Original Article

Analysis of daily COVID-19 death bulletin data during the first two waves of the COVID-19 pandemic in Thiruvananthapuram district, Kerala, India

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Abstract

Context: Coronavirus disease 2019 (COVID-19) mortality trends can help discern the pattern of outbreak evolution and systemic responses. **Aim:** This study aimed to explore patterns of COVID-19 deaths in Thiruvananthapuram district from 31 March 2020 to 31 December 2021. **Setting and Design:** Secondary data analysis of COVID-19 deaths in Thiruvananthapuram district was performed. **Materials and Methods:** Mortality data were obtained from the district COVID-19 control room, and deaths in the first and second waves of COVID-19 were compared. **Statistical Analysis:** We summarised data as proportions and medians with the inter-quartile range (IQR) and performed Chi-square tests to make comparisons wherever applicable. **Results:** As on 31 December 2021, 4587 COVID-19 deaths were reported in Thiruvananthapuram district, with a case fatality rate of 0.91%. We observed high mortality among older persons (66.7%) and men (56.6%). The leading cause of death was bronchopneumonia (60.6%). The majority (88.5%) had co-morbidities, commonly diabetes mellitus (54.9%). The median interval from diagnosis to hospitalisation was 4 days (IQR 2–7), and that from hospitalisation to death was 2 days (IQR 0–6). The deaths reported during the second wave were four times higher than those of the first wave with a higher proportion of deaths in the absence of co-morbidities ($p < 0.001$). The majority of the deceased were unvaccinated. Ecological analysis with vaccine coverage data indicated 5.4 times higher mortality among unvaccinated than those who received two vaccine doses. **Conclusions:** The presence of co-morbidities, an unvaccinated status, and delay in hospitalisation were important reasons for COVID-19 deaths. Primary level health providers can potentially help sustaining vaccination, expeditious referral, and monitoring of COVID-19 patients.

Keywords: Co-morbidities, COVID-19, elderly, mortality, public health surveillance

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Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused by the novel coronavirus (2019-nCoV) is a major cause of mortality worldwide. As of 31 December 2021, the World Health

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Organisation (WHO) had reported 286,698,666 COVID-19 cases and 5,431,442 related deaths globally, whereas India reported 3,48,27,023 cases and 4,81,162 deaths.[1,2] Concomitantly, the state of Kerala reported 52,47,177 COVID-19 cases and 47,794 deaths.[3] Among the 14 districts in Kerala, nearly 10% of the cases and the highest number of deaths were reported from Thiruvananthapuram district.[2] Despite these high reported numbers, we found a paucity of local studies on characteristics of COVID-19 deaths.

From the beginning of the pandemic, Thiruvananthapuram district, with a population of 3.3 million, consistently figured in the top three districts for reported COVID-19 cases, probably because of the high population density, an international travel hub, a long coastal belt with many seafaring communities, and being a main portal to the neighbouring state.[2-4] The Department of Health and Family Welfare, Government of Kerala, implemented daily compilation of COVID-19 cases and deaths, with reports disseminated during daily press meetings chaired by the honourable state Chief Minister. Surveillance based on death counts is classically denominator-free data. Case-specific data of all COVID-19 cases, and not just deaths, are preferable, but often only aggregate data are available on these, even in resource rich countries.[5] Analysing patterns in death counts may still offer clues of disease burden in sub-groups or changes over time. Daily death surveillance data included information on basic demographic, disease-related, and hospital admission details. Analysing potential epidemiological patterns in these may offer important insights to improve treatment outcomes and may help administrators to plan district/state-specific interventions. Family physicians are often the first point of contact for COVID-19 patients, and such a study may help identify clinical patterns that may facilitate triage, early referral, or enhanced monitoring of COVID-19 cases at the primary care level.[6] The objective of this analysis, therefore, was to summarise demographic and clinical characteristics of COVID-19-related deaths reported in Thiruvananthapuram district for 22 months ending December 2021.

