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Cause-specific excess mortality in rural India during the COVID-19 pandemic 2020–2023: longitudinal analyses of deaths in 0.2 million rural health facilities

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ABSTRACT

Objective India had an estimated three to five million excess deaths from causes attributable to SARS-CoV-2 during 2020–2021, far exceeding official government statistics. Most deaths in India occur in rural areas, where medical certification of deaths is limited. Yet, the effects of the pandemic in rural settings remain largely undocumented. We estimated the cause-specific excess mortality in rural areas of selected states of India.

Design Longitudinal analyses of hospital mortality data.

Settings India's Health Management Information System (HMIS) reports the number of deaths by cause for adolescents or adults aged 10 years or more. We examined eight states with high coverage of the expected number of deaths in rural areas.

Participants We analysed monthly death reports from the HMIS, which covered approximately 0.2 million health facilities during 2018–2023. We compared excess deaths during the peak COVID-19 months in rural health facilities to pre-COVID-19 and non-peak periods of 2021, and categorised reported causes by their probable association with COVID-19.

Primary outcome measure Excesses of cause-specific and total mortality.

Results During the April–June 2021 SARS-CoV-2 wave, predominantly driven by the Delta variant, monthly deaths in rural health facilities across India surged from approximately 200 000 to 500 000. In eight states with high-quality reporting, rural facility deaths increased by 270% (95% CI 267% to 272%) compared with the same months in 2018–2019, prior to the COVID-19 pandemic. Notably, this surge occurred despite a sharp decline in hospital admissions following the national lockdown in March 2020. The largest relative increase was for fever-related and respiratory diseases, and these deaths were markedly elevated even when compared to non-peak months of 2021. Generalising these findings from eight states to all of rural India yields an estimate of approximately 2.6 million excess rural deaths in April–June 2021. In contrast, there were few excess deaths during the Omicron viral waves in 2022–2023.

Conclusion COVID-19 substantially increased deaths in rural India during April–June 2021, but reassuringly, no significant excess mortality was observed in subsequent years. The HMIS provides an important opportunity to strengthen routine mortality surveillance in rural India.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This study used data from the national Health Management Information System, which captures deaths from approximately 200 000 health facilities, to estimate cause-specific excess mortality related to COVID-19 in rural India.
⇒ Excess deaths during successive SARS-CoV-2 waves were estimated by grouping hospital-assigned causes of death into COVID-19–related and unrelated categories and comparing their temporal patterns with test-confirmed SARS-CoV-2 cases.
⇒ Analyses were limited to eight diverse states, representing about 40% of rural deaths nationally, with consistently high completeness of death reporting.
⇒ Because facility-based death reporting includes only 14 broad cause-of-death categories, the study was restricted to assessing excess deaths within these categories, which remained unchanged over time.

INTRODUCTION

Globally, the World Health Organization (WHO) estimated that the new SARS-CoV-2 virus caused approximately 15 million excess deaths during 2020–2021.[1] Subsequent estimates[2 3] suggest an additional 10 million excess deaths may have occurred during 2022–2023 globally. India alone is believed to have accounted for around three to five million of these excess deaths during 2020–2021.[1 4]

The excess deaths in India constitute at least one-third of the global gap of nine million 'missing' deaths in 2020–2021, that is, the difference between the WHO's estimate of 15 million excess deaths and the six million COVID-19 deaths officially reported by governments.[1]

Life expectancy in India declined by over 2.5 years in 2021 alone, largely due to the consequences of the COVID-19

pandemic.[5] Estimates of India's excess mortality from COVID-19 have been controversial as the Indian government has been reticent to change its official stance of about 0.4 million cumulative COVID-19 deaths by December 2021. Against this, substantial under-reporting of COVID-19 deaths in India is widely acknowledged by independent researchers and international agencies.[6] Four key aspects of India's excess mortality from COVID-19 remain largely unexamined. First is the impact of widespread infection in rural areas, where nearly two-thirds of India's 1.4 billion population lives, and where over 70% of all the approximately 10 million annual deaths occur.[7] Second, excess mortality from specific causes of death during the April–June 2021 SARS-CoV-2 viral wave, predominantly driven by the Delta variant, led to a dramatic surge in infections and deaths in just over three months.[4] Third, it remains unclear whether elevated mortality continued in 2022 and 2023. Despite India achieving high vaccination coverage after the Delta wave in 2021,[8] the country experienced a substantial increase in infections during the Omicron wave of late 2021 and early 2022.[3] Finally, the abrupt and complete lockdown initiated on 25 March 2020 may have affected care-seeking behaviour, particularly in rural areas.

