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Pandemics and Historical Mortality in India

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Abstract

This paper presents selected historical mortality statistics of India and analyses their characteristics and trends. Statistics are collated from a wide range of sources as time series at different regional scales, and particularly for the pandemics related with cholera, plague and influenza between 1817 and 1920. The paper analyses rare burial records in 19th century Calcutta, constructs the global distribution of deaths due to pandemic cholera in the 19th and early 20th century, and provides new mortality estimates of the 1918 influenza pandemic in India. The paper also presents a bibliography of over 250 studies on pandemics and historical mortality in India.

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Introduction

Covid-19 brought 'pandemics' to the centre of the world's attention in 2020. Pandemics have occurred in the past due to several diseases and cholera, plague and influenza, in particular, ravaged the Indian subcontinent in the 19th and early 20th century. This paper provides a factsheet of that era, highlighting the special nature of the period from 1817, marking the onset of the cholera pandemic, to 1920, after which mortality in India, steadily reduced.

Mortality statistics in India appear in a systematic manner from the 1860s as part of the annual reports of the 'Sanitary Commissioner' of British India and indirectly from the decennial Census of India that regularly took place since the 1870s. The analysis of these statistics is usually placed in the field of 'historical demography', and has attracted the attention of several demographers (Davis 1951, Dyson 1989, Dyson 2018) and historians (Klein 1972, Arnold 1993, Guha 2001).

The Sanitary Commissioner reports at the All-India and provincial levels often provided data at the sub-district level such as municipalities and local social groups. Data was presented for the British army, the native army and the general population. By the 1910s, the causes of death were registered under eight categories: Fevers, Respiratory Diseases, Cholera, Dysentery and Diarrhoea, Plague, Smallpox, Injuries, Others. Much of this aggregated data would also be presented in the annual Statistical Abstracts of British India.

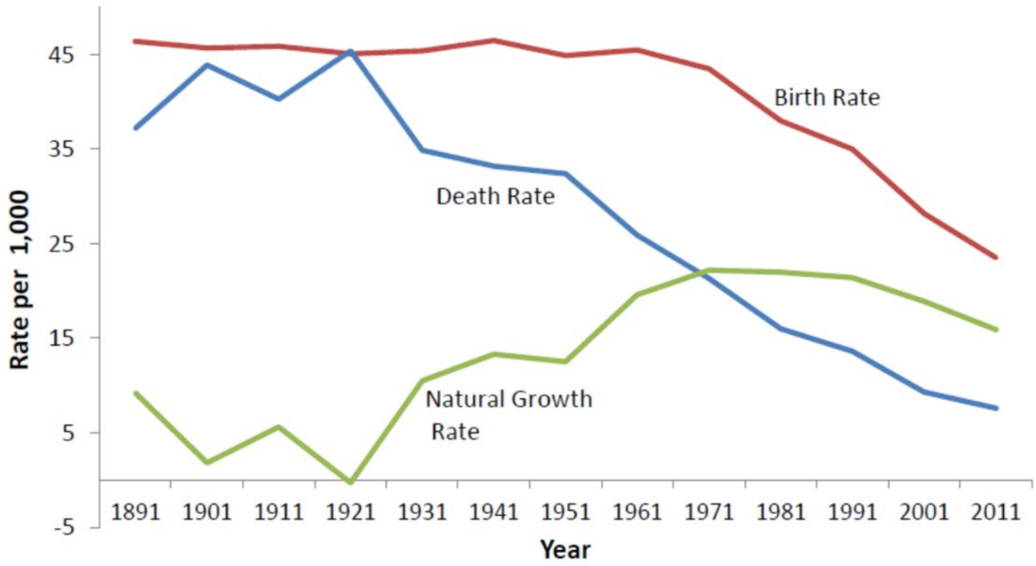
Death registration was certainly not perfect in the late 19th and early 20th century and encountered several problems: the reporting of the deaths at the village level was often done by people not well qualified in health matters and during epidemic or pandemic years, the statistical machinery would be overwhelmed and break down. Further, the Sanitary Commissioner reports usually covered only British India and left out the princely states, which held around 40% of the land and 20% of the population in the Indian subcontinent. The Census of India did cover the princely states, and thus provided valuable information, even if the statistics were not collected as frequently as the Sanitary Commissioner reports. As Dyson (1989) has argued, the historical mortality statistics of India can be fruitfully used by researchers when due consideration is given to the weaknesses of the data generating process.

The rest of this paper is arranged as per the following **Sections**:

1. The Mortality Transition of India

Demographers have recognized the significance of the mortality transition (from high death rates to low death rates) in fostering the overall demographic transition of a region. Fig. 1.1 shows that the death rate of India was high and increasing in the 1890s, peaked in the 1911-1921 decade at around 45 deaths per 1,000 people per year, and steadily declined thereafter over the course of the twentieth century to a level of under 10 in recent years. Birth rates fell much later and India's natural growth rates therefore picked up since the 1920s and began falling only in the closing decades of the 20th century.

Figure 1.1: The Demographic Transition of India, 1901-2011



Source: Dyson (2004) and SRS statistics.

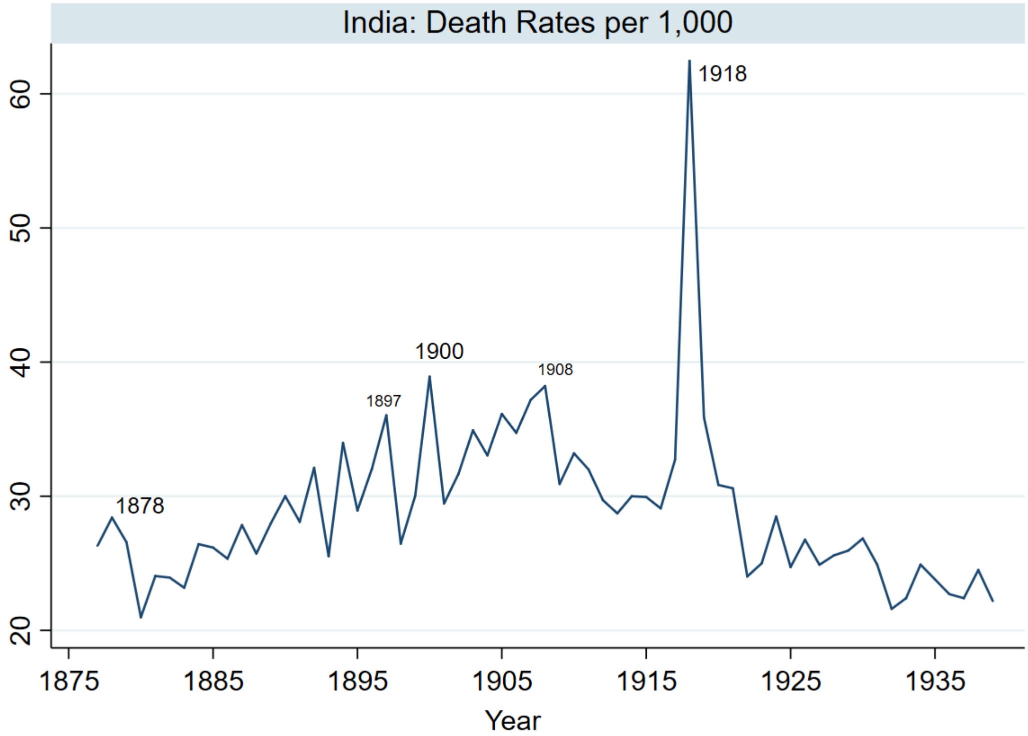
Chart from Chinmay Tumbe (2016), "Urbanization, Demographic Transition and the Growth of Cities in India, 1870-2010". IGC Working Paper.

The 1920s therefore mark a critical inflection point in India's mortality transition. Several theories have been brought forward to explain this mortality decline. Davis (1951) had pointed out to better control over famines by development of rail, roads and irrigation and also the role of modern medicine in controlling epidemic disease. Klein (1990) claimed that there was better immunity due to changes in host-parasite relations. Guha (1991) argued that climatic change since the 1920s towards less monsoon variability improved nutrition balance and thus reduced overall mortality. Other factors for improvement were "the withdrawal of the plague, the non-recurrence of the lethal influenza, and perhaps by public health measures that checked *kala azar*, cholera and smallpox" (Guha 1991, p. 387).

Fig. 1.2 shows that at the All-India level, death rates were steadily rising since the 1870s, and began to fall steadily after 1908, with the influenza pandemic year of 1918 causing a one-time massive spike in mortality, after which mortality resumed its downward trajectory.

Another interpretation of the chart is that the half-century period 1870-1920 was unusually lethal in Indian history, and that death rates in the 1920s and 1930s only reflected levels that presumably prevailed before the 1870s. A comparison with Fig. 7.1 on rainfall shows that this period did display extreme climatic variations with three of the worst droughts in recorded history (in 1877, 1899 and 1918).

Figure 1.2: Death Rate of India, 1877-1939



Source: Statistical Abstracts of British India.

Figs. 1.3a and 1.3b shows the causes of death over time. 'Fevers' contributed to the highest number of deaths in this period, reflecting mostly malaria (especially in 1908) and in 1918, influenza. Since 1903, respiratory diseases (reflecting Tuberculosis) were classified as a separate category and showed an increasing trend over time.

Figure 1.3a: Causes of Death, 1877-1939

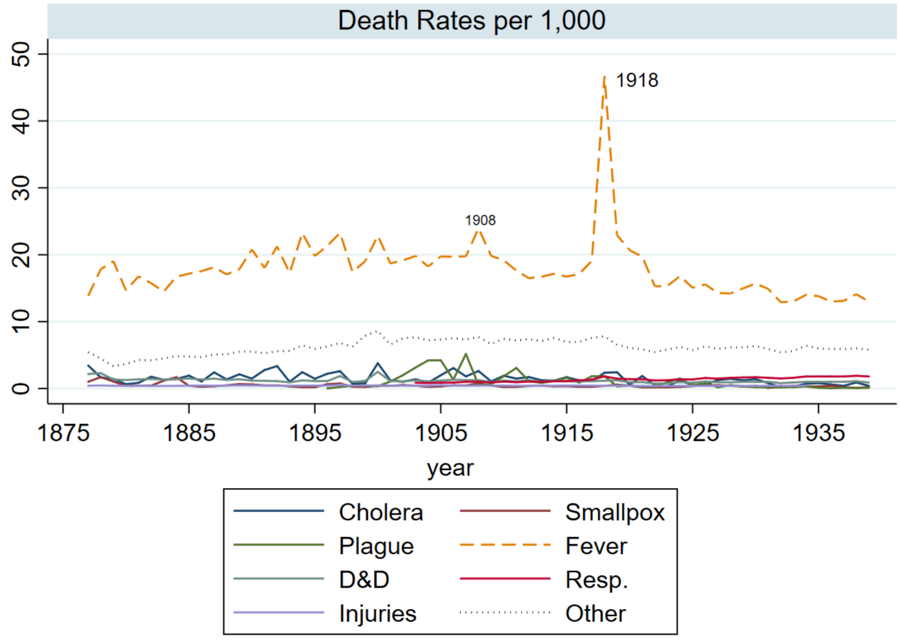
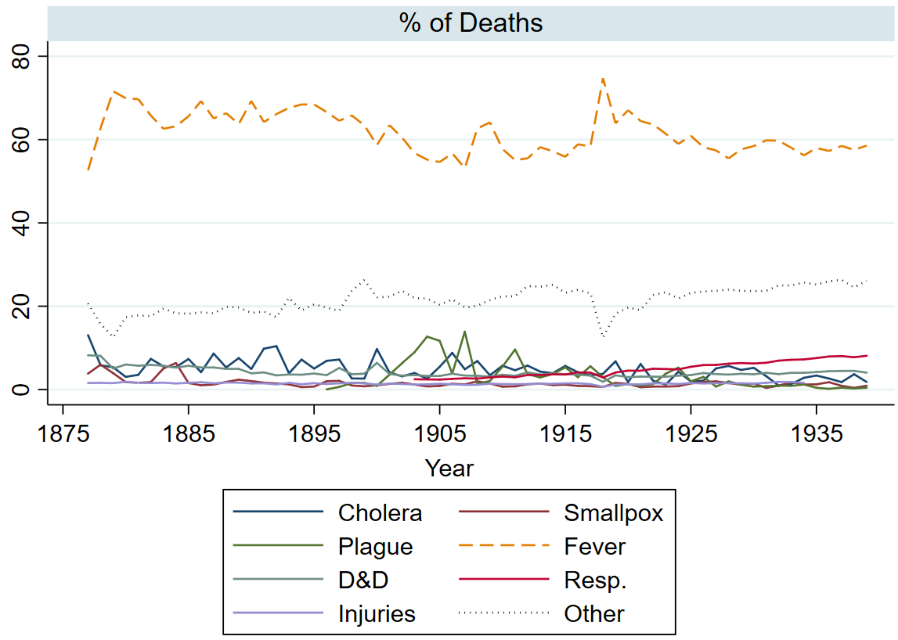


Figure 1.3b: Causes of Death as % of Total Deaths, 1877-1939

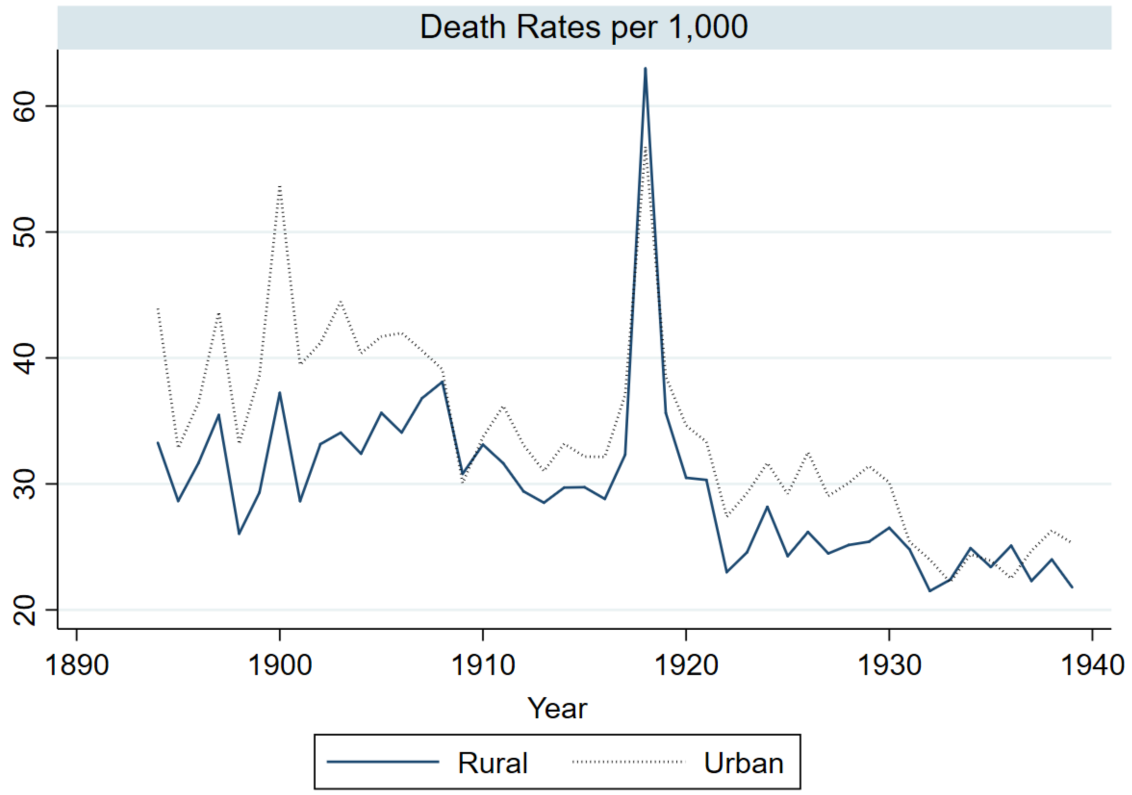


Source: Statistical Abstracts of British India. Resp.= Respiratory Diseases [Category since 1903], D&D = Dysentery & Diarrhoea, Plague category since 1896.

Rural vs. Urban Death Rates

Rural and urban death rates tracked each other closely between the 1890s and 1940, with urban death rates outstripping rural death rates for most of the period. As Fig. 1.4 shows, the only year in those five decades when the rural death rate was significantly higher than the urban death rate was in 1918, the year of the influenza pandemic. One caveat is that the lower rural death rates could also represent under-registration of deaths.

Figure 1.4: Rural and Urban Death Rates in India, 1890s-1940

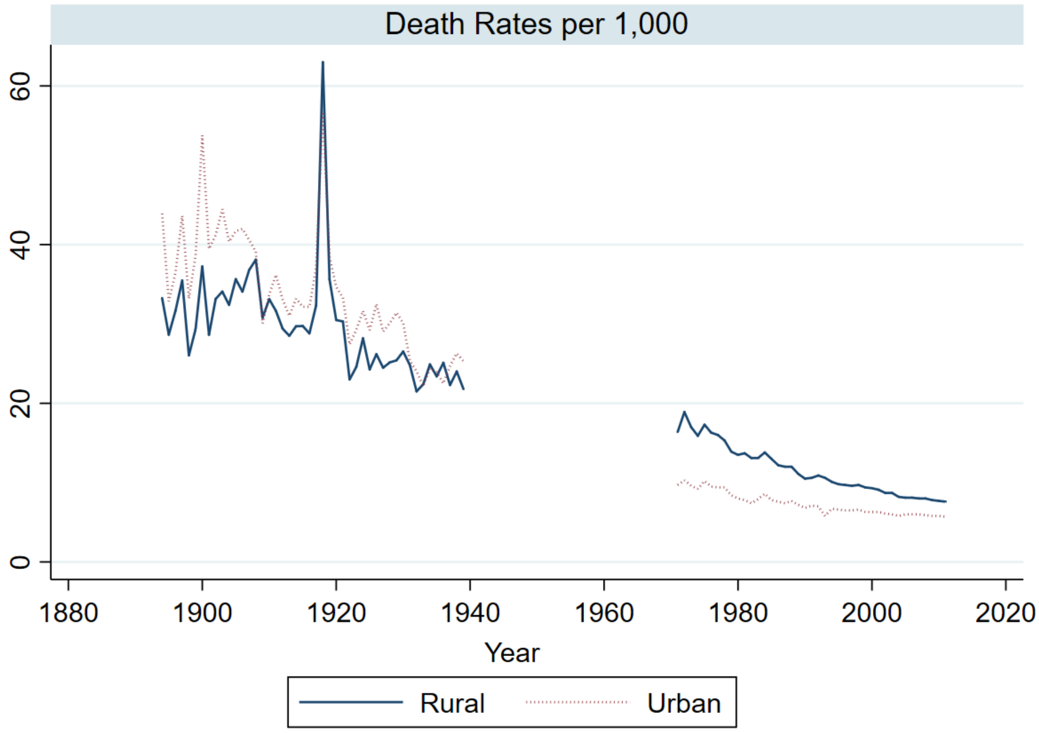


Source: Statistical Abstracts of British India.

Fig. 1.5 shows that urban death rates plummeted faster than rural death rates in the third quarter of the twentieth century such that by the 1970s, the urban death rate was nearly double the rural death rate. This urban-rural difference steadily narrowed down from the 1970s to 2011.

The urban-rural fertility differential did not however narrow down, opening up a demographic divergence between urban and rural natural growth rates that contributed to slower urbanization in this period (Tumbe 2016).

Figure 1.5: Rural and Urban Death Rates in India, 1890s-1940 & 1971-2011



Source: Statistical Abstracts of British India, Sample Registration Statistics, 1971-2011.

Mortality in the Popular Discourse

The mortality transition of India can also be captured in the popular discourse. Table 1.1 shows the relative frequencies of the words denoting key epidemics in the English daily *Times of India* (See Tumbe 2019 for the research method). The word 'death' appeared in around 10-11% of all articles published in the daily between the 1830s and 1910s and begins to fall thereafter, in line with the observed data on mortality statistics. Similarly, 'famine' appears strongly in the 1870s, 1890s and 1900s, in line with the observation on deficient rainfall. It also sharply reduces after 1920 (barring the 1940s Bengal Famine period).

Despite malaria being the biggest killer, it was cholera that captured the popular discourse in the 19th century until the 1890s after which plague held sway until the 1920s. Cholera, Plague and Influenza appeared in over 3% of all the articles published in the daily before the 1920s, after which there was a sharp reduction.