Materials and Methods

Setting and design

The overall approach to COVID-19 control in Kerala has been published earlier.[7] Soon after the first case in Kerala, the district established a control room under the District Medical Officer (DMO), the senior-most health official at the district level. Around ten teams were formulated for various purposes, of which one was assigned COVID-19 death reporting. The team comprised a doctor as a nodal officer, a public health expert, and data entry operators under the leadership of DMO and the District Surveillance Officer (DSO). We performed secondary data analysis of COVID-19 death surveillance data obtained from the control room of Thiruvananthapuram district, which reported its first COVID-19 case on 11 March 2020 and the first COVID-19 death on 31 March 2020.

Study variables

According to the COVID-19 guidelines, a confirmed COVID-19 case is defined as a positive result by using real-time reverse transcription polymerase chain reaction (RT-PCR)/molecular tests/rapid antigen test (RAT) and the death resulting from a clinically confirmed COVID-19 case. For "brought dead" cases, a positive RT-PCR/RAT/cartridge-based nucleic acid amplification test (CBNAAT) result in a post-mortem sample was taken as COVID-19 death if the person had not undergone any COVID-19 test before death.[8] We excluded deaths because of suicides, homicides, or accidents even if the person was COVID-19-positive at the time of death.

The treating physician/medical superintendent of the hospital where COVID-19 deaths occurred was required to prepare a medical bulletin containing demographic details, test results, admission, and the cause of death. The reporting process had two phases: (i) from 31 March 2020 to 15 June 2021, the bulletin was sent to an e-mail created exclusively for COVID-19 death reporting. Reports of the preceding 24 hours were verified and forwarded to a state-level COVID-19 death audit committee, who finalised the list of COVID-19 deaths on a daily basis. (ii) From 16 June 2021 onwards, through an online portal called "COVID-19 death online portal".[9] The portal has two functionalities – death entry for reporting institution and death audit for declaration at the district level. The declaration process of COVID-19 deaths was decentralised to the district level, though the state continued to have complete data access. Death reports were obtained from public and private sector institutions through appropriate directives. A nodal officer was posted exclusively for private hospital collaboration for COVID-19 control activities.

Statistical analysis

Data were divided into two time periods: deaths declared during the (a) first wave, extending from 31 March 2020 to 16 April 2021, and the (b) second wave, extending from 17 April 2021 to 31 December 2021. All programmatically confirmed deaths were included for our analysis. The variables included for the analysis were (i) sociodemographic characteristics – age, gender, area of residence, and place of death – and (ii) clinical characteristics – symptoms, comorbidities, cause of death, interval between the date of confirmation of COVID-19 and hospital admission, and the interval from admission to death. We summarised data as median with inter-quartile range (IQR) or proportions, along with 95% confidence intervals (CI), with performed Chi-square tests wherever applicable. For the vaccination status, we computed mortality rate using denominators from vaccination coverage data in the district.[10]

Ethics

This analysis was part of a larger study on district level interventions during the COVID-19 pandemic in Thiruvananthapuram district. The proposal was reviewed and cleared by the institutional ethics committee of Health Action by People, Thiruvananthapuram district *(IEC. No EC1/P3/Aug/2021/HAP; dated 6th September 2021).* Data extracted were de-identified and stored securely with the investigators. No harm was expected from this analysis as it fell under less than minimal risk according to the national ethical guidelines for the Indian Council of Medical Research (ICMR).

Results

As on 31 December 2021, Thiruvananthapuram district had reported 52,47,177 confirmed COVID-19 cases and 4587 COVID-19 deaths, with an estimated case fatality of 0.91% (95% CI 0.88–0.94%). In the first wave, it was 0.86% (95% CI 0.81–0.92%), and in the second wave, it was 0.93% (0.89–0.96%). The monthly COVID-19 death counts during the period studied are displayed in Figure 1. The second wave witnessed about four times more deaths than the first wave (3663 to 924).

Demographic characteristics

The demographic details of the deceased are given in Table 1. The proportion of males was significantly higher in the first wave as compared to the second wave ($P < 0.001$). Female deaths increased during the second wave, peaking in June and July 2021, and then followed the overall pattern of male deaths. The median age of the deceased was 67 years (IQR 56–75), with the highest proportion being in those aged over 60 years. Women did not have an advantage over men in terms of median age of mortality as shown in Figure 2. Among all deaths, the proportion of persons above 60 years was comparable in the first and second waves (66.12% and 66.85%, respectively, $P = 0.60$). There were 172 deaths reported among those under 40 years of age in the second wave. Overall, there were more deaths in rural areas, with no evidence of a significant shift from urban to rural areas in the second wave ($P = 0.16$).