The completeness of death registration in India, which is critical for estimating excess mortality, is estimated at only about 70% nationally, and lower in rural areas.[9] Medically certified causes of death are largely limited to selected facility-based deaths, mostly in urban areas, and covering roughly 22% of all registered deaths.[10] The Indian Sample Registration System (SRS) offers a robust national sampling frame that captures physician-coded causes of verbal autopsy deaths for approximately 1% of randomly-selected homes across the country, including rural areas. However, the SRS does not yet release monthly data, which is needed to document the various viral waves of SARS-CoV-2.[11]

In the absence of complete routine death registration data, we used India's Ministry of Health and Family Welfare (MoHFW) system of facility-based deaths called the Health Management Information System (HMIS), which covers about 200 000 health facilities across all regions of the country. The HMIS provides a crude classification of the causes of death. We first analysed national monthly mortality patterns for 2020 through 2023 and the impact of the national lockdown on facility attendance. We then focused on eight diverse states which provide more consistent, complete and good-quality reporting of data to assess the cause-specific number of excess deaths in 2021–2022. Within these states, we examined the trends in cause-specific mortality, with particular attention to causes of death categorised by their probable association with COVID-19. We extrapolate our findings from states with high-quality data to the whole of India.

METHODS

Data source

We use the data available online from the HMIS, a surveillance system that tracks key indicators relevant to monitoring various national health programmes.[12] The HMIS covers around 200 000 public hospitals (and a very few private facilities) nationally. Facility deaths cover sub-health centres, primary health centres, community health centres, sub-district hospitals and district hospitals in rural areas. The vast majority of HMIS deaths (>85%) occur in rural areas (online supplemental appendix table 1). The HMIS provides 14 broad causes of death for adolescents and adults aged more than 10 years (online supplemental appendix 1 on details of the causes of death in HMIS). HMIS admission data include information on the number of emergency cases and inpatient and outpatient volumes. Therefore, we focused on adolescents and adults combined (aged 10 years and older) in rural areas only. The HMIS cause of death classification does not follow the International Classification of Diseases (ICD) coding guidelines.[13] Rather, it employs a broad mortality classification system, in which causes of death are assigned by facility staff based on clinical assessment and available medical records. While diagnostic capacity in rural facilities is limited, the use of broad cause categories (eg, fever-related, respiratory, cardiac) helps minimise potential misclassification bias. We reclassified the 14 HMIS causes of deaths into three COVID-19 related categories: (1) *highly related* to COVID-19 (respiratory infections, fever-related, known acute diseases, known chronic diseases, heart diseases including hypertension and neurological disorders including stroke); (2) *less related* to COVID-19 (diarrhoea, HIV/AIDS and cancer); and (3) *not related* to COVID-19 (accidents, burns, suicides, tuberculosis, animal bites or stings).

During 2018–2019, the HMIS reported 1.9–2.1 million deaths (online supplemental appendix table 2). According to the SRS, in 2019 and prior to the pandemic, 44% of rural deaths (and 49% nationally) occurred in health facilities. We applied to each state the 2019 SRS-specific proportion of rural deaths estimated to occur in rural health facilities and compared this to the United Nations Population Division (UNPD)[14] estimates for total deaths portioned into states by rural/urban areas, using procedures already described.[15] Thus, in 2019, the HMIS captured about 72% of all expected rural facility deaths based on SRS death rates. To minimise the potential bias for incomplete or variable mortality reporting across states, our main analysis focused on the best-performing eight states where completeness of the reported number of deaths in 2018–2019 exceeded 80% compared with the expected number of deaths (online supplemental appendix 2).

These eight states were Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Maharashtra, Odisha, Tamil Nadu and West Bengal. We excluded Delhi as it is largely urban and has many migrants, distorting the expected numbers of deaths. We excluded three other states with

>80% completeness: Punjab, which had implausibly high coverage estimates (greater than 100%); Haryana, which had a rapid increase in coverage between 2018 and 2019; and Himachal Pradesh, which is a relatively smaller state (online supplemental appendix 2 and appendix table 2). We used district-level monthly data for deaths among adolescents and adults aged ≥10 years from January 2018 to May 2021. MoHFW stopped publishing district-level data in May 2021. Thus, we used state-level data from June 2021 onwards.

Analysis

The excess death patterns were most pronounced during the Delta viral wave of COVID-19 during April–June 2021; thus, our estimations mainly focused on this period. We compared the number of total and cause-specific deaths during the Delta wave of April–June 2021 (R_i) with two reference groups (G_i): (1) the average number of deaths in April–June of 2018–2019 (corresponding to pre-COVID-19 months) and (2) the average number of deaths in all months of 2021, excluding March–July, representing the non-viral peak months of 2021.

We limited our first reference group to 2018–2019 because HMIS mortality reporting has shown progressive annual improvements.[16] The average deaths from these two years, therefore, provide a more representative baseline immediately preceding the onset of the COVID-19 pandemic. Using a longer baseline (eg, 2015–2019) could introduce bias due to progressive improvements in HMIS reporting quality over time. Furthermore, the HMIS did not provide stratified data by rural–urban status prior to April 2017.

