjab and Bengal, 1870-1947. In Ts'ui-jung Liu et al., (Eds.), *Asian Population History*, (pp. 206-349). Oxford University Press, Oxford.

Ramanna, M. (2004). Local Initiatives in Healthcare: Bombay Presidency, 1900-1920. *Economic and Political Weekly*, 4560-4567.

Ramanna, Mridula (2012). *Healthcare in Bombay Presidency, 1896-1930*. Primus Books, New Delhi.

Saito, O., Takahama, M. D., & Kaneko, R. (2005). Contrasts in Vital Rates: Madras and Punjab in the Colonial Period. Discussion Paper Series No. 68, Institute of Economic Research, Hitotsubashi University, Tokyo. <http://hermes-ir.lib.hit-u.ac.jp/hermes/ir/re/14081/D04-68.pdf>

Sekher, T.V. (2007). Public Health Administration in Princely Mysore: Tackling the Influenza Pandemic of 1918. In W. Ernst and B. Pati (Eds.), *India's Princely States: People, Princes and Colonialism*. Routledge, London.

Sekher, T.V. (2018). Addressing Public Health and Sanitation in Mysore: 1881-1921. In W. Ernst, B. Pati and T.V. Sekher (Eds.), *Health and Medicine in the Princely States, 1850-1950*. Routledge, London and New York.

United Nations (1983): *Indirect Techniques for Demographic Estimation, Manual X*, Department of International Economic and Social Affairs, *Population Studies*, No. 81, New York.

Visaria, P. and V. Chari (1998). India's Population Policy and Family Planning Program: Yesterday, Today, and Tomorrow. In A. Jain (Ed.), *Do Population Policies Matter: Fertility and Politics in Egypt, India, Kenya and Mexico?* The Population Council, USA.

Table 1: Estimated year-wise life expectancy (e_0^0) at birth for males and females between 1891 and 1940 for Bombay Presidency.

Year	Males e_0^0	Females e_0^0
1891	27.6	28.3
1892	23.8	24.4
1893	27.3	27.4
1894	23.8	24.6
1895	26.4	26.8
1896	25.3	24.8
1897	19.2	20.8
1898	25.4	26.4
1899	22.2	23.2
1900	9.2	10.2
1901	24.6	24.4
1902	21.1	21.0
1903	18.5	18.2
1904	20.1	19.7
1905	23.3	23.7
1906	21.5	21.8
1907	30.2	30.2
1908	27.7	28.2
1909	27.8	28.2
1910	25.3	25.7
1911	26.6	26.5
1912	21.4	21.3
1913	26.8	26.8
1914	25.0	23.0
1915	28.6	28.3
1916	22.7	22.4
1917	19.0	18.3
1918	8.1	7.6
1919	21.6	22.0
1920	24.2	25.3
1921	27.2	27.9
1922	29.9	30.0
1923	29.0	28.4
1924	25.4	27.3

1925	31.9	30.8
1926	28.9	27.3
1927	31.8	30.0
1928	31.5	29.3
1929	29.7	26.9
1930	31.1	28.3
1931	38.6	35.6
1932	36.5	35.8
1933	35.3	34.7
1934	34.6	34.6
1935	35.2	35.3
1936	35.9	36.4
1937	35.9	36.7
1938	33.4	34.5
1939	36.1	37.2

Table 2: Estimated decadal life expectancy (e_0^0) for males and females between 1891-1940 and difference for Bombay Presidency.

Decade	Males e_0^0	Females e_0^0	Difference in e_0^0 (Male-Female)
1891-1900	23.0	23.7	-0.66043
1901-1910	24.0	24.1	-0.08979
1911-1920	22.4	22.2	0.243938
1921-1930	29.6	28.6	1.024589
1931-1940	35.7	35.1	0.08323

Appendix

Appendix Table 1: Estimating number of deaths in the five-year age group from 10-year age groups using a four-degree polynomial for Bombay Presidency, 1891.

Age Group	No. of Deaths	X	Estimated Deaths	Age Group	Interpolation no. of deaths	10-year age group mortality rate	Estimated no. of Deaths
20-29	19,508	1.0	19,508	20-24	19,508.0	0.4826	9,415
30-39	22,461	1.5	20,912	25-29	20,911.9	0.4821	9,406
40-49	22,978	2.0	22,461	30-34	22,461.0	0.4918	11,046
50-59	22,673	2.5	23,210	35-39	23,209.9	0.5025	11,287

Age Group	No. of Deaths	X	Estimated Deaths	Age Group	Interpolation no. of deaths	10-year age group mortality rate	Estimated no. of Deaths
60+	35,397	3.0	22,978	40-44	22,978.0	0.5069	11,648
		3.5	22,349	45-49	22,349.4	0.4964	11,406
		4.0	22,673	50-54	22,673.0	0.4652	10,548
		4.5	26,063	55-59	26,062.7	0.4241	9,615
		5.0	35,397	60 +	35,397.0	1.0000	35,397

Appendix Table 2 (a): Fitting straight line with death statistics using LINEST function of MS Excel

No. of Deaths	x	x^4	x^3	x^2
19508	1.0	1.0	1.0	1.0
22461	2.0	16.0	8.0	4.0
22978	3.0	81.0	27.0	9.0
22673	4.0	256.0	64.0	16.0
35397	5.0	625.0	125.0	25.0

Appendix Table 2 (b): Estimated parameters using straight line using four-degree polynomial

Parameters	Estimated Values	Coefficients estimated	Estimated Values
x^2	15013.63	A	509.875
x^3	-4829.75	B	-4829.75
x^4	509.875	C	15013.63
x	-15927.8	D	-15927.8
E	24742	E	24742

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The Institute served as a regional centre for Training and Research in Population Studies for the ESCAP region. The Institute was re- designated to its present title in 1985 to facilitate the expansion of its academic activities and was declared as a 'Deemed University' in August 19, 1985 under Section 3 of the UGC Act, 1956 by the Ministry of Human Resource Development, Government of India. This recognition has facilitated the award of degrees by the Institute itself and paved the way for further expansion as an academic institution. The faculty members and the supporting staff belong to diverse interdisciplinary background with specialization in some core areas of population sciences, trained in India and abroad.

Institute is the hub of population and health related teaching and research in India, playing a vital role for planning and development of the country. During the past years, students from different countries of Asia and the Pacific region, Africa and North America have been trained at the Institute. The alumni are occupying prestigious positions at national and international organisations, universities and non-governmental organisations.

The Institute offers Post-Graduate, Doctoral, and Post-Doctoral courses. After completing the course, students are well prepared for: (i) admission to higher degree programmes in the best universities of the world; (ii) a good career in teaching & research; (iii) for a multi-disciplinary professional career; (iv) as independent consultant.

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Vision “To position IIPS as a premier teaching and research Institution in population sciences responsive to emerging national and global needs based on values of inclusion, sensitivity and rights protection.”

Mission “The Institute will strive to be a centre of excellence on population, health and development issues through high quality education, teaching and research, This will be achieved by (a) creating competent professionals, (b) generating and disseminating scientific knowledge and evidence, (c) collaboration and exchange of knowledge and (d) advocacy and awareness.”