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Nutritional Status and COVID-19 among Older Persons in Kerala, India

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Abstract

Background and Aims: The COVID-19 pandemic has posed an unprecedented public health crisis globally irrespective of age. There is no doubt that the older population (above the age of 60) is the most vulnerable age category due to multiple comorbidities, which often is not in their favour. Age category, types of co-morbidities and nutritional levels indeed play a pivotal role in determining mortality rates. This paper focuses on Kerala, a southern Indian state and how it maintained low mortality levels due to COVID-19 during the first wave despite being the state with the highest proportion of the older population. The present study argues although the state possessed a robust health system and had an active engagement of the public health sector with its citizens through local governments, it was the state's meticulous planning, innovative schemes centred around older persons such as reverse quarantine, the prevailing excellent nutritional status among its population and initiatives to ensure good nutrition through food security schemes like 'essential grocery kits' and 'community kitchens' that helped to develop the body's resistance to infection and thus played a significant role in flattening the curve for Kerala's older adult COVID-19 deaths effectively, thereby achieving a high recovery rate and low rates of fatality during the first wave of COVID-19 in Kerala. **Methods:** Pre-COVID-19 health conditions of older adults in Kerala were analysed through Kerala Ageing Survey (KAS) panel data and Longitudinal Ageing Survey in India (LASI) data. Percentage analysis, Logistic regression method and Cox hazard regression methods were used to analyse the effect of nutritional levels on health and mortality among older adults in Kerala. Publically available COVID-19 data from the Government of Kerala and the Government of India were used to analyse the COVID-19 death rates. In addition, changes in dietary patterns and other preventive measures taken to fight against COVID-19 were investigated through qualitative response. **Result:** The study found that nutritional status influences mortality and co-morbidities among older adults in Kerala in the pre-COVID situation. Furthermore, the study found that though nutritional indicators, that is, overweight or obese, significantly increases the risk of comorbid conditions among older adults, good nourishment reduces the risk of all-cause mortality. The study also found that Kerala's COVID-19 fatality was much lower when compared to India and developed nations like the US, UK and Italy. Even if Kerala is one of the highly COVID-19 affected states, the effective nutritional intervention by the Government of Kerala through its various schemes to build up the general immunity of the state's citizens, especially high-risk groups; thereby achieving low COVID fatality in the state. **Conclusion:** Based on Kerala's experience, nutritional factors influence the population in building up the body's resistance to infection against COVID-19. Even though the fatality rate is very low, obesity coupled with non-communicable diseases affects preventive measures of the state. There is an immediate and persuasive need to find new and more efficient clinical studies apart from socio-epidemiological studies, which could play a pivotal role in determining COVID-19 health outcomes.

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Keywords

ageing, COVID-19, food security, health policy, malnutrition, nutritional status, population density, social isolation, odds ratio, India

Highlights

What Do We Already Know About This Topic?

There is a lack of research on COVID-19 mortality among older adults. Furthermore, the lack of knowledge about the relationship between nutritional status and COVID-19 mortality among older persons makes the study extremely relevant in the current situation.

How Does Your Research Contribute to the Field?

The majority of the COVID-19 deaths were among older people. However, due to its well-designed nutritional and care policies, Kerala was the only state able to successfully reduce COVID-19 mortality among older persons. Because of the limited research available on COVID-19 mortality among the older adults, the current study aims to prove that proper nutrition can help to prevent it.

What are Your Research's Implications Towards Theory, Practice, or Policy?

The present study will aid in the formulation of policies regarding the nutritional status of the older persons in the future, allowing them to live a longer and healthier life.

Introduction

Older adults are at the highest risk of COVID-19 mortality and thereby demographically the most affected group worldwide. This is due to social exclusion and restrictions on certain rights, such as those which result from the imposition of quarantine or isolation that limit freedom of movement intending to contain the spread of the virus. It is due to the same reason that this category of the population faces a challenge and fear of illness and death in the wake of the COVID-19 pandemic.¹ Both population density² and the age profile of the population^{3,4} have been flagged as factors in the pandemic. Older adults have been medically identified as

more susceptible to death. According to a meta-analysis of COVID-19 positive patients up to May 7, 2020, from China, Italy, Spain, the United Kingdom, and New York State, more than 23% of the subjects were aged 80 years and above.⁴ The lowest per cent of octogenarians (90+ years) affected was in China, and the highest was in the U.K. and New York State.

Kerala's public health authorities have long been mindful of the state's susceptibility to global epidemics. This comparatively high uncertainty is attributed to the high degree of engagement with the global economy, the huge non-resident community residing in many parts of the world,⁵ and the state economy's dependence on domestic and international tourism. The Nipah virus epidemic in 2018 was one such incident that raised awareness of such a threat. Since then, Kerala has adopted a surveillance mechanism to aggressively search for emerging pathogens that may affect the state's health. Kerala became alert as soon as the COVID-19 pandemic broke out in China and released appropriate guidelines like the 'Break the Chain' campaign. Through an active strategy of quarantining susceptible cases, testing all high-risk contacts and, if found positive, tracing their contacts and keeping them isolated, Kerala achieved low transmission rates initially, thereby increasing the rates of recovery among existing COVID-19 cases. Though positive cases were originally isolated in healthcare institutions, home-based isolation and management were introduced later in the state due to the increasing number of cases. Presently, symptomatic persons (except the mild ones) and high-risk positive cases (older adults, those with co-morbidities) are isolated and managed institutionally. Also, high recovery rates were achieved because of proactive management of cases with strict management guidelines in healthcare institutions wherever indicated. The rapid expansion of healthcare infrastructure to manage COVID-19 was also an important reason.

Being the Indian state with the highest number of older persons,^{6,7} Kerala was expected to have the maximum number of COVID-19 deaths as they were at the greatest risk of serious infection and death if infected. But strikingly, according to the Ministry of Health and Family Welfare, the state performed better than the nation and became a global example in containing the virus with the best recovery statistics (around 94.4% recovered and .4% died, which is less than the national average (1.5%) during the first wave. Though the primary reason for Kerala's low case fatality is early diagnosis, isolation and comprehensive management, the current article tries to prove that nutrition played a significant role in bringing down COVID-19 deaths among older adults in Kerala during the first wave.

Conceptual Framework

The risk of survival or death among the older population arising from the COVID-19 virus is primarily determined by three major underlying causes, household access to quality food, health and hygiene, and the treatment/care habits practised by the household where an older person lives. But the immediate causes are individual food intake and health status or other underlying diseases. The combined effect of these variables influences individual food consumption and their health status (Figure 1). Also, the interplay between these variables determines the nutritional state of older adults, which regulates their survival, recovery or mortality from the virus. The conceptual framework used in the article is an adaptation of the UNICEF Conceptual Framework for the cause of malnutrition.⁸

Material and Methods

Data

The paper analyses the Kerala Ageing Survey (conducted by the Centre for Development Studies over the last 15 years in Kerala) to study the pre-COVID nutritional level of older persons in Kerala. The survey covered a total of 4940 older persons in 2004 and continued as a longitudinal survey repeated every three years and has completed its 6th iteration in 2019.⁶ The study uses data from 2004 as the baseline, while data from 2019 is considered a follow-up. The sample size covered in 2004 was 4940 older adults. However, in 2019, a gradual decrease in the number of people throughout the survey was noted, 988 adult persons were alive, and 238 adult persons had died in 2019. Individuals who were not interviewed, or those with missing data, were excluded. The paper also incorporates data on COVID-19 cases from the Government of Kerala dashboard⁹ and the Directorate Health Services (DHS) website¹⁰ Government of India,¹¹ Ministry of Health and Family Welfare, 2020 and the world data were taken from Global Change Data Lab. website¹²

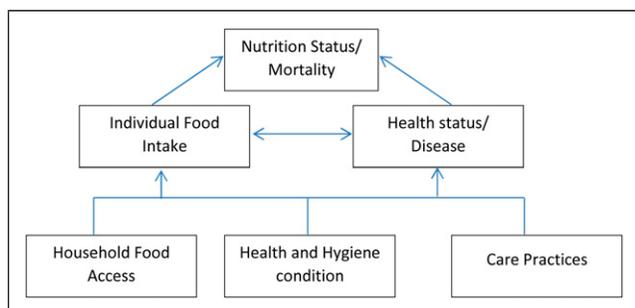


Figure 1. Conceptual framework of nutrition and COVID-19 mortality and survival among older persons. Source: Developed by the authors. Original model available at Bellamy C. The State of the World's Children 1998: Focus on Nutrition. UNICEF, UNICEF House, 3 UN Plaza, New York, NY 10017; <http://www.unicef.org/1998>.