Table 1.1: Percentage of articles in the Times of India (TOI) newspaper, with the following words:

Decade	Total TOI Articles	Influenza	Cholera	Plague	Small Pox	Malaria	Kala Azar	Famine	Pandemic	Epidemic	TB	Yellow Fever	Death	Five Diseases	Three Diseases
1830s	3,095	0.03	1.58	0.52	0.10	0.10		1.26		0.23		0.10	10.8	2.3	2.1
1840s	21,536	0.05	2.49	0.47	0.45	0.15		0.85		0.50		0.06	12.1	3.6	3.0
1850s	20,449	0.01	2.06	0.32	0.50	0.17		0.57		0.48		0.06	10.3	3.1	2.4
1860s	15,425	0.00	2.91	0.48	0.45	0.22		1.94		0.70		0.09	9.9	4.1	3.4
1870s	80,594	0.01	2.02	0.31	0.69	0.09		4.41		0.53		0.07	10.2	3.1	2.3
1880s	123,209	0.03	2.54	0.25	0.95	0.08		1.40		0.53	0.01	0.09	11.3	3.9	2.8
1890s	103,325	0.48	1.83	4.58	0.46	0.12	0.00	2.55	0.00	1.09	0.04	0.07	11.9	7.5	6.9
1900s	154,287	0.16	1.39	4.84	0.67	0.39	0.01	2.87	0.00	0.90	0.09	0.09	11.4	7.4	6.4
1910s	172,539	0.47	1.43	2.90	1.02	0.60	0.02	1.58	0.01	0.89	0.29	0.07	10.7	6.4	4.8
1920s	225,043	0.54	0.89	1.30	0.64	0.54	0.03	0.96	0.01	0.86	0.23	0.03	9.4	3.9	2.7
1930s	344,664	0.20	0.72	0.72	0.32	0.40	0.01	0.54	0.00	0.67	0.33	0.04	7.5	2.4	1.6
1940s	181,776	0.06	0.41	0.32	0.10	0.25	0.00	1.04	0.00	0.39	0.20	0.02	5.5	1.1	0.8
1950s	312,282	0.12	0.27	0.12	0.08	0.20	0.00	0.69	0.00	0.32	0.22	0.03	4.2	0.8	0.5
1960s	262,993	0.05	0.19	0.09	0.06	0.10	0.00	0.49	0.00	0.21	0.13	0.02	4.2	0.5	0.3
1970s	261,412	0.04	0.21	0.11	0.06	0.18	0.01	0.58	0.00	0.23	0.15	0.01	5.1	0.6	0.4
1980s	314,753	0.03	0.14	0.13	0.02	0.16	0.01	0.39	0.00	0.24	0.15	0.02	6.3	0.5	0.3
1990s	425,896	0.03	0.10	0.29	0.02	0.24	0.01	0.20	0.02	0.32	0.16	0.02	6.0	0.7	0.4
2000s	574,056	0.10	0.05	0.16	0.01	0.22	0.00	0.08	0.08	0.27	0.13	0.04	5.4	0.5	0.3
Total	3,597,334	0.14	0.58	0.76	0.24	0.26	0.01	0.81	0.02	0.45	0.17	0.04	6.9	2.0	1.5

Note: 1830s decade= 1838, 1839; 1840s decade= 1840-1849 and similar for remaining decades; TB= Tuberculosis, Five Diseases= Influenza, Cholera, Plague, Small Pox, Malaria; Three Diseases= Influenza, Cholera, Plague.

Source: ProQuest Times of India Digital Database.

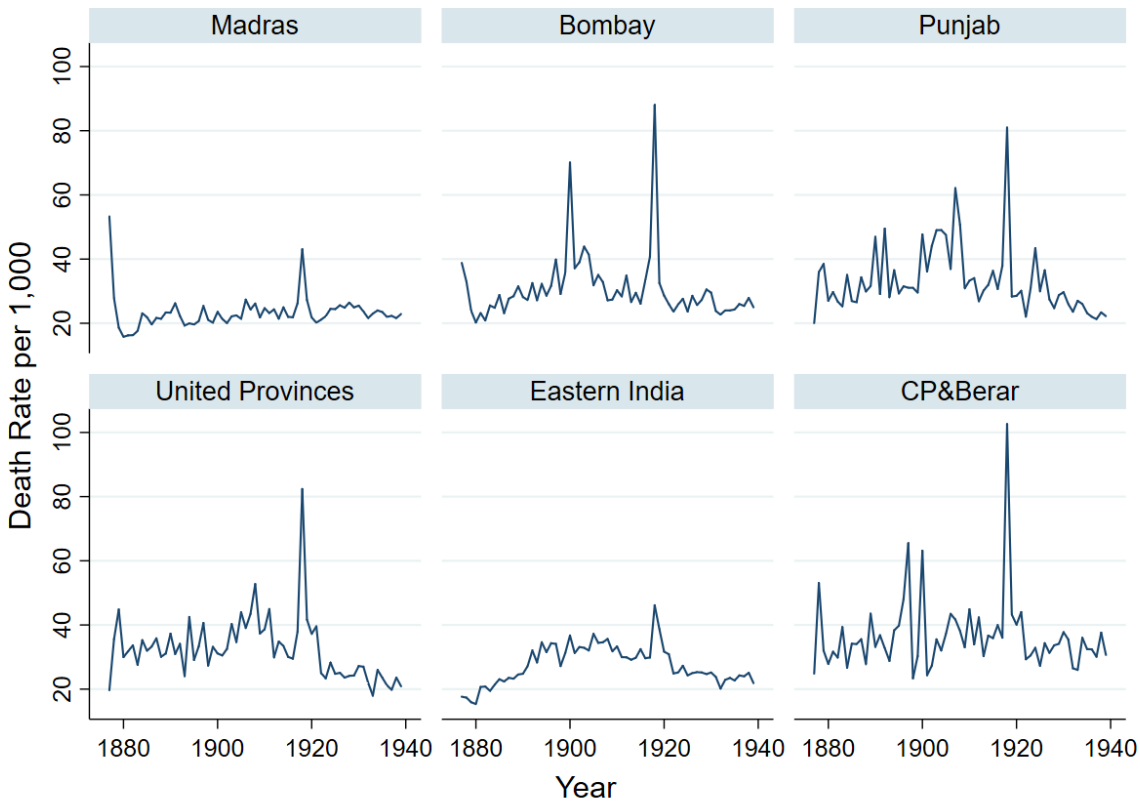
Regions

The All-India statistics on mortality mask significant variation across regions over the years and for different diseases.

Fig. 1.6 shows south India, proxied by the Madras Presidency, to reside in a low-pressure mortality regime (Dyson 2018) throughout 1877-1939 barring the 1877 famine period and 1918 influenza pandemic. It poses an important counterpoint to existing theories on the mortality transition in India after the 1920s by pointing out that mortality barely rose or fell during this long period, and presumably starting falling only after the 1930s.

India's overall mortality transition thus needs to be seen in region-specific terms. Fig. 1.6 shows that the rise and fall in mortality occurs in regions outside south India. As will be seen in later sections, a large part of this regional trend can be explained by the presence or absence of cholera, plague and influenza, and perhaps malaria in specific time periods.

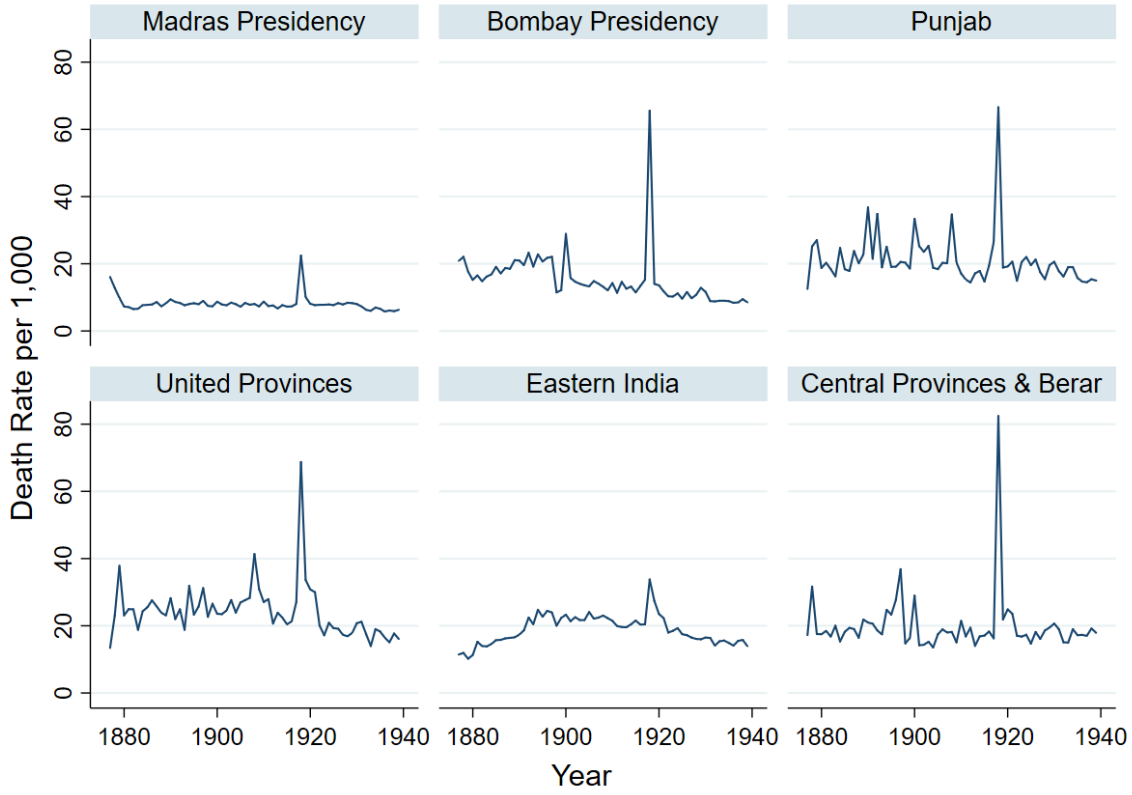
Figure 1.6: Death Rates in India: Regions, 1877-1939



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

Fig. 1.7 shows the remarkable consistency of 'fever' related death rates in the Madras Presidency over nearly 60 years. In most regions, it does not exhibit a general upward trajectory and prominently spikes up during the 1918 influenza pandemic year.

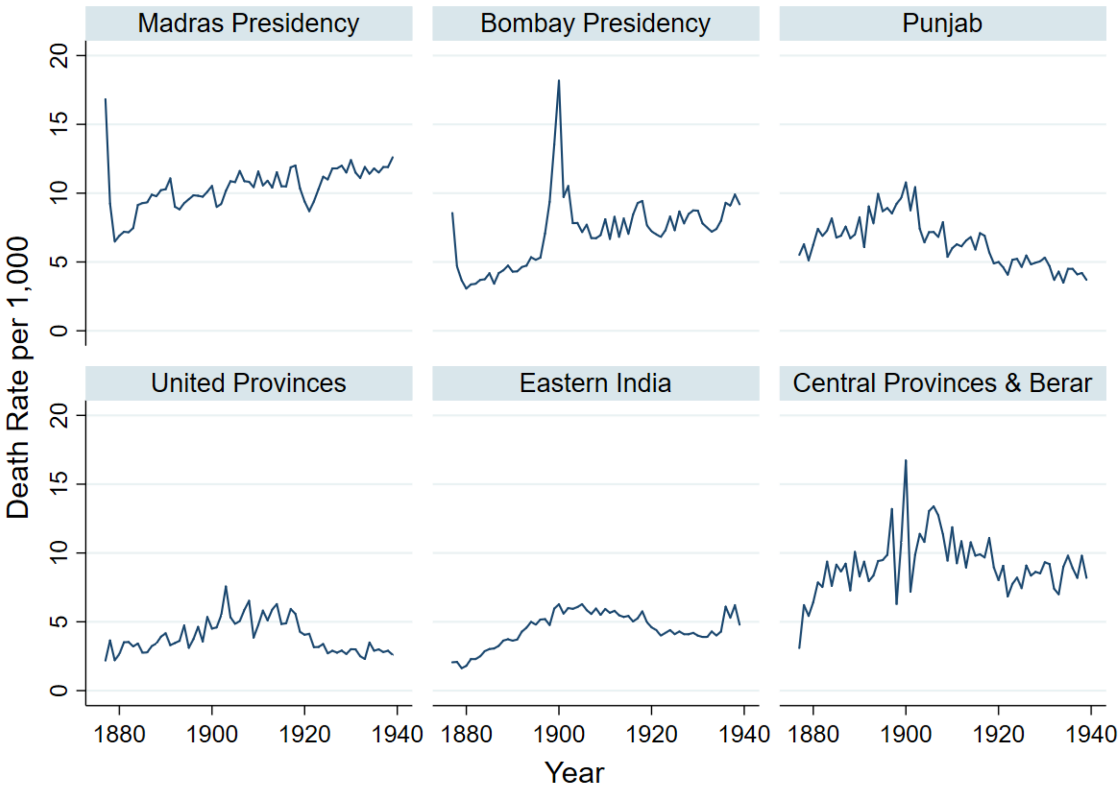
Figure 1.7: Death by 'Fever': Regions, 1877-1939



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

Fig. 1.8 shows that India's overall increase in mortality in the late 19th century could be significantly driven by the rise in deaths due to 'other causes', which notably coincides with the famine years. This could suggest better registration of deaths or the difficulty in classifying deaths during a period of rising mortality.

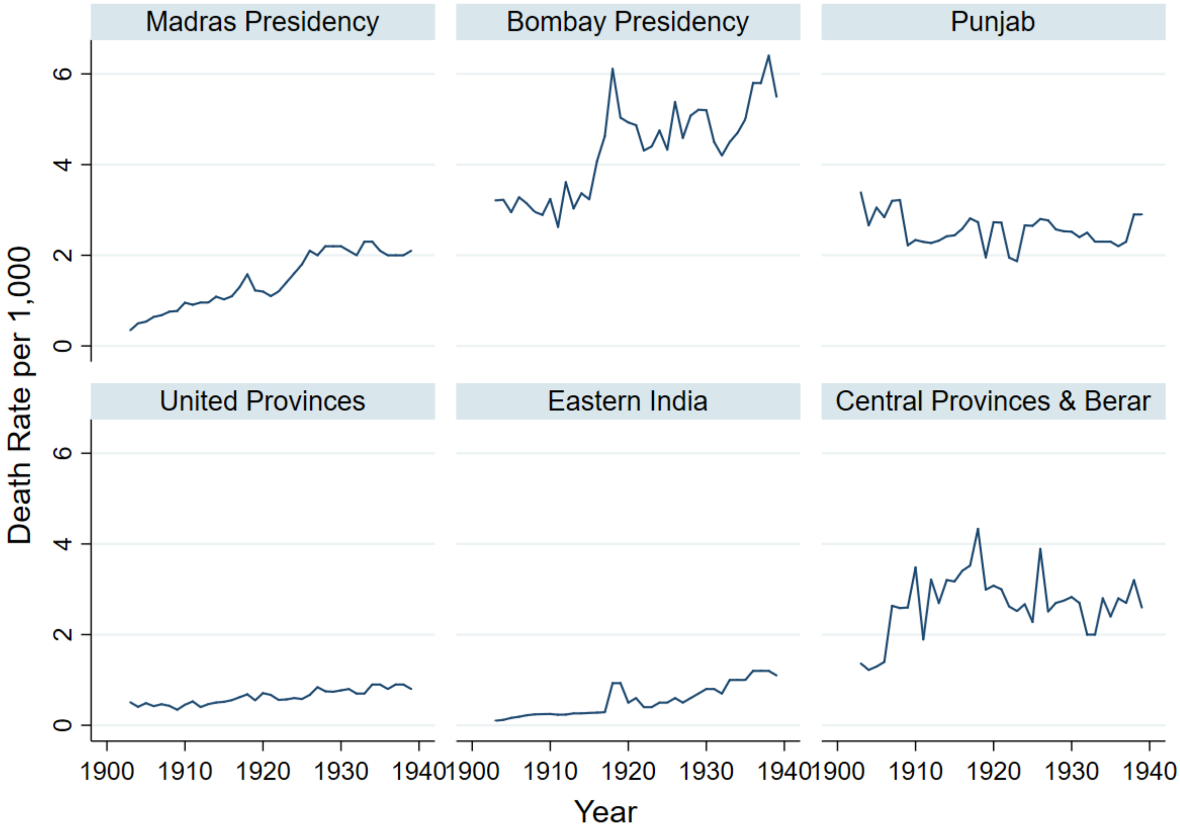
Figure 1.8: Death by 'Other Causes': Regions, 1877-1939



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

Fig. 1.9 shows that after 'respiratory diseases' (reflecting Tuberculosis among others) was classified as a separate category in 1903, it began to rise steadily in Madras and Bombay Presidencies, but had little upward movement in Punjab and United Provinces.

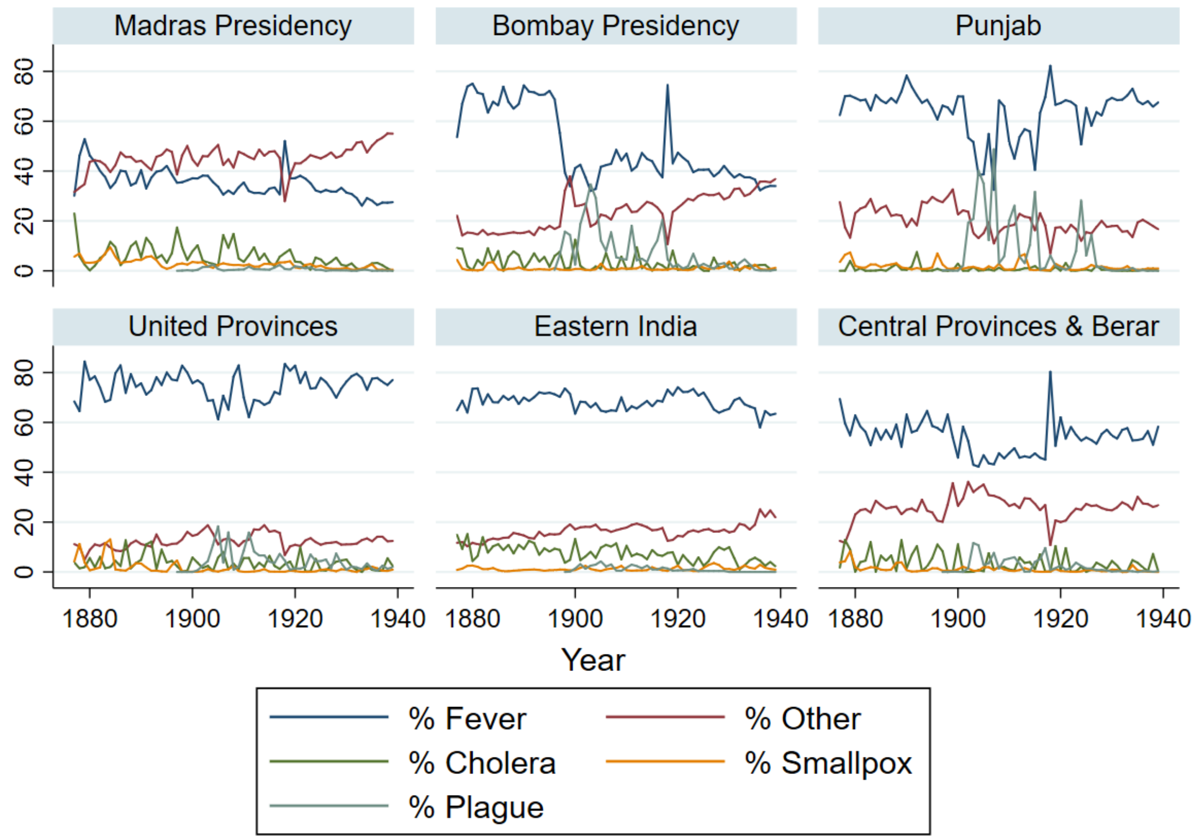
Figure 1.9: Death by Respiratory Diseases: Regions, 1903-1939



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

Fig. 1.10 shows the significance of 'other' causes to be of greater significance than the 'fever' category in Madras Presidency, in stark contrast to other regions of India, where 'fevers' are by far the most important cause of death. It also shows the significance of cholera for southern and eastern India, and plague in the Bombay Presidency and Punjab for certain time periods.

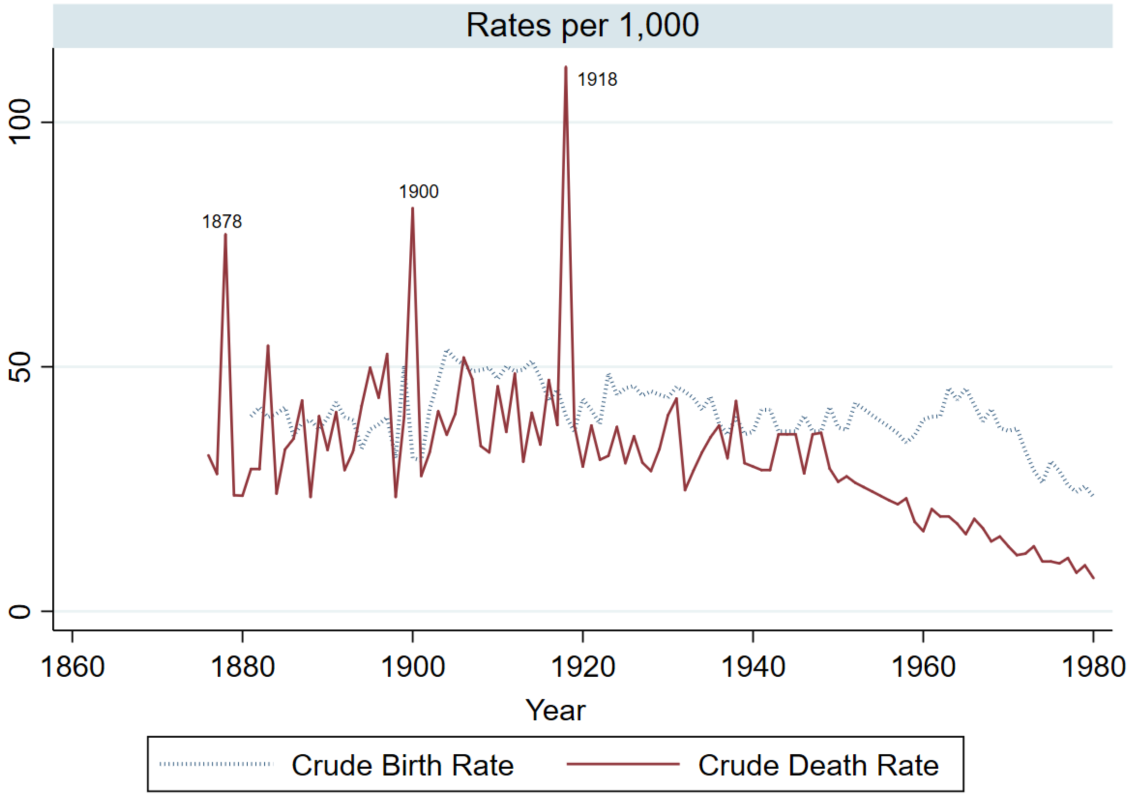
Figure 1.10: % of Deaths due to major causes: Regions, 1877-1939



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

Fig. 1.11 displays the vital rates calculated by Tim Dyson for Berar in central India, which shows that the major part of the mortality transition began only after the 1930s. It also shows the mortality spikes for 1878 and 1900, after the droughts of 1877 and 1899 and the mortality spike for 1918 reflecting the drought of 1918 as well as the influenza pandemic.