Clinical characteristics

The majority (94%) of the deceased were symptomatic, with the most common being influenza-like symptoms (ILI) including fever, cough, and sore throat. Other symptoms reported included fatigue (5.3%), myalgia (3.4%), diarrhoea (1.8%), and vomiting (1%). About 98% deaths were in a hospital, mostly in government hospitals (77.99% – mainly in Government Medical College, the biggest teaching hospital in the area). The most frequent cause of death was bronchopneumonia. Other causes included acute respiratory distress syndrome (ARDS), multiple organ dysfunction (MODS), renal failure, sepsis hepatic failure, and diabetic ketoacidosis. Three quarters of the deceased had lung damage. The proportion of bronchopneumonia with ARDS

Table 1: COVID-19 deaths – Demographic characteristics and reported cause of death

Variables and categories	First wave (N1=924) *n* (%)	Second wave (N2=3663) *n* (%)	Total (N=4587)
Age in years			
≤30	15 (1.6%)	47 (1.3%)	62 (1.4%)
31-40	24 (2.7%)	125 (3.4%)	149 (3.2%)
41-50	75 (8.1%)	346 (9.4%)	421 (9.2%)
51-60	199 (21.5%)	696 (19.0%)	895 (19.5%)
61-70	282 (30.5%)	943 (25.7%)	1225 (26.7%)
>70	329 (35.6%)	1506 (41.1%)	1835 (40.0%)
Gender			
Male	600 (64.9%)	1997 (54.5%)	2597 (56.6%)
Female	324 (35.1%)	1666 (45.5%)	1990 (43.4%)
Area of residence			
Rural	443 (47.9%)	1945 (53.1)	2388 (52.1%)
Urban	371 (40.2%)	1731 (47.3%)	2102 (45.82%)
Domicile in other states	27 (2.9%)	70 (1.9%)	97 (2.1%)
Place of death			
Government hospital	845 (91.5%)	2599 (70.9%)	3444 (75.1%)
Private hospital	69 (7.5%)	947 (25.9%)	1016 (22.1%)
Home (including "brought dead")	10 (1.0%)	117 (3.2%)	127 (2.8%)
Cause of death*			
Bronchopneumonia	774 (83.8%)	2008 (54.8%)	2782 (60.6%)
Bronchopneumonia with ARDS	632 (17.3%)	949 (25.9%)	1581 (34.5%)
MODS	46 (5.0%)	29 (0.8%)	75 (1.6%)
Sepsis	68 (7.3%)	273 (7.5%)	341 (7.4%)
Renal	123 (13.3%)	122 (3.3%)	245 (5.3%)
Hepatic	38 (4.1%)	65 (1.7%)	103 (2.2%)
Diabetic ketoacidosis	4 (0.4)	19 (0.5%)	23 (0.5%)

*Multiple causes possible in some cases, totals do not add up to 100. ARDS: Acute respiratory distress syndrome; MODS: Multi-organ dysfunction syndrome

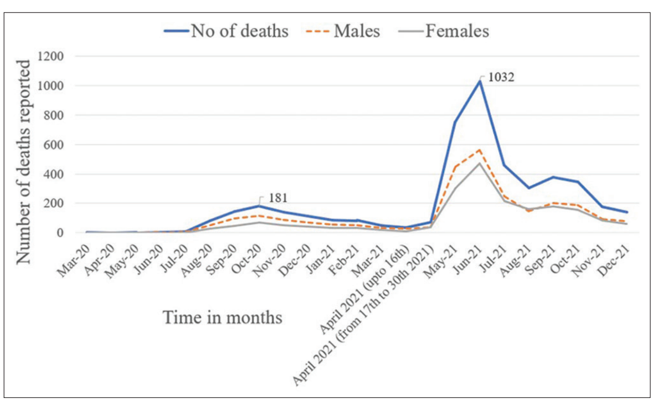

Figure 1: Trend of COVID-19 death count in Thiruvananthapuram district in the first two waves of the COVID-19 pandemic – total and sex-specific