Measures

Nutritional Status: The Mini Nutritional Assessment (MNA) was used to assess respondents' nutritional status. The 18 items in the MNA were grouped into anthropometric assessment, general assessment, dietary assessment and subjective assessment. Each item was scored in the standardised procedure with total scores ranging from 0 to 40.¹³ Respondents were then categorised into one of three categories: well-nourished (a score of 24 or higher points), at risk of malnutrition (17–23.5 points) and malnourished (a score below 17 points).

Body Mass Index: Body mass index was calculated using the height and weight of the older persons with the formula weight/height.² The scores were categorised into Underweight (<18.5), Normal (18.5–24.9), Overweight (25–29.9) and obese (30 and above).

Methods

Cox hazard regression was used to analyse the effect of nutritional status on all-cause mortality, and logistic regression analysis was performed to assess the association between nutritional indicator BMI and incidence of co-morbidity condition among older adults in Kerala.

Preliminary Case Fatality Rate (CFR) for the period March 2020 to February 2021 were computed using the formula, $CFR = (\text{Number of COVID-19 death} / \text{Number of confirmed cases}) * 100$

In addition, to understand the role of nutritional status in averting infection and death of older persons amidst the COVID-19 pandemic, specific case studies were done with health professionals, ASHA (Accredited Social Health Activist workers), Kudumbashree members, COVID-19 survivors and family members of the deceased.

Results

Nutrition History of Older Adults in Kerala: Pre-COVID-19 Scenario

Of the 4940 participants, 2272 (46%) were male and 2668 (54%) were female. The mean age (SD) of the population was 69.9 (7.6) years. Among all participants, 458 (9.3%) were undernourished, 2937 (59.4%) were at risk of under-nutrition and 1545 (37.6%) were well nourished. Of the total sample, 2045 (41.3%) died during the 15-year follow-up period. 'Undernourished' and 'at risk of under nutrition' groups contributed to most of the deaths. Of the total alive in 2019, nearly 40% were 'well-nourished' (Table.1)

Effect of Nutritional Risk Factors on All-Cause Mortality

To investigate the effect of nutritional risk factors on all-cause Mortality among older persons in general, cox hazard

regression analysis was done and the results presented in Table 2. Those in the undernourished and those at risk of under-nutrition show significantly greater risk for all-cause mortality. In comparison with well-nourished, the risk of dying of undernourished was found to be significantly ($P < .001$) higher with a hazard ratio (95% CL) of 1.967 (1.690–2.290). Also, when compared to well-nourished, those at risk of under-nutrition had a significantly ($P < .001$) higher risk of dying with a hazard ratio (95% CL) of 1.214 (1.092–1.348). Thus, being undernourished or being at the risk of under-nourishment is one of the risk factors among older persons over 15 years. When comparing the older persons of poor/very poor health condition, with people of excellent/good health condition, the later had a significantly ($p = .001$) lower risk of dying with a hazard ratio (95% CL) of .669 (.592–.756), and people with fair health condition had significantly ($p = .001$) higher risk with hazard ratio .705 (95% CL .635 – .783). Nutritional indicator, that is, BMI on all-cause mortality indicates that BMI and risk of mortality are inversely related; thus, the lower the body cell mass, the higher the mortality. Regression analysis found that ‘overweight’ or ‘obese’ were not significant risk factors for all-cause mortality

Table 1. Nutritional level of the older persons in Kerala, KAS 2004–2019.

Nutritional Level of Older persons in Kerala, 2004–2019			
Nutritional Status	2004	2019	
		Alive	Died
Undernourished	9.3	4.3	13.6
At risk	59.4	57.5	61
Well-nourished	31.3	38.3	25.4
Total	100	100	100

Source: Special Tabulations from Kerala Ageing Survey 2004–2019, co-ordinated by the first author.

among older persons. This is consistent with the findings of the international study published in the Journal of The American Geriatrics Society that adults aged over 70 years and classified as overweight were less likely to die over 10 years than adults who were in their normal weight range. Mortality risk was lowest for participants with a BMI classified as overweight and this benefit was not seen in those people who were obese; overweight may not be associated with mortality.¹⁴

COVID-19 Pandemic

COVID-19 crisis had effects on lives of human beings, both at individual and community levels, in its various dimensions. The World Health Organization (WHO) declared Coronavirus Disease 19 (COVID-19) a pandemic on March 11, 2020.¹⁵ Majority of COVID-19-related deaths occurred among older adults, particularly in individuals with two or more co-morbidities, with cardiovascular disease, diabetes, chronic obstructive pulmonary disease, malignancy and chronic renal disease being the most common causes.¹⁶ Ensuring nutrition is the ‘best practice’ against COVID-19 pandemic and in fact is one of the most cost-effective strategies to assist healthcare systems in managing patients and individuals in their recovery from COVID-19.¹⁷ Preventive measures taken to contain the spread of the virus such as repeated lockdowns brought economic disruption which threatened nearly half the world’s workforce with loss of their livelihoods (Impact of COVID-19 on people’s livelihoods, their health and our food systems).¹⁸ This global economic downturn caused by lockdown has adversely affected people’s ability to access food. Movement restrictions and stay-at-home orders aimed at containing the virus have directly affect the household’s ability to purchase enough food.¹⁹ According to Moseley and Battersby,²⁰ people with co-morbidities are more vulnerable to COVID-19 which often results in higher mortality and morbidity rates and thereby

Table 2. Results from the Cox regression analysis showing the hazard ratio from Kerala Ageing Survey 2004–2019.

Hazard Ratio					
	Reference Category	P-value	Hazard Ratio	95.0% CI	
				Lower	Upper
Nutrition in 2004					
Undernourished	Well nourished	.000	1.967	1.690	2.290
At risk		.000	1.214	1.092	1.348
Health perception in 2004					
Good/Excellent	Poor/	.000	.669	.592	.756
Fair	Very poor	.000	.705	.635	.783
Body mass index in 2004					
Underweight	Overweight/	.000	1.583	1.356	1.848
Normal	Obese	.062	1.106	.995	1.229

Source: Special Analysis from Kerala ageing survey 2004–2019, co-ordinated by the first author.

indirectly affecting other aspects like labour, income and food access. The virus and measures to contain its spread have had profound implications for food security, nutrition and food systems. Good nutrition is a key for backing up the human immune system and lowering the perils of infections. However, as people's ability to access food declines in the crisis, this adversely affects their ability to manage a healthy diet.²¹ This impact is mostly felt in low- and middle-income countries, where the poorest households typically spending more than half of their income on food compared to households in high-income countries.²² The shift in consumption towards to poor nutritious food during the crisis could have underpinning effects, as people who are experiencing malnutrition are more vulnerable to contracting the disease and aggravating the situation.^{23,24} In this background, there is a need to understand food security and the nutritional implications of the crisis and its relation to COVID-19 vulnerability.

Adequate nutrition is a crucial line of defence against viral infections.²⁵ Even modest deficiency of several micronutrients might affect the immune response.^{26,27} Relevant micronutrient consumption particularly of iron and vitamins B12, C and D have found to have an inverse relationship with illness incidence and mortality, particularly in populations with a genetic susceptibility to low micronutrient status. On the other hand, the global incidence of hunger and trace element insufficiency is expected to have an impact on COVID-19 results (Fedele et al 2021).²⁸

COVID-19 and Obesity

Obesity has been identified as a major negative prognostic factor for COVID-19.²⁹ Obesity may influence infection risk as well as overall clinical outcomes in individuals infected with H1N1 swine flu, as it was seen during the 2009 pandemic.³⁰ Obesity-related chronic illnesses (such as hypertension, diabetes mellitus and others) are linked to severe COVID-19 consequences; therefore, the influence of obesity on the severity of COVID-19 has attracted much interest.³¹ Due to quarantine and social isolation, changes in food habits and lifestyle factors may result in nutritional deficiency. Obesity and concomitant co-morbidities are linked to physiological changes that increase susceptibility to infection, pathogenicity, and COVID-19 transmission (Figure 1).³²

COVID-19 and Nutrition

Malnutrition has been linked to increased hospital length of stay, mortality and re-admission rates and has been recognised as an adverse prognostic factor.³³ As a result, malnutrition and undernutrition are circumstances that may increase the severity and prognosis of the disease; nevertheless, suffering from COVID-19 generates a state that leads to body weight loss and malnutrition.³⁴ COVID-19 infection symptoms might influence food intake as well.³⁵ A significant link

Table 3. Self-reported prevalence (%) of diagnosed multi-morbidity conditions among older adults, states/uts, LASI wave 1, 2017-18.

