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RESEARCH ARTICLE

# GENDER DIFFERENTIAL IN SYMPTOMS, MORBIDITY, AND CASE FATALITY RATE IN THE COVID-19 PANDEMIC IN INDIA.

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## ABSTRACT

### BACKGROUND:

The COVID-19 epidemic has taken a considerable toll worldwide and has harmed both male and female health. Statistics revealed that fewer females were directly affected than males; however, the latter may be more affected by the consequences. Some studies at the global level have suggested gender as the key determining factor in COVID-19, but there is a lack of such studies in developing countries like India. In light of the situation, this study has analyzed the gender-wise pattern of symptoms, morbidity, multimorbidity, and mortality due to COVID-19 in Karnataka, India.

### METHODS:

We used patient-level raw data from COVID19-India application programming interface (API) from 09th March to 05th September 2020. We have used descriptive statistics such as frequency, percentage distribution, and latent class analysis (LCA) to carry out this analysis.

### FINDINGS:

The study comprised 78,983 COVID-19 patients who were 63.6% males and 36.4 % females. Out of the total patients, 10.1% were reported as deceased, of which 68.4% were males and 31.6% were females. We found that all three symptoms (cough, breathlessness, and fever) were higher among males than females in the case of disease symptoms. Males had a higher risk of severe infection and mortality in general. In comparison, females suffered from comorbidities like diabetes and hypertension were at higher risk of mortality due to COVID-19 than their male counterparts. The latent class analysis also revealed that females had a more significant proportion of two or more symptoms, whereas males had more than two comorbidities.

### INTERPRETATION:

Given the differences in lethality between the two genders, we believe that our study has found the root causes of the gender differentials in the COVID-19 pandemic. Furthermore, our research mapped gender differences in various aspects of COVID-19, which will help policymakers find suitable interventions to reduce the burden.

### KEYWORDS

COVID-19, pandemic, gender, patients, morbidity, mortality.

## INTRODUCTION

The COVID-19 pandemic has resulted in a dramatic loss of human life and caused an incomparable threat to public health [1,2). Its economic and social uncertainties are catastrophic; on the other hand, it has triggered a focused area of scientific research globally [3].

Many developing countries already coping with humanitarian disasters have become vulnerable to the consequences of COVID-19 [4]. India, a developing country already dealing with many public health challenges, is a member of this group [5–7], recorded as having the second highest COVID-19 cases following the USA [8]. The COVID-19 pandemic has adversely affected the health of both genders. However, statistics reveal that fewer females are affected directly than males, though the former might be more affected by its consequences [9,10]. Thus, it is essential to analyze the impact of both diseases and their consequences on both genders to help policymakers adopt appropriate measures in the ongoing fight against the problem. But a limited number of studies on the gender differentials in COVID-19 may restrict the development of a proper policy response [11,12].

Studies at the global level suggest gender as the key determining factor of the severity of the symptoms, multimorbidity and mortality among COVID-19 patients [13–15]. To date, no such have included the above-mentioned factors in the Indian context [16–20]. Considering the need for such reviews, the present study has analyzed the gender differentials for the COVID-19 pandemic in the Karnataka state of India.

In the case of COVID-19 in Karnataka, the state confronted the pandemic with a lot of preparation. It was the first state to raise the Epidemic Diseases Act's provisions 1897 [21]. Nevertheless, the Karnataka government responded to COVID-19 well before the virus arrived on its land [22,23]. The first confirmed COVID-19 patient in Karnataka appeared 40 days after the first case in India [24,25]. However, the Karnataka government had already put a comprehensive response system in place well before the WHO declared it a public health emergency of international concern. However, it could not wholly succeed compared to other states in containing the virus [26,27]. Despite sincere efforts and practising the 5T (Tracing, Tracking, Treatment, Technology and Testing) government policy, Karnataka stood at the second highest position with 8,41,889 confirmed and 11,347 deceased cases. With almost equal population distribution of gender across the state, it has been reported that the proportion of males out of total cases was significantly higher than the females [25,28]. By keeping in view an equal population proportion to an unequal burden, this paper deals with the gender differentials in the COVID-19 prevalence rate (PR), case fatality rate (CFR), the pattern of symptoms and multimorbidity, along with the latent class analysis of the symptoms and multimorbidity in the state.

## METHODS AND DATA SOURCE

### METHODOLOGY

This study used publicly available patient-level raw data from the COVID-19 application programming interface (API) from 09th March 2020 to 05th September 2020 and segregated it for gender and age for the analysis [29]. We have used categorical and nominal coding to transform raw data and applied quantitative methods for the study [30]. The Agency's data provided state bulletins and official handles (such as the Government of India: Press Information Bureau (PIB) and Ministry of Health and Family Welfare (MoHFW)) to update COVID-19 cases and provided time series data for the daily and cumulative numbers at the district and state levels. The government of India was collecting data related to COVID-19 with the help of authorized collection centre persons spread throughout the country [31]. Thus, the possibilities of data skewness are no longer applicable. We extracted information at the unit level for patients whose gender and age were available. Hence, we used a complete case analysis and discarded the cases whose information was missing.