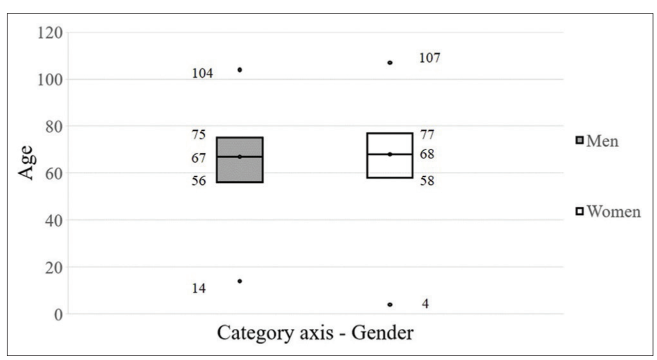

Figure 2: Median, quartiles, and minimum and maximum values of age at death because of COVID-19 for men and women in Thiruvananthapuram district

was significantly higher during the second wave ($p < 0.001$). Three of the deceased had aspergillus infection, and 12 had mucormycosis (of invasive, pulmonary, and cutaneous types).

Table 2 provides the co-morbidity patterns reported. More than four-fifth of the (88.2%) COVID-19 deceased had at least one co-morbidity, and most had multiple co-morbidities. The most common co-morbidities reported were diabetes mellitus and hypertension. The second wave witnessed a significantly higher proportion of deaths without any associated co-morbidities ($p < 0.001$). Compared to the first wave, the proportion of deaths with diabetes mellitus increased, whereas the proportion of deaths with other co-morbidities such as cerebrovascular accidents, coronary artery disease, renal problems, and so on was lower in the second wave. We expect this to be a relative decrease consequent to a steeper increase in mortality in those without co-morbidities or those with diabetes.

We found that the median time from the date of COVID-19 confirmation and hospital admission was 4 days (IQR 2–7) and that between hospital admission and death was 2 days (IQR 0–6). Some COVID-19 death bulletins mentioned reticence of patients to seek institutional care initially, followed by direct referral to tertiary care centres on deterioration of conditions.

Deaths reported in special groups

We found that 18 health care workers (HCWs) had deaths because of COVID-19 in total. Among them, six were during the first wave and 12 were during the second wave. During the second wave, the district started witnessing COVID-19 deaths in certain categories. It included four antenatal deaths, whose age ranged from 28 to 32 years. Three pregnant women had co-morbidities – diabetes mellitus (in all three), hypothyroidism, and asthma. The district also reported two infant deaths (age – 39 days and 3.18 months) and one neonatal death (age – 3 days) ascribed to COVID-19. Four COVID-19 deaths were reported from among tribal communities.

Table 2: Co-morbidity pattern reported with COVID-19-associated deaths

Variables and categories	First wave (N1=924) *n* (%)	Second wave (N2=3663) *n* (%)	Total (N=4587)
Presence of co-morbidity			
No	23 (2.5%)	349 (9.5%)	372 (8.1%)
Single	130 (14.1%)	349 (9.5%)	479 (10.4%)
Multiple	711 (76.9%)	2873 (78.5%)	3584 (78.1%)
Missing	60 (6.5%)	92 (2.5%)	152 (3.3%)
Co-morbidity reported*			
Diabetes mellitus	401 (43.4%)	2121 (57.9%)	2522 (54.9%)
Hypertension	466 (50.4%)	1900 (51.9%)	2366 (51.6%)
Coronary artery disease	196 (21.2%)	675 (18.4%)	871 (18.9%)
Cerebrovascular diseases	72 (7.8%)	189 (5.2%)	261 (5.7%)
Renal problems	197 (21.3%)	553 (15.1%)	750 (16.4%)
Chronic liver disease	38 (4.1%)	118 (3.2%)	156 (3.4%)
Dyslipidaemia	74 (8.0%)	248 (6.8%)	322 (7.01%)
Cancer	46 (4.9%)	107 (2.9%)	153 (3.3%)
Respiratory disorders	105 (11.4%)	344 (9.4%)	449 (9.8%)
Obesity	36 (3.9%)	58 (1.6%)	94 (2.0%)
Others	23 (2.3%)	302 (8.2%)	325 (7.1%)