<i>Comorbid Conditions among the Older Persons in Kerala, 2017–18</i>			
		<i>Kerala</i>	<i>India</i>
Age 45-59*	No morbidity	43.5	63.1
	Single health condition	30.1	24.3
	Two or more health conditions	26.4	12.7
	Number	1277	40 682
Age ≥ 60	No morbidity	21.4	47.9
	Single health condition	26.4	28.8
	Two or more health conditions	52.2	23.3
	Number	1206	31 386
Total	No morbidity	32.1	56.1
	Single health condition	28.2	26.3
	Two or more health conditions	39.8	17.5
	Number	2483	72 068

Source: Longitudinal Ageing Survey in India 2017-18* Including spouse irrespective of age 1 multi-morbidity conditions refer to the presence of two or more chronic diseases which include hypertension, chronic heart diseases, stroke, any chronic lung disease, diabetes, cancer or malignant tumour, any bone/joint disease, any neurological/psychiatric disease or high cholesterol

exists between vitamin D deficiency and severe COVID-19 symptoms.³⁶

Impaired nutritional status is linked to advanced age and comorbidities.³⁷ Due to changes in both innate and adaptive immune responses, the complex interplay between immunity and nutrition in ageing is clinically important and has a detrimental influence on antibody generation, vaccination response and infection susceptibility.^{38,39}

Adults with greater rates of malnutrition were found to have an increased risk of pneumonia.⁴⁰ The new strands of COVID-19 appears to be linked to the nutritional condition of patients. Older adults, who are often malnourished, are particularly sensitive to this virus, and obesity has been linked to an increased risk of ill health and death following COVID-19 infection.⁴¹

Malnutrition or co-malnutrition are major risk factors for many older COVID-19 patients, according to clinical findings.⁴² Hospitalized older people with COVID-19 who are malnourished or have a low BMI have a higher risk of death.⁴³ The majority of elderly individuals admitted to hospitals for COVID-19 therapy are malnourished.⁴⁴

Co-Morbid Conditions Among Older Adults in Kerala and India

Kerala is the most advanced state in India in terms of demographic transition, with mortality levels close to those of developed nations for the last several decades.⁴⁵⁻⁴⁷ Morbidity levels are comparatively higher than elsewhere in India.⁴⁸ This scenario continues with the recent national-level Longitudinal Ageing Survey in India; 2017–18 reporting

Table 4. Results of logistic regression analysis using KAS data 2004–2019.

Nutritional indicators	β	P-value	Odds Ratio	95% CL	
				Lower	Upper
Underweight	-.691	.000	.501	.447	.562
Normal weight	-.285	.000	.752	.701	.806
Overweight/Obese®			1		

Source: Special Analysis from Kerala Ageing Survey 2004–2019, co-ordinated by the first author.

morbidity in Kerala well above that in India (Table 3). Comparing the reported morbidity in Kerala with the overall national scenario, single morbid conditions and multi-morbid conditions were higher in Kerala for ages between 45–59 years. Considering older adults, multi-morbid conditions were much higher in Kerala – more than half the older persons (aged 60 and above) in the state reported having been diagnosed with two or more health conditions.⁴⁹

In India, 26.3% of older adults aged 45 and above reported having been diagnosed with a single health condition and 17.5% with two or more health conditions. Around a quarter of older adults aged 60 and above had two or more health conditions (23.3%) compared with 12.7% among older adults aged 45–59. On the other hand, in Kerala, 28.2% of older adults aged 45 and above reported single health conditions and nearly 40% reported multiple morbid conditions. More than half of older adults aged 60 years and above have multiple morbid conditions compared with a quarter of older adults aged 45–49. This health profile suggests that Kerala has been going through an epidemiological transition with an unprecedented increase in the non-communicable disease burden.⁴⁹

Multiple comorbid conditions constitute a major public health challenge and the state is facing a high burden of NCDs and their risk factors. A systematic review of the prevalence of NCDs reveals that cardiac problems, diabetes, and all forms of cancers and chronic respiratory diseases are significantly high in Kerala.⁵² One of the studies from Kerala pointed out that overweight was more predominant among the upper socio-economic class.⁵³ Another study observed that in Kerala, the risk factors for NCD start early in life. Kerala is a highly consumerist state in India which increasingly depends on commercially available food preparations with high content of salt, energy and trans-fats that favour the development of risk factors.⁵⁴

Kerala Ageing Survey (2004–2019) was used to estimate the association between nutritional indicator BMI and co-morbidity among older adults in Kerala. Co-morbidity was measured as the simultaneous presence of two or more chronic health conditions including cardiovascular diseases, hypertension, stroke, diabetes, cancer, chronic respiratory diseases, arthritis and asthma. Logistic regression model was fitted to test for association between BMI and prevalence of co-morbidity. Estimated crude odds ratio shows being underweight (OR = .051; 95% CL: .447–.562; $P < .001$) and

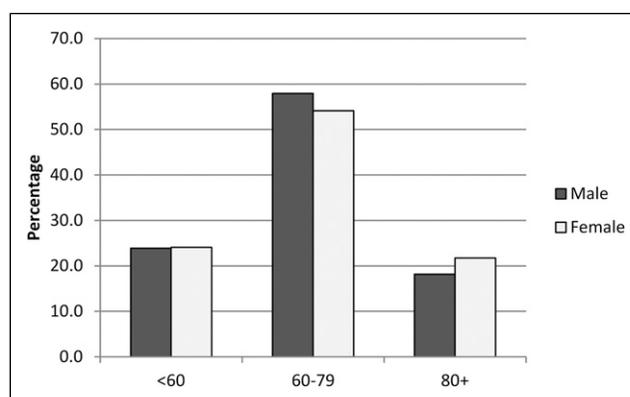


Figure 2. Percent distribution of COVID-19 deaths by age and sex in Kerala 2020–2021. Source: <https://dashboard.kerala.gov.in/deaths.php> Deaths up to February 16, 2021, as of 21/02/2021

normal weight (OR = .752; 95% CL: .701–.806; $p = .001$) was associated with significantly less likelihood of having co-morbidity as compared to overweight/obese category (Table 4). The likelihood of co-morbidity was higher among the overweight/obese category. This independent association between BMI and co-morbidity demonstrates that overweight or obesity is an important predecessor to multiple chronic morbidities and also an important risk factor for future morbidity.

Existing health condition highlights how the on-going COVID-19 pandemic puts older persons and persons with co-morbidities at the highest risk of contracting the disease. According to the WHO, older people and people of all ages with pre-existing medical conditions (such as diabetes, hypertension, heart disease, lung disease or cancer) appear to develop serious illnesses more often than others.

COVID-19 Death Among Older Persons in Kerala

As per the data released by the Kerala government through its COVID-19 dashboard, more than half of all COVID-19 fatalities in the state occurred in the age group of 60–79 years (Figure 2). Out of the total deaths that occurred in Kerala, 56.9% of estimated deaths are in the age groups of 60–79 years and 19.1% are in age groups of 80+ years. COVID-19 deaths were predominantly among older persons compared to other age groups. Gender differentials in COVID-19 deaths also vary significantly by age, with the gender pattern of death rate not

being the same in all age groups. For example, among individuals aged 0–19, 20–39 and 80+ years, females have a comparatively higher COVID-19 mortality, whereas the death rate was high among males in the 40–50 and 60–70 years age group. Up to 80 years of age, the COVID-19 death rate rises by age for both males and females.

Figure 3 shows the monthly distribution of COVID-19 death among older adults in Kerala from March 2020 to February 2021. From May onwards, interstate and international travel was allowed, Keralites in Gulf and other foreign countries returned to Kerala, consequently the number of COVID-19 cases increased. However, the effective health system of the state was able to curb the death rate. From August onwards, a sudden peak in COVID-19 death was observed in Kerala and the maximum death rate was recorded between the month of October and December.