Figure 1.11: Vital Rates for Berar, 1876-1980



Source: Dyson (1989) adjusted rates series, Statistical Abstract of British India for unadjusted crude death rate for 1876-79.

2. Calcutta's South Park Street Cemetery Burial Records

Burial records have been frequently used by researchers to study historical demography in Europe. In India, the predominant practice of cremation among Hindus left behind few records on mortality but burial records, especially among Christian communities, do exist. James and Rajan (1998) studied parish records in Kerala using data from the early twentieth century to compute a time series on vital statistics. Nelson Soy's ongoing doctoral dissertation in historical demography at IIPS, Mumbai, also makes use of parish records.

An important source of burial records in the 19th century is preserved in a booklet available at the counter of Calcutta's South Part Street Cemetery (BACSA 1992). To the best of the author's knowledge, this is the first time that this dataset is being studied.

Also known as the 'The Great Cemetery', the South Park Street Cemetery was mostly used by Britishers who lived in colonial Calcutta. The British community was a small subset of the overall population of Calcutta which grew to over half a million over the course of the 19th century. The population of the 'Park Street' locality was 4,968 as per the 1881 Census of the Town and Suburbs of Calcutta (Table III-IV), of which 1,278 were enumerated as Christians (728 male, 550 female). The male-dominance reflected the migration patterns of British army and civil service officials who circulated between India and Britain.

The burial records show over 3,200 points marked in the cemetery, spanning the years 1768 to 1926, though the cemetery had reached near-saturation by 1870. Of these, the age can be verified for over 2,200 individuals. Females were identified in the dataset by the titles used such as 'Miss' or by the name and around 40% of the records could be classified as being female. Table 2.1 shows that 20% of deaths were recorded in the 0-9 age group category and 8% in the 10-19 age group category, reflecting high child mortality of those times. While the overall population was male-dominated, as also reflected in the deaths, the sex ratio of mortality in the early-childbearing ages of 10-19 shows a distinct female bias, underscoring high maternal mortality.

Table 2.1: Age-Sex Characteristics of South Park Street Cemetery Burial Records

	Total Burials				% of Total Deaths		
Age Group	Male	Female	Total	Sex Ratio	Male	Female	Total
0--9	250	209	459	836	19	22	20
10--19	79	110	189	1392	6	12	8
20--29	258	239	497	926	19	26	22
30--39	281	156	437	555	21	17	19
40--49	226	93	319	412	17	10	14
50--59	129	46	175	357	10	5	8
60plus	114	84	198	737	9	9	9
Total	1337	937	2274	701	100	100	100

Notes and Sources: BACSA (1992) analysis; Sex Ratio is females per 1,000 males.

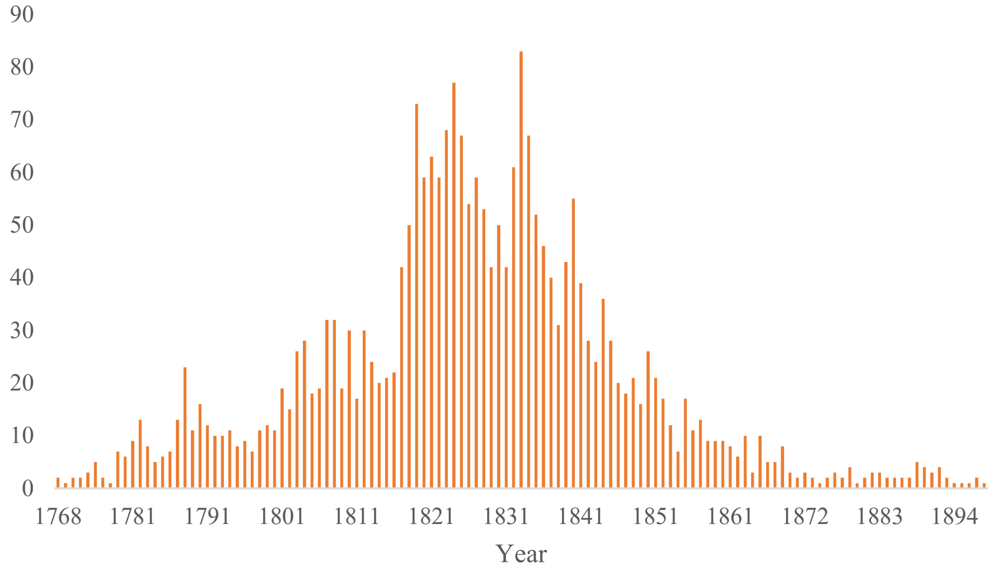
Table 2.2 and Figure 2.1 shows the time series on burial records at the cemetery. It shows that the cemetery gained traction in usage from the 1780s, which lasted until the 1860s. It also shows that from 1817, the year usually marked as the onset of the cholera pandemic, deaths doubled from the average of 20s per year to 40s and 50s thereafter, until the early 1840s. 1833, another major cholera outbreak year, witnessed 83 burials, the highest recorded in this dataset. The burial records therefore preserve an important imprint of the 19th century cholera pandemic.

Table 2.2: Number of Burials by Year of Death, 1768-1926

Year	Records	Year	Year	Records	Year	Year	Records
1768	2	1803	26	1835	52	1867	5
1769	1	1804	28	1836	46	1868	8
1772	2	1805	18	1837	40	1870	3
1773	2	1806	19	1838	31	1871	2
1774	3	1807	32	1839	43	1872	3
1776	5	1808	32	1840	55	1873	2
1777	2	1809	19	1841	39	1875	1
1778	1	1810	30	1842	28	1876	2
1779	7	1811	17	1843	24	1877	3
1780	6	1812	30	1844	36	1878	2
1781	9	1813	24	1845	28	1879	4
1782	13	1814	20	1846	20	1880	1
1783	8	1815	21	1847	18	1881	2
1784	5	1816	22	1848	21	1882	3
1785	6	**1817**	**42**	1849	16	1883	3
1786	7	1818	50	1850	26	1884	2
1787	13	1819	73	1851	21	1885	2
1788	23	1820	59	1852	17	1887	2
1789	11	1821	63	1853	12	1888	2
1790	16	1822	59	1854	7	1889	5
1791	12	1823	68	1855	17	1890	4
1792	10	1824	77	1856	11	1891	3
1793	10	1825	67	1857	13	1892	4
1794	11	1826	54	1858	9	1893	2
1795	8	1827	59	1859	9	1894	1
1796	9	1828	53	1860	9	1895	1
1797	7	1829	42	1861	8	1896	1
1798	11	1830	50	1862	6	1898	2
1799	12	1831	42	1863	10	1926	1
1800	11	1832	61	1864	3		
1801	19	**1833**	**83**	1865	10		
1802	15	1834	67	1866	5	**Total**	**2,450**

Notes and Sources: BACSA (1992) analysis.

Figure 2.1: Number of Burials by Year of Death at the South Park Street Cemetery



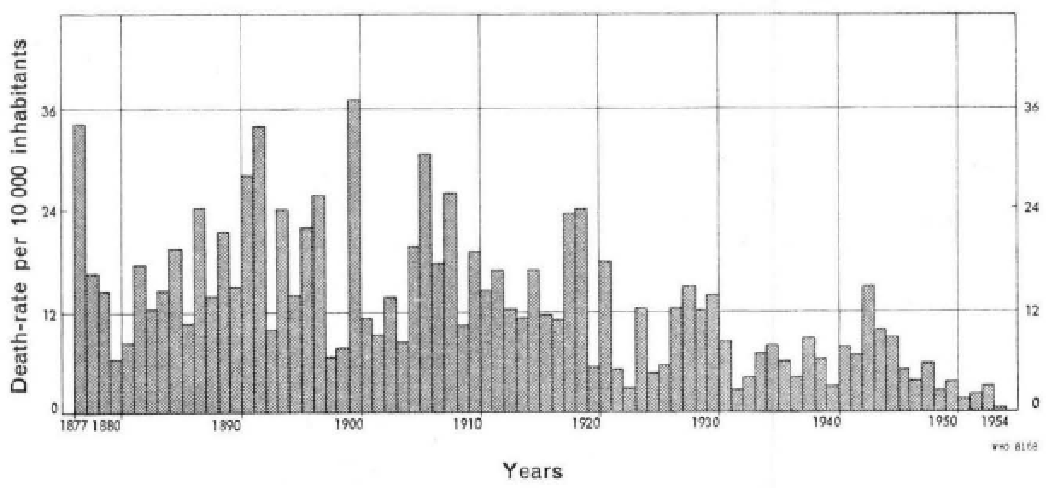
3. Cholera

Cholera is considered to be endemic in Bengal and some other parts of India and its symptoms of painful diarrhoea and vomiting followed by rapid death, have been noted in the Indian subcontinent since at least the 16th century (Pollitzer 1959). However, a particularly virulent strain of *Cholerae Vibrio*, the disease-causing bacteria, appears to have broken out in 1817, which swept across the world in the 19th century.

Cholera is primarily a water-borne disease spread by the faecal-oral transmission method and hence, clean water supplies constitutes a major preventive check on the spread of the disease. In recent research, food-borne transmission has also been detected (Hamlin 2009). The treatment through oral rehydration was perfected only in the twentieth century, drastically cutting down case-fatality rates from over 50% to negligible levels.

Cholera claimed roughly 5% of all deaths in British India in the late 19th and early 20th century. Figures 3.1 and 3.2 shows the evolution of the death rate, dipping substantially in the second quarter of the 20th century.

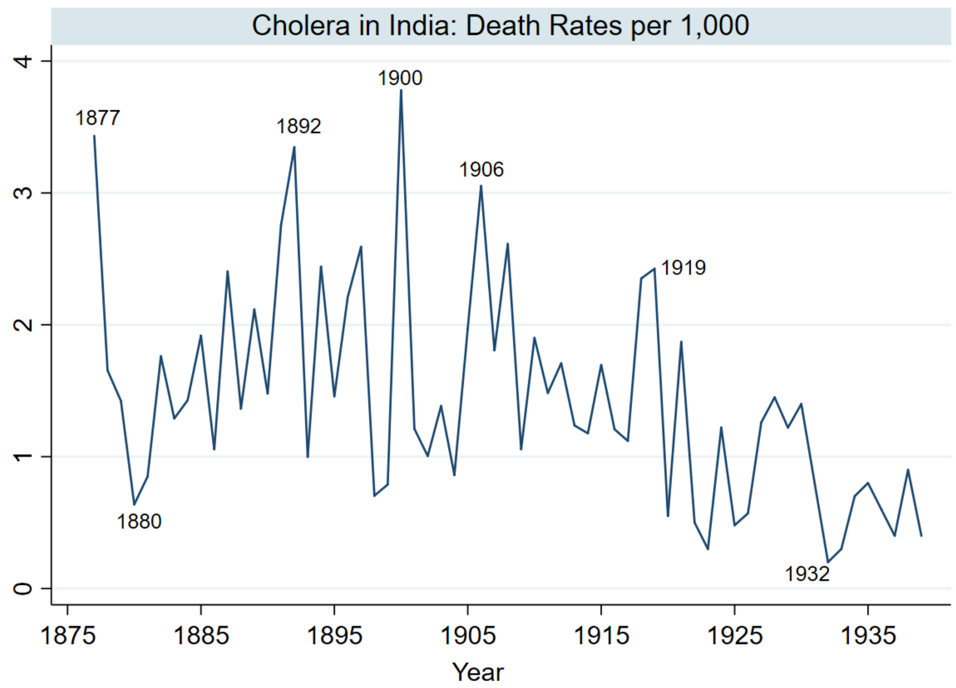
Figure 3.1: Pollitzer Series on 'Annual Cholera Death-Rate in India, 1877-1954', per 10,000 persons



Source: Pollitzer (1959, Fig 6., p. 78).

Cholera was closely associated with famines and thus cholera deaths were higher in the famine years of 1877 and 1900 (Arnold 1989), as depicted in Fig 3.2. Cholera death rates rose in the last two decades of the 19th century, peaked in 1900, and began a downward slide from roughly 1910. Table 3.1 shows that annual cholera-deaths in British India hovered above 300,000 between 1880 and 1920, after which it began falling, and sharply reducing in the 1950s.

Figure 3.2: Cholera Death Rates in India, 1877-1939



Source: Statistical Abstracts of British India.

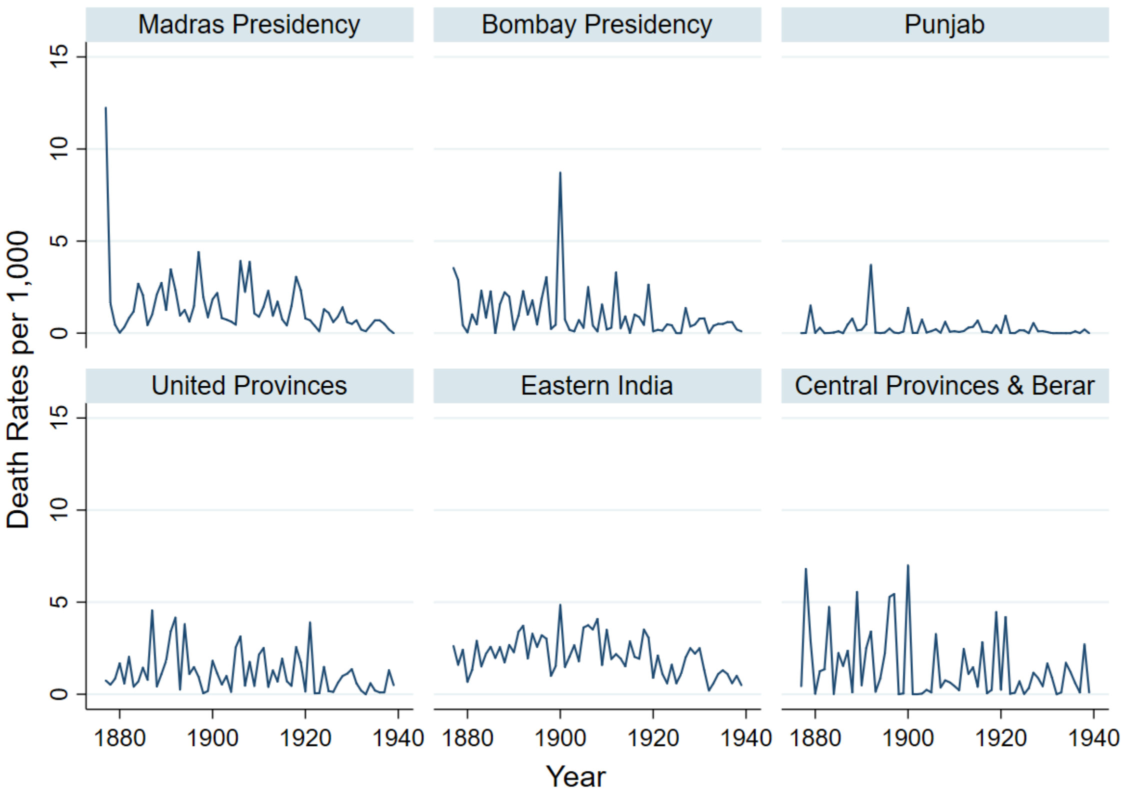
Table 3.1: Cholera Deaths in British India, 1865-1960

Period	Decennial Average of Annual Deaths	Period	Avg. Annual Cholera Mortality Rate	Expressed as a % of the 1874-1899 figure
1865-1870 (6 years)	146,998	1874-1899	1.68	
1871-1880	218,033	1900-1924	1.58	94
1881-1890	301,040	1925-1947	0.74	44
1891-1900	444,923	1948-1963	0.17	10
1901-1910	374,298	1963-1968	0.0017	0.1
1911-1920	350,631			
1921-1930	243,467			
1931-1940	144,147			
1941-1950	214,512			
1951-1960	53,023			

Source: Arnold (1989, Table 1-2, p. 264-5). Figures in second column exclude Burma and princely states. They also exclude East Bengal for 1946-9 and include Pakistan for 1947-60. Figures in next fourth column: Figures for 1874-1947 refer to British India and 1948-1968 refer to India and Pakistan.

Cholera death rates however varied substantially across regions, with Bengal exhibiting the highest rates, followed by Central Provinces & Berar and the Madras Presidency and other areas and Punjab showing the lowest rates. Fig 3.3 and Table 3.2 show this in greater detail.

Figure 3.3: Cholera Death Rates in India: Regions, 1877-1939



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

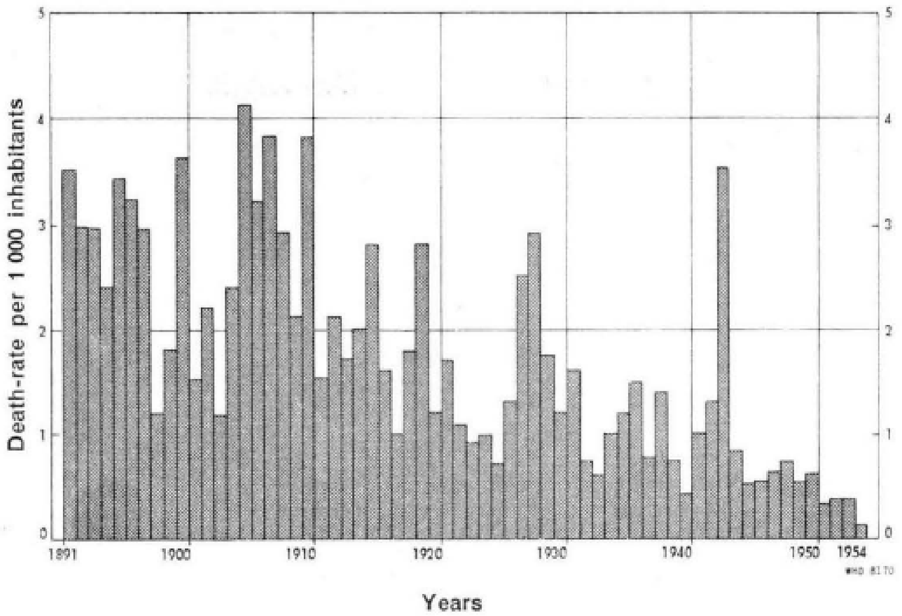
Table 3.2: Average Cholera Death Rates per 1,000, across regions, 1877-1939

Region	1877-1910	1911-1939	1877-1939
British India	1.8	1.0	1.4
Madras Presidency	1.9	0.9	1.4
Bombay Presidency	1.4	0.6	1.0
Punjab	0.3	0.2	0.3
United Provinces	1.4	0.9	1.2
Eastern India	2.5	1.6	2.1
Central Provinces & Berar	1.8	1.0	1.5
Burma	1.2	0.4	0.9

Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam. Data for Burma until 1934.

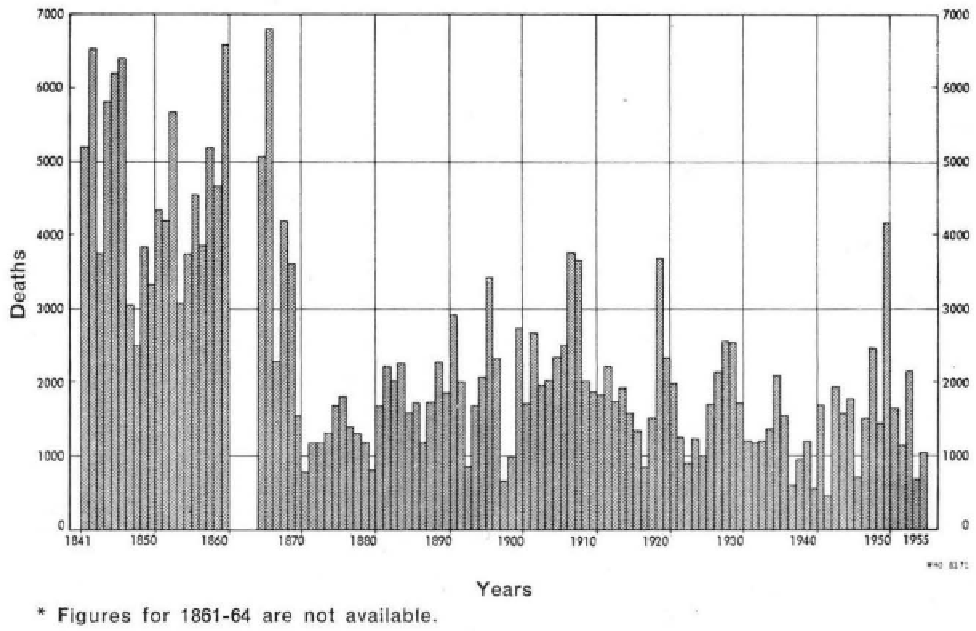
Cholera death rates were the highest in Bengal over the long run, reflecting the endemic character of the disease in that region. Fig 3.4 shows a gradual fall in death rate is observed in the 20th century, with one large spike in 1943 during the Bengal famine. Fig 3.5 shows a sharp fall in cholera deaths in Calcutta after the 1860s, as filtered water supply commenced from November 1869 (Klein 1973, p. 650).

Figure 3.4: Pollitzer's series on 'Annual Cholera Death-Rate in Bengal, 1891-1954'



Source: Pollitzer (1959, Fig 11, p. 89).