### DATA ANALYSIS AND STATISTICAL TOOLS

We used descriptive statistics such as frequency and percentage distribution to represent the gender-wise age distribution of total and deceased cases. Here gender implies males and females, which were distributed in five age categories: 0-14, 15-25, 26-40, 41-60, 61 and above years. We examined the average age at diagnosis and death using mean and standard deviation. For deceased cases, the descriptive statistics have been extended for influenza type (influenza-like illness (ILI), severe acute respiratory infections (SARI), symptoms (fever, breathlessness, and cough), multimorbidity (diabetes hypertension and others) and place of death (designated hospital, private hospital, and residence). Gender-wise district-level analysis of prevalence rate (PR) and case fatality rate (CFR) for the state has been calculated and plotted using ERIS ArcGIS Enterprise 10.8 version [32]. To calculate the PR, we used 2020-year data from the Directorate of Economics and Statistics official website, which the Government of Karnataka maintains [33]. We used data from the Karnataka COVID-19 Dashboard webpage to compute CFR [25]. The Weka 3.8.4 version has been used to calculate the gender-specific pattern of symptoms and multimorbidity for deceased cases (34). Latent class analysis (LCA) has been performed on the RStudio 4.0.3 version to separate classes for deceased cases based on their symptoms and multimorbidity pattern [35]. LCA detects the intensity of symptoms and comorbidity in deceased patients by revealing hidden groups in the data. The novelty behind segregating data for deceased patients into different classes is that we can effectually predict their symptoms and morbidity by just knowing the number of symptoms and morbidity they suffer.

## RESULTS

This section explains the analysis in this order: 1) gender-wise demographic and clinical profile of COVID-19 patients in the study area, 2) gender-wise district-level COVID-19 PR and CFR, 3) gender-wise pattern of symptoms and multimorbidity, and 4) gender-wise LCA of symptoms and multimorbidity of the deceased cases.

### DEMOGRAPHIC AND CLINICAL PROFILE OF COVID-19 PATIENTS IN THE STUDY SAMPLE

Table 1 shows the results for 78,983 COVID-19 patients, consisting of 50,255 (63.6%) males and 28,728 (36.4%) females, have been included in this study. In each age category, the proportion of males was higher than that of females. Out of the total male population, a higher proportion of COVID-19 patients was in the 41-60 age category. The higher proportion of COVID-19 patients in the female population was in the 26-40 age category.

Out of the total patients, 7,989 (10.1%) were deceased due to COVID-19, of which 5,463 (68.4%) were males and 2,526 (31.6%) were females. With the increase in age, the proportion of deceased cases increased, higher for males than females in all age categories. The average age at death was higher than the average age at diagnosis, except for females in the 0-14 years category. Further, concerning gender, the average age at diagnosis and death was found to be higher for males than females in the study. The influenza type was also given in the dataset for deceased cases, based on World Health Organization (WHO) definition. As of January 2014, WHO global guidelines for influenza surveillance described the meaning of the surveillance case for ILI: a person with acute respiratory infection with onset within the last ten days and having a high fever (≥ 100.4°F) with a cough. Simultaneously, SARI is defined as a combination of ILI requiring hospitalization [46]. The proportion of SARI was higher than ILI among both males and females. More females suffered from SARI than males, whereas more males suffered from ILI compared to females.

There are three symptoms of COVID-19 given in the dataset: fever, breathlessness, and cough. The proportion of breathlessness was higher than fever and cough for both males and females. The male ratio for all three symptoms was higher than females in all age groups.