According to the Kerala Health department, most COVID-19 deaths were observed in cases without any known source of infection, while lower death rates were

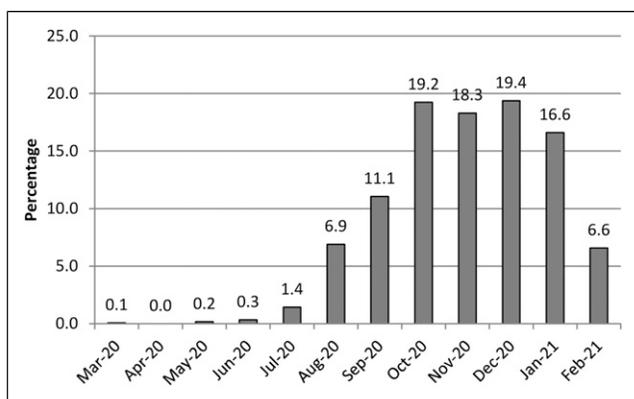


Figure 3. Monthly COVID-19 deaths (%) among older persons in Kerala, March 2020 to February* 2021. *Deaths up to February 16, 2021 (As of 21/02/2021) Source: <https://dashboard.kerala.gov.in/deaths.php>

observed for those with a known source of infection. It was also revealed that the major co-morbidities found in Kerala’s COVID-19 death cases were cardiovascular diseases, diabetes, chronic respiratory diseases, hypertension and cancer and most deaths were diagnosed with multiple co-morbidities.

Comparison of Case Fatality Rate of COVID-19

The case fatality rate (CFR) is a measure of the ability of a virus to infect a host in infectious disease and is described as the proportion of deaths within a defined population, that is, the percentage of cases that result in death.⁵⁵ CFR helps to recognise the disease severity, identify the risk of the population and assess the quality of the healthcare system. Compared to other states in India, the case fatality rate of COVID-19 is very low in Kerala even as the state stands second in numbers of reported positive cases (Figure 4).

Figure 5 shows the CFR of COVID-19 for the state of Kerala in comparison to India and other countries. Here, the CFR is computed from March 2020 to February 2021. Even though Kerala is one of the states highly affected by COVID in the country, the number of reported COVID-19 deaths in the state is much lower than those in India as well as other highly affected nations. Kerala had a CFR of .4%; much lower than the national average (1.4%). Also, Kerala’s CFR is lower than that of the USA, UK and Italy. Thus, in comparison to India and other countries, the incidence of COVID 19 death was much lower in Kerala.

If we compare the Case Fatality Rate (CFR) of Kerala with Italy, where more than 23% of the population are older persons, Italy has a CFR of 3.4%. Applying Kerala’s (.4%) to Italy, there would be an 88% reduction in the current deaths of 96,974 (as of February 26, 2021). When a similar exercise was applied to the United Kingdom, we see an 86% reduction in total deaths. Furthermore, Figure 6 clearly states that Kerala shows a lower death rate among older persons compared to Italy.

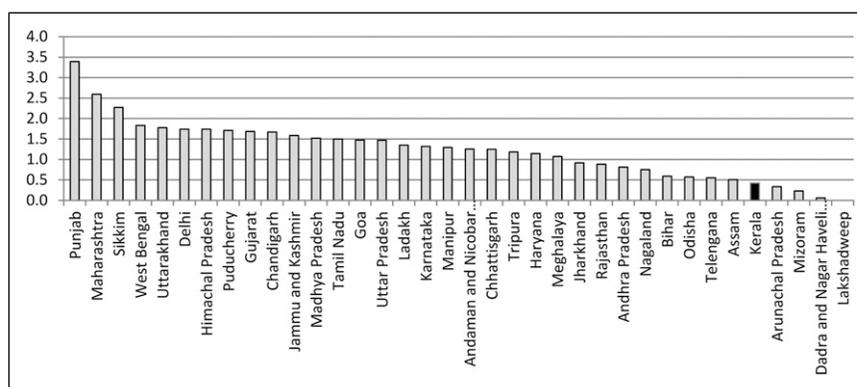


Figure 4. Case fatality rates (%) of COVID-19 by states in India, up to February 16, 2021. Source: <https://www.mohfw.gov.in/>

Kerala's Approach in Controlling COVID-19

From the 1990s till now, India's public health system was crumbling due to a lack of public investment and political commitment towards a positive social change. As a result, when the pandemic hit India, its health system as a whole was vulnerable and strained, unable to overcome new challenges. Kerala, on the other hand, has injected a new vigour into the public health system. Changes have been implemented in the state's public health over the last four years through a primary care-centric health project called *Aardram*.⁵⁶ Modern public health facilities were constructed as part of the mission, with proportional enhancements in the numbers of physicians, nurses and other healthcare personnel. The programme also helped deepen neighbourhood management and strengthened hygiene and sanitation in the state. The strategy has been a huge success, and its impact was first showcased when Kerala warded off the Nipah virus outbreak in 2018.⁵⁶ Kerala's recent accomplishment in combating the COVID-19 virus

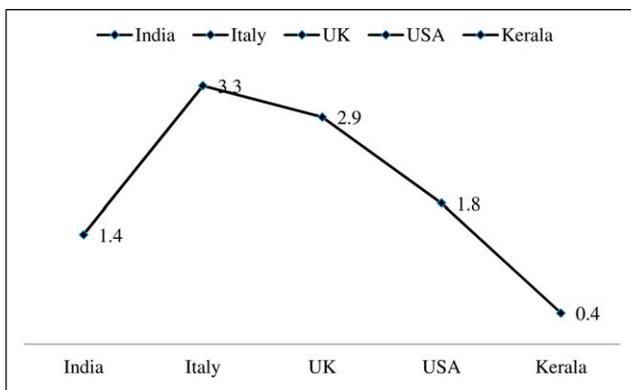


Figure 5. Comparison of COVID-19 Case fatality rate of selected countries and Kerala. Source: <https://ourworldindata.org/coronavirus>

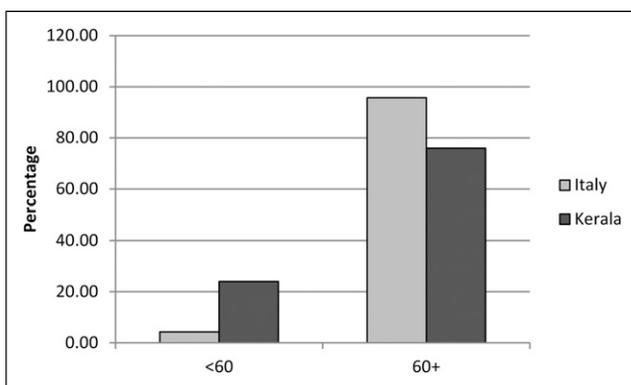


Figure 6. Percent distribution of deaths by age in Italy and Kerala. Source: <https://www.statista.com/statistics/1105061/coronavirus-deaths-by-region-in-italy/>; Source: <https://dashboard.kerala.gov.in/deaths.php> Deaths up to February 16, 2021, as of 21/02/2021 for both Italy and Kerala.

further strengthens this argument. Kerala witnessed the recovery of an old couple aged 93 and 88 years from COVID-19 with special care from a dedicated team of doctors and paramedical staff in the public health system, in stark contrast to the high COVID-19 mortality rate in the older population globally.⁵⁷

To encounter an infectious epidemic like COVID-19, the best approach is a participatory style of governance that can rapidly achieve population dissemination, and wherein the relationship between the state and its citizens is solid, trustworthy and organic. In Kerala's approach, primary functions were discharged by local councils through active citizen engagement. To bolster this, the state also had a huge volunteer force of 377 308 that played a major role in ensuring the supply of food and relief material and also helped in maintaining steady surveillance of the population.⁵⁶ It is this powerful participatory governance mechanism that has helped Kerala's COVID-19 control initiatives. A decentralised model of governance, a strong public health system and education are the three main pillars that influenced the nutritional and health-seeking behaviour of the population.

As soon as news began to spread about the COVID-19 virus, the Kerala state government began planning control measures. To prevent community transmission of COVID-19 in Kerala, the state government had to overcome various hurdles like high population density, a high proportion of older population and people with co-morbidities, and groups of internal migrants camping together (302, 02, 016 migrants were in relief camps during the first lockdown period, about 47.9% of the total migrants in relief camps/shelter homes all over India).⁵⁸ Furthermore, the government foresaw isolating the international migrant population returning to the state to prevent spread. Following international practice, the state government implemented a pre-planned state lockdown on March 23, 2020, one day before the Indian government announced a nationwide lockdown. The Government of Kerala released instructions for the control of the virus as soon as the virus outbreak was reported, and began recording, monitoring and quarantining suspected individuals arriving from possible epicentres and their contacts using its comprehensive 'COVID-19 *Jagratha*' portal to contain the spread of the virus.