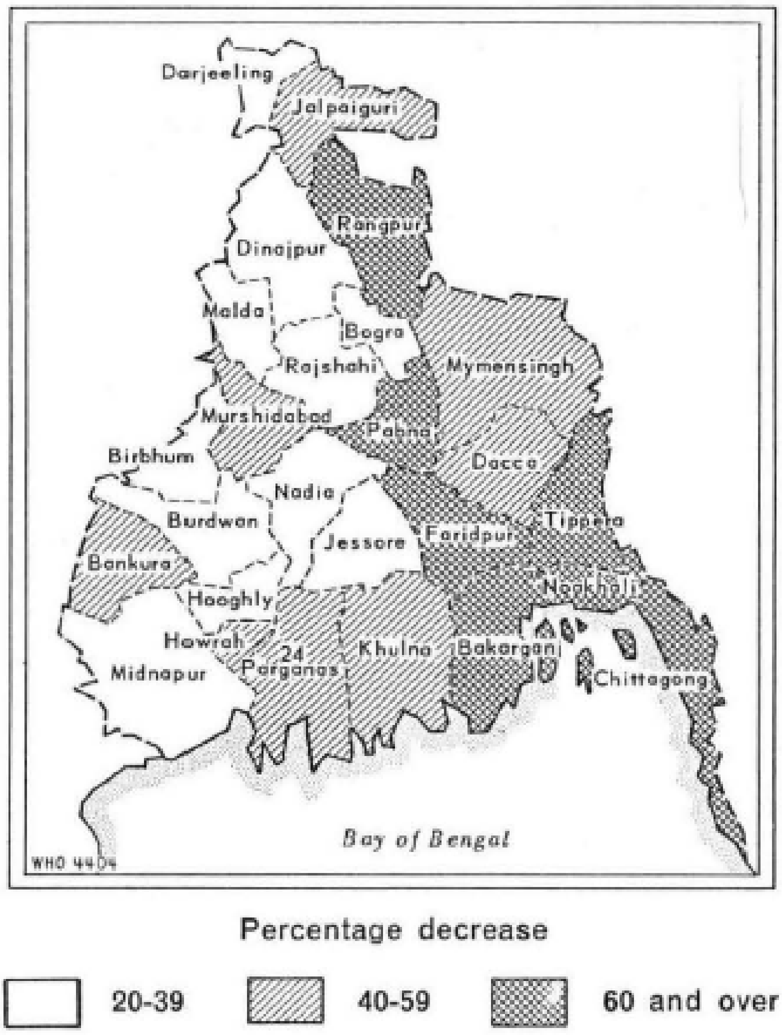
Figure 3.5: Pollitzer's series on 'Annual Cholera Deaths in Calcutta, 1841-1955'



Source: Pollitzer (1959, Fig 13, p. 94).

Fig 3.6 shows the fall in cholera death rates in Bengal in the early 20th century.

Figure 3.6: Pollitzer map on 'Percentage Decrease of Cholera Mortality From 1901-10 to 1934-43 in Bengal



Source: Pollitzer (1959, Fig 12, p. 90).

While cholera was higher in Bengal than most other parts of India, it also varied within, as shown in Table 3.3. The cholera outbreak of 1817 is considered to have started from Jessore, which continued to show relatively higher rates of cholera death rates in the early 20th century, whereas cholera was virtually absent in the hilly areas of Darjeeling.

Recent research shows that environmental factors do play a role in shaping the behaviour of *Cholerae Vibrio*, and thus the intensity of cholera outbreaks (Hamlin 2009).

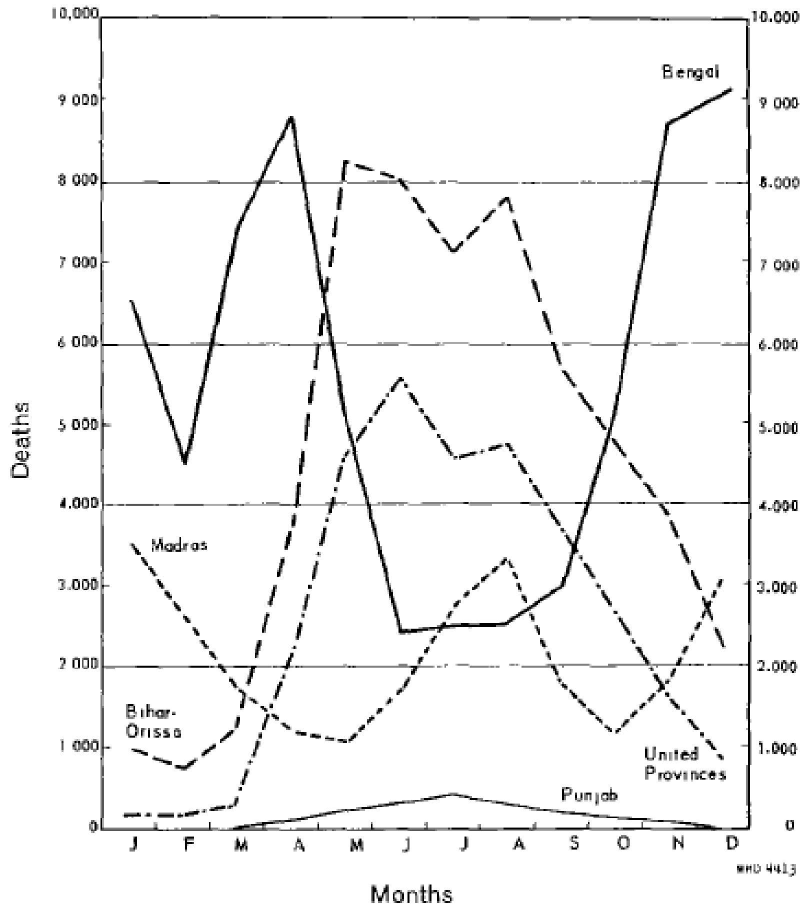
Table 3.3: Pollitzer series on 'Decrease in Cholera Mortality Rate from 1901-10 to 1934-43 by districts in Bengal'

Districts	Average death-rate per 1000 population		Percentage decrease from 1901-10 to 1934-43
	1901-10	1934-43	
Burdwan	2.65	0.86	67.5
Birbhum	2.89	0.94	67.5
Bankura	1.65	0.77	53.3
Midnapore	3.26	0.83	74.5
Hooghly	2.27	0.81	64.3
Howrah	4.14	1.71	58.7
24 Parganas	4.04	1.70	57.9
Calcutta	2.91	1.00	75.6
Nadia	3.61	1.22	66.2
Murshidabad	2.65	1.08	59.2
Jessore	3.17	1.23	61.2
Khulna	3.09	1.46	52.8
Rajshahi	3.28	0.80	75.6
Dinajpur	0.89	0.25	71.9
Jalpaiguri	0.95	0.49	48.4
Darjeeling	0.32	0.04	87.5
Rangpur	1.48	1.02	31.1
Bogra	2.43	0.66	72.8
Pabna	2.92	1.90	34.9
Malda	2.53	0.50	80.2
Dacca	2.96	1.64	44.6
Mymensingh	3.10	1.30	58.1
Faridpur	2.76	2.08	24.6
Bakarganj	3.47	2.51	27.7
Chittagong	1.54	1.23	20.1
Noakhali	2.63	1.73	34.2
Tippera	2.06	**1.53**	25.7
Bengal	2.73	1.27	53.5

Source: Pollitzer (1959, Table XV, p. 91).

Cholera mortality exhibited tremendous seasonality, which varied across regions, as shown in Fig. 3.7. In Bengal, deaths would start picking up in September, peak in December, fall in Jan-Feb, again rise in March-April, before declining to lows in August.

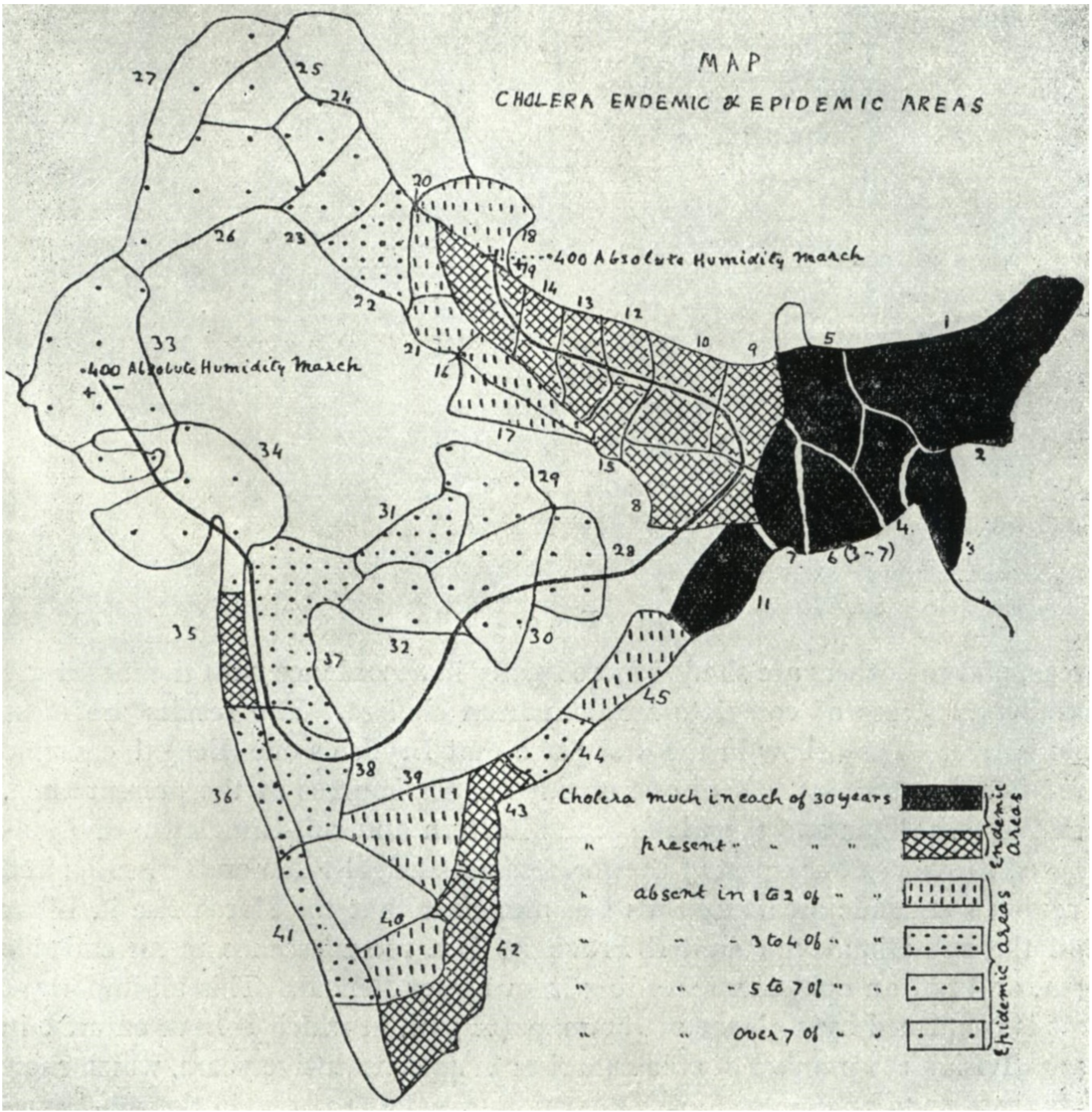
Figure 3.7: Pollitzer series on 'Mean Monthly Cholera Deaths for Five Indian Provinces, 1925-46'



Source: Pollitzer (1959, Fig 2, p. 55).

On the basis of cholera death occurrence, Leonard Rogers, credited with contributing to the intravenous treatment of cholera, created a map on endemic and epidemic areas of cholera, and related this with humidity levels arguing that cholera was suppressed by low absolute humidity. Fig 3.8 below reproduces this map. The data for princely states is absent and marked as vacant spaces on the map.

Figure 3.8: Rogers map on Cholera Endemic & Epidemic Areas in India



Source: Rogers (1927, Fig 8, p. 329).

A similar map was provided by R. Pollitzer, reproduced below in Fig 3.9.

Figure 3.9: Pollitzer's map on 'Cholera Endemicity Level in India and Pakistan, 1901-45'

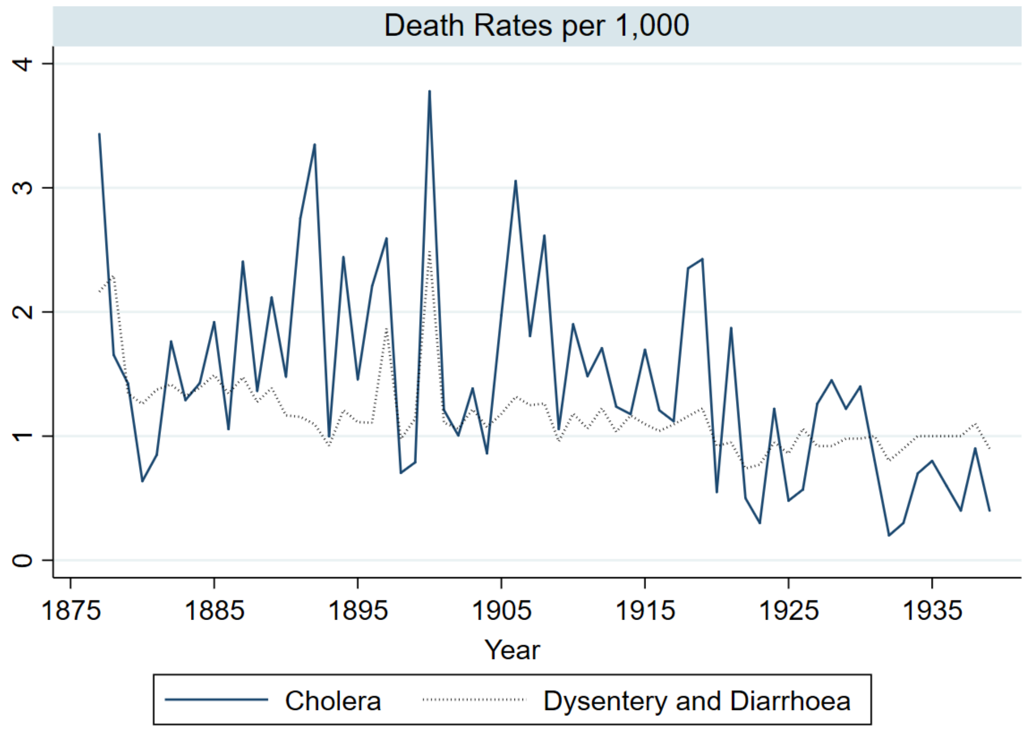
The endemicity level is shown in relation to the river system by the variation in the density of the dots. This level is expressed by the average annual cholera death-rate during the fifteen years of lowest incidence in the period 1901-45.

Source: Pollitzer (1959, Fig 1, p. 53).

The symptoms for cholera and dysentery & diarrhoea were similar and they could have been reporting errors between the two. Fig 3.10 shows that the death rates for the two series are somewhat correlated (Correlation Coefficient= +0.6) and track each other well in famine years in which case, both would spike up. This correlation was particularly strong for Bombay Presidency and Central Provinces and Berar and weak elsewhere.

While cholera death rates were usually higher, by the 1930s, this pattern had flipped.

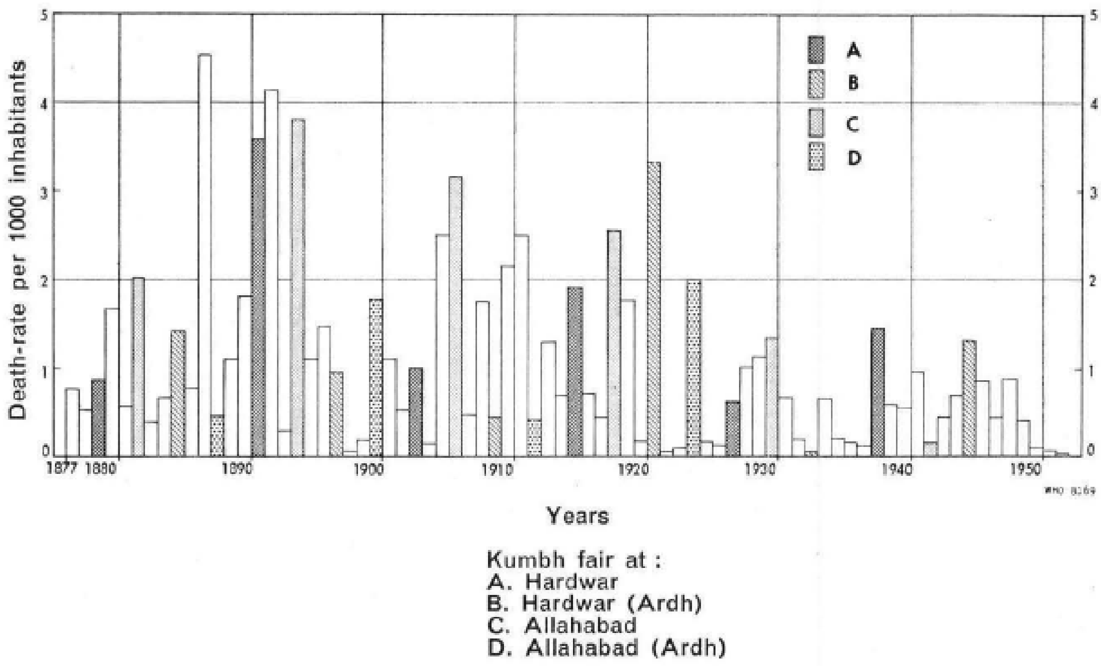
Figure 3.10: Cholera and Dysentery & Diarrhoea Death Rates in India, 1877-1939



Source: Statistical Abstracts of British India.

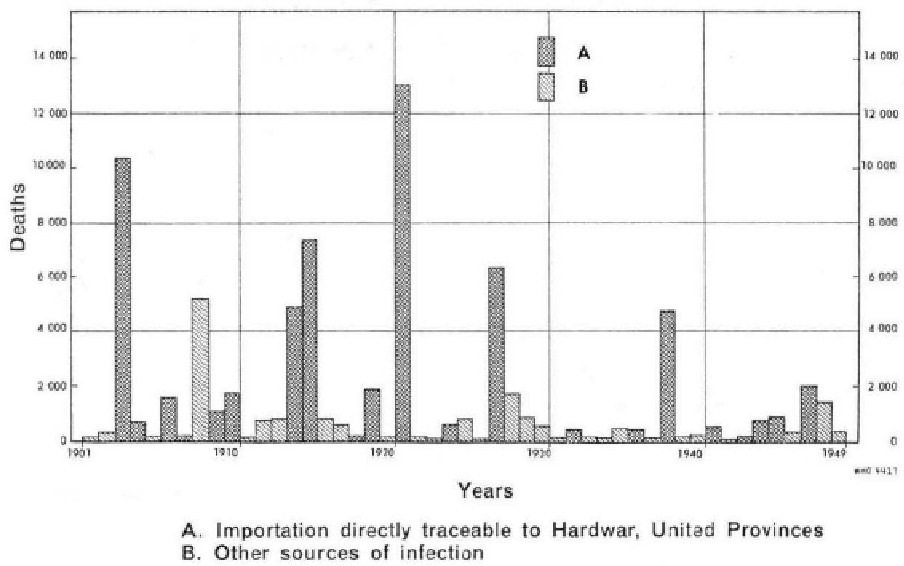
Military campaigns and pilgrimage routes were often identified as the key ways of cholera transmission in India. R. Pollitzer posited a close relationship with the Kumbh fairs that drew in millions, and cholera death, reproduced below in Figs 3.11 and 3.12.

Figure 3.11: Pollitzer series on 'Annual Cholera Death-Rate in the United Provinces and Influence of Kumbh Fairs, 1877-1952'



Source: Pollitzer (1959, Fig 7, p. 80).

Figure 3.12: Pollitzer series on 'Annual Cholera Deaths in the Punjab, 1901-49, and Sources of Infection'



Source: Pollitzer (1959, Fig 8, p. 81).

The Cholera Pandemic/s

Table 3.4 shows the dates of the cholera pandemics provided by different authors. Except for the most recent one which is said to have begun in Indonesia, most of the cholera pandemics are said to have originated in India, though this interpretation is now undergoing revision (Hamlin 2009). Recent research on cholera in Japan shows that it is likely that cholera became endemic there over time, and that each outbreak need not have been linked to India as was previously thought (Johnston 2019). This paper builds on this perspective to suggest that the traditional 'six' cholera pandemics from 1817 to the 1920s should be seen as being nested within one large cholera pandemic (Tumbe 2020).

Table 3.4: The 'Seven' Cholera Pandemic Periods as per Different Researchers

Pandemic No.	Reinhard Speck (1993)	Pollitzer (1959)	Sticker (1912)	Hirsch (1883)	Haeser (1882)
1	1817-1823	1817	1817-38	1817-23; 1826-37	1816-23; 1826-37
2	1827-1837	1829	1840-64	1846-63	1840-50
3	1839-1855	1852			1852-60
4	1863-1874	1863	1863-75	1865-75	1863-1873
5	1881-1896	1881	1881-96		
6	1899-1923	1899	1899-		
7	1961-				

Notes: The data for Sticker, Hirsch and Haeser, come from Pollitzer (1959, Table 1, p. 17).

The spread of the cholera pandemic is presented through a series of maps created by Leonard Rogers for different time periods, reproduced in Figs 3.13-3.19. These maps however do not show the spread to the Americas, Africa and East Asia.