*Multiple causes possible in some cases, totals do not add up to 100

COVID-19 deaths and vaccination

More than 80% of the deceased had not received even a single dose of a COVID-19 vaccine. About 15% of deaths were in vaccinated persons (691), in whom 62.37% had received a single dose (431) and 37.62% had received two doses (260). Most of them had received a viral vector vaccine (82.19%, 568). We analysed COVID deaths and the vaccination status pertaining to death data of 1 month (September 2021), and the results are given in Table 3. The total number of COVID-19 deaths reported during September 2021 was 387. Among the deceased, 94% (363) belonged to the over 45 age group. The proportion of unvaccinated (not received any dose) was 53% (207), and 47% (180) had received at least a single dose (both doses – 55 and single dose only – 125). Using the vaccination coverages reported up to 31 August 2021 as denominators of unvaccinated persons, those who had received a single dose and those who had received two doses, we ecologically estimated mortality rate in each of these groups. As compared to those who received two doses of vaccines, those who were unvaccinated can be considered to have 5.38 times higher rate of mortality (95% CI 4.02–7.29). Similarly, as compared to those who had received at least one dose of vaccine, unvaccinated persons had a 3.65 (95% CI 2.93–4.56) times higher rate of mortality. As compared to those who received both doses, the mortality rate in those who had received one dose was 1.48 times higher (95% CI 1.08–2.04).

Discussion

Our study attempted to provide insights into the evolution of the COVID-19 pandemic in Thiruvananthapuram district, Kerala. We tried comparing the mortality profile of the first and second waves, and we discuss our findings in terms of demographic, clinical, and system-related aspects. Mortality was marked in the elderly and those with co-morbidities. Men were disproportionately affected in the beginning, but by the second wave, mortality in women caught up with mortality in men. The mortality pattern in the second wave also saw a higher proportion of young persons and those without co-morbidities. We estimated the aggregate case fatality as nearly 1% but could not use case-based death rates for analysis because of paucity

Table 3: Reported vaccination coverage in Thiruvananthapuram district and the vaccination status of the deceased persons during September 2021

Vaccination status	Population over 18 in the district*	Deaths (From study data)	Estimated deaths per million
Unvaccinated	631188	207	328
One dose	1390282	125	90
Two doses	902643	55	61
Total	2924113	387	479

* State vaccination bulletin – 31 August 2021[9]

of data. In this section, we discuss the preponderance of deaths in elderly and males, the possible underlying clinicopathological picture, patterns around the comorbidity profile, the vaccination status, and mortality among HCWs. As this study is based on secondary data analysis, we also discuss about the reporting system and possible limitations thereof.

As expected, people aged over 60 years predominated in the counts.[11,12] However, the absolute number of youngsters dying because of COVID-19 increased over the period we studied, a pattern seen globally.[13] The reasons for this need to be explored further. Men seem more vulnerable than women.[14] This may be biological – the increased expression of angiotensin-converting enzyme 2 receptors for the coronavirus in males and immunological differences in sex hormones and chromosomes.[15] It could also be behavioural – because od smoking and alcohol use.[16] We could not find a rural–urban divergence. Kerala has a faint rural–urban divide in general, and this seems to extend to COVID-19 patterns as well.

Similar to other studies, the predominant symptoms reported were ILI, with respiratory failure as the leading cause of death.[17,18] Known pathological models have demonstrated direct viral attack of ACE2-expressing cells (in blood vessels and lung alveolar epithelial cells) and infected lungs showing desquamation of pneumocytes.[19,20] Renal or hepatic problems and MODS are also patterns reflected in the literature on COVID-19 mortality.[21-23] Deaths in maternal and neonatal/infant sub-groups were generally very low, suggesting lesser mortality risk or the presence of optimal care systems.