We use the following formulae to calculate the relative excess deaths.

$$\textit{Relative Excess Deaths}\ (X) = \frac{\sum_i (R_i - G_i)}{\sum_i G_i} \times 100$$

X denotes relative excess deaths, R_i denotes the number of deaths during the ith pandemic month (April–June 2021) and G_i denotes the number of deaths from the corresponding pre-pandemic reference period (average of April–June 2018–2019) of the same population or the non-viral peak months of 2021. We calculated 95% CIs for state-level estimates by applying the SD of excess mortality observed at the district level during the same period, using the formulae 95% $CI = \mu \pm z_\alpha \sigma$, where μ is the cause-specific excess mortality in the state; $z_\alpha = 1.96$; and σ is the standard deviation derived from district data.

RESULTS

We observed an unprecedented surge of deaths in rural health facilities across India from April to June 2021, coinciding with the Delta variant wave of COVID-19 (figure 1A). The reported number of monthly deaths more than doubled from approximately 200 000 to nearly 500 000, peaking in May 2021. A smaller increase was also evident during September–October 2020, corresponding to the Alpha wave. By contrast, there were no prominent peaks in 2022 or 2023, including during the Omicron waves of late 2021 to early 2022.

The selected eight states (figure 1B) accounted for approximately 40% of the rural population and rural deaths in India (table 1). Between 2018 and 2021, over 8.6 million deaths among ages ≥10 years were reported in rural HMIS facilities nationally, with these eight states accounting for more than two-thirds, or around 5.9 million deaths.

The total number of polymerase-chain reaction (PCR) confirmed (test-positive) cases of SARS-CoV-2 from official government sources of these eight states showed a bimodal curve with a smaller peak in September 2020 and a much larger surge during April–June 2021 (dotted black in figure 2). A marked increase in deaths at ages ≥10 years in rural health facilities was observed in September 2020 and again during April–June 2021 (solid red), corresponding closely in time with the surge in PCR-confirmed cases.

The increase in rural facility deaths was observed despite a drop of about 40% in emergency and inpatient registrations, which coincided with the national lockdown on 25 March 2020 (shown in the are shaded blue). Although the number of emergency and inpatient cases slightly improved after the lockdown, it fell again during the time of the Delta viral wave. Since September 2021, the overall levels of inpatient and emergency cases remained below the pre-pandemic levels. The monthly average number of outpatient visits also dropped from around 40 million before COVID-19 to 26 million during the nationwide lockdown and declined further to 25 million during April–June 2021. Similar patterns were observed across individual states, with Andhra Pradesh showing the highest peaks and Chhattisgarh the lowest (data not shown).

We examined temporal trends in causes of death grouped by their potential association with COVID-19 (figure 3). Each of the crude causes of death classified as highly related to COVID-19 exhibited a decline during the nationwide lockdown, a modest increase during the September–October 2020 wave and a pronounced surge during the April–June 2021 wave, closely paralleling the trajectory of PCR-confirmed cases shown in figure 2 (figure 3A). The number of deaths attributed to unknown causes in HMIS showed a similar temporal pattern to test-positive cases (figure 3B).

Causes of death not related to COVID-19 infections, such as accidents, burns and suicides, showed a sharp decline in April 2020 compared with preceding months, coinciding with the national lockdown. Thereafter, these causes followed a similar downward trend in subsequent months as the pre-lockdown period (figure 3C).

Deaths attributed to tuberculosis exhibit a steady decline throughout the period, appearing largely unaffected by either the national lockdown or the subsequent viral waves of COVID-19. Overall patterns across individual states were broadly consistent, though some variations were observed in the leading causes of death during the April–June 2021