Kerala was the first state in India to report a COVID-19 case on January 30, 2020; a student from Wuhan, China. After resolving the first case, the first wave started on March 10 with 12 cases in a family returning from Italy. On March 10, a day before the World Health Organisation declared the Coronavirus outbreak a pandemic, Kerala shut down all educational establishments and entertainment centres banned large congregations and called on people to stop visiting religious sites. As of May 1, 2020, Kerala had the lowest case fatality rate of .8% while the nationwide average was 3.23%.⁵⁹ By May 1, 2020, Kerala's doubling time of 30 days was almost three times the national average of 11 days.⁵⁶ On 1st, 2nd and 5th May 2020, Kerala reported zero new cases. The state authorities had flattened the early curve through a

series of steps that included creative contact-tracing and segregation, strict enforcement of lockdown measures and a comprehensive local public health system. The containment paradigm of the COVID-19 pandemic in Kerala was lauded not only in India but across the world.

The next phase of the pandemic started with the opening of international, national and state borders on May 7, 2020, and posed a significant challenge to holding the virus at bay, but the government again responded with committed preparation like proper documentation and screening at airports, institutional quarantine and proactive COVID-19 testing.

But merely placing people under a lockdown to prevent deaths and transmission was not easy. During the lockdown, all activities except the essential ones were to go into shutdown mode. With the economy at a halt and no daily income, families would go hungry and finally break lockdown protocols to satisfy their basic need of food. Thus, the Kerala government had to accomplish a herculean task to save lives from COVID-19 and tackle hunger in parallel.

Food Security

Among the 17 Sustainable Development Goals (SDGs) announced by the United Nations, the second one deals solely with food and nutrition, and categorically with stopping malnutrition, ensuring food security, enhancing nutrition, and fostering sustainable agriculture. India's National Health Policy 2017 has also established a movement to shift away from 'sick-treatment' to 'wellness'. This cannot be done without maintaining sufficient nutritional care for the general population, and children and women in particular.⁶⁰

According to FAO (1996),⁶¹ food security is attained when 'all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. The pandemic has affected food flow globally. This can be attributed to a number of reasons mainly 'food availability', prices and vendors and personal aspects, including geographical access, affordability, convenience and desirability".⁶²

Nationwide lockdown in India to contain the spread of the virus caused economic disruption which has created unemployment in the informal sector. Since most Indians (more than 380 million) seek jobs in the informal sector are not supported by any labour laws, a formal work contractor steady income which is very likely anticipated to a decline in nutritional status.⁶³ According to Headey and Ruel,⁶⁴ the pandemic has acted as a catalyst for a 'global malnutrition'. It is likely that the underprivileged will respond to the crisis by purchasing the cheapest calories they can find. The United Nations System Standing Committee on Nutrition⁶² states that sustainable healthy diets with sufficient fruit and vegetables will be crucial in protecting people's immunity against COVID-19. This is particularly important for those with pre-existing non-communicable diseases.⁶⁵ The measures to contain the spread of virus have had intense consequences for

food security, nutrition and food systems. At the same time, malnutrition (including obesity) increases vulnerability to COVID-19.²⁴ Keeping this in mind, Government of Kerala has introduced the community kitchen and food kits through public distribution system as food security for all the people in Kerala whoever needed irrespective of their economic and social status.

The government of Kerala recognised that food security is the central threat to the population breaking lockdown protocols. They opened community kitchens on March 30, 2020, in collaboration with Kudumbashree self-help groups, local self-governments, public sector institutions, co-operatives and voluntary organisations. Under this scheme, any family or individual unable to prepare food at home was delivered meals through rapid response delivery chains, with special focus on individuals and families in quarantine/isolation, bedridden and older people, destitute persons and those living in temporary accommodation.

The Kerala government also distributed Grocery Food Kits from the state's Public Distribution System through its local self-government institutions. Under the scheme, every family in the state of Kerala was eligible to get a food kit that contained essential raw food items for daily use (refer Table 5).

The governmental policy of food security through grocery kits was indeed an effective strategy. It helped the internal migrant community as well as others to prepare food items of their own choice. It also had a significant impact on the COVID-19 situation in Kerala as it ensured that people stayed indoors and followed lockdown protocols, thereby reducing the rates of transmission. The delivery of food kits and food parcels through the volunteers also was a form of double-checking to ensure that none of the individuals under quarantine or lockdown broke protocols and thus helped develop an effective case monitoring mechanism.

Dietary Suggestions During the Pandemic From Various Branches of Medicine

Since nutrition is important in building the body's resistance to infection, the former has an inevitable role in a pandemic situation.⁶⁶ Some dietary suggestions given by various bodies are the inclusion of fruits, vegetables, whole grains and nuts in the diet; ensuring that food is served at acceptable temperatures; reducing the intake of salt, sugar and oil; and avoiding fast food, bakery foods and soft drinks. Kerala also started the use of *ayurvedic* medicines and other natural remedies as a preventive measure in mitigating the spread of COVID-19.⁶⁷

The efficacy of the immune system is largely derived from the diet. Several vitamins (A, B6, B12, C, D, folate and E) and trace elements (zinc, copper, selenium and iron), as well as essential amino acids and fatty acids, play key roles in supporting to reduce the risk of infections, of which zinc and selenium seem to be particularly important for the latter.

Table 5. Contents of the grocery kit distributed by the government of Kerala and its calorie distribution.

Contents of Grocery Kit		
Item	Quantity	Calories
Sunflower oil	1 kg	8840
Coconut oil	1/2 kg	4310
Salt	1 kg	0
Wheat flour	2 kg	7280
Rava	1 kg	3600
Green gram	1 kg	3470
Black channa	1 kg	1630
Toor dal	1/4 kg	858
Mustard	100 gm	66
Fenugreek	100 gm	323
Coriander	100 gm	23
Urad dal	1 kg	3500
Chilli powder	100 gm	40
Sugar	1 kg	3870
Tea	250 gm	3
Soap	2 No's	N / a

Source: <https://www.onmanorama.com/kerala/top-news/2020/03/29/kerala-government-food-kit-coronavirus-lockdown-list-of-items.html>

Dietary approaches to achieve a healthy microbiota can also benefit the immune system.

The older population of the state was the most affected because they were instructed not to go out of their homes due to their high probability of contracting the virus and developing serious infection leading to death. Similar was the case with bedridden persons, older people living alone, and those suffering from chronic illnesses and organ failures. Inability to access healthcare and procure food and other essential supplies made the situation much worse for them. The government of Kerala introduced what was known as reverse quarantine to meet the needs of these vulnerable sections of the population.

Through this scheme, any older individual (bedridden, living alone, those suffering from chronic illness and organ failures) was delivered food, medicines and other essential items through volunteer groups, local self-government (LSG) institutions and the *Janamaithri* Police. Primary health workers, also known as ASHAs (Accredited Social Health Activists), played a pivotal role as intermediaries between the individual and the LSG and local primary care institutions. They reported to these institutions, made lists of potential beneficiaries in their area of jurisdiction, and ensured that all essential items were delivered on time as per need. Through this mechanism, the government not only ensured minimum contact for the above-mentioned group of individuals but their nutritional and other essential needs as well, helping curb COVID-19 spread and mortality in the state.

Qualitative Study Report

Qualitative response of health professional, ASHA workers, older COVID-19 survivors and family members of the deceased older persons were collected to investigate the changes in lifestyle and dietary pattern during the pandemic.

Responses from health professionals reveal that infected patients at home or in ICUs, as well as persons under surveillance, were advised to follow a specific diet with vitamin supplements. They were also advised to drink plenty of water and follow personal hygiene and ensure proper sleep. This helped them to improve bodily defence systems and thereby reduce their vulnerability to infection. For older persons and those with advanced co-morbidity, reverse quarantine was advised. Older persons with co-morbidities were also advised to follow a disciplined lifestyle, eat healthy meals, take medications without fail and closely monitor their health condition. They were advised to report immediately to the health facilities if they noticed any suspected symptoms.

The information collected from ASHA workers revealed that close monitoring of older persons who were in reverse quarantine was done, and ASHAs were actively willing to help with their needs regarding medicines, food and other essentials. These persons were visited frequently to enquire about their health conditions and encouraged to follow a proper nutritional diet and good personal hygiene.

Interviews with older COVID-19 survivors indicated they followed the advice of health professionals and ASHA workers properly by changing their dietary patterns. During their reverse quarantine period, they were forced to change their lifestyle behaviour through intake of timely dietary food, and natural herbs and other *ayurvedic* medicine as preventive measures. Even with co-morbidities, the change in their nutritional behaviour improved their ability to cope with the infection.

Interviews with family members of deceased older persons revealed that most deaths occurred while under treatment for co-morbidities. Older persons admitted for the treatment of co-morbidities got infected through their bystanders or by other means.