**TABLE 1 DEMOGRAPHIC AND CLINICAL PROFILE OF COVID-19 PATIENTS IN THE STUDY SAMPLE**

| Categories | Age | 0-14 | 15-25 | 26-40 | 41-60 | 61 above | Total |
|---|---|---|---|---|---|---|---|
| Males | F (%) | 2540 (5.1) | 6234 (12.4) | 16766 (33.4) | 16898 (33.6) | 7817 (15.6) | 50255 (63.6) |
| Females | F (%) | 2251 (7.8) | 4790 (16.7) | 9209 (32.1) | 8434 (29.4) | 4044 (14.1) | 28728 (36.4) |
| Total | F (%) | 4791 (6.1) | 11024 (14.0) | 25975 (32.9) | 25332 (31.1) | 11861 (15.0) | 78983 (100) |
| **Average age at diagnosis** | | | | | | | |
| Males | μ (σ) | 8.1 (4.1) | 21.5 (2.9) | 33.0 (4.3) | 50.2 (5.7) | 69.7 (7.7) | 41.8 (17.5) |
| Females | μ (σ) | 7.9 (4.0) | 21.4 (2.9) | 32.6 (4.4) | 50.7 (5.8) | 70.0 (7.2) | 39.4 (18.5) |
| Total | μ (σ) | 8.0 (4.1) | 21.5 (2.9) | 32.9 (4.4) | 50.3 (5.7) | 69.8 (7) | 40.9 (17.9) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Deceased cases** | | | | | | | |
| Males | f (%) * | 10 (0.4) | 46 (0.7) | 425 (2.5) | 2138 (12.7) | 2844 (36.4) | 5463 (10.9) |
| Females | f (%) * | 9 (0.4) | 32 (0.7) | 179 (1.9) | 1050 (12.4) | 1256 (31.1) | 2526 (8.8) |
| Total | f (%) * | 19 (0.4) | 78 (0.7) | 604 (2.3) | 3188 (12.6) | 4100 (34.6) | 7989 (10.1) |
| **Average age at death** | | | | | | | |
| Males | μ (σ) | 10.8 (5.3) | 22.3 (2.3) | 35.5 (3.9) | 52.9 (5.5) | 71.2 (7.4) | 60.8 (13.7) |
| Females | μ (σ) | 7.1 (4.7) | 22.0 (2.6) | 35.3 (4.5) | 53.1 (5.5) | 71.5 (7.4) | 60.4 (14.1) |
| Total | μ (σ) | 8.9 (5.3) | 22.2 (2.5) | 35.4 (4.1) | 53.0 (5.5) | 71.3 (7.4) | 60.6 (13.9) |
| **Influenza type of deceased cases **** | | | | | | | |
| Males | ILI | 3 (30.0) | 8 (17.4) | 72 (16.9) | 388 (18.1) | 565 (19.9) | 1036 (19.0) |
| | SARI | 5 (50.0) | 26 (56.5) | 265 (62.4) | 1385 (64.8) | 1826 (64.2) | 3507 (64.2) |
| | Data N/A | 2 (20.0) | 12 (26.1) | 86 (20.2) | 351 (16.4) | 436 (15.3) | 887 (16.2) |
| Females | ILI | 3 (33.3) | 3 (9.4) | 36 (20.1) | 187 (17.8) | 235 (18.7) | 464 (18.4) |
| | SARI | 3 (33.3) | 21 (65.6) | 107 (59.8) | 701 (66.8) | 808 (64.3) | 1640 (64.9) |
| | Data N/A | 3 (33.3) | 8 (25.0) | 35 (19.6) | 155 (14.8) | 206 (16.4) | 407 (16.1) |
| Total | ILI | 6 (31.6) | 11 (14.1) | 108 (17.9) | 575 (18.0) | 800 (19.5) | 1500 (18.8) |
| | SARI | 8 (42.1) | 47 (60.3) | 372 (61.6) | 2086 (65.4) | 2634 (64.2) | 5147 (64.4) |
| | Data N/A | 5 (26.3) | 20 (25.6) | 121 (20.0) | 506 (15.9) | 642 (15.7) | 1294 (16.2) |
| **Symptoms among deceased cases **** | | | | | | | |
| Males | Fever | 7 (70.0) | 14 (30.4) | 179 (42.1) | 940 (44.0) | 1282 (45.1) | 2422 (44.3) |
| | Breathlessness | 5 (50.0) | 29 (63.0) | 281 (66.1) | 1526 (71.4) | 2034 (71.5) | 3875 (70.9) |
| | Cough | 4 (40.0) | 9 (19.6) | 150 (35.3) | 740 (34.6) | 993 (34.9) | 1896 (34.7) |
| Females | Fever | 6 (66.7) | 9 (28.1) | 67 (37.4) | 452 (43.0) | 568 (45.2) | 1102 (43.6) |
| | Breathlessness | 4 (44.4) | 21 (65.6) | 109 (60.9) | 742 (70.7) | 886 (70.5) | 1762 (69.8) |
| | Cough | 2 (22.2) | 2 (6.3) | 47 (26.3) | 354 (33.7) | 404 (32.2) | 809 (32.0) |
| Total | Fever | 13 (68.4) | 23 (29.5) | 246 (40.7) | 1392 (43.7) | 1850 (45.1) | 3524 (44.1) |
| | Breathlessness | 9 (47.4) | 50 (64.1) | 390 (64.6) | 2268 (71.1) | 2920 (71.2) | 5637 (70.6) |
| | Cough | 6 (31.6) | 11 (14.1) | 197 (32.6) | 1094 (34.3) | 1397 (34.1) | 2705 (33.9) |
| **Multimorbidity among deceased cases **** | | | | | | | |
| Males | Diabetes | 1 (10.0) | 9 (19.6) | 91 (21.4) | 993 (46.4) | 1412 (49.6) | 2506 (45.9) |
| | Hypertension | 2 (20.0) | 8 (17.4) | 83 (19.5) | 849 (39.7) | 1415 (49.8) | 2357 (43.1) |
| | Others *** | 1 (10.0) | 15 (32.6) | 105 (24.7) | 518 (24.2) | 848 (29.8) | 1487 (27.2) |
| Females | Diabetes | 0 (0.0) | 3 (9.4) | 50 (27.9) | 527 (50.2) | 626 (49.8) | 1206 (47.7) |
| | Hypertension | 0 (0.0) | 5 (15.6) | 41 (22.9) | 430 (41.0) | 699 (55.7) | 1175 (46.5) |
| | Others *** | 0 (0.0) | 9 (28.1) | 33 (18.4) | 223 (21.2) | 291 (23.2) | 556 (22.0) |
| Total | Diabetes | 1 (5.3) | 12 (15.4) | 141 (23.3) | 1520 (47.7) | 2038 (49.7) | 3712 (46.5) |
| | Hypertension | 2 (10.5) | 13 (16.7) | 124 (20.5) | 1279 (40.1) | 2114 (51.6) | 3532 (44.2) |
| | Others*** | 1 (5.3) | 24 (30.8) | 138 (22.8) | 741 (23.2) | 1139 (27.8) | 2043 (25.6) |
| **Place of death **** | | | | | | | |
| Males | Designated hospital | 5 (50.0) | 19 (41.3) | 144 (33.9) | 844 (39.5) | 1091 (38.4) | 2103 (38.5) |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Private hospital | 1 (10.0) | 11 (23.9) | 116 (27.3) | 488 (22.8) | 819 (28.8) | 1435 (26.3) |
| | Residence | 0 (0.0) | 2 (4.3) | 43 (10.1) | 188 (8.8) | 188 (6.6) | 421 (7.7) |
| | Data N/A | 4 (40.0) | 14 (30.4) | 122 (28.7) | 618 (28.9) | 746 (26.2) | 1504 (27.5) |
| Females | Designated hospital | 3 (33.3) | 7 (21.9) | 80 (44.7) | 416 (39.6) | 518 (41.2) | 1024 (40.5) |
| | Private hospital | 2 (22.2) | 9 (28.1) | 31 (17.3) | 241 (23.0) | 316 (25.2) | 599 (23.7) |
| | Residence | 3 (33.3) | 6 (18.8) | 8 (4.5) | 85 (8.1) | 95 (7.6) | 197 (7.8) |
| | Data N/A | 1 (11.1) | 10 (31.3) | 60 (33.5) | 308 (29.3) | 327 (26.0) | 706 (27.9) |
| Total | Designated hospital | 8 (42.1) | 26 (33.3) | 224 (37.1) | 1260 (39.5) | 1609 (39.2) | 3127 (39.1) |
| | Private hospital | 3 (15.8) | 20 (25.6) | 147 (24.3) | 729 (22.9) | 1135 (27.7) | 2034 (25.5) |
| | Residence | 3 (15.8) | 8 (10.3) | 51 (8.4) | 273 (8.6) | 283 (6.9) | 618 (7.7) |
| | Data N/A | 5 (26.3) | 24 (30.8) | 182 (30.1) | 926 (29.0) | 1073 (26.2) | 2210 (27.7) |