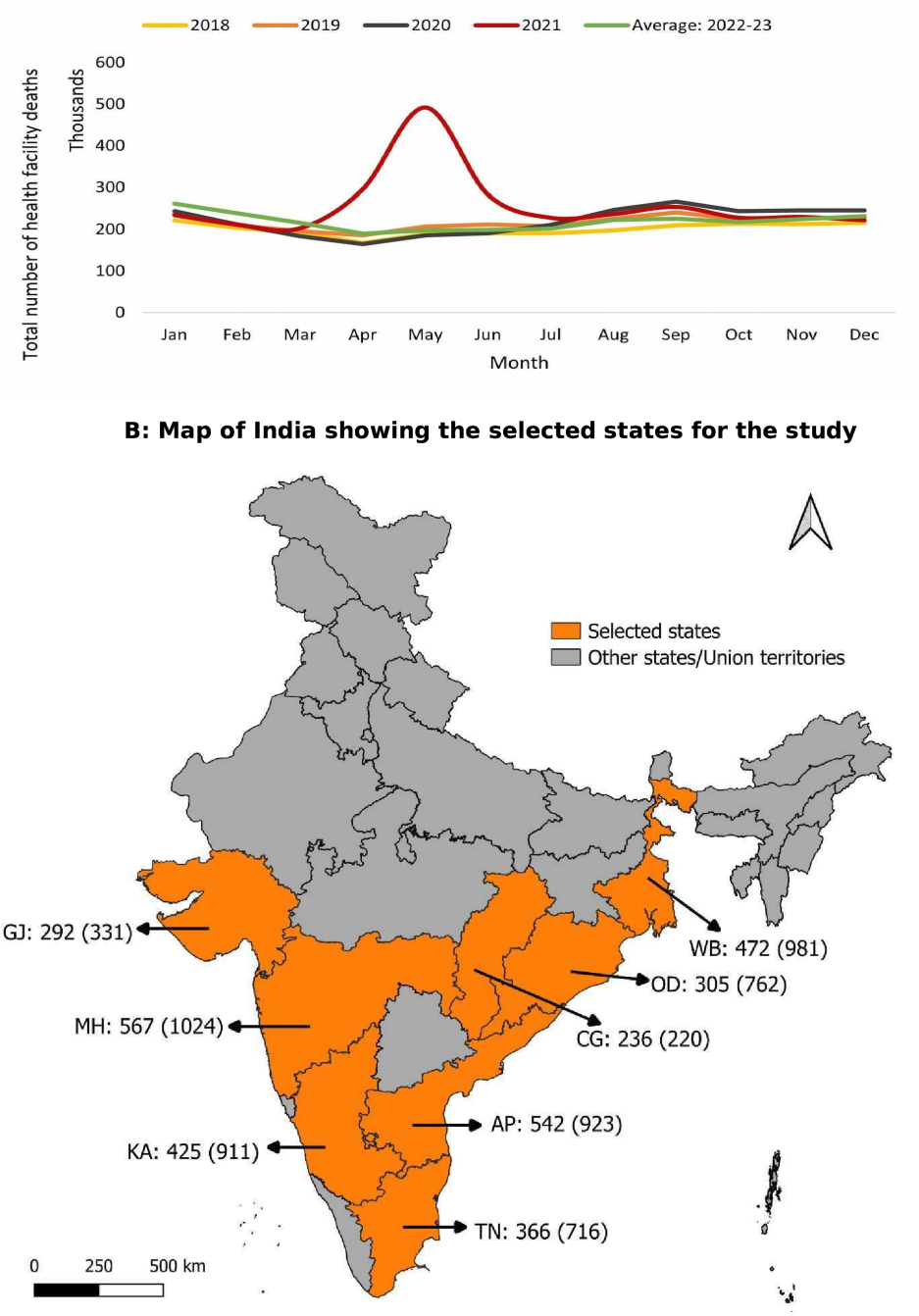

Figure 1 (A) Number of deaths in all Health Management Information Systems facilities (all ages) in India, 2018–2023 and (B) map of India showing the eight selected states for the analysis in the study. Note: Total facility deaths in (A) include both public and private facilities in rural (over 85% of the deaths) as well as a few urban areas. Since monthly counts for 2022 and 2023 were almost identical, these 2 years have been averaged. The initials and numbers in the map correspond to each selected state's abbreviation, total rural deaths in 2020 reported by the United Nations (in 1000s) and in parentheses, rural health facility deaths ages ≥10 years during 2018–2021 reported in HMIS (in 1000s). AP, Andhra Pradesh; CG, Chhattisgarh; GJ, Gujarat; HMIS, Health Management Information System; KA, Karnataka; MH, Maharashtra; OD, Odisha; TN, Tamil Nadu; WB, West Bengal.

viral wave (online supplemental appendix figure 1). The national lockdown led to a sudden and severe restriction of movement and healthcare service provision. Consequently, hospitalisations declined sharply, and the reported number of deaths was substantially lower than the average for the corresponding months in 2018–19 (online supplemental appendix table 3).