The qualitative report of the study clearly revealed that during the pandemic period the state population fought against the virus by changing their lifestyle behaviour like by taking a healthy and nutritional diet. Eating home cooked food, drinking plenty of hot water, avoiding overuse of junk and other processed foods not only helped the population to improve their nutritional level but also enhance their resistance to infection. There are several situations during the pandemic that could have compromised access to adequate nutrition due to social isolation; a necessary measure to contain the spread of COVID-19. However, the effective implementation of the food security system through proper decentralisation of work dissemination helped the government manage this situation efficiently. The main preventive public health strategies of the state in response to COVID-19 was to

provide essential health services and social services including integration of sustainable food system interventions to promote the production, distribution and consumption of healthy diets. Thus, the state was able to manage the low fatality rates of COVID 19 through evidence-based strategic plans.

Discussion

The Government of India formulated the National Nutrition Policy in 1993. In general, major nutrition problems in Kerala are undernutrition, anaemia, overweight, obesity and dietary/nutritional disorders. Disproportionate dietary and nutritional disorders in older adults make them more vulnerable as they pass through multiple ailments. The state of Kerala has a nutrition policy to reduce these problems based on a 'life cycle approach', which was formulated in 2014 with the technical support of UNICEF. According to the National Family Health Survey (NFHS – 4), Kerala reported, overweight and obesity as most prevalent in older adults. Several non-communicable disease (NCD) risk factors, including obesity, diabetes and cardiovascular disease, are associated with an increased risk of serious illnesses and death from COVID-19. This has evidence from the words of a family member of a deceased older adult that the patient had chronic co-morbidities such as heart problems and diabetes. Also, this study proved that the post-COVID-19 condition is highly vulnerable to co-morbidities and may lead to death. This was proven by the words of an ASHA worker who was directed to take the information of a deceased older woman aged 70 years and had no serious diseases before COVID-19. Coming home with a negative certificate of COVID-19 infection, she again was admitted to the hospital after 15 days with severe heart and kidney problems and eventually died. To rectify this issue, the state health department of Kerala launched a major mission for COVID-19 recovered through post-COVID-19 outpatient clinics with the assistance of ASHA workers and health staff.⁶⁸

Another older person who had been admitted to the hospital with a history of respiratory problems died, and only after his death did the family realise that he had COVID-19. COVID-19 infection is associated with the risk of malnutrition, and malnutrition due to illness puts immune-compromised people at a higher risk of acquiring the infection. Older age and the existence of comorbid disorders are considered to be linked with impaired nutritional status and sarcopenia.⁶⁹ A high body mass index with COVID-19 also tends to be correlated with a bad prognosis and indicates that sarcopenic obesity plays a significant role.⁷⁰

Higher IFR (Infection Fatality Ratio) is mostly coupled with co-morbidities like diabetes, obesity and heart diseases. However, countries with improved healthcare systems will be able efficiently care for people infected by COVID-19 and thereby have better chances of survival.⁷¹

On the other hand, the COVID-19 Case Fatality Rate is very low in Kerala for the general population as well as for older persons. Community kitchens during the lockdown

period and grocery kits delivered every month through the public distribution system ensured that the population met the nutritional needs to prevent COVID-19 along with *ayurvedic* and homoeopathic preventive medicines and natural herbs. One ASHA worker remarked that the community kitchen was introduced particularly for those who are old, destitute, bedridden and living alone. Under their guidance, three meals and two snacks were prepared daily and distributed – breakfast, lunch with leafy vegetables, and dinner at optimum temperatures – through volunteers. A senior official at the Health Department said that through community kitchen services, they not only fulfilled nutritional needs but also ensured beneficiaries were following lockdown and quarantine rules by not giving them a reason to step out of the house. Recent evidence shows that individual nutritional status has a substantial effect not only on individual response to pathogens but also on the viral genome's genetic make-up, viral intensity and reproducible genome mutations. Micro-nutrient intake in combination with a well-balanced macro-nutrient diet can help boost the resistance of the body to fight off viruses.⁷²

A doctor pointed out that even if the person does not have vitamin supplements, actual nutrition demands were met through their food. Thus, it has been proven by the analysis of the pre-COVID-19 situation among older persons that nutrition has a significant role in determining mortality. In other words, older persons who are at risk of nutrition have higher chances of dying. In the analysis, overweight or obese conditions of older persons have no significant role in determining mortality. However, things have changed in the COVID-19 period. Though an older person with normal nutritional levels has a lesser risk of mortality during the pandemic, older people with comorbid conditions and who are overweight/obese have a higher risk of mortality. COVID-19's association with the global increase in chronic disease and associated risk factors, such as obesity, elevated blood sugar, cardiovascular disease and other non-communicable diseases (NCDs) elevate the risk of serious illness and death from COVID-19.^{73,74}

The study is undertaken from a socio-epidemiological perspective and hence the study could not dive into any clinical nutritional assessments of the COVID-19 patients. The study utilises the KAS and LASI datasets to analyse how nutritional status associates with the comorbid conditions and mortality of the older population in the pre-COVID-19 period. For comparative purposes, the study rather relies on the data collected through qualitative interviews with surviving COVID-19 patients as well as families of the deceased, leading health practitioners and frontline health workers in the state.

Conclusion

Kerala has ensured a good nutritional status to its population, especially its older population which helped in enhancing

their ability to resist infection and serious complications during the COVID-19 pandemic, leading to low COVID-19 mortality in the state. However, non-communicable diseases and underlying risk factors such as obesity are high among older persons, making them a particularly high-risk group. Obesity has a significant role in determining COVID-19-related mortality while its role was statistically insignificant during the pre-COVID-19 situation.

The COVID-19 outbreak has brought a great challenge for communities and healthcare systems across the world. Considering the absence of specific therapeutic treatment or an effective vaccine in the initial stages of the outbreak, countries were forced to take strong precautionary measures to contain the spread of COVID-19, ranging from social distancing to community quarantine. With no sudden end to the pandemic, and with new strains and variants emerging globally, it is important to alter people's behavioural and dietary patterns to fight against current and future pandemics. Therefore, the study suggests there is an utmost need for alerting the general population about the nutritional impact on COVID-19 outcome. In addition, nutritional status must be considered as a key indicator while drafting the COVID-19 health policy to ensure the better good of the community.

Post Script – Updates After First Wave

The second wave of the COVID-19 pandemic hit India around April–May of 2021. It was much bigger than the first, in terms of caseload, mortality and the way it affected not just the poor and vulnerable but the rich and healthy as well. The second wave, at its peak, pushed health systems in many parts of the country to the brink of collapse. Popular media was rife with reports of people from all walks of scampering to arrange beds, ventilators and oxygen cylinders for loved ones. Hospitals reportedly overflowed with patients, and NGOs and voluntary organizations operated drive-through oxygen parlours to support dying patients with prized sniffs of the life-saving gas. Through gory images of dead bodies floating on the Ganges and empty parking lots turning into mass funeral pyres, the second wave painted a picture of gloom and doom over the whole country.

One small corner of India, however, was managing to keep its nose above the water through the cataclysm. Through its successful management of the first wave, Kerala had learned that decentralized management was the cornerstone of any success against this deadly virus. It had, in anticipation of the exponential increase in cases through the second wave, set up more than 1.5 lakh beds in field hospitals across more than one thousand panchayats and municipalities (local governance regions) to bolster the existing healthcare system. It had ensured the availability of adequate centralized oxygen beds, Medical Oxygen storage capacities, ICU beds, and ventilators in all districts. As the second wave gained momentum, the government in Kerala set up a centralized Oxygen War Room

to streamline the production, transportation, distribution, storage, and usage of Medical Oxygen. As a result of this rigorous effort, there was not a single COVID-19 death due to the unavailability of Medical Oxygen or Intensive Care in Kerala.

In addition to stepping up medical care facilities, an important lesson that Kerala had learned through its first wave experience was the importance of nutrition and food security in effectively managing the impact of the pandemic. Multiple studies and reports, including the present one, had highlighted the impact of nutrition and food security not only in helping build immune resistance but also indirectly ensuring adherence to quarantine and isolation guidelines. The 'Grand Care' elderly protection programme implemented jointly by the Health Department and the Kudumbashree Mission had, through its syndromic surveillance during the first wave, found out a significant reduction in cases among elderly persons in districts where their mobility was lower, and also identified a similar positive correlation between reduced mobility and doorstep availability of food and long-term medication.⁷⁴ Such evidence, coupled with its overall success in ensuring availability of food through its community kitchens and Public Distribution System, prompted Kerala's government to continue its efforts at ensuring availability of food, adequate in quantity and quality, to its population.