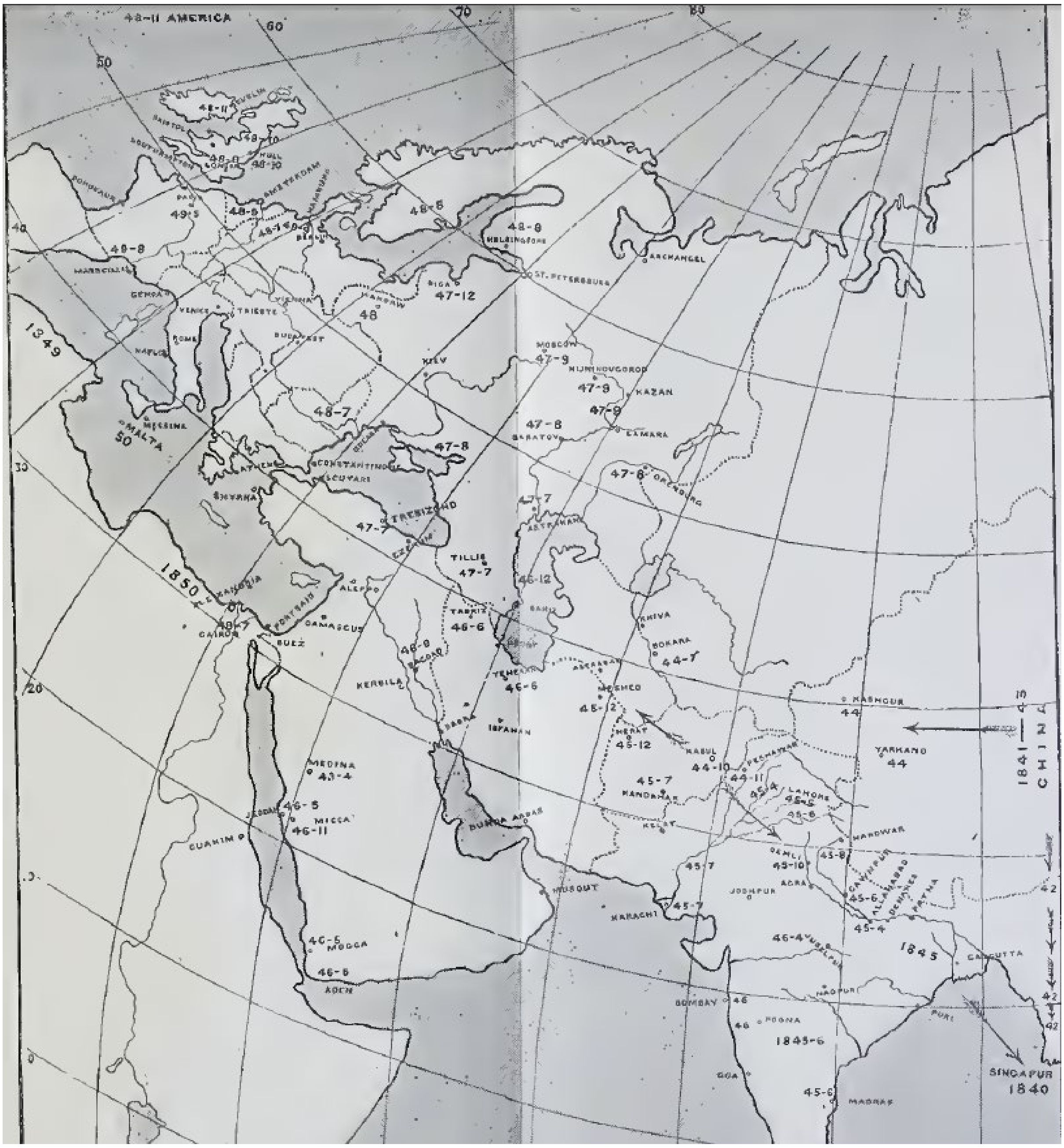
Figure 3.13: Rogers Map on Cholera Spread in India, 1817-19

Source: Rogers (1927, Fig. 1, p. 323).

Figure 3.14: Rogers Map on 1826-37 'Epidemic in India, Afghanistan, Persia, Europe and America'

Source: Rogers (1911, Map1).

Figure 3.15: Rogers Map on 1840-9 'Epidemic in India, China, Europe and America'



Source: Rogers (1911, Map 2).

Figure 3.16: Rogers Map on 1848-53 'Epidemic in India, Persian Gulf, Europe and America'

Source: Rogers (1911, Map 3).

Figure 3.17: Rogers Map on 1863-6 'Epidemic in India, Arabia, Egypt, Europe and America, as well to Africa in 1868-9'

Source: Rogers (1911, Map 4).

Figure 3.18: Rogers Map on 1866-70 'Epidemic in India, Afghanistan, Persia and Europe'

Source: Rogers (1911, Map 5).

Figure 3.19: Rogers Map on 1892-94 'Epidemic in India, Afghanistan, Persia and Europe'

Source: Rogers (1911, Map 6).

Table 3.5 presents conservative estimates of deaths in the cholera pandemic around the world between 1817 and 1920, with detailed notes presented below it. A key difficulty in arriving at a global total is the treatment of cholera deaths in India, where the disease was mostly endemic. Accordingly, we provide estimates for India as endemic (31 million) and epidemic (8 million) deaths and consider only the epidemic deaths for the global total on cholera pandemics. India comprised around 40% of cholera pandemic deaths, and around 80% of all cholera-related deaths between 1817-1920, when overall, around 50 million died to due cholera. The cholera pandemic between 1817 and 1920, claimed around 20 million lives, 8 million in India alone and over 11 million elsewhere. Russia was hit substantially with millions of lives lost due to cholera. Egypt perhaps suffered the most due to cholera, as a share of its population.

Table 3.5: Estimates of Cholera Pandemic Deaths (1817-1920) Worldwide

Region		Deaths, Millions	% of World Total	Population in 1870 (Millions)	Deaths/ Population in 1870, %
Asia		11.5	61	765	1.5
	India (Epidemic)	8.0	42	253	3.2
	China	1.0	5	358	0.3
	Japan	0.4	2	34	1.2
	Thailand	0.4	2		
	Burma	0.4	2		
	Philippines	0.3	2		
	Rest of Asia	1.0	5		
Europe		5.8	30	328	1.8
	Russia	3.0	16	88	3.4
	Spain	0.6	3	16	3.8
	Hungary	0.5	3		
	France	0.3	2	38	0.8
	Germany	0.2	1	39	0.5
	UK	0.15	1	31	0.5
	Rest of Europe	1.0	5		
Africa		1.0	5	90	1.1
	Egypt	0.6	3	6	10.0
	Rest of Africa	0.4	2		
North America		0.2	1	40	0.5
South America		0.5	3	40	1.3
Oceania		-			
World Total		**19.0**	**100**	**1272**	**1.5**
World ex-India		11.0		1019	1.1
India (Endemic 31m + Epidemic 8m)		39.0		253	15.4
World*= World Total+ Endemic India (31m)		50.0		1272	3.9
India (Endemic + Epidemic) as % of World*			78		

Notes to Table 3.5

The mortality figures are taken from a wide range of sources on the history of cholera in the 19th century, but primarily from Pollitzer (1959, Ch. 1 & 2)'s textual description. Where two estimates exist for the same event, the lower number has been taken. Thus, the estimates presented in Table 3.5 are lower-bounds.

Population figures for 1870 are taken from Maddison (2007, Table A1, p. 376), except for Egypt, which is from McCarthy (1976, Table 20, p. 20).

Cholera mortality for a few specific regions which had large mortality and are thus critical for the 'world total', are derived as follows:

<u>India</u>

Total Registered Deaths due to cholera in British India (ex-Burma) from 1877-1920 amounted to 16.5 million (Various Statistical Abstracts of British India).

Based on a close reading of the time series for 1877-1920, it was observed that about 300,000 deaths occurred on average, every year, even when there was no epidemic reported in the non-endemic regions such as Punjab. Such endemic deaths would have been lower between 1817-1877 as the population base of India was smaller. On the other hand, the reported deaths exclude the princely states of India and suffered from under-registration. Taken together, we estimate 300,000*104= 31 Million as the figure for endemic cholera-related deaths in the Indian subcontinent for the period 1817-1920.

To find out the epidemic component, we again analyse the 1877-1920 series and find that of the 16.5 million reported deaths, endemic deaths (assuming 300,000 deaths per annum) totalled 13.2 million and the balance of 3.3 million could be considered as epidemic. This was 25% per cent of all endemic cholera deaths. Applying this percentage on the 31 million figure for 1817-1920, gives a figure close to 8 million.

The total number of cholera deaths for the Indian subcontinent for 1817-1920 is thus estimated to be 31+8 or 39 million.

<u>Burma</u>

There were over 230,000 reported cholera deaths in Burma between 1877-1920 (Statistical Abstracts of British India), or on average around 5,000 a year. This figure is extrapolated to around 0.4 million for the period 1817-1920, which would imply an annual average of close to 4,000 deaths a year.

<u>China</u>

Based on various descriptions provided by Pollitzer (1959), the one million figure is a lower-bound estimate, implying annual deaths of around 10,000 between 1817-1920.

<u>Japan</u>

According to Johnston (2019), the cholera mortality rate was 22 per 100,000 between 1877 and 1920, which when applied to its 1870 population, yields annual deaths of around 7,500 people. Using this rate for 44 years between 1877-1920, yields a figure of 0.33 million cholera deaths, and 0.78 million for 1817-1920. Cholera was noted in Japan in epidemic form in 1832, 1858-60 and then in 1877, 1879, 1882, 1886, 1890, 1891 and 1895. Between, 0.33 and 0.78, a figure of 0.4 million is taken to be the death toll for 1817-1920, considering fewer attacks before 1877.

<u>Egypt</u>

The total cholera epidemic deaths for 1831, 1850, 1855, 1865, 1883, 1896 and 1902, provided by McCarthy (1976, Table 5, p. 8), aggregate to 0.56 million. Cholera was noted in other years as well. The figure for Egypt for 1817-1920 is estimated to be 0.6 million.

<u>Rest of Africa</u>

Cholera affected mainly northern Africa and east Africa during the various outbreaks. The fourth pandemic was the worst for Africa. In East Africa, it has been estimated that hundreds of thousands died around the years 1869-70, with Zanzibar particularly hard hit (Echenberg, p. 58). Tunisia lost around 80,000 lives in the outbreaks before 1867 (Echenberg, p. 65).

<u>Spain</u>

The figure of 0.6 million in 'four great invasions' is taken from Cooper (1986, p. 467), which in turn cites this figure from the work of E. A. Cardenas in 1971.

<u>Russia</u>

Pollitzer (1959, p. 42 and 60) provides cholera cases and deaths data for Russia for key epidemic years between 1823 and 1926. The total cases for the 1823-1920 period were 5.3 million. Where data on cases and deaths were reported, the case fatality ratio was on average half. Thus, cholera deaths for Russia for 1817-1920 are taken to be around 3 million.

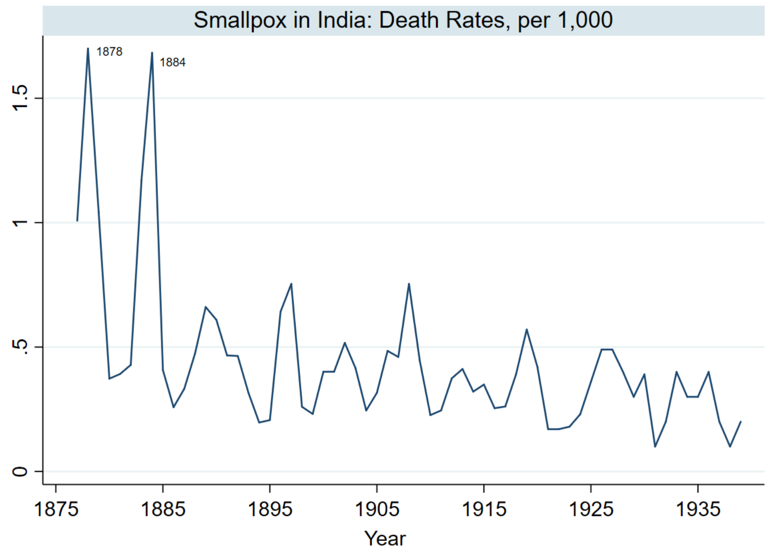
<u>South America</u>

The figure for Brazil for 1855-56 has been previously estimated to be 200,000 (Cooper, 1986, p. 468). The figure for the Caribbean islands has been placed at 200,000 (Kiple, 1985, p. 177). In most parts of South America, cholera lasted for only brief periods (Llopis & Halbrohr, 1991). A figure of 0.5 million is conservatively taken for cholera deaths in South America.

4. Smallpox

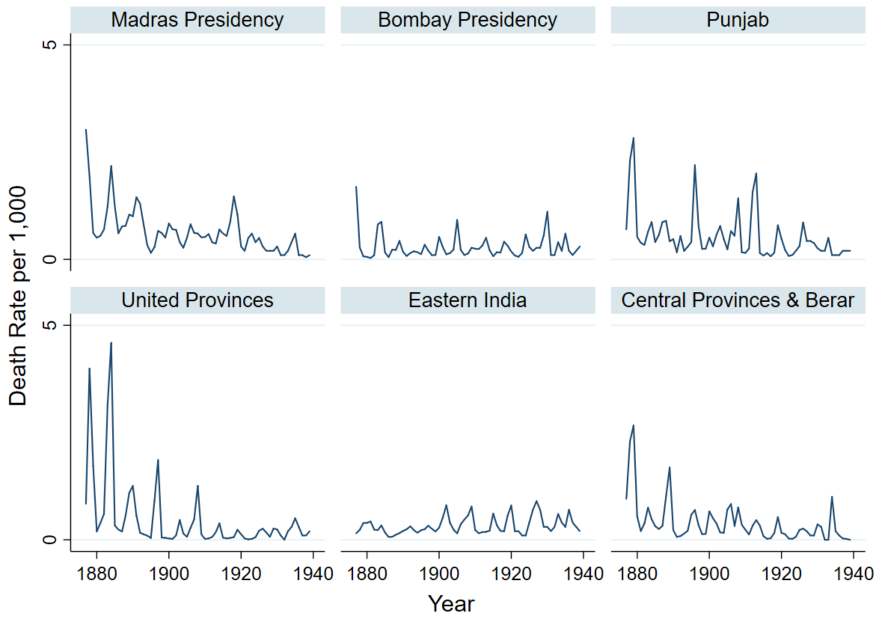
Smallpox was a deadly disease caused by the virus- *Variola Major* or *Variola Minor*- that caused a lot of suffering, especially through the blisters that developed on the body. It was one of the first diseases which invited targeted vaccination drives since the 19th century that played an important role in bringing about immunity against the disease. Figs. 4.1 and 4.2 show that smallpox related mortality was low and steadily declined in India since the 1890s. It was successfully eradicated in the late 20th century. The 'Miscellaneous' section of the bibliography lists several historical studies on smallpox in India.

Figure 4.1: Smallpox Death Rates in India, 1877-1939



Source: Statistical Abstracts of British India.

Figure 4.2: Smallpox Death Rates in India: Regions, 1877-1939



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

5. Plague

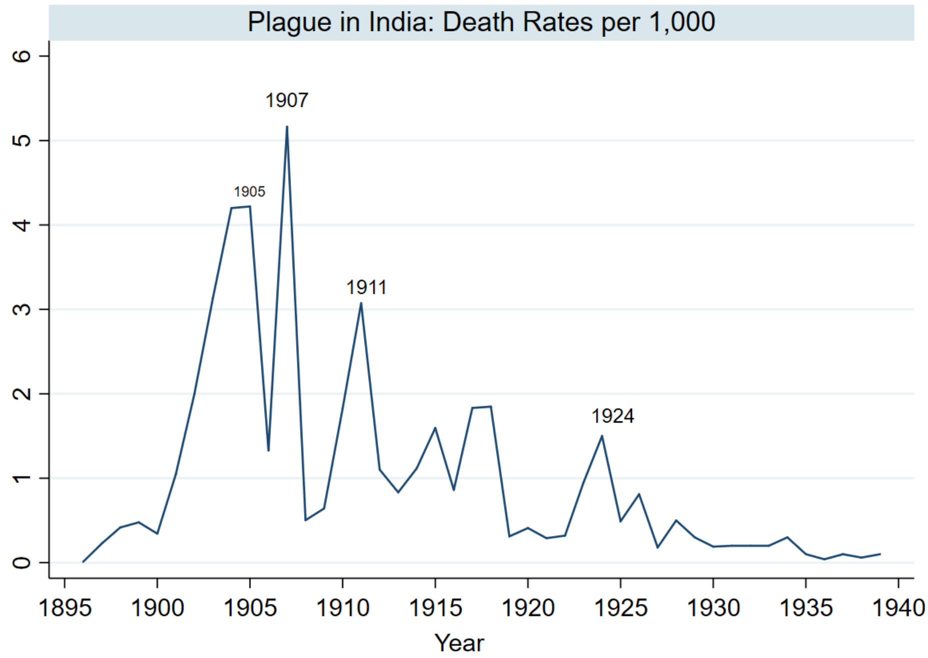
Plague has had a long history in India, observed in different centuries, especially in connection with the unusual mortality of rats that preceded human mortality and the *bubo* or lump that appeared on plague-stricken bodies (Simpson 1905). It struck Bombay in 1896 as part of the third plague pandemic recorded by historians over the past two millenniums, and then onwards, it took root in various parts of India, declining only after the mid-1920s (Pollitzer 1954, Klein 1988, Arnold 1993, Catanach 2001, Dyson 2018). The most likely source is attributed to ships arriving from Hong Kong, which was affected since 1894.

The transmission of plague, long a mystery, was finally decoded around 1905 when it was shown that the plague bacillus *Yersinia pestis* (discovered in 1894) was transmitted to humans from rats via the bites of rat fleas. Other transmission mechanisms have also been proposed including airborne transmission through cough droplets in the case of pneumonic plague.

Figure 5.1 and Table 5.1 shows that the biggest impact in India occurred in the first decade of the 20th century, with plague-death rates peaking at over 5 per 1,000 in 1907. It steadily declined since 1911, rising once again in the early 1920s, before steadily slipping away. By 1960s, the annual case count was less than a thousand, and barring the Surat plague scare of 1994, it stands as being virtually eradicated in India. The greater immunity of rodents to plague is seen as one of the reasons why this happened, along with better plague prevention measures. The development of antibiotics also made plague a curable disease.

Plague prevention measures evolved over time and included measures such as the following: Disinfection, Evacuation, Inoculation, Medical Relief, Public Education, Rat Proofing, Rat Extermination and Improvements in sanitation.

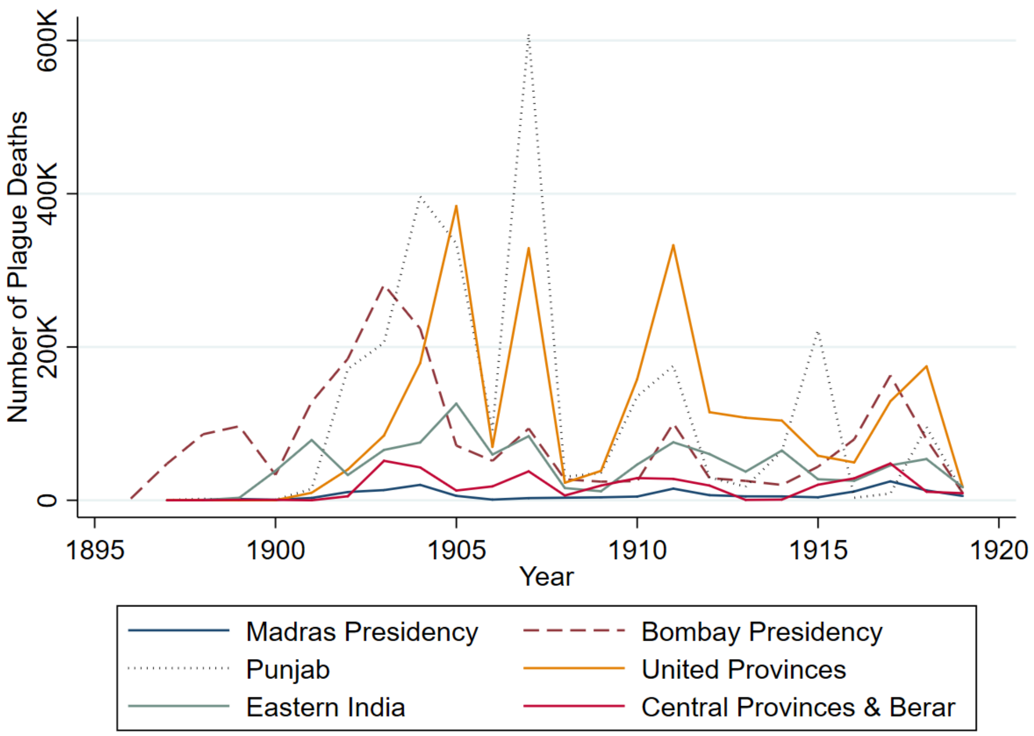
Figure 5.1: Plague Death Rates in India, 1896-1939



Source: Statistical Abstracts of British India.

As Figure 5.2 shows, between 1896 and 1900, plague was confined almost entirely in the Bombay Presidency with annual deaths usually less than 100,000. Between 1900 and 1907, it steadily rose across India, especially in Punjab and United Provinces in north India, peaking overall in 1907, with over a million deaths at the All-India level. Plague deaths rose in the Bombay Presidency till 1903, after which it started declining. Since 1907, plague deaths at the All-India level exhibited a downward trend with a brief uptick in 1911 and a few other years.

Figure 5.2: Plague Deaths in India: Regions, 1896-1919



Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam. K=Thousand.

Table 5.1 displays the research of S. C. Seal, and it shows that between 1898 and 1968, plague claimed over 13 million lives in India, the actual number being much higher due to under-registration, especially in the high-outbreak years. These figures include the numbers for the major princely states as well. The number of deaths between 1896 and 1898 was less than 100,00. The Census of India in 1901 and 1911 mentioned that the actual number of plague deaths was higher by at least 35% and that the reporting system would break down during when the epidemic was raging (GoI 1955, 283-284). Using a conservative scaling factor of 1.2, assuming that registration improved over time, the 13.3 million figure in Table 5.1 would be raised to 16 million people. That is, around 16 million people died in the Indian subcontinent, between 1896 and 1968. At the peak of the plague pandemic, between 1896 and 1918, around 10.3 million people were registered to have died due to plague, or over 12 million, again using a scaling factor of 1.2.

Table 5.1: Plague Deaths in India, 1898-1968

	Total Deaths	Total population in each period	Specific Mortality rate/10,000	Plague as % of total deaths 1898-1968	Average Annual % of Total Deaths
1898-1908	6,032,693	329,191,600	183.3	47.47	4.32
1909-1918	4,221,529	315,592,638	133.8	33.22	2.32
1919-1928	1,762,718	328,319,580	51.9	13.4	1.34
1929-1938	422,880	361,945,872	11.7	3.33	0.33
1939-1948	268,596	396,592,490	6.8	2.11	0.21
1949-1958	590,059	328,764,907	1.8	0.46	0.55
1959-1968	942	468,364,958	0.2	0.0001	0.01
Total	13,299,417				

Source: Seal (1987), Table 1, p. 11. Pakistan excluded after 1948.