All selected states showed similar trends in both overall and cause-specific excess deaths, though some variations were observed across states (online supplemental appendix

Table 1 Population, average number of health facilities, total deaths ages ≥10 years in rural health facilities and estimates of excess deaths in eight selected states of India, 2018–2021

State/regions (rural population 2021 (millions) and rural deaths (1000s))	Average hospital coverage (2018–2020)*	Rural health facility deaths ages ≥10 years (2018–2021)†	Proportion of facility deaths in India	Excess deaths in rural area (2020–2021, all ages in 1000s)‡	Proportion of excess deaths (all ages) in India
Andhra Pradesh (34,542)	9227	923 960	11	66	6
Chhattisgarh (22,236)	6563	220 065	3	23	2
Gujarat (37,292)	13 866	331 115	4	78	9
Karnataka (38,425)	12 632	911 183	11	45	6
Maharashtra (65,567)	13 923	1 024 325	12	70	12
Odisha (37,305)	8526	762 313	9	49	3
Tamil Nadu (36,366)	11 168	716 437	8	83	9
West Bengal (63,472)	12 388	980 530	11	106	10
State sub-total (349, 3205)	**88 293**	**5 869 928**	**68**	**519**	**56**
India (895, 7664)	**206 367**	**8 623 289**	**100**	**1023**	**100**

The rural population of India and its states was compiled from the Government of India population projections.[26]
Number of rural deaths estimated from UN World Population Prospects, 2022.[14]
*Average number of health facilities covered under HMIS reporting system during 2018–2020.
†Aggregate total number of deaths ages ≥10 years in rural health facilities reported in HMIS during 2018–2021.
‡Author calculation of excess deaths due to COVID-19 during 2020–2021 compared with 2018–2019 using CRS number of registered deaths CRS during 2018–2021.[11]
CRS, Civil Registration System; HMIS, Health Management Information System.

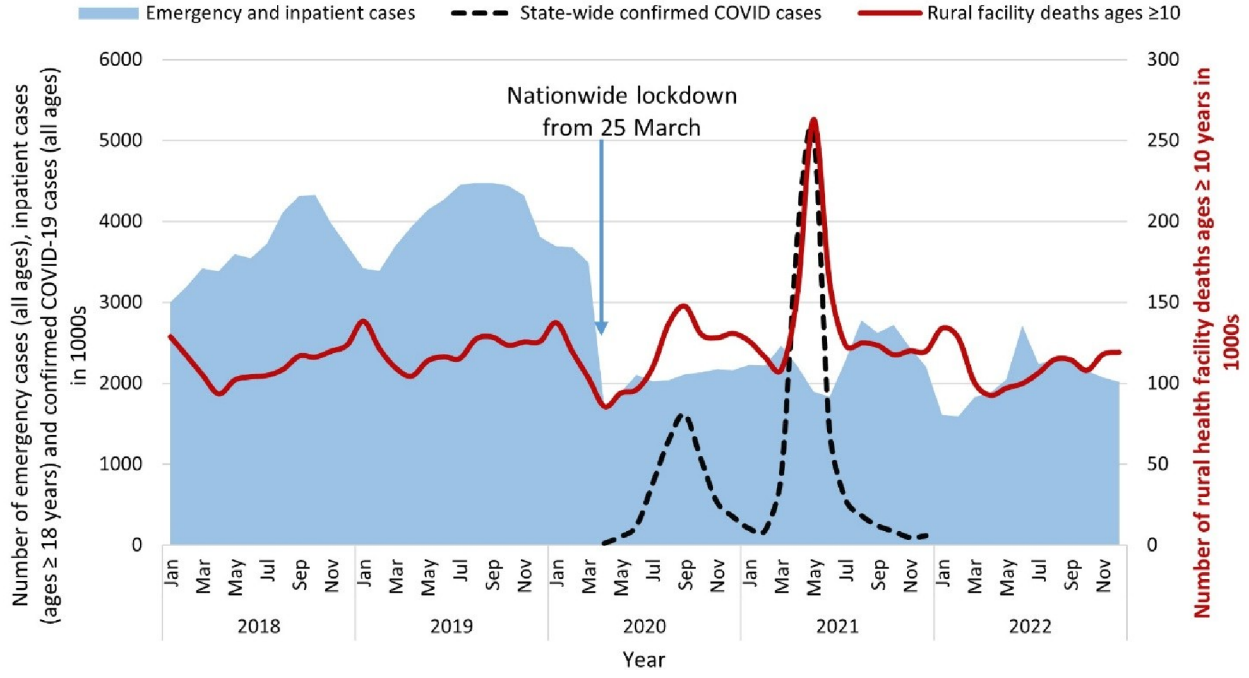

Figure 2 Number of cases reported in the emergency department (all ages), cases of in-patient department (ages ≥18 years), health facility deaths ages ≥10 years in rural health facilities and PCR confirmed SARS-CoV-2 cases (all ages) in the selected eight states of India, 2018–2022. These states are Andhra Pradesh, Chhattisgarh, Gujarat, Karnataka, Maharashtra, Odisha, Tamil Nadu and West Bengal. The emergency cases include the total number of cases registered in the emergency department on each day. The in-patient cases correspond to the total number of adult males and females ages ≥18 years registered in the rural health facility. The total deaths are adolescent/adult deaths aged 10 or above. PCR confirmed COVID-19 cases include the total number of confirmed COVID-19 cases of all ages in eight selected states reported and compiled by Covid19India.org API until October 2021, and then continued the same by Covid19Bharath.org API of DATALAB.