F= frequency of all cases, % =number of patients in each age group as a fraction of the number with respective gender

μ= mean age, σ= standard deviation

f= frequency of deceased cases in each age group with respective gender, * = Number of deceased cases in each age group as a fraction of the number of total cases in each age group with respective gender, ILI =influenza-like illness, SARI= severe acute respiratory infections, Data N/A =data not available, ** number of deceased cases in a particular category in each age group as a fraction of the number of total deceased cases in each age group with respective gender.

*** others (chronic kidney disease, chronic obstructive pulmonary disease, chronic liver disease, ischemic heart disease, stroke, rheumatic heart disease, myocardial infarction, coronary artery disease, anemia, adrenoleukodystrophy, acute myeloid leukemia, acute respiratory distress syndrome, acute renal failure, asthma, bilateral patchy pneumonitis, benign prostatic hyperplasia, bronchopneumonia, carcinoma cancer, colon cancer, cardiomyopathy, renal disease, chronic respiratory disease, dementia, demyelinating, headache, dermatitis herpetiformis, diarrhea, anorexia, deep vein thrombosis, tuberculosis, filariasis, giddiness, weakness, fatigue, rashes, hepatitis b surface antigen, hypothyroidism, inflammatory bowel disease, interstitial lung disease, encephalitis, multiple organ dysfunction syndrome, obesity, absolute neutrophil count, pneumonia, percutaneous transhepatic cholangiography, restlessness, renal tubular acidosis, sensorium, sepsis, septic shock, chills, tiredness, thyroid, vomiting, wheezing, convulsions)

The study categorizes multimorbidity as diabetes, hypertension, and others. The other category includes almost all other ailments except the above mentioned two. Overall, females' diabetes (47.7) and hypertension (46.5) proportion were higher than males' diabetes (45.9) and hypertension (43.1). Females have diabetes in the age group 41-60, and 61 and above, whereas males affected with diabetes were more in the age groups 0-14, 15-25 and 26-40. The pattern was the same for hypertension as well. In the case of other diseases, males were more affected than females.

The proportion of males (26.3) admitted to private hospitals was more significant than females (23.7), whereas the females' (40.5) proportion was higher than males' (38.5) in the case of designated hospital admission. Overall, the proportion of patients admitted to designated hospitals was higher (39.1) than private (25.5) hospitals. For the age groups 26-40 and 41-60, the females' proportion of death at residence was higher than that of males, and a reverse pattern was found for other age groups.

## GENDER WISE DISTRICT LEVEL COVID-19 PREVALENCE RATE AND CASE FATALITY RATE

The gender-wise prevalence rate has been calculated per 10,000 population for each district of Karnataka. Figures 1 and 2 results were plotted on a district map of Karnataka using ERIS ArcGIS 10.8 version. The prevalence rates for both males and females were 14.0 and 8.2, respectively. The prevalence rate was higher for the Bengaluru Urban district for both males (33.1) and females (21.4), whereas the same was lower for the Chitradurga district for both males (2.4) and females (1.0). The overall prevalence rate for each district was higher for males as compared to females. Bengaluru Urban was the worst-hit district, followed by Udupi (19.4), Dakshina Kannada (18.5) and Dharwad (13.3). On the other hand, the least hit districts were Chitradurga (1.7), Belagavi (Belgaum) (2.5), Tumakuru (Tumkur) (3.5) and Haveri (4.0). The overall case fatality rate of males and females was 11.1% and 8.86%, respectively. The CFR was highest in Chikkamagaluru (Chikmagalur) district for both males (54.9) and females (37.0). In contrast, it was lowest in the Yadgir district for both males (3.6) and females (1.9). The female CFR in the case of Bengaluru rural

(8.0), Mandya (13.0), Chitradurga (16.1), Ballari (Bellary) (11.6) and Tumakuru (Tumkur) (24.0) was higher than males.