Table 5.2 shows that over 70% of plague related mortality occurred in three provinces – Punjab, Bombay Presidency and United Provinces. Mysore state was also considerably affected in terms of mortality rates. The last column, using the scaling factor of 1.2 shows that around 15 million people died due to plague between 1898 and 1932.

Table 5.2: Plague Deaths in India (including Burma), July 1898- June 1932

Sr. No.	**Province**	**Mean Population Census**	**Total Plague Deaths**	**% of All-India Total**	**Mortality/1000 of mean population**	**Total Plague Deaths (Corrected using scaling factor of 1.2)**
1	Punjab	21,142,793	34,89,123	28.7	165.0	4,186,948
2	Bombay	19,877,756	24,60,132	20.2	123.8	2,952,158
3	United Provinces	47,164,594	29,11,837	23.9	61.7	3,494,204
4	Bihar and Orissa	34,692,676	11,13,937	9.2	32.1	1,336,724
5	Central Provinces	13,991,863	4,68,165	3.8	33.5	561,798
6	Hyderabad	12,855,934	4,25,302	3.5	33.0	510,362
7	Mysore	5,970,446	3,14,673	2.6	52.7	377,608
8	Rajputana	10,330,957	2,82,312	2.3	27.8	338,774
9	Madras	42,168,483	2,27,184	1.9	5.4	272,621
10	Central India Agency	7,653,893	1,49,941	1.2	19.6	179,929
11	Burma	5,970,446	1,49,427	1.2	25.0	179,312
12	Other areas	38,477,465	1,09,597	0.9	2.8	131,516
13	Bengal	46,109,157	68,809	0.6	1.5	82,571
	Total	**306,406,463**	**12,170,439**	**100.0**		**14,604,527**

Source: Seal (1987), Table 3, p. 15, for the first six columns. See in-text discussion on the choice of the scaling factor to correct for under-registration.

Hirst (1953) had provided a global distribution of plague deaths, for which, the data on India relied on registered deaths. The figure of 12.5 million for India accords well with the data shown in Table 5.1, for the period 1896-1938. Using a scaling factor of 1.2, this translates to around 15 million deaths in the Indian subcontinent in this period. Accordingly, using the same distribution for other regions provided for Hirst (and providing a separate entry for Burma), the global plague mortality count for this period, 1894-1938, is likely to be upwards of 15 million.

India was the worst affected country in the plague pandemic, accounting for over 95% of the total lives lost, as seen in Table 5.3. Plague also affected China and Taiwan and Indonesia in a major way and to a lesser extent port cities across continents.

As per the World Health Organization (WHO), Madagascar continues to witness plague outbreaks in the 21st century.

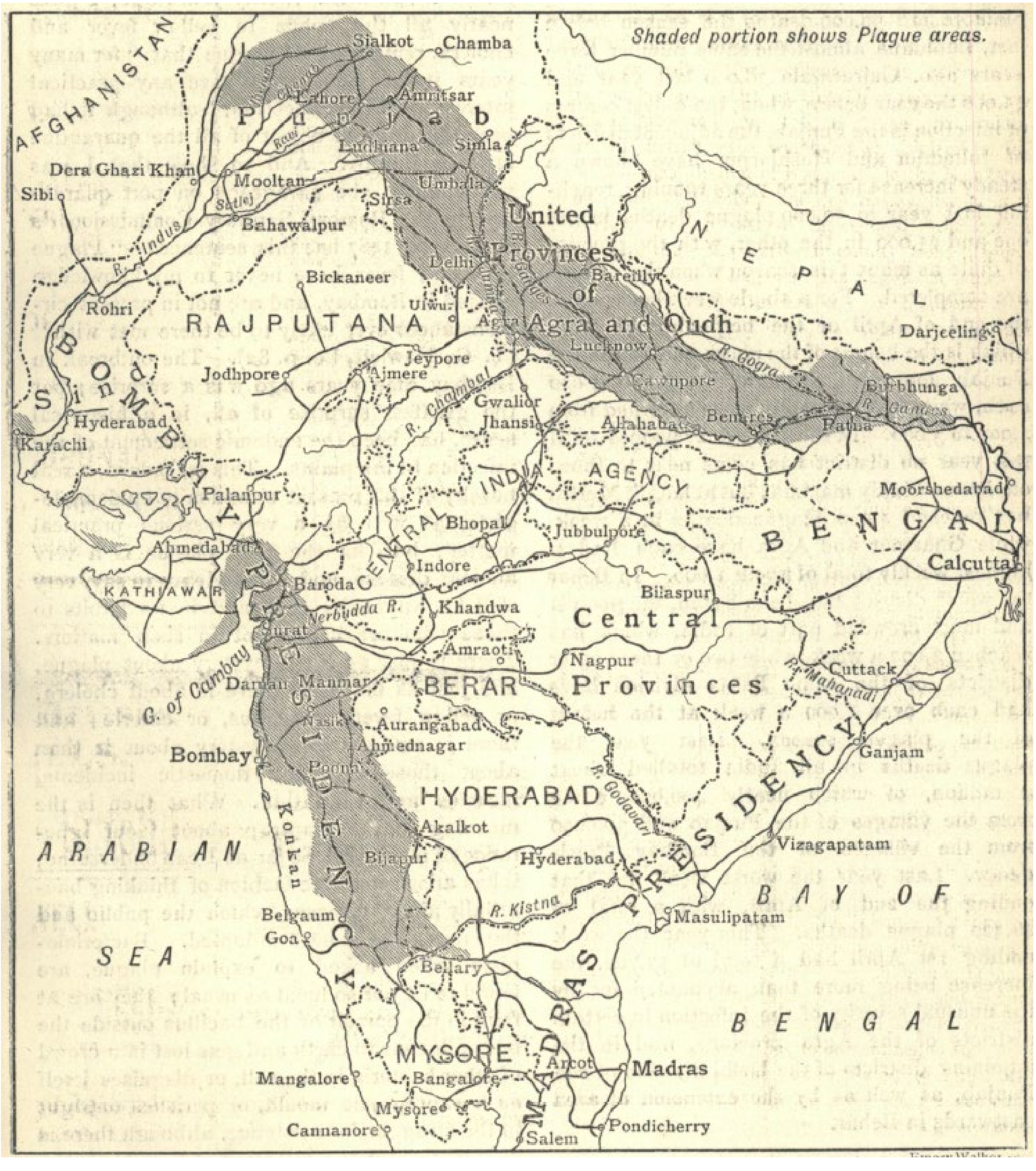
Table 5.3: Plague Deaths in the World, 1894-1938

Region	**Hirst (1953)**	**With India Correction**
India	12,500,000	14,800,000
Burma		200,000
China and Taiwan	250,000	250,000
Indonesia	214,000	214,000
Madagascar	32,000	32,000
Africa	120,000	120,000
North America	1,000	1,000
South America	24,000	24,000
Europe	1,000	1,000
Rest of World	10,000	10,000
Total	13,152,000	15,652,000
Deaths in India as a share of world total, %	95	96

Source: Hirst (1953), p. 300; See in-text discussion on the correction for the Indian number.

The regional impact of plague in India was highly uneven. In 1905, Dr. Creighton presented a map on major plague areas of India, reproduced here as Figure 5.3, which provides an essence of the distribution in its formative years. Later, plague also hit Mysore and Hyderabad to some effect.

Figure 5.3: Creighton's 'Map of India showing Plague areas', 1905

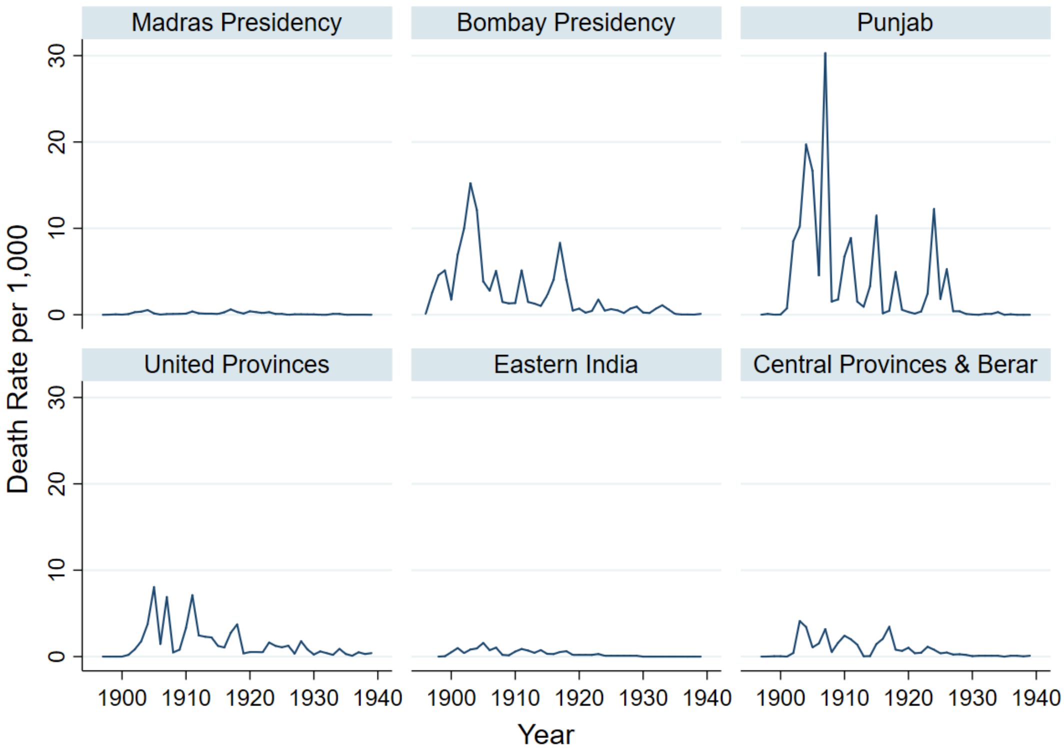


Source: Creighton (1905), Fig. 1, p. 811.

As Figure 5.3, Table 5.2 and Figure 5.3 below show, plague in India primarily affected Punjab, United Provinces and the Bombay Presidency and to a lesser extent, also the princely states of Hyderabad and Mysore. One reason why South India and Eastern India may have escaped high mortality is the relative absence of the *X. cheopis* variety of rat flea that is an efficient vector of plague transmission (Seal 1987). Other arguments on regional variation include sanitation and housing patterns, in particular compact fortified villages and those houses made of mud, being more susceptible to attracting plague (Creighton 1905).

Plague in India also killed most people in rural areas, and in north India, it was observed that young adult women and men were more likely to be attacked by plague (GoI 1955, p. 284).

Figure 5.3: Plague Death Rates in India: Regions, 1896-1939

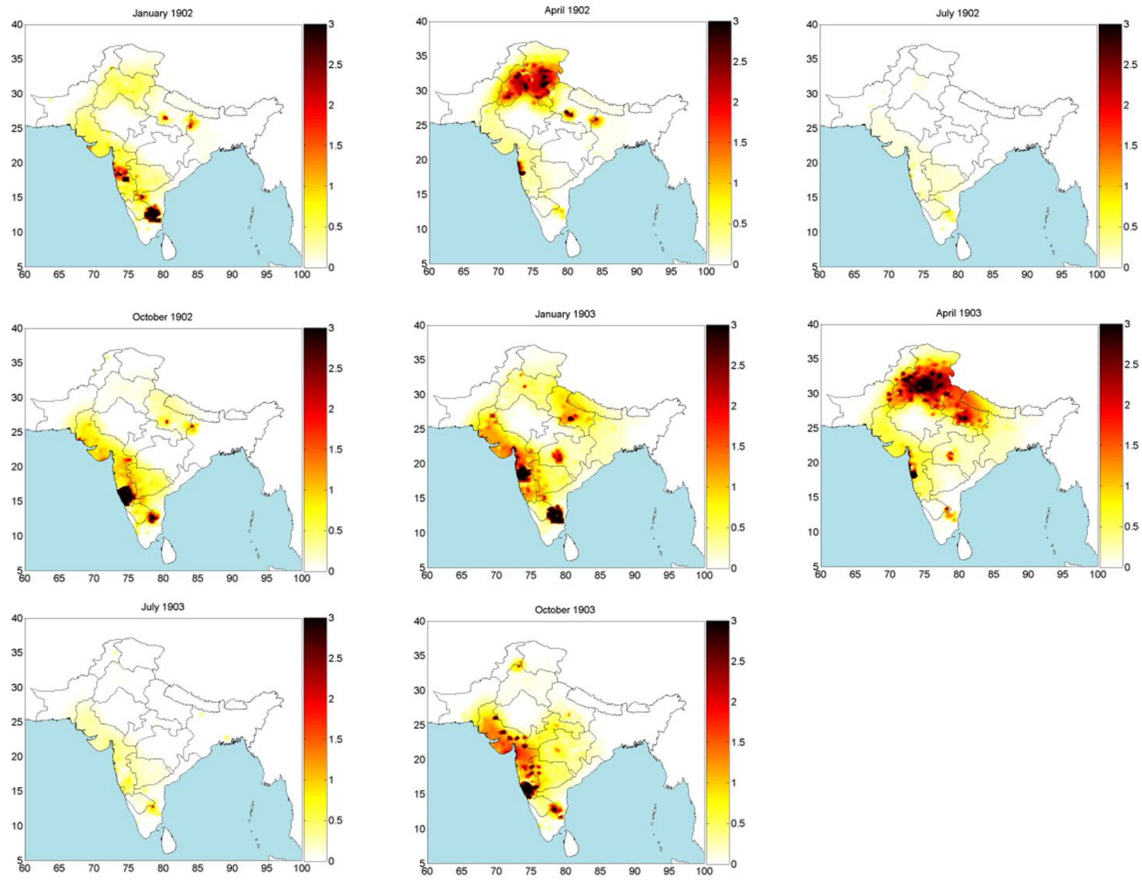


Source: Statistical Abstracts of British India. Eastern India refers to Bengal, Bihar & Orissa and Assam.

Yu and Christakos (2006) mapped the outbreak of plague in India between Sep 1896 to Oct 1906. The study shows that plague in India witnessed high levels of seasonality, typically peaking in the first half of the year, almost disappearing during the monsoon, only to return again later in the year. The cycles were a little different across the major regions. According to Seal (1987), the rat flea's potency as a transmission mechanism for plague would die out due to higher humidity, thus explaining the seasonality.

Figure 5.4, the seasonality map, shows plague disappearing virtually everywhere by July and peaking in the non-monsoon periods in different places at different times.

Figure 5.4: Yu & Christakos (2006)- 'Space-time mortality rate maps, 1902-1903'



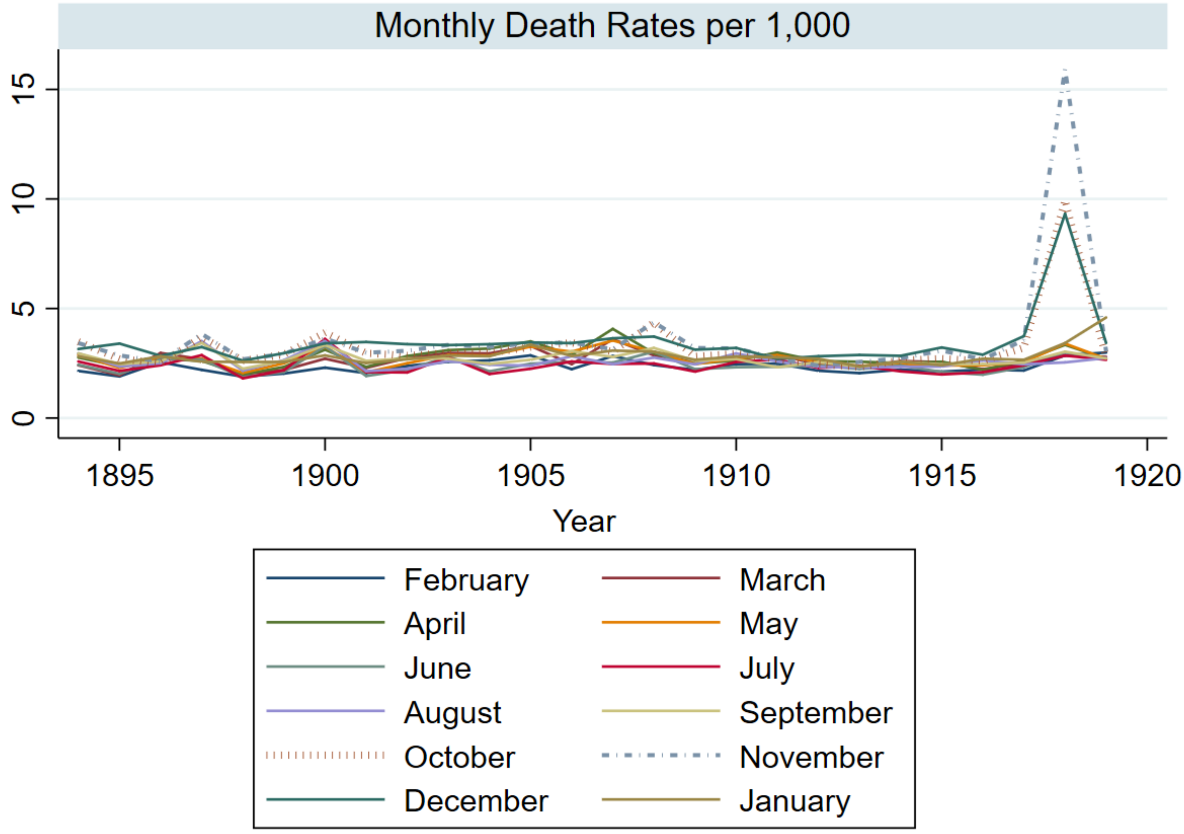
Source: Yu and Christakos (2006), Fig. 2, p. 3.

6. Influenza

All death registration statistics of influenza are likely to be substantial underestimates of true mortality since the health-recording systems were overwhelmed by the pandemic (White 1919), even as the statistics may be useful to understand broad trends.

The influenza pandemic struck India in 1918 in two clear waves, first mildly appearing in May-June for a few months and then again striking fiercely from September through December, peaking in October in Bombay Presidency but in November, at the All-India level.

Figure 6.1: Monthly Death Rates in India, 1894-1919

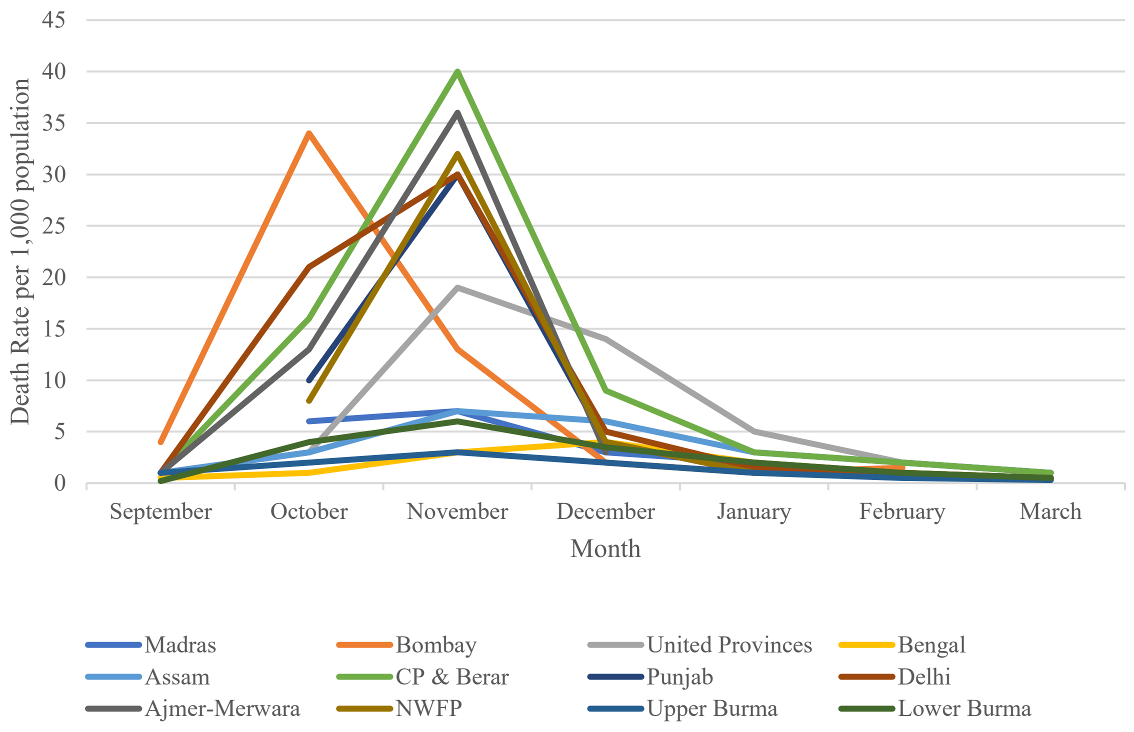


Source: Statistical Abstracts of British India.

As Figure 6.2 shows, regional registered mortality rates varied substantially across India, with highest severity in West, Central and North India and low rates in East and South India. Influenza was mostly registered under the 'Fevers' section in the cause of deaths.

Weekly death rate data at regional levels was mapped and analysed by Reyes et. al. (2018), which also shows the evolution of pandemic mortality across the Indian subcontinent.

Figure 6.2: "Monthly Excess Mortality due to Fevers and Respiratory Diseases: Major Areas of British Rule, Sep 1918-Mar 1919" as per I. D. Mills.



Source: Mills (1986), p. 8-9.

Mills (1986) had used regional epidemic data of prisons to show that while infection rates were broadly uniform, it was the case-mortality rates of influenza that were substantially different across the country. He argued that the diurnal temperature range was positively associated with influenza pandemic mortality in India. However, in a cross-country study, Murray et. al. (2006) found no correlation between latitude (as a potential proxy for temperature) and influenza mortality, and a strong correlation between per capita income and influenza mortality.