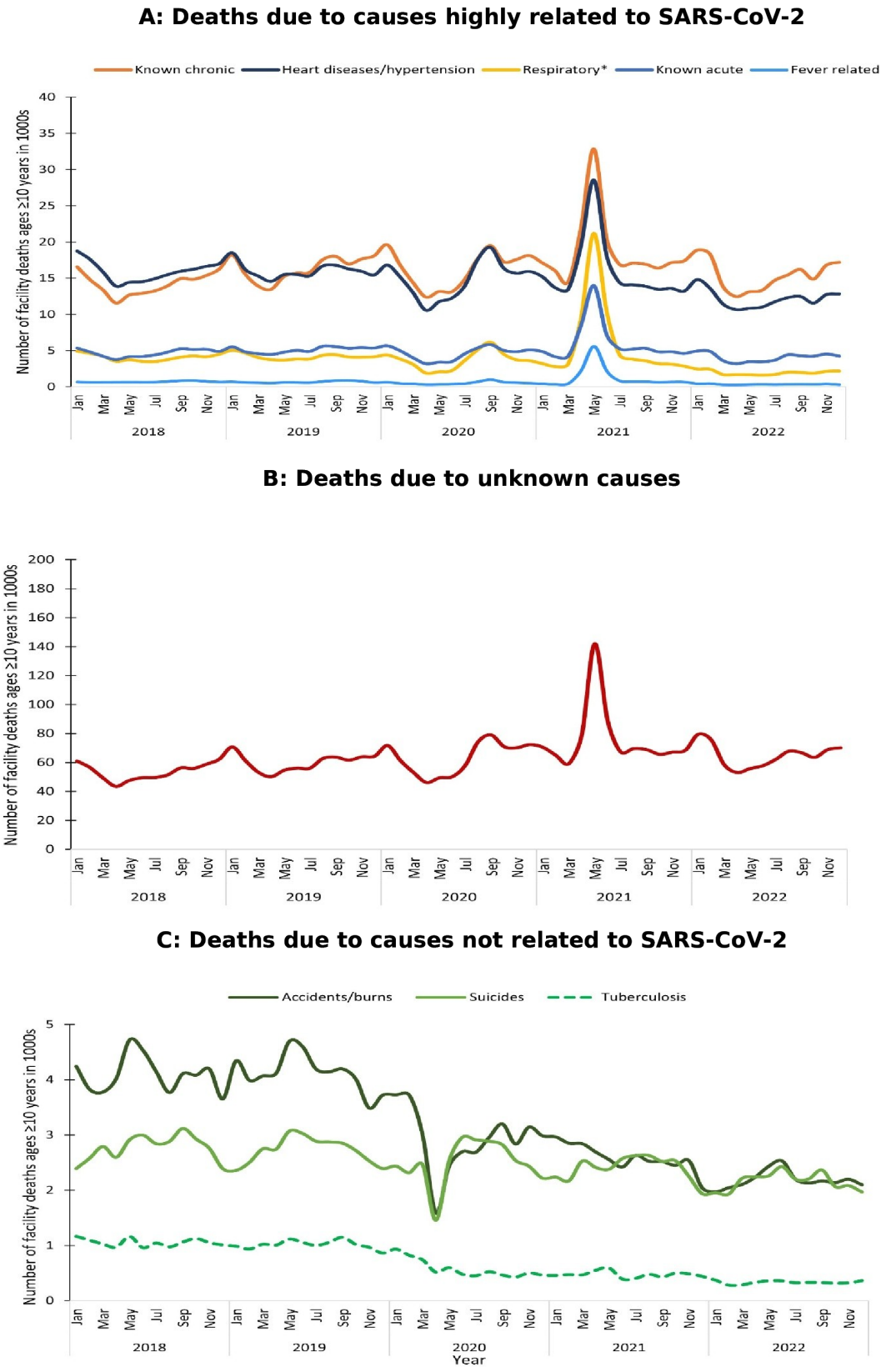

Figure 3 Deaths of adolescents/adults at ages ≥10 years in rural health facilities by cause 2018–2022 in eight selected states; (A) causes highly related to SARS-CoV-2; (B) unknown causes; (C) causes not related to SARS-CoV-2. *Respiratory includes all respiratory infections other than tuberculosis. Unknown causes were the largest categorised causes of death in the HMIS data; therefore, we presented it separately. Causes highly related to SARS-CoV-2 include respiratory infections, fever-related, known acute diseases, known chronic diseases, heart diseases including hypertension and neurological disorders including stroke; causes not related to SARS-CoV-2 include accidents, burns, suicides, tuberculosis, animal bites or stings. HMIS, Health Management Information System.

table 4). Overall, in the selected states, 423408 excess rural health facility deaths among individuals aged ≥10 years were reported during the Delta wave in April–June 2021, compared with the corresponding months of 2018–2019 (table 2). This represents a 270% increase (95% CI 267% to 272%) relative to the pre-COVID-19 baseline (average of 2018–2019) and a 60% increase (95% CI 59% to 61%) compared with the elevated mortality levels observed during the other months of 2021 (January–February and August–December).