**FIGURE 1 DISTRICT WISE PREVALENCE RATE AS PER 10,000 POPULATION (MALES, FEMALES, AND TOTAL CASES)**

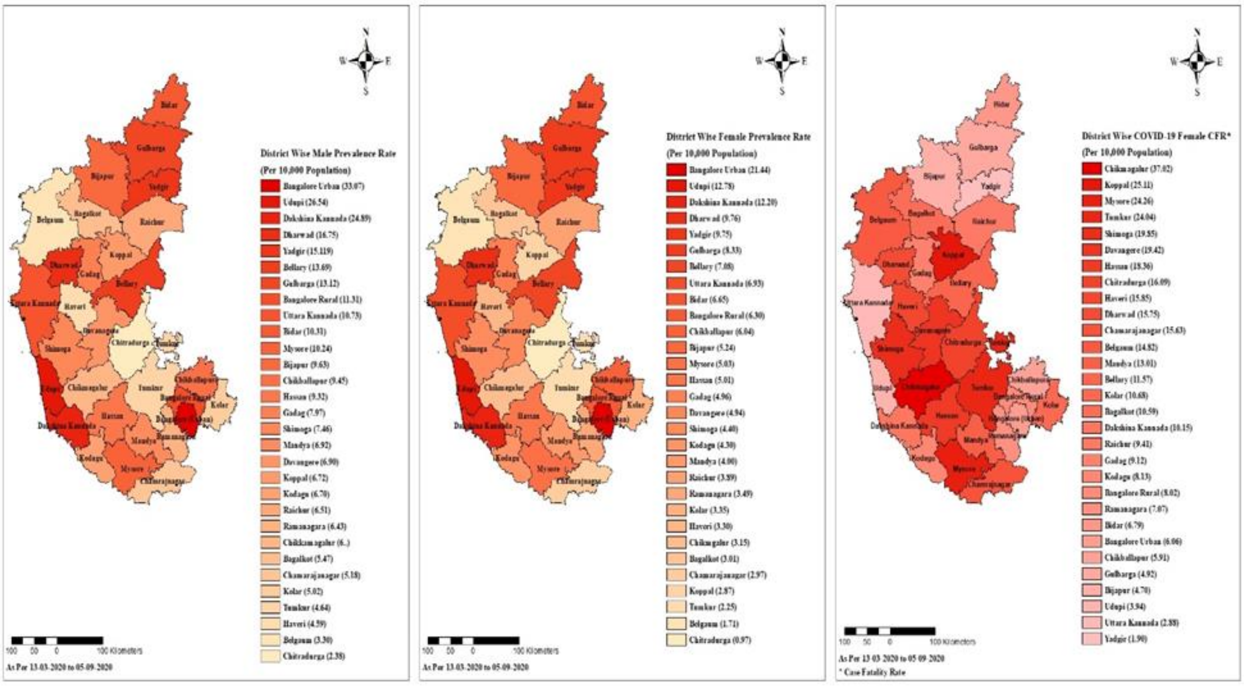
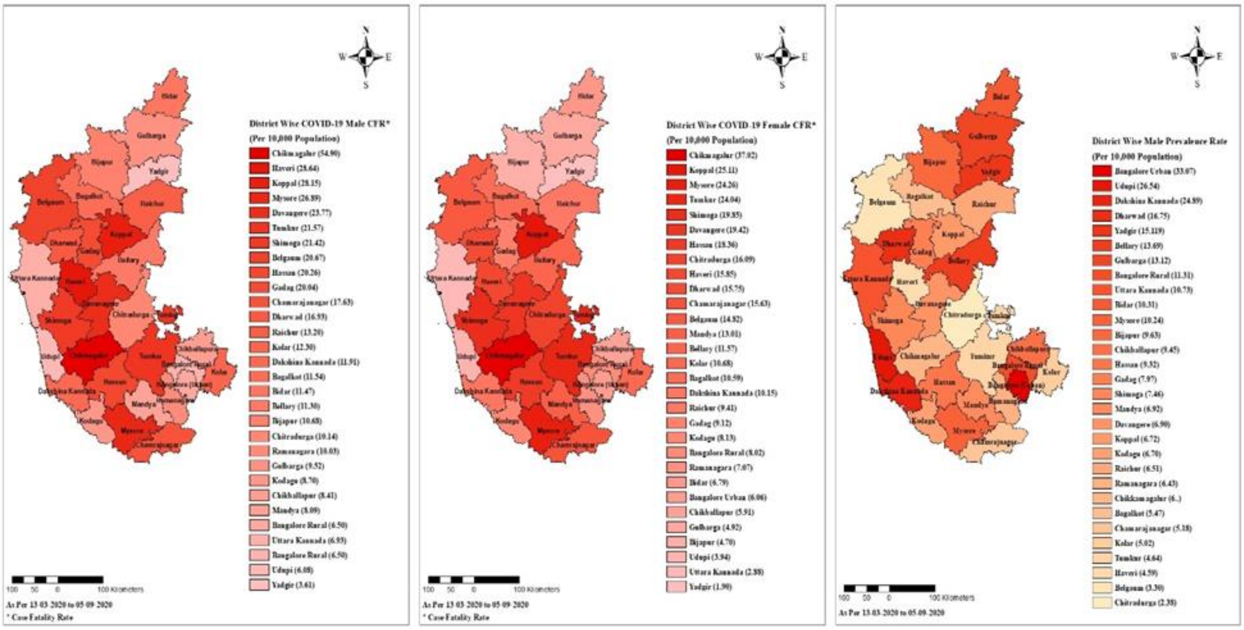