With the easing of lockdown measures and increasing mobility of the population following the decline of the first wave, community kitchens were phased out and replaced by 'ration kits' containing adequate supplies of grains, pulses and other essentials. The government ensured universal access to these kits through its extensive public distribution network, with the assumption that any method of targeting would result in exclusion of some communities, an outcome that was untenable in the midst of the second-wave crisis. Serendipitously timed with Kerala's general elections, this strategy was widely touted as an important reason for the government's landslide re-election to power, in addition to being critically important in ensuring resilience to the vastly more devastating second wave.⁷⁵ Having successfully overcome the second wave and cases and mortality declining steadily, the government in Kerala seems to have decided that the nutrition route is here to stay. In a recent announcement by its Chief Minister, Kerala's government decided to continue the expansion of 'Janakeeya Hotels'. These budget restaurants, initially transformations of COVID-19 community kitchens and later included in the annual budget as part of the 'Hunger-free Kerala' programme, are run by the grassroots women's collective Kudumbashree with a 50% subsidy support from the government, and provide packed meals at affordable rates (20 Indian rupees or .27 USD) to the public. As on October 11, 2021, more than 1.76 lakh daily meal packets were served through 1132 such budget restaurants.⁷⁵

Kerala's policymakers have realized, through experience, the importance of nutrition and food security in the resilience of its community against unprecedented shocks such as the

COVID-19 pandemic. Through strategies such as community kitchens and ration kits, Kerala was able to adequately support its health system in effectively mitigating the effects of the pandemic. More importantly, however, the experience has ensured the centrality of nutrition and food security in Kerala's policy discourse in the long term.

Author Contribution

The corresponding author conceptualised the main idea for the manuscript and encouraged all the authors to investigate the cause. All the authors contributed equally in drafting, analysing, revising and approving the manuscript.

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References

- Bauer JM, Morley JE. Editorial: COVID-19 in older persons: the role of nutrition. *Curr Opin Clin Nutr Metab Care*. 2021; 24(1):1-3.
- Coşkun H, Yıldırım N, Gündüz S. The spread of COVID-19 virus through population density and wind in Turkey cities. *Sci Total Environ*. 2021;751(141663):141663.
- Mallapaty S. The coronavirus is most deadly if you are older and male - new data reveal the risks. *Nature*. 2020;585(7823):16-17.
- Bonanad C, García-Blas S, Tarazona-Santabalbina F, et al. The effect of age on mortality in patients with COVID-19: A meta-analysis with 611,583 subjects. *J Am Med Dir Assoc*. 2020; 21(7):915-918.
- Rajan SI, Zachariah KC. Emigration and Remittances: New Evidences from the Kerala Migration Survey 2018. Centre for Development Studies Working Paper; 2019:483.
- Rajan SI, Mishra US. *Senior Citizens of India: Emerging Challenges and Concerns*. Singapore: Springer; 2020.
- Rajan SI. Aging in Kerala: one more population problem? *Asia Pac Popul J*. 1989;14(2):19-48.
- Bellamy C. *The State of the World's Children. Focus on Nutrition*. 3. UN Plaza, New York: UNICEF, UNICEF House; 1998.
- Official Kerala Dashboard. Gov.in. <https://dashboard.kerala.gov>. Accessed October 18, 2021.
- DHS – Directorate of Health Services. Gov.in. <http://dhs.kerala.gov>. Accessed October 18, 2021.
- MoHFW. Gov.in. <https://www.mohfw.gov.in/>. Accessed October 18, 2021
- Ritchie H, Mathieu E, Rodés-Guirao L, et al. Coronavirus pandemic (COVID-19). *Our World in Data*. 2020. <https://ourworldindata.org/coronavirus>. Accessed October 18, 2021.
- Bollwein J, Volkert D, Diekmann R, et al. Nutritional status according to the mini nutritional assessment (MNA) and frailty in community dwelling older persons: a close relationship. *J Nutr Health Aging*. 2013;17(4):351-356.
- Flicker L, McCaul KA, Hankey GJ, et al. Body mass index and survival in men and women aged 70 to 75. *J Am Geriatr Soc*. 2010;58(2):234-241.
- Director-General WHO. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19*. Geneva, Switzerland: World Health Organization; 2020.
- Emami A, Javanmardi F, Pirbonyeh N, Akbari A. Prevalence of underlying diseases in hospitalized patients with COVID-19: A systematic review and meta-analysis. *Archives of Academic Emergency Medicine*. 2020;8(1):e35.
- Mentella MC, Scaldaferrri F, Gasbarrini A, Miggiano GAD. The role of nutrition in the COVID-19 pandemic. *Nutrients*. 2021; 13(4):1093.
- Joint statement by ILO, FAO, IFAD and WHO. Impact of COVID-19 on people's livelihoods, their health and our food systems. Who.int. 2020. <https://www.who.int/news/item/13-10-2020-impact-of-covid-19-on-people's-livelihoods-their-health-and-our-food-system>. Accessed October 18, 2021.
- Moseley WG, Battersby J. The vulnerability and resilience of African food systems, food security, and nutrition in the context of the COVID-19 pandemic. *Afr Stud Rev*. 2020;63(3):449-461.
- FAO; IFAD; Unicef WFP; W H O. *The State of Food Security and Nutrition in the World 2020. Transforming Food Systems for Affordable Healthy Diets*. Rome: FAO; 2020.
- The Food and Agriculture Organization of the United Nations (FAO). *The State of Food Insecurity in the World*; 2011. <https://www.fao.org/3/i2330e/i2330e.pdf>. Accessed October 18, 2021.
- Micha R, Mannar V, Afshin A, et al. *Global Nutrition Report: Action on Equity to End Malnutrition*. Bristol, UK: Development Initiatives; 2020.
- Van Schothorst M, Zwietering MH, Ross T, Buchanan RL, Cole MB. Relating microbiological criteria to food safety objectives and performance objectives. *Food Control*. 2009;20(11):967-979.
- Calder P, Carr A, Gombart A, Eggersdorfer M. Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients*. 2020;12(4):1181.
- Calder PC. Nutrition, immunity and COVID-19. *BMJ Nutrition, Prevention & Health*. 2020;3(1):74-92.
- Bhaskaram P. Immunobiology of mild micronutrient deficiencies. *Br J Nutr*. 2001;85(Suppl 2):S75-S80.
- Fedele D, De Francesco A, Riso S, Collo A. Obesity, malnutrition, and trace element deficiency in the coronavirus