Cause-specific excess deaths during the Delta wave were significantly elevated among all causes except tuberculosis, relative to both the pre-COVID-19 baseline and the remaining months of 2021. The pattern of relative excess mortality across causes remained largely consistent between the two reference periods.

Compared with the 2018–2019 baseline, the highest relative excess deaths during the Delta wave were observed for deaths due to fever-related diseases (1016%; 95% CI 1003% to 1029%), followed by deaths due to respiratory infections (612%; 95% CI 598% to 626%) and deaths due to known acute diseases (354%; 95% CI 349% to 359%). Deaths from unknown causes also rose markedly by 315% (95% CI 311% to 318%). Similar patterns of overall and cause-specific excess deaths were observed across each selected states, with some minor variation (online supplemental appendix table 5).

Across rural India, there were about 6.2 million deaths annually, or about 520000 deaths monthly, among individuals aged ≥10 years in 2019, based on estimated UNPD death adjusted to rural proportions in the SRS data.[15] Applying a 167% increase (the lowest 95% confidence interval observed in rural facility deaths) and ignoring seasonality, this corresponds to approximately 865000 excess deaths every month. This implies around 2.6 million excess deaths over three months of the Delta wave (April–June 2021). Using the upper confidence interval yielded an estimate of 2.7 million excess deaths.

DISCUSSION

Despite persistently lower hospital admissions in rural health facilities following the national lockdown in late March 2020, the massive SARS-CoV-2 viral wave driven predominantly by the Delta variant during April–June 2021 likely resulted in at least 2.6 million excess deaths in rural regions of India. While crude, our estimate aligns closely with other studies estimating between three and five million excess deaths due to COVID-19 across India during 2020–2021.[1 4 5 17–21]

Our results are consistent also with the excess in death rates reported in the Registrar General of India (RGI)'s SRS reports for for 2020 and 2021, although these do not provide monthly data.[11] As well, the RGI has published cause of death information, but has not yet released individual year data. A preliminary examination of these reports[22] shows a notable excess of respiratory deaths at all ages in 2021.[7] Further detailed analyses of these reports, as well as the Civil Registration System data[23], are warranted, taking into account both changes in registration levels or in SRS completeness of surveys.[11]

No major spikes in excess deaths were observed in 2022, likely reflecting the combined effects of widespread hybrid immunity acquired from the household transmission during the intense Delta wave, along with the rapid expansion of vaccination from July 2021 onward, which achieved coverage exceeding 90% of the population.[8] Since January 2022, monthly patterns of deaths in the HMIS closely resemble pre-COVID-19 patterns, suggesting that the impact of the Omicron variant during late 2021 and early 2022 was modest. Few excess deaths occurred in 2022 despite evidence from urban Mumbai in Maharashtra state indicating that the SARS-CoV-2 viral loads, a reliable marker of transmissibility, were comparably high during the Omicron and Delta waves.[24]

The national lockdown had lasting effects on health facility inpatient admissions, which remained below the pre-COVID-19 levels through at least December 2023. The full implications of this are uncertain; the 2020 SRS reported a modest increase in under-five mortality, possibly reflecting reduced access to health facilities for treatable childhood illnesses such as pneumonia and diarrhoea, disruptions to vaccination and preventive care services.[7] However, excess mortality among children directly attributable to COVID-19 is likely to be small.

Our study provides the first comprehensive assessment of cause-specific excess mortality related to COVID-19 in rural India, using nationwide health facility death data reported to the MoHFW. The 200000 predominantly rural health facilities contributing to the HMIS are not fully representative of all rural deaths. However, the HMIS remains the only national data source that has maintained a broadly consistent reporting system since 2013. We focused on states with relatively high and stable coverage of expected rural deaths; our detailed evaluation of excess mortality by broad causes of death is unlikely to be significantly affected by the broader shortcomings of HMIS data across Indian states. The HMIS provides only crude cause of death information and lacks detailed age and sex information. Therefore, we could not validate findings from recent household surveys suggesting that excess COVID-19 deaths affected overall life expectancy in rural India.[5] The classification of deaths within the HMIS remained unchanged during the pandemic, and we found no indication that causes were disproportionately shifted into the unknown category (data not shown). As expected, the largest excesses of deaths were observed for fever and respiratory-related causes, while reassuringly low excess deaths were observed due to accidents, burns, bites and tuberculosis. Although comparisons with pre-COVID-19 periods are complicated by the sharp drop in hospital admissions, especially during the lockdowns, interwave comparison periods (non-pandemic months of 2021) revealed marked surges in causes consistent with COVID-19 activity. Given data limitations, we could not determine whether hospital mortality increased more than home deaths, an outcome that might have been expected if the most severely ill individuals continued to seek hospital care during the Delta wave.