**FIGURE 2 DISTRICT WISE CASE FATALITY RATE (MALES, FEMALES, AND TOTAL CASES)**



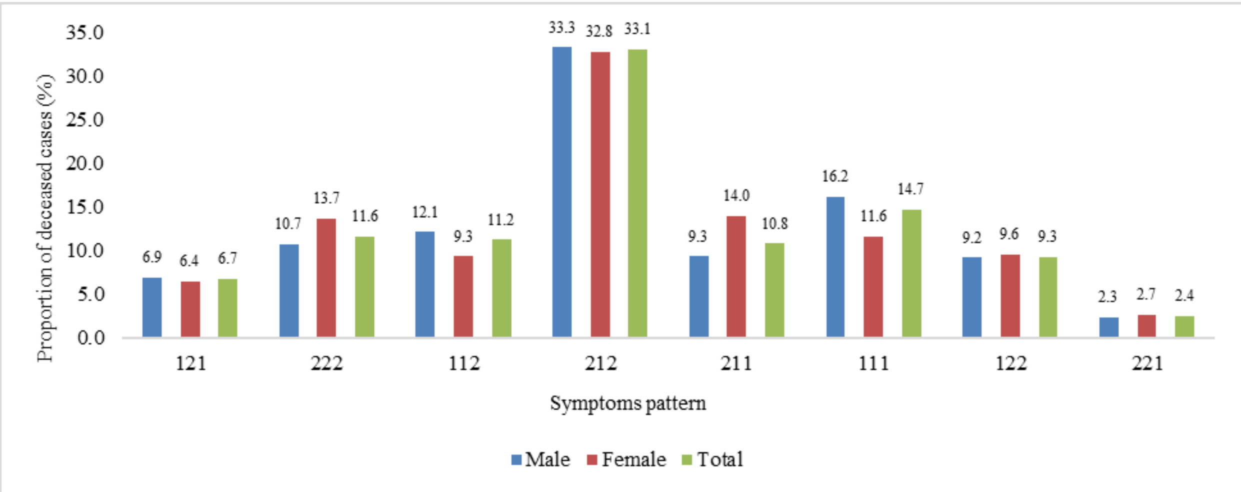
## GENDER WISE PATTERN OF SYMPTOMS (FEVER, BREATHLESSNESS, AND COUGH)

Only three symptoms, i.e., fever, breathlessness, and cough, were given in the dataset. The results in Table 2 show the eight latent variables that were not directly observed but inferred from the three observed symptoms. From these latent variables, we have calculated the pattern of symptoms for COVID-19 deceased cases. As per Figure 3 findings, the proportion of only breathlessness (no fever and cough) was more significant for both males and females, meaning that the severity of breathlessness was greater in deceased cases. 33.3% of males and 32.8% of females reported breathlessness that died due to direct and indirect implications of COVID-19. More females (13.7) were asymptomatic compared to the males (10.7) counterparts. Females (14.0) with breathlessness and cough but having no fever were higher in proportion than the males (9.3) in the same latent variable.

**TABLE 2 LATENT VARIABLES FOR A DIFFERENT PATTERN OF SYMPTOMS**

| The pattern of symptoms (latent variable) | Patient suffering from |
|---|---|
| 121 | Fever and cough, no breathlessness |
| 222 | Asymptomatic |
| 112 | Fever and breathlessness, no cough |
| 212 | Only breathlessness, no fever and cough |
| 211 | Breathlessness and cough, no fever |
| 111 | All three symptoms present |
| 122 | Only fever, no breathlessness and cough |
| 221 | Only cough, no fever and breathlessness |

**FIGURE 3 GENDER WISE PROPORTION OF DECEASED CASES IN LATENT VARIABLES FOR EACH PATTERN OF SYMPTOMS**




1 Yes, 2 No, Three-digit pattern representing three symptoms: fever comes at the first position, breathlessness comes at the second position, and cough comes at the third position.

## GENDER WISE PATTERN OF MULTIMORBIDITY (DIABETES, HYPERTENSION, AND OTHERS)

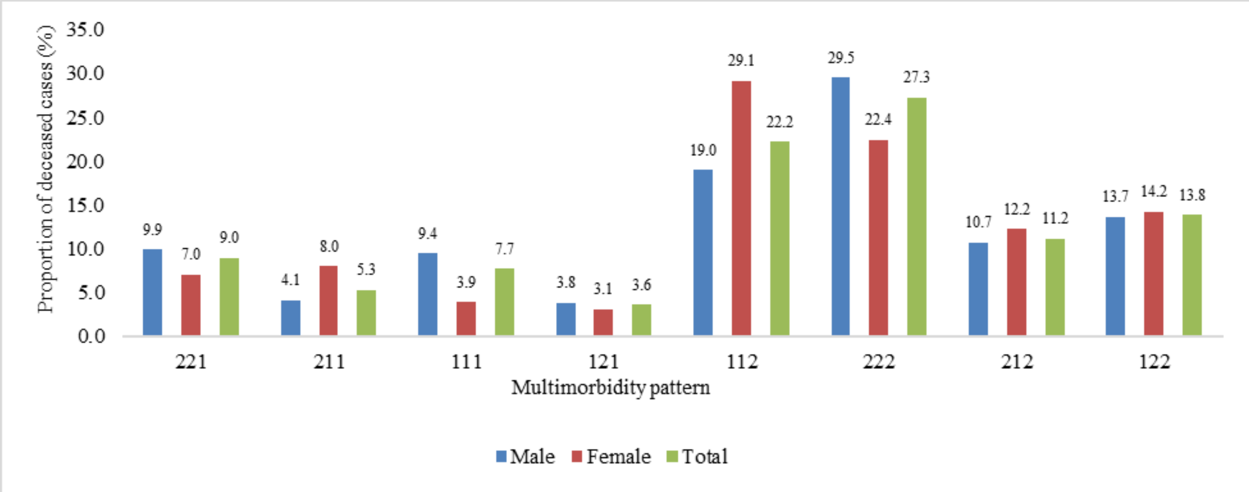
In line with the symptoms pattern, Figure 4 has also analyzed the multimorbidity pattern of COVID-19 deceased patients. From three observed variables, diabetes, hypertension, and others, we constructed eight latent variables for the multimorbidity pattern analysis (see Table 3). Total COVID-19 patients that died with no morbidity were 27.3%, in which the male (29.5) proportion was higher than the female (22.4) ratio. In the case of latent variable 112 (patient suffering from diabetes and hypertension with no other morbidity), the proportion of females (29.1) was more significant than that of males (19.0). The same pattern was observed for the latent variable 211 (patient suffering from hypertension and others with no diabetes), 212 (patient suffering from hypertension only with no diabetes and others disease), and 122 (patient suffering from diabetes only with no hypertension and others disease).