- disease (COVID-19) pandemic: An overview. *Nutrition*. 2021; 81:111016.
28. Simonnet A, Chetboun M, Poissy J, et al. High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. *Obesity*. 2020;28(7):1195-1199.
 29. Louie JK, Acosta M, Samuel MC, et al. A novel risk factor for a novel virus: obesity and 2009 pandemic influenza A (H1N1). *Clin Infect Dis*. 2011;52(3):301-312.
 30. Ryan DH, Ravussin E, Heymsfield S. COVID 19 and the Patient with Obesity—The Editors Speak Out. *Obesity*. 2020; 25(5):847.
 31. Silverio R, Gonçalves DC, Andrade MF, Seelaender M. Coronavirus disease 2019 (COVID-19) and nutritional status: the missing link? *Advances in Nutrition*. 2021;12(3):682-692.
 32. Agarwal E, Ferguson M, Banks M, et al. Malnutrition and poor food intake are associated with prolonged hospital stay, frequent readmissions, and greater in-hospital mortality: results from the nutrition care day survey 2010. *Clinical Nutrition*. 2013;32(5):737-745.
 33. Barazzoni R, Bischoff SC, Breda J, et al. ESPEN expert statements and practical guidance for nutritional management of individuals with SARS-CoV-2 infection. *Clinical Nutrition*. 2020;39(6):1631-1638.
 34. Holdoway A. Nutritional management of patients during and after COVID-19 illness. *Br J Community Nurs*. 2020;25(Sup8): S6-S10.
 35. Grant WB, Lahore H, McDonnell SL, et al. Evidence that vitamin D supplementation could reduce risk of influenza and COVID-19 infections and deaths. *Nutrients*. 2020;12(4):988.
 36. Leij-Halfwerk S, Verwijs MH, van Houdt S, et al. Prevalence of protein-energy malnutrition risk in European older adults in community, residential and hospital settings, according to 22 malnutrition screening tools validated for use in adults ≥ 65 years. *Maturitas*. 2019;126:80-89.
 37. Alam I, Almajwal AM, Alam W, et al. The immune-nutrition interplay in aging - facts and controversies. *Nutr Healthy Aging*. 2019;5(2):73-95.
 38. Bencivenga L, Rengo G, Varricchi G. Elderly at time of coronavirus disease 2019 (COVID-19): possible role of immunosenescence and malnutrition. *GeroScience*. 2020;42(4): 1089-1092.
 39. Altuna-Venegas S, Aliaga-Vega R, Maguiña JL, Parodi JF, Runzer-Colmenares FM. Risk of community-acquired pneumonia in older adults with sarcopenia of a hospital from Callao, Peru 2010-2015. *Arch Gerontol Geriatr*. 2019;82:100-105.
 40. Lidoriki I, Frountzas M, Schizas D. Could nutritional and functional status serve as prognostic factors for COVID-19 in the elderly? *Med Hypotheses*. 2020;144:109946.
 41. Pallath MM, Ahirwar AK, Tripathi SC, Asia P, Sakarde A, Gopal N. COVID-19 and nutritional deficiency: a review of existing knowledge. *Horm Mol Biol Clin Investig*. 2021;42(1):77-85.
 42. Recinella G, Marasco G, Serafini G, et al. Prognostic role of nutritional status in elderly patients hospitalized for COVID-19: a monocentric study. *Aging Clin Exp Res*. 2020;32(12): 2695-2701.
 43. Pironi L, Sasdelli AS, Ravaioli F, et al. Malnutrition and nutritional therapy in patients with SARS-CoV-2 disease. *Clinical Nutrition*. 2021;40(3):1330-1337.
 44. Bhat PNM, Rajan SI. Demographic Transition in Kerala Revisited. *Econ Polit Wkly*. 1990;25(35-36). 1957-1980.
 45. Zachariah KC, Rajan SI, eds. *Kerala's Demographic Transition: Determinants and Consequences*. New Delhi: SAGE; 1997.
 46. Rajan SI, Zachariah KC. *Kerala's Demographic Future: Issues and Policy Options*. New Delhi: Academic Foundation; 2012.
 47. Rajan SI, Mishra US, Sarma PS. *India's Elderly: Burden or Challenge*. New Delhi: SAGE; 1999.
 48. Mishra US, Rajan SI, eds. *India's Aged: Needs and Vulnerabilities*. Hyderabad: Orient Blackswan; 2017.
 49. Thankappan KR, Shah B, Mathur P, et al. Risk factor profile for chronic non-communicable diseases: results of a community-based study in Kerala, India. *The Indian journal of medical research*. 2010;131:53-63.
 50. Sebastian MSN, Haveri SP, Jesha MJM. Chronic non communicable diseases and risk factors among adults in rural Kerala. *J Community Health Manag*. 2013;3(2):87-90.
 51. Sivasankaran S, Thankappan KR. Prevention of non-communicable diseases requires a life course approach: a case study from Kerala. *The Indian journal of medical research*. 2013;137(5):874-877.
 52. Kanchan T, Kumar N, Unnikrishnan B. *Encyclopedia of Forensic and Legal Medicine*. 2nd ed. Amsterdam: Elsevier Inc; 2015.
 53. Isaac TT, Covid-19 SR. Public health system and local governance in Kerala. *Econ Polit Wkly*. 2020;2355(21):35.
 54. PTI. Kerala. *Elderly Couple Surviving COVID-19 Brings Ray of Hope: Experts*. Economic Times. 2020 https://economictimes.indiatimes.com/news/%20politics-and-nation/kerala-elderly-couple-surviving-covid-19-brings-ray-of-hope-experts/articleshow/74916356.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst. Accessed October 18, 2021.
 55. Tijo George Mala R, Mishra US. COVID-19 and lockdown – the divergent trajectory of inter-state migrants in Kerala. *Azimpremjuni-versity.edu.in*. <https://practiceconnect.azimpremjuniiversity.edu.in/covid-19-and-lockdown-the-divergent-trajectory-of-inter-state-migrants-in-kerala/>. Accessed October 18, 2021
 56. Vijayan P. *Challenges in the Midst of the COVID-19 Pandemic*. Mumbai, India: Economic Political Weekly; 2020.
 57. Ministry of Health and Family Welfare. National Health Policy 2017. [nhp.gov. https://www.nhp.gov.in/nhpfiles/national_health_policy_2017.pdf](https://www.nhp.gov.in/nhpfiles/national_health_policy_2017.pdf). https://www.nhp.gov.in/nhpfiles/national_health_policy_2017.pdf October 18, 2021. Accessed
 58. Food and Agricultural Organization of the United Nations. Report of the World Food Summit. [Fao.org. Published. 1996. http://www.fao.org/3/w3548e/w3548e00.html](http://www.fao.org/3/w3548e/w3548e00.html). Accessed October 18, 2021.
 59. UNSCN. The COVID-19 pandemic is disrupting people's food environments: a resource list on food systems and nutrition responses - *UNSCN*. [unscn.org. 2020. https://www.unscn.org/en/newsevents/recent-news?idnews=2039](https://www.unscn.org/en/newsevents/recent-news?idnews=2039). Accessed October 18, 2021.

60. Summerton SA. Implications of the COVID-19 pandemic for food security and social protection in India. *Indian Journal of Human Development*. 2020;14(2):333-339.
61. Headey DD, Ruel MT. *The COVID-19 Nutrition Crisis: What to Expect and How to Protect*. IFPRI.; 2020. <https://www.ifpri.org/blog/covid-19-nutrition-crisis-what-expect-and-how-protect>.
62. NCDs account for 53% of the disease burden in India: study. *The Hindu Business Line*. 2016. <https://www.thehindubusinessline.com/news/science/ncds-account-for-53-of-the-disease-burden-in-india-study/article9187723.ece>. Accessed October 18, 2021.
63. Cobb TD. *Reclaiming Our Food: How the Grassroots Food Movement Is Changing the Way We Eat*. North Adams, Massachusetts: Storey Publishing; 2011.
64. Golechha M. *Time to Realise the True Potential of Ayurveda against COVID-19*. India: Brain, Behavior, and Immunity; 2020.
65. Rajan SI, Sivakumar P, Srinivasan A. The COVID-19 pandemic and internal labour migration in India: A 'crisis of mobility'. *The Indian Journal of Labour Economics* 2020; 63(4):1021-1039. doi:10.1007/s41027-020-00293-8.
66. COVID 19 Outbreak Control and Prevention State Cell Health and Family Welfare Department, Government of Kerala. *Guidelines for Setting up Post COVID Clinics*. <https://dhs.kerala.gov.in/wp-content/uploads/2020/10/Guidelines-Post-COVID-Clinics.pdf>. Accessed October 18, 2021.
67. Graf CE, Pichard C, Herrmann FR, Sieber CC, Zekry D, Genton L. Prevalence of low muscle mass according to body mass index in older adults. *Nutrition*. 2017;34:124-129.
68. Peng YD, Meng K, Guan HQ. Clinical features and outcome of 112 cases of novel coronavirus pneumonia in cardiovascular patients. *China Journal of Cardiology*. 2020;48(6):450-455.
69. Nancy S. Nutrition odds to even out corona. *J Postgrad Med Educ Res*. 2020;54(3):145-149.
70. Murray CJ, Aravkin AY, Zheng P, et al. Global burden of 87 risk factors in 204 countries and territories, 1990-2019: a systematic analysis for the global burden of disease study 2019. *Lancet (London, England)*. 2020;396(10258):1223-1249.
71. Vos T, Lim SS, Abbafati C, et al. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the global burden of disease study 2019. *Lancet (London, England)*. 2020;396(10258):1204-1222.
72. Kudumbashree K. Grand Care. Kudumbashree.org. <https://www.kudumbashree.org/pages/862>. Accessed October 19, 2021.
73. Attri V. Kerala assembly elections: votes for tackling the coronavirus. *Hindu*. 2021. <https://www.thehindu.com/elections/kerala-assembly/kerala-voted-ldf-for-tackling-the-coronavirus-finds-csds-lokniti-survey/article34502863.ece>. Accessed October 18, 2021.
74. Kudumbashree. Community Kitchen COVID-19. Kudumbashree.org. <https://kudumbashree.org/pages/826>. Accessed October 18, 2021.
75. Rajan SI, and Anjana A. Disability Free life Expectancy among the elderly. In: Mishra US and Rajan SI, eds. *India's Aged: Needs and Vulnerabilities*. Hyderabad, India: Orient Blackswan; 2017:114-125.