The HMIS is a practical system to monitor mortality, as it primarily requires training a core group of staff in each facility. Implementing standardised ICD-coded death certification

Table 2 Excess rural facility deaths ages ≥10 years (normalised to 3 months) from selected causes during the SARS-CoV-2 Delta viral wave (April–June 2021) in the eight selected states of India

Causes of deaths	Number of deaths ages ≥10 years*			Excess deaths during the Delta wave compared with non-viral-peak months in 2021		Excess deaths during the Delta wave compared with the pre-pandemic, 2018–2019	
	Delta wave (April–June 2021)	Non-viral peak months in 2021 (January–February, August–December deaths normalised to 3 months)	Pre-pandemic (April–June 2018–19)	Number of excess deaths	Percentage excess (95% CI)	Number of excess deaths	Percentage excess (95% CI)
Causes highly related to SARS-CoV-2							
Respiratory†	40 971	9706	5756	31 265	322 (315 to 330)	35 215	612 (598 to 626)
Fever related	10 011	1785	897	8226	461 (454 to 467)	9114	1016 (1003 to 1029)
Known acute	29 605	14 573	6526	15 032	103 (101 to 105)	23 080	354 (349 to 359)
Known chronic	75 229	50 649	20 064	24 580	49 (48 to 49)	55 165	275 (272 to 278)
Heart disease/ hypertension	66 095	41 668	22 400	24 427	59 (58 to 60)	43 696	195 (192 to 198)
Stroke‡	19 882	14 972	8181	4910	33 (32 to 34)	11 701	143 (140 to 146)
Causes less related to SARS-CoV-2							
Diarrhoea	337	262	212	75	29 (24 to 33)	126	59 (55 to 64)
Tuberculosis	1533	1394	1572	139	10 (8 to 12)	–39	–2 (–4 to –1)
HIV/AIDS	910	685	689	225	33 (31 to 34)	222	32 (30 to 34)
Cancer	9771	8195	5021	1576	19 (19 to 20)	4750	95 (93 to 96)
Causes not related to SARS-CoV-2							
Accidents/burns	7674	7673	6352	1	0 (0 to 1)	1322	21 (20 to 22)
Animal bites/stings	1134	918	480	216	24 (22 to 25)	655	136 (134 to 139)
Suicide	7369	6983	4219	386	6 (5 to 6)	3151	75 (74 to 76)
Unknown causes	309 967	203 787	74 714	106 180	52 (51 to 53)	235 253	315 (311 to 318)
Total deaths	**580 488**	**363 251**	**157 080**	**217 237**	**60 (59 to 61)**	**423 408**	**270 (267 to 272)**

Pre-pandemic years: January 2018–December 2019, non-viral-peak months: January–February, August–December 2021, Delta wave: April–June 2021.
*In calculation of relative excess deaths due to Delta wave (April–June 2021) for non-peak months, the denominator was three times the average monthly deaths during non-peak months of 2021 (Column (3)) and for pre-COVID-19 the average of 2018 and 2019 April-June death totals (Column (4)).
†Respiratory includes all respiratory infections other than tuberculosis.
‡Stroke includes neurological diseases as well.

across all rural hospitals would not only improve pandemic surveillance but also support India's broader goal of reducing premature child and adult mortality.[15]

The Government of India could help inform the ongoing debate about the true mortality toll of the various SARS-CoV-2 viral waves by including a question on deaths since 2020 in the upcoming Census, now planned for 2027. We recommend that the forthcoming Census modify its existing question on mortality in the last year to this question: 'Since January 2020, has there been a death in the house? If yes, capture the age, sex and month of each death'.[25] This simple effort would provide a simple, transparent and direct estimate of any excess deaths during the viral waves of COVID-19.

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Contributors PK and PJ conceived the study. PK, PJ, WS and AK obtained the data and performed statistical analyses. PK drafted the initial manuscript. PJ finalised the manuscript. All authors reviewed and approved the final manuscript. PJ is the guarantor.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study does not involve human participants. The Unity Health Toronto Research Ethics Board (REB#15-231) granted ethics approval for the project.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. This study uses data from the Annual report published by the Ministry of Health and Family Welfare's (MoHFW's) Health Management Information System (HMIS) which are publicly available at https://hmis.mohfw.gov.in/#!/standardReports.

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