**TABLE 3 LATENT VARIABLE FOR DIFFERENT MULTIMORBIDITY PATTERN**

| Multimorbidity Pattern (latent variable) | Patient suffering from |
|---|---|
| 221 | Only others, no diabetes and hypertension |
| 211 | Hypertension and others, no diabetes |
| 111 | All morbidity present |
| 121 | Diabetes and others, no hypertension |
| 112 | Diabetes and hypertension, no others |
| 222 | No morbidity |

| | |
|---|---|
| 212 | Only hypertension, no diabetes and others |
| 122 | Only diabetes, no hypertension and others |

**FIGURE 4 GENDER WISE PROPORTION OF DECEASED CASES IN LATENT VARIABLES FOR EACH MULTIMORBIDITY PATTERN**




1 Yes, 2 No, Three-digit pattern representing three morbidities: diabetes comes at the first position, hypertension comes at the second position, and others come at the third position.

## GENDER WISE LATENT CLASS ANALYSIS OF SYMPTOMS OF COVID-19 DECEASED CASES

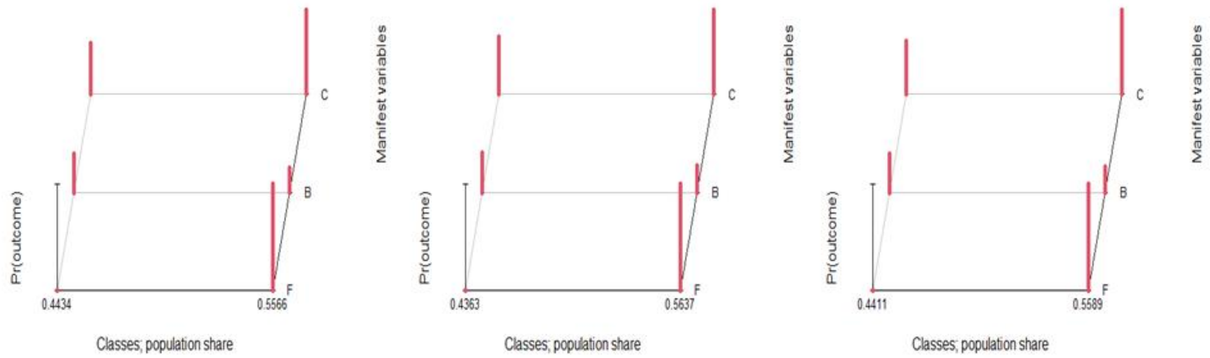
We performed LCA to split COVID-19 deceased cases into subgroups based on an unobservable construct. After completing LCA for symptoms, we got the best-fit model for two classes. The two latent classes were assumed to be mutually exclusive and exhaustive. Thus, each patient belonged to one and only one latent class. Patients with two or fewer symptoms were classified as Class 1, whereas those with three were in Class 2. The higher proportion in Class 2 demonstrates that patients suffering from three symptoms were more likely to succumb. Results in Table 4 show that if a male patient belonged to Class 1, he had fewer chances of having a fever, a 76.59% chance of having breathlessness, and a 20.98% chance of coughing. Conversely, if a male patient belonged to Class 2, he had a 100% chance of having a fever, a 63.83% chance of having breathlessness, and a 51.96% chance of coughing. The pattern was the same for female COVID-19 patients.

**TABLE 4 GENDER-WISE PROBABILITY OF HAVING SYMPTOMS FOR EACH CLASS OF DECEASED CASES**

| | Males | | Females | | Total | |
|---|---|---|---|---|---|---|
| **Symptom** | **Class 1 (44.34)** | **Class 2 (55.66)** | **Class 1 (43.63)** | **Class 2 (56.37)** | **Class 1 (44.11)** | **Class 2 (55.89)** |
| Fever | 0 | 1 | 0.0000 | 0.9999 | 0 | 1 |
| Breathlessness | 0.7659 | 0.6383 | 0.7472 | 0.6334 | 0.7599 | 0.6368 |
| Cough | 0.2098 | 0.5196 | 0.2121 | 0.4601 | 0.2105 | 0.5010 |

Value in parenthesis is the population share of deceased cases in each class

FIGURE 5 POPULATION SHARE OF EACH CLASS OF DECEASED CASES




## GENDER WISE LATENT CLASS ANALYSIS OF MULTIMORBIDITY PATTERN OF COVID-19 DECEASED CASES

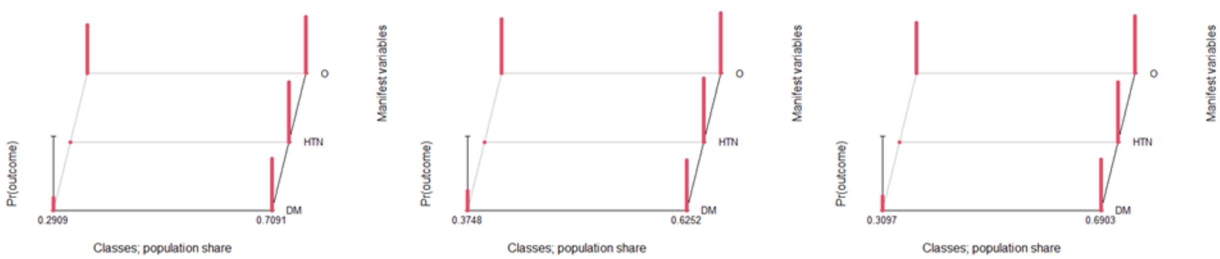
Same as above, the results in Table 5 extended the analysis where LCA was performed to classify deceased COVID-19 cases into latent classes based on their multimorbidity pattern. Patients with two or fewer morbidities were classified as Class 1, whereas those with three were in Class 2. If a male patient belonged to Class 1, he had a 30.71% chance of having diabetes, 19.89% of hypertension, and 24.08% of other diseases. On the other side, if a male patient belonged to Class 2, he had an 82.83% chance of having diabetes, 99.91% chance of hypertension, and 34.89% of other diseases. Female COVID-19 patients in the study region showed the same trend.