Table 6.1 presents provincial statistics on selected indicators and estimates of excess mortality attributed to influenza by Mills (1986) and Murray et. al. (2006). Both their estimates are similar in magnitude and variation. However, since registered death data was not systematically collected for princely states, most studies so far have tended to ignore those regions. As the table shows, the annual population growth rates between 1911 and 1921 were acutely negative for the large princely states of Hyderabad and Rajputana in central and western India respectively. This suggests that these regions may have suffered even more than the Central Provinces, which registered the highest mortality rate.

In the small sample of provinces, annual population growth rates for 1911-1921 display a negative correlation with excess mortality due to influenza with a correlation coefficient of about -0.5. Population growth rates in that decade were strongly negatively correlated with rainfall JJAS (June-July-August-September) Z-scores (standard normal distribution) for the year 1918, with a coefficient of -0.7 and with rice-price inflation in 1917-18 at -0.6.

Rainfall scores were negatively correlated with excess mortality measures (with or without Burma) at about -0.4 to -0.5. A separate study had indicated the inverse relationship between the level of rainfall and disease burden of influenza in India in 1918 (Reyes et. al. 2018).

Rice price inflation for 1917-18 exhibited the strongest correlation with the excess mortality measures (at -0.8) and annual population growth rates (at -0.6), with or without Burma.

These correlations tentatively suggest that while the rainfall shock of 1918 (third worst drought year on record after 1877 and 1899, See Figure 7.1) did matter, food price inflation (as proxied here by rice prices) also could have mattered for influenza mortality. That food prices were a major concern that year, leading to riots is borne out by one research study (Arnold 1979). And while the rainfall shock did contribute to the sudden upsurge in rice prices, it was not necessarily uniform as grain markets stumbled that year due to war-induced changes in transportation lines.

Since many parts of North India consumes more wheat than rice in daily diets, it should be pointed out that wheat price inflation was even more severe than rice price inflation, jumping from around 4% in 1917 to 31% in 1918 (Statistical Abstracts of British India). Rice price inflation at an All-India level, jumped up from near-zero in the years preceding 1918 to 13% in 1918, with wide variations as shown in Table 6.1.

A possible relationship between food prices and mortality has been noted before in the context of the Madras Presidency in south India for the early twentieth century (Gopinath 2010, p. 94) and is explored in further detail in a later section.

Literacy rates were more negatively correlated with excess mortality measures (at about -0.5 to -0.6) than urbanization, suggesting a potential role for developmental variables in the cross-regional variation of influenza mortality, as suggested in a cross-country study (Murray et. al. 2006) and as we document further in the a later section using district level data.

Finally, the spike in deaths in October and November in all-cause mortality did witness a minor increase in cholera (often a sign of famines in India), but was mostly registered in the catch-all category called 'fevers'. As Figure 6.1 shows, the last time such a spike took place in October and November, though of considerably lower magnitude, was in 1908, a year widely known for the malaria epidemic in North India. Afkhami (2003) has pointed out a possible link between chronic malarial sites, anaemia and high influenza mortality in Iran, and that death rates among Indians stationed in British troops there was very large in 1918. A similar possibility for India cannot be ruled out.

Humidity or dryness has been considered as a possible factor for the *transmission* of influenza, but evidence of effects on mortality is limited.

Table 6.1: Selected Regional Statistics, 1911-1921

	Population, 1911	Population, 1921	Annual Population Growth Rate, 1911-21, %	Mills (1986), Influenza Excess Mortality	Mills (1986) Influenza Excess Mortality, %	Murray et. al. (2006) Influenza Excess Mortality, %	Annual Rice Price Growth, 1917-18 %	June-Sep Rainfall Z Score, 1918	Literacy, 1911, %	Urbanization, 1911, %
India	315,156,396	318,942,480	0.12			4.39	12.77	-1.2	5.9	9.4
Madras	41,405,404	42,318,985	0.22	630,370	1.90	2.59	16.71	-2	13.8	11.8
Bombay	19,672,642	19,348,219	-0.17	1,062,852	5.55	6.18	28.46	-2.9	12.1	19.0
Punjab and Delhi	19,974,956	21,173,212	0.58	889,900	4.50	4.57	25.68	-1.4	6.5	11.1
United Provinces	47,182,044	45,375,787	-0.39	2,211,737	4.50	7.09	21.27	-2	6.1	10.2
Bengal	45,483,077	46,695,536	0.26	540,195	1.20	2.33	-12.29	0.2	14.0	6.5
Central Province & Berar	13,916,308	13,912,760	0.00	941,076	7.20	7.82	25.48	-1.3	6.8	8.5
Bihar and Orissa	34,490,084	34,002,189	-0.14	743,995	3.40	3.60	7.34	0.2	8.0	3.7
Assam	6,713,635	7,606,230	1.26	158,087	2.30		-17.08	2.4	8.8	2.0
Coorg	174,976	163,838	-0.66	123		3.44		-2.4	15.7	5.7
Mysore	5,806,193	5,978,892	0.29					-2.4	11.2	11.3
Ajmer Merwara	501,395	495,271	-0.12	26,572	5.30			-2.2	12.4	28.0
North West Frontier Pr.	2,196,933	2,251,340	0.24	90672	4.50				5.7	13.3
Hyderabad	13,374,676	12,471,770	-0.70					-1.7	5.1	9.7
Rajputana	10,530,432	9,844,384	-0.67					-2.2	5.9	12.8
Kashmir	3,158,126	3,320,518	0.50						3.8	9.5
Burma	12,115,217	13,212,192	0.87	141,868	1.50	2.12	0.47		37.6	9.3

Source: Mills (1986), Murray et. al. (2006), Census of India-1911, Statistical Abstracts of British India.

Estimating Influenza Pandemic Mortality in India

Table 6.2 shows different estimates of pandemic influenza mortality in India, broadly ranging from 10 million to 20 million. Research methods using death registration statistics lead to lower counts and those using intercensal growth methods obtain higher counts. Because the registration system was overwhelmed in 1918, it is likely that the intercensal method is more robust to estimate absolute magnitudes.

Table 6.3 shows that the global death count also varies substantially from around 17 million to fifty million, with one study even placing an upper estimate of 100 million. India is the country with the highest mortality, across methods.

Table 6.2: Influenza Mortality Estimates in India, 1918-19

Source	Influenza Mortality Estimate	Method	Issues
White (1919)	5 Million in British India districts	Death registration until Nov 30, 1918	Under-registration of deaths
Marten (1923)	8.5 million in British India districts	Excess mortality for 1918-19	Assumptions of reference year mortality and under-registration of deaths
Marten (1923)	12-13 million in Indian subcontinent	Intercensal population growth rates	Assumptions of pre-1918 and post-1918 population growth rates
Davis (1951)	18.5 million in the Indian subcontinent	Excess mortality method with average of 1914-17 and 1920-24 as reference years, along with registration correction factor	Assumptions of reference year mortality and correction factor
Davis (1951)	22.6 million in the Indian subcontinent	Intercensal population growth rates, 1901-1931	Assumptions of pre-1918 and post-1918 population growth rates
Mills (1986)	10 million in the Indian subcontinent	Excess mortality for 1918-19 over 1913-17 average	Assumptions of reference year mortality and under-registration of deaths
Mills (1986)	17 million in the Indian subcontinent	Applying under-registration correction factor of 1.7 to excess mortality estimates	Assumptions of correction factor
Mills (1986)	18.5 million in the Indian subcontinent	Intercensal growth rates	Assumptions of pre-1918 and post-1918 population growth rates
Hill (2011)	13.3 million in British India districts	Excess mortality method	Leaves out native states

Hill (2011)	17.8 million in the Indian subcontinent	Intercensal growth rates	Assumption of pre-1918 population growth rate
Chandra, Kuljanin and Wray (2012)	13.8 million in British India districts	Panel estimation using Census district level data from 1891 to 1941	Leaves out native states
Barro, Ursua and Cox (2020)	16.7 million in Indian subcontinent in 1918-20	Excess mortality method	Under-registration of deaths

Table 6.3: Global Influenza 1918-20 Mortality Estimates

Source	**Influenza Mortality Estimate**	**Method**	**Issues**
Jordan (1927)	Over 21.5 million	Aggregation of country estimates	Validity of country estimates
Patterson and Pyle (1991)	24.7-39.3 million	Aggregation of country estimates based on large number of studies	Validity of country estimates
Johnson and Mueller (2002)	32-42 million	Aggregation of country estimates based on large number of studies	Validity of country estimates
Johnson and Mueller (2002)	50-100 million	Correction of reported 32-42 million estimate on account of under-registration and under-coverage of countries	Assumptions to arrive at correction factor
Murray et. al. (2006)	62 million in 2004	Using 1918-19 excess mortality data, per capita incomes in prediction model	No estimate for 1918-19 itself
Spreeuwenberg, Kroneman and Paget (2018)	17.5 million	Excess mortality method: 13 countries in Human Mortality Database plus British India	Under-registration of deaths and narrow sample with only one non-European country
Barro, Ursua and Cox (2020)	39 million	Excess mortality method, 43 countries, Projections for world, 1918-20	Under-registration of deaths

For India, Chandra, Kuljanin and Wray (2012), henceforth CKW, use a random coefficients panel model to estimate influenza mortality of 15.51 million, when using data from 1901-1941 and 13.88 million, when using data from 1891-1941. The key idea of this method is to estimate a pre-1918 and post-1918 population growth rate using data on a large number of regions for as many Census years as possible.

CKW study 199 districts directly ruled by the British in India, that covered around 75% of the population enumerated by the Census of India in 1901. One limitation of this study is that it excludes the princely states of India, some of which as reported in Table 6.1 were likely to be affected severely by influenza.

If one were to extrapolate CKW's figures for all of India, inclusive of the princely states, the numbers corresponding to 13.88-15.51 million would by 18.46-20.63 million, using a scaling factor of 1.33 (i.e. inverse of 75%).

It is, however, possible to increase coverage of the princely states and replicate the CKW estimation exercise for 1901-1941, as done below.

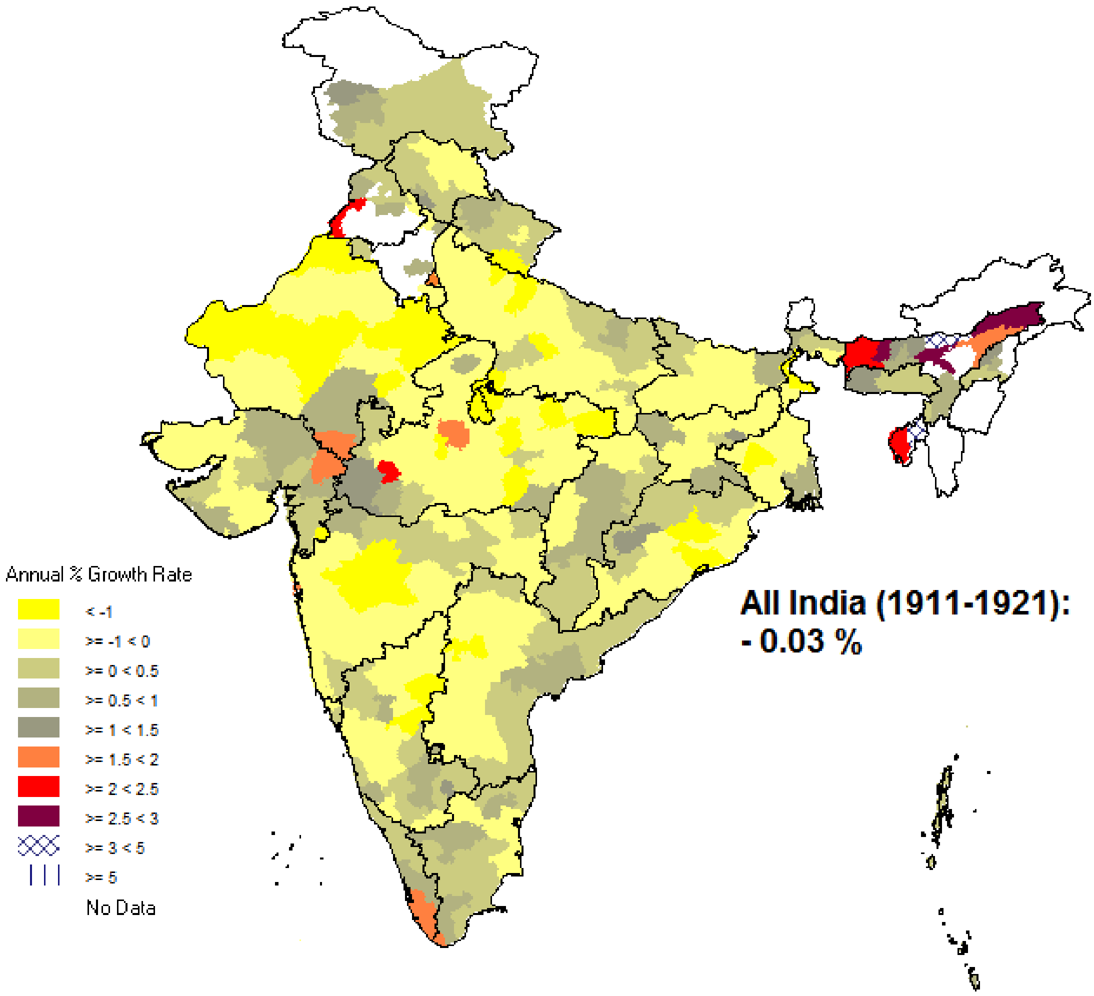
First, we take data for Indian districts prepared by the Census of 2001 administration from the District Census Handbooks for districts of India in 2001 that provide back-casted data for each decennial Census year from 1901. This covers the directly ruled and indirectly ruled regions of the past and all the territory of post-1947 India, including Goa (earlier Portuguese ruled) and Pondicherry (earlier French ruled). Data is available for 1901-1941 for 527 of the 593 districts in the jurisdiction boundaries of 2001, representing over 97% of the population. In addition, we use the same districts used by CKW for the region corresponding to East Pakistan (now Bangladesh) and West Pakistan (now Pakistan). Thus, our district sample increases from 199 used by CKW to 566 and increases coverage from 75% to 96% of the population enumerated by the Census of India in 1901.

Figure 6.3 shows the annual population growth rates from 1911-1921 at the district level in the jurisdiction boundaries of 2001 for India. Data for the states of Haryana and Punjab are missing since many of these district boundaries have changed substantially, making back-casting of data difficult. The north-eastern region also shows missing data where local data was not collected and in general high growth rates due to high migration in that decade.

Table 6.4 shows the results of the regression exercise. When we run the model on districts in 2001 boundaries closely corresponding to erstwhile districts directly ruled by the British (the CKW sample), we get broadly similar estimates for the annual population growth rates after 1918, but a slightly higher annual population growth rate prior to 1918, and correspondingly a higher estimate for influenza mortality of roughly 17.5 million, corresponding to the sample population of around 75% coverage, similar to CKW.

However, when we run the full model, which covers 96% of the population of the Indian subcontinent, our post-1918 population growth rate estimates continue to be broadly the same as CKW, but we obtain a substantially higher post-1918 annual population growth rate of 0.84%. Consequently, we get a much higher estimate of influenza mortality at 30 million due to newer model parameters, corresponding to virtually the entire Indian subcontinent. The scaling factor from British Indian districts to almost-all-India districts is no longer 1.33 but 1.7 (i.e. 30/17.5), suggesting that princely or native districts were more affected by influenza than British districts.

Figure 6.3: Annual Population Growth Rate at the District Level, %, 1911-1921 (Jurisdiction boundaries of 2001)



Source: District Census Handbooks India, 2001.

Table 6.4: Model estimates of Influenza Mortality in India

	CKW		Fuller Sample	
	Unrestricted Model	Restricted (Davis) Model	Unrestricted Model: British Indian Districts only	Unrestricted Model
Coefficient Estimate				
Intercept	13.71***	13.68***	12.87***	12.71***
	(0.04)	(0.04)	(.05)	(0.04)
Time Trend	0.0050***	0.0106***	0.0067***	0.0084***
	(0.0007)	(0.0003)	(.0007)	(0.0006)
Flu dummy variable (Post-1918=1)	-0.19***	-.12***	-0.16***	-0.16***
	(0.01)	(0.01)	(.01)	(0.01)
Time Trend*Flu dummy variable	0.0070***		0.0050***	0.0039***
	(0.0007)		(.0008)	(0.0007)
Number of Observations	995	995	1940	2835
Estimates of Key Demographic Phenomenon				
Influenza Population loss (millions)	15.51	25.56	17.5	30.0
Annual Population Growth Rate to 1918, %	0.50	1.06	0.67	0.84
Annual Population Growth Rate after 1918, %	1.20	1.06	1.17	1.23

Table 6.4 shows the replication exercise of the CKW model with new estimates in comparison to estimates mentioned by CKW. **The dependent variable is log of population of district in a particular year.**

Compared to the 18-21 million estimate of CKW projected for all of India based on a simple extrapolation, the influenza mortality for the Indian subcontinent is potentially higher and possibly in the range of 20-30 million.

It is also useful to compare these results with those obtained by Hill (2011). First, by the scaling method of 1.7 for princely state coverage, Hill's own estimate of 13.3 million in British India districts by the excess mortality (correcting for under-registration) method, goes up to 22.61 million. Further, Hill's study did show the difference in mortality estimates for princely states and British-ruled districts using a simple intercensal method and the scaling factor there also turned out to be 1.7. That is both Hill (2011) and our study show that princely states were much more affected than British-ruled districts and that the scaling factor has to be above 1.33 that corresponds to a similar population based extrapolation to arrive at an estimate for the entire Indian subcontinent.

Hill (2011), using age-data analysis, also pointed out to an important finding that a large part of the loss attributed to influenza in the intercensal growth method could be due to lower fertility (in the years after influenza) rather than influenza mortality itself. Taking this into account, we consider the 30 million figure arrived in Table 6.4 as an upper-estimate and **the true figure to be upward of *20 million* for the Indian subcontinent comprising of present day India, Pakistan and Bangladesh.** This is also in line with CKW and Hill (2011) estimates for the Indian subcontinent using a scaling factor of 1.7 on their estimates for British Indian districts. And hence, similar to what Davis (1951) had originally posited. This figure represents about 6.4% of the population in India, projected for early 1918 (313 million).

The difference between these estimates and those on the lower side by Hill (2006) or Spreeuwenberg, Kroneman and Paget (2018) (which posit *global* influenza mortality to be under 20 million) fundamentally relate with how much one can trust death registration statistics in an exceptionally high-mortality year like 1918 in India to make claims on absolute magnitudes. Judging by the studies on pandemic influenza in India, it seems quite plausible that millions of deaths went unreported (Ramanna 2003, Hardiman 2012, Arnold 2019).

Given the extreme drought conditions of 1918 and surge in foodgrain prices, it is also quite likely that a large part of the unusually high mortality in India compared to other countries, was because of the interaction of influenza with prevailing adverse conditions that could have greatly reduced immunity (Katona and Katona 2008; Stanke et. al. 2013; Reyes et. al. 2018) or with malaria and anaemia as hypothesised for Iran (Afkhami 2003).

Correlates of Influenza Mortality in India

A preliminary exploration on the correlates of influenza mortality is presented in Table 6.5 based on the analysis of district level data in the jurisdiction boundaries of 2001. The dependent variable is annual population growth rate, %, 1911-1921 and it is assumed that those districts badly affected by influenza mortality, would tend to show lower growth rates in this decade.

As independent variables, we take the following variables:

- Annual population growth rate, %, 1901-1911, to control for prior growth rates.
- Rainfall shock score defined the following,

  Rainfall shock score= Std. Normal Score of June-Sep rainfall in 1918* % of annual rainfall received in June-Sep

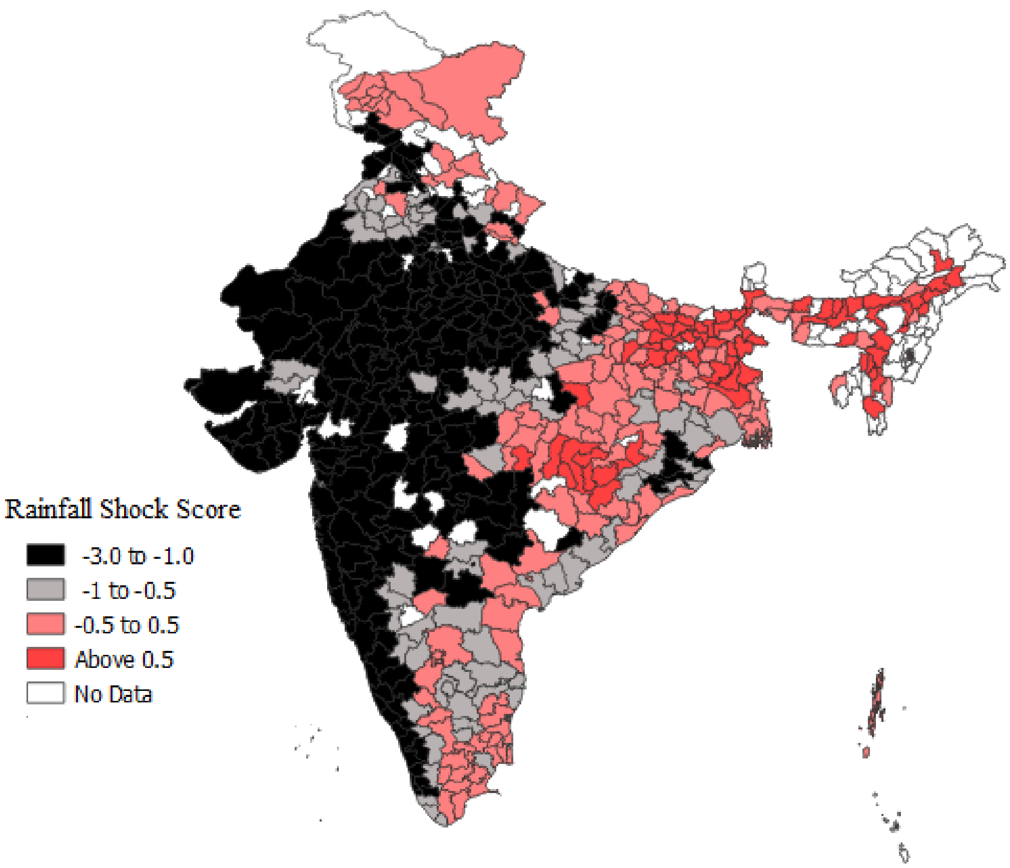
  For instance, the z-score for Agra was -1.82 and it receives 88.7% of its annual rainfall in the monsoon season of June-Sep, so the variable takes the value 0.887*-0.182= - 1.52.

The variable is mapped out in Figure 6.4. It is expected that the coefficient on this variable will be positive such that a negative score (intense drought) will lead to lower population growth rate in the decade due to higher influenza mortality.

Rainfall data is taken from India Meteorological Department publication on monthly district rainfall for 1901-2010.

- Crude Literacy Rate for the year 1961, as per the Census. We assume the inter-district variation was similar in 1911. Cross-district variation in developmental variables such as urbanization have been shown to be persistent at the state/province level across the twentieth century (Tumbe 2016). We assume that the coefficient on this variable will be positive such that better educated/developed regions had lower influenza mortality and higher population growth rates between 1911 and 1921, similar to the cross-country relationship observed by Murray et. al (2006)
- Log of Population Density in 1911
- % of Scheduled Castes in India in 2001. We assume the cross-district variation would have been broadly similar in 1918.
- % of Scheduled Tribes in India in 2001. We assume the cross-district variation would have been broadly similar in 1918.
- Dummy variables if the district lies on the coast and whether it had a railway track in 1911.

Figure 6.4: Rainfall Shock, Jun-Sep 1918 [Boundaries of 2001]



Source: MET rainfall data. See text for definition of rainfall shock score.

Table 6.5 shows the results of the Ordinary Least Squares Regression. After controlling for prior growth rates, rainfall shock and literacy rates are both strongly significant at the 1% level.

Districts which experienced serious monsoon droughts in 1918 and were dependent on the monsoon for most of its water requirements (negative rainfall shock scores), saw significantly lower population growth rates in 1911-21.

Districts with 10% higher percentage points in literacy had annual growth rates higher by 0.3% points, outlining the significant of developmental variables. It is quite likely that those regions were better able to withstand influenza due to a more informed population and better health infrastructure.

Districts with greater share of Scheduled Castes saw substantial declines in population growth rates, suggesting that Scheduled Castes were badly affected by influenza mortality in this period. However, since the data on Scheduled Castes is taken for 2001, there are likely to be confounding factors in this interpretation.

Collectively, these results strongly show that influenza mortality in India was likely to be conditioned by socio-economic variables and the water scarcity of many regions in 1918. While Reyes et. al (2018) had documented the significance of the *level* of the rainfall, we are able to show that it was the intense departure from normal rainfall between June and September that was the likely cause of deep distress before the second wave of lethal influenza in Sep-Dec. We also find population density not to be a significant variable because many of the districts in erstwhile Rajputana and Hyderabad state, that is a part of our sample and not Reyes et. al. (2018), were badly hit by influenza, but had low population densities.

Table 6.5: OLS Regression

Dep Variable: Annual Population Growth Rate, %, 1911-21	**Coefficient**		**Robust Std. Errors**
Rainfall Shock Score, 1918	0.218	***	0.05
Crude Literacy Rate, %, (1961)	0.030	***	0.00
Annual Population Growth Rate, %, 1901-11	0.109	**	0.04
Log of Population Density, 1911	0.029		0.06
% Scheduled Castes (2001)	-0.023	***	0.01
% Scheduled Tribes (2001)	-0.001		0.00
Dummy variable, Railways in district==1	-0.095		0.11
Dummy variable, Coastal district==1	-0.058		0.10
Constant	-0.265		0.31
Number of Observations= 470			
R. Sq. = 0.26			

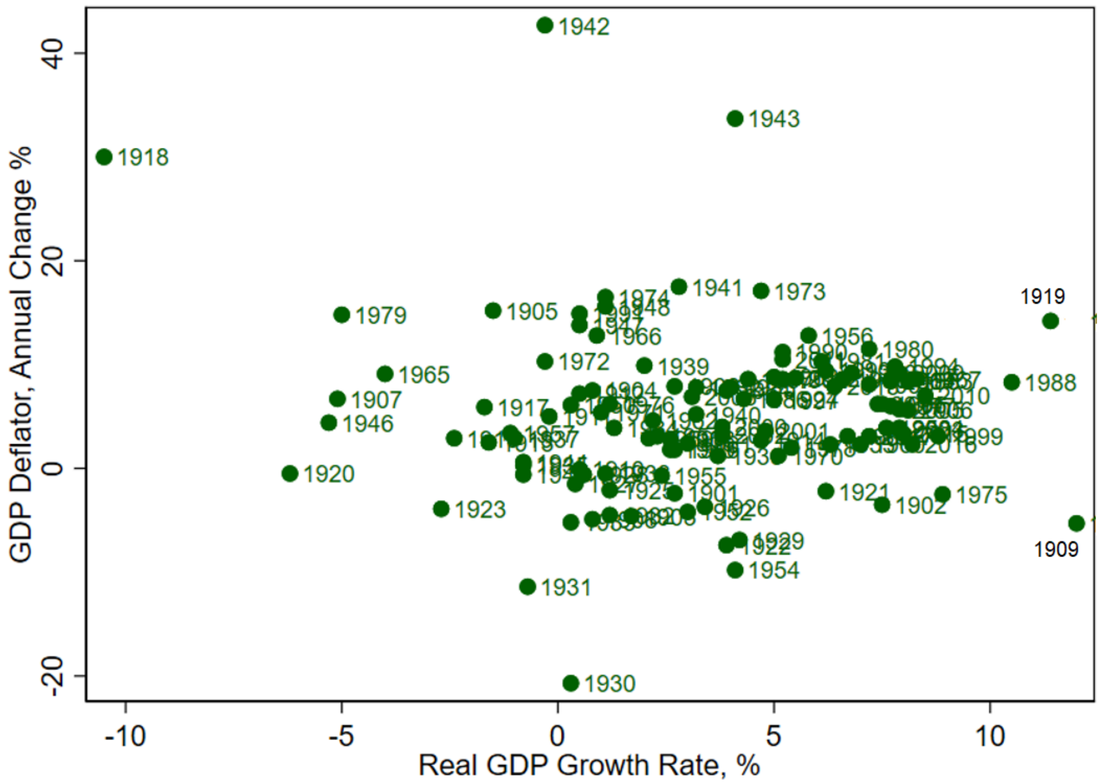
***Significant at the 1% level, **Significant at the 5% level.

Economic Situation of 1918

The drought and influenza pandemic in India in 1918 also had a substantial fallout on economic activities in that year. As Figure 6.5 shows, 1918 was the worst year in recorded economic history in India since 1900 with negative real GDP growth rate of 10 per cent and inflation surging to 30%, suggesting a massive supply-side shock to the economy.

In 1919, however, the economy bounced back as agriculture, the mainstay of the economy resumed cultivation of lands that had remained fallow the earlier year.

Figure 6.5: Economic Growth and Inflation in India, 1900-2018



Source: Sivasubramonian (2000); CSO India. 1900-1946 GDP series uses 1938-39 as base year, 1947-1999 GDP series uses 1948-49 as base year and 2000-2017 series uses 2011-12 as base year. Growth rate for 2017 refers to 2017-18.

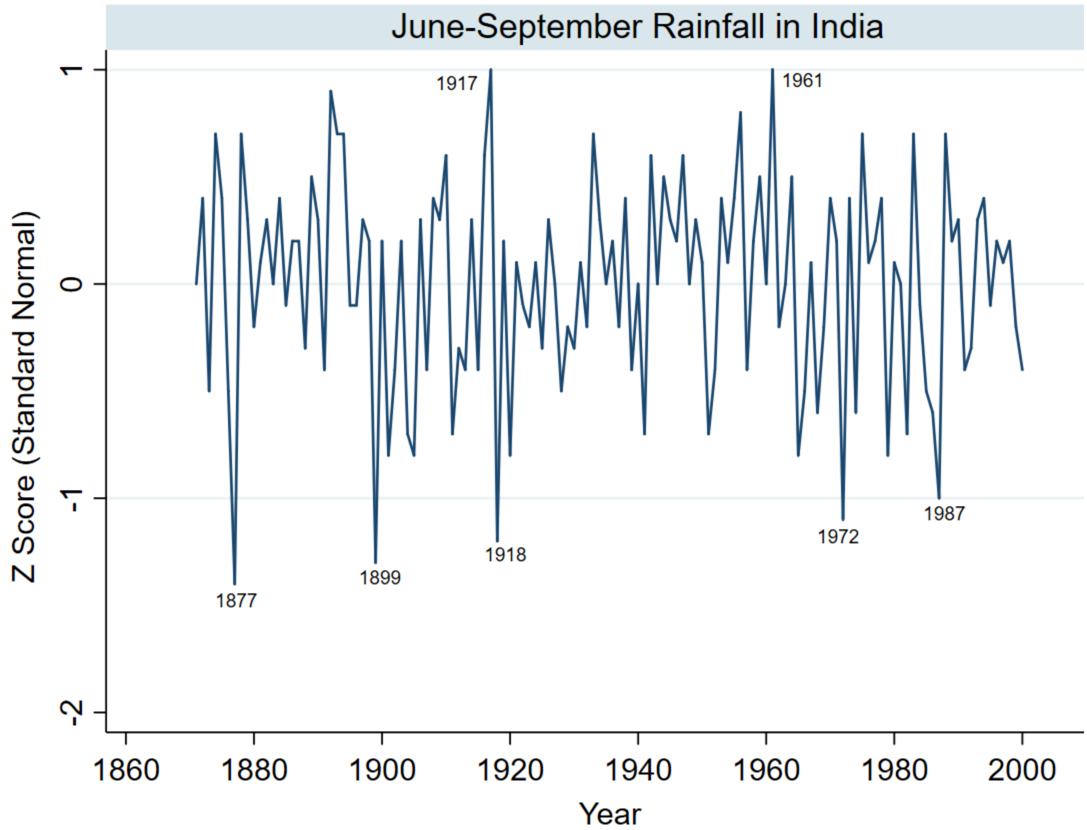
7. Rainfall and Rice Prices in India

India's monsoon dependent economy has historically experienced famines when rains were deficient, thereby stressing its food production system. The southwest monsoon from June to September brings most of the rainwater to the Indian subcontinent. Famines have been noted in Indian history since ancient times, caused primarily due to droughts of the southwest monsoon.

Systematic collection of rainfall statistics began only in the late 19th century and as Figure 7.1 shows, the rainfall shocks of 1877, 1899 and 1918 were severe, and remain unsurpassed till 2000. While 1877 and 1899 were closely associated with famines and high death rates in the year of the drought and the subsequent year, in 1918, the influenza, as we have seen, led to mass mortality, acting on under-fed bodies.

In contrast, high-rainfall years are few, and 1917 and 1961 stand out as years with excess rainfall.

Figure 7.1: All-India June-September Rainfall in India, 1871-2000



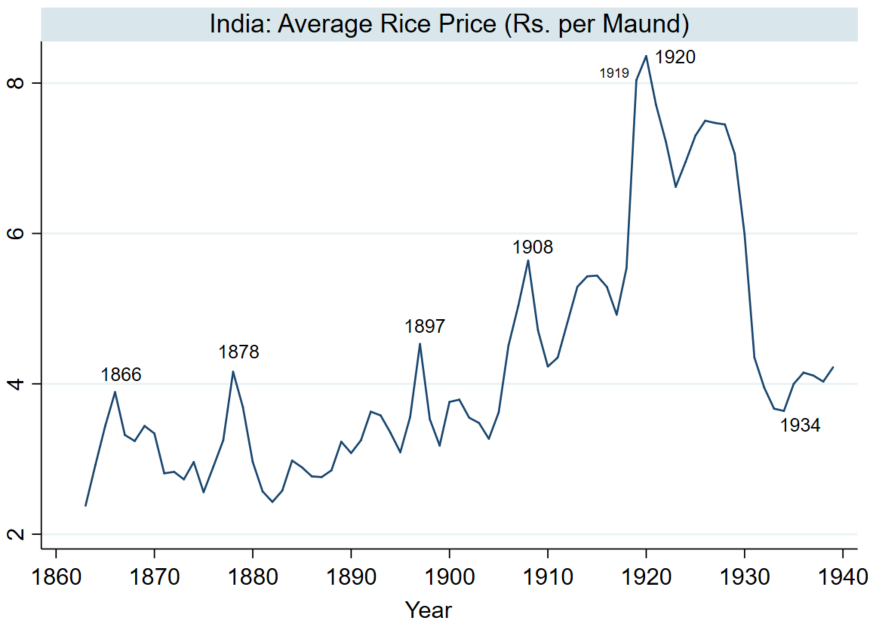
Source: Parthasarathy, Munot and Kothawale (1995) and updates. Computed All-India Z-scores are Area-Weighted Z-Scores for 29 different regions of India.

Rainfall deficiency could raise food prices if the crops failed, and as Fig. 7.2 shows, this clearly happened around the famines in the 1860s, 1870s, 1890s and 1918.

Fig. 7.2 shows a steady rise in rice prices in the 1880s and 1890s, then again leading up to 1908 and then during World War I and 1918. From the late 1920s, there was a huge correction, especially due to the Great Depression, such that prices in the 1930s were the same as in the 1890s.

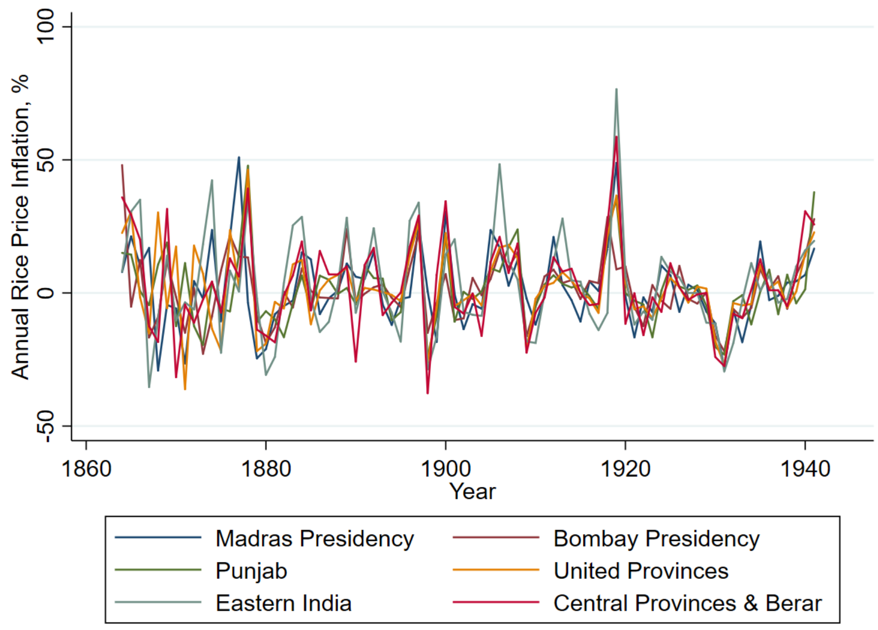
Annual rice price inflation rates tended to track together across regions, as shown in Fig. 7.3, with 1918 and 1919 recording particularly high inflation, and as observed earlier, high influenza related deaths.

Figure 7.2: Rice Prices in India, 1863-1939



Source: Statistical Abstracts of British India. One Maund = 82.286 Lbs. Average annual retail prices of centres across British India.

Figure 7.2: Annual Rice Price Inflation, %, 1864-1939



Source: Statistical Abstracts of British India. One Maund = 82.286 Lbs. Average annual retail prices of centres across British India.

8. Major Demographic Disasters in the Indian Subcontinent

In the past, severe droughts would translate into famines, especially in the late 19th century, which witnessed several episodes of El Nino driven volatility. GoI (1953, pp. 265-270) provides a list of famines and scarcities in the India between 1770 and 1947. In addition, there have been pandemics which have claimed a large number of lives. Wars do not appear to have matched the high levels of mortality seen in major famines and pandemics, in the Indian subcontinent. Estimates for the 1857 uprising range from the hundreds of thousands to a few millions. A list of major demographic disasters is presented below.

Table 8.1: Major Demographic Disasters in the Recorded History of the Indian Subcontinent

Disaster	Years	Deaths	Geographical Coverage	Source
Influenza Pandemic	1918-19	20 Million+	Most parts of the Indian subcontinent; lesser in the east and the south	See earlier working; Other estimates listed in Table 6.2 suggest 10-20 million
Plague Pandemic	1896-1918	12 Million+	Concentrated in Punjab, United Provinces and Bombay Presidency	See Table 5.1 and scaling factor of 1.2; For 1896-1968: 16m; For 1896-1908: 7m+
Famine	1769-1770	5-10 Million*	Concentrated in Bengal	Roy (2012, p. 30)
Famine	1876-1878	5-8 Million	Concentrated in South India	Maharatna (1996, p. 15): 8.2m, Seavoy (1986, p. 242): 6.1m; GoI (1955, p. 273): 5.25m
Famine	1899-1900	3-4 Million	Large parts of the Indian Subcontinent	Seavoy (1986): 3.3m, Maharatna (1986): 3m-4.4m, GoI (1955, p. 274): 4m
Famine	1896-1897	2-5 Million	Large parts of the Indian Subcontinent	Seavoy (1986): 5.2m, Maharatna (1986): 2.6m-4.1m, GoI (1955, p. 274): 1m
Partition of India	1947-48	3.4 Million 'Missing Persons'	Concentrated in Punjab and Bengal	Khwaja, Mian and Bharadwaj (2008)
Famine	1943-44	2-3 Million	Concentrated in Bengal	See Dyson (2018, p. 186) for a range of estimates

Notes: m=Million, *Estimates are probably on the higher side. The famine of 1782-1784 is said to have been as large as the famine in 1769-70 (Dyson 2018, p. 79-81).

9. Deaths due to Pandemics, 1817-1920

The period 1817-1920 witnessed the pandemics of cholera, plague and influenza that, as Table 9.1 shows, claimed over 70 million lives worldwide. Around 40 million, or more than half the global total, died in the Indian subcontinent.

For cholera, India comprised around 40% of global pandemic deaths, though as observed earlier, this figure rises to around 80% if India's cholera-endemic deaths are also counted. For plague, virtually all the deaths occurred in India. For influenza, India's share of the global death toll was around half.

Table 9.1: Deaths due to Pandemics, 1817-1920, Millions

Pandemics	Period	World	India
Cholera	1817-1920	19	8
Plague	1894-1920	13	12
Influenza	1918-1920	40	20
Total		72	40

Notes: India refers to the Indian subcontinent. For Cholera, see Table 3.5. Cholera for India only refers to Epidemic deaths. For Plague, see Table 5.3 for 1894-1938 data which has been adjusted for 1894-1920 period. World influenza toll from Barro, Ursua and Cox (2020) and for India, see Table 8.1.

Table 9.2 enables a comparison of deaths due to pandemics with deaths due to conflict. Between 1817 and 1920, while around 70 million people died globally in pandemics, the number attributed to conflicts is nearly half, at 35 million. The 70 million deaths due to pandemics between 1817 and 1920 is also greater than the estimate of around 60 million deaths attributed to the two World Wars of the 20th century.

The estimates for World War I suggest around 10 million battle casualties and lesser than 20 million in total casualties, which is lesser than India's loss of around 20 million due to the 1918-20 influenza pandemic.

These comparisons make it clear that the 'age of pandemics' between 1817 and 1920 due to cholera, plague and influenza and their disproportionate impact on India constitute an important demographic epoch in history.

Between 1920 and 2019, deaths due to pandemics can be placed at a figure under 40 million, with over 30 million attributed to HIV-AIDS. The global population in this period rose from under 2 billion to over 7 billion. Pandemic deaths between 1920 and 2019 thus represented only 1-2% of the global population in this period. In contrast, during the 'age of pandemics' between 1817 and 1920, this figure was over 5%, quite possibly the highest in any century of recorded history barring perhaps the 6th century (Justinian plague pandemic) and the 14th century (Black Death plague pandemic).

Table 9.2: Deaths due to Conflicts over the Long Run

Time Period	No. of Events	No. of Events with Estimates on Fatalities	% Events with Estimates	Military Fatalities (Millions)	Total Fatalities (Millions)	Major Events
1400-1816	2,185	558	26	7	33	Thirty Years War, 1618-48 (8m), Napoleonic Wars, 1803-15 (4m)
1817-1920	938	394	42	20	35	World War I (20m), China's Taiping Rebellion, 1850-65 (2m)
1921-1936	109	40	37	1	4	Chinese Civil War, 1926-35 (1m)
1937-1945	52	20	38	22	52	World War II (42m), Genocide of Jews (6m)
1946-2000	424	204	48	10	25	China 1950-51 (2m)
Total	3,708	1,216	33	60	149	World War I & II (62m)

Notes: m=Millions.

Source: Based on the Conflict Catalog 18 vars.xls, developed by Dr. Peter Brucke.

URL: https://brecke.inta.gatech.edu/research/conflict/, accessed on Nov 30, 2020.

All major conflicts were provided with mortality estimates in this database, such that the absence of estimates for many events, is unlikely to significantly skew the periodic aggregates.

10. Selected Bibliography on Pandemics and Historical Mortality in India

This section presents a list of over 250 studies related with pandemics, cholera, plague, influenza and few other diseases, mostly related with India, for the period 1817-1920. It is complementary to the bibliography presented in the Notes section of the book, *The Age of Pandemics*.

The bibliography is presented in five sections:

a) General References
b) Cholera
c) Plague
d) Influenza
e) Miscellaneous

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