COVID-19 patients with underlying diseases are more likely to develop critical illness and progress to death.[23-26] The Kerala population is particularly vulnerable because of high prevalence of non-communicable diseases, especially diabetes, and this was reflected in the study.[27] However, we found increasing deaths among those without any co-morbidities from the first wave to the second wave. Probably, this reflects a triage pattern – patients with medical conditions might have been prioritised for hospital admission. A saturation of hospital facilities with such patients might suggest less availability of life-saving services when rapid patient deterioration occurs in the absence of co-morbidities. In this context, we found a small but important number of COVID-19-associated home deaths. Another finding of concern is the median time from admission to death of 2 days. A study in Tamil Nadu reported this as 4 days.[28] Delay in seeking hospital admission, the tendency to follow home isolation, and inability to follow home isolation protocols might be the reasons for the shortest stay. The occurrence of home deaths or deaths soon after admission pointed the lacunae in monitoring of patients on home isolation protocols or the secondary care level, and this needs further exploration.

Even when looking at just death counts, a protection and dose response effect is suggested. When compared with population counts of the vaccination status, our findings strongly hint at this plausibility. The district started its vaccination drive against COVID-19 on 16 January 2021. The health department and state administration systematically expanded vaccination based on the availability.[10,29]

The pandemic witnessed commendation of commitment and professionalism of HCWs but many deaths among them as well.[1] We found doubling in the number of deceased HCWs during the second wave, probably a consequence of the general increase in disease and deaths. Most HCW infections in Kerala were reported to happen in non-COVID care areas. The risk or protective factors of individual or occupational nature need to be explored further.[31]

In our study, we found that the majority of the deceased were admitted in government hospitals. Kerala is acclaimed, or its public health care system with well-equipped infrastructure and resourceful manpower and patient preference towards public health care institutions might be a possible reason. Moreover, the government hospitals provided enhanced COVID-19 testing, protocol-driven laboratory investigations, and treatment facilities free of cost, leading to a much higher admission of COVID-19 patients in government hospitals. However, several research questions can be raised here, such as the quality of care at different levels, referral patterns, and reporting practices from private sectors.

The main limitation of this paper is that the data have limitations in terms of completeness of reporting and the lack of information regarding treatment responses and laboratory reports were not available for the analysis. Even if there is consistent under-reporting, the trends may still be useful unless there is differential reporting for different sub-groups based on demographic or clinical characteristics (e.g., more reporting from urban than from rural), which is unlikely in Kerala. Also, mortality measures can be considered as hard health data, unlike morbidity surveillance. Our findings emerge solely from death counts. Rothman deems drawing inferences from such data as "fragile" but reiterates the value of monitoring of death statistics, citing John Graunt and William Farr.[31]

COVID-19 mortality estimates continue to climb upwards in Kerala. The median age of the reported deaths falls well below the most recent average life expectancy at birth of 78 years for women and 71 years for men.[32] The lack of a longevity advantage in women in COVID-19 deaths needs further exploration. Thus, exploring patterns discernible from available surveillance data remains useful.

Key take-away points and implications for family physicians and primary care providers:

Our study reiterates the need to prioritise COVID-19 in elderly and patients with co-morbidities such as diabetes mellitus.[33,34] Based on our findings, what we would like to stress upon is the increased death among young and those without co-morbidities when there is a big wave of disease. With saturated health systems, family physicians will continue to be important first-point contacts in such situations.[6] Rigorous patient self-monitoring and judicious triaging and referral by family physicians and primary care providers may be helpful to minimise mortality in those with no obvious risk factors. Telehealth facilities may be useful in establishing and maintaining such systems.[34]

Conclusion

Our study based on COVID-19 mortality data found consistent patterns of COVID-19 mortality among the usual risk groups. The pandemic augmented the vulnerability of the elderly population and became a peril to the people with non-communicable diseases. The state needs to sustain vaccination levels. The short duration between hospital admission and death would be carping, and the reasons for this should be elucidated and addressed. Additionally, documenting practices related to quality care and referral at all levels from home isolation through all tiers of the health system may be very useful. Any large wave of the pandemic may potentially result in avoidable mortality in those who may have survived otherwise.

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Conflicts of interest

There are no conflicts of interest.

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