TABLE 5 GENDER-WISE PROBABILITY OF HAVING MULTIMORBIDITY FOR EACH CLASS OF DECEASED CASES

| | Males | | Females | | Total | |
|---|---|---|---|---|---|---|
| **Multimorbidity** | **Class1 (29.09)** | **Class2 (70.91)** | **Class1 (37.48)** | **Class2 (62.52)** | **Class1 (30.97)** | **Class2 (69.03)** |
| Diabetes | 0.3071 | 0.8283 | 0.3240 | 0.7334 | 0.3123 | 0.8023 |
| Hypertension | 0.1989 | 0.9991 | 0.1450 | 0.9994 | 0.1905 | 0.9999 |
| Others | 0.2408 | 0.3489 | 0.1895 | 0.2712 | 0.2252 | 0.3233 |

Values in parenthesis are the population share of deceased cases in each class

FIGURE 6 POPULATION SHARE OF EACH CLASS OF DECEASED CASES




## DISCUSSION

The study indicates the presence of gender differences in disease prevalence and CFR in COVID-19 in Karnataka. Out of the total number of COVID-19 patients, the male population proportion was higher than females, and out of total deceased cases, the proportion of males was higher than females. The higher proportion of COVID-19 patients and the higher fatality among males can be attributed to the higher co-persistence of all three disease symptoms, i.e., fever, breathlessness, cough, and high ILI cases in males.

Furthermore, the overall prevalence rate in each district in Karnataka was also higher for males than females. The higher antibody production and the likelihood of low immune dysregulation in females may account for the differences between males and females. As neutralizing antibodies like Immunoglobulin G (IgG) prevent the disease from worsening, it is higher in females (36). The respiratory tract differences among males and females in terms of the larger size of males' lungs further augment the ground on which the gender difference in COVID-19 can be explained [37]. Also, lifestyle is another major cause of gender-based disparities, as COVID-19 was more severe among smokers than non-smokers [38]. Since males are more likely to smoke in India than females [39], smoking can potentially augment this disparity. In India, as compared to females, more males go out to earn the family's livelihood [40]. This exposure could be another potential cause of the disease's high prevalence among males in the state.

The results also showed that the number of deceased cases and age were directly proportional. The decrease in sex hormones with an increase in age seems to be an essential factor responsible for the increased proportion of deceased cases among older people, as these hormones affect immune responses [41]. Due to the age-dependent decrease of sex hormones, these hormones can be considered excellent therapeutic options, especially estrogen therapy [42]. The estrogen therapy further fuels the revealed gender difference in deceased cases among the elderly population, leading to a better immune system among females against COVID-19, as evident from other similar studies [43,44].

However, District-wise, CFR analysis showed a non-uniform pattern for males and females. CFR for females in districts like Bengaluru, Mandya, Chitradurga, Ballari and Tumakuru was higher than for males. The observed higher CFR among females could be attributed to numerous overlapping reasons like disproportionate work in the informal or grey economy, inadequate access to social securities, lower earnings, lower savings, and a higher burden of unpaid care & domestic work [45].

Besides this, our gender-wise analysis of multimorbidity also reflected that the proportion of females for latent variables 112, 211, 212, and 122 was significantly higher than males and contributed to the COVID-19 fatalities. This higher proportion among females can be due to several biological, psychological, and social factors like poor nutrition, poor respiratory health because of indoor air pollution, mainly due to cooking with solid fuels and higher post-traumatic stress syndrome (PTSS) [46]. Worrying aggressively about other family members' health and more significant concern about managing households under the loss of income due to a workplace closure than males could also have contributed to the same [36,46].

Gender-wise analysis of the pattern of symptoms showed a gender-neutral way for latent variable 212 (only breathlessness, no fever and cough) that highlights the severity of breathlessness in deceased cases among both genders. Although, for the latent variable 222 (Asymptomatic), the females' proportion was higher than the male counterparts. The latent class analysis also revealed that females had a more significant proportion of two or more symptoms, whereas males had more than two comorbidities.

## IMPLICATIONS

Gender integration in health research has long been emphasized, yet it remains insufficient, especially in COVID-19 research [47]. Clinical trials, social and behavioural research, health service delivery innovations, and gender mainstreaming in health systems and public governance are all part of the emerging gender and COVID-19 research agenda [48–50]. Thus, in the same direction, this research offered a quantitative approach that has amplified the perspectives of India's gender-related research in the case of COVID-19. Our study has been conducted to understand the potential differences in prevalence rates, CFR, symptom and morbidity patterns, and related outcomes among males and females. In our study, males were at increased risk for infectivity; therefore, intensive care unit admission was recommended for male patients with more morbidities.

Furthermore, we advocated better precautions for females with more symptoms since their chances of succumbing were high in our study. In addition, patients with breathlessness among both genders should have received special treatment, as our research highlighted that the severity of breathlessness was a significant cause of mortality. Furthermore, to limit the possibility of getting COVID-19 and developing accompanying symptoms, asymptomatic patients, particularly females, must strictly adhere to preventative measures such as wearing masks, practising hand hygiene, and keeping physical distance. In this direction, ongoing research is required to provide insights into these complexities and inform public health strategies to understand such gender disparities. As a result, we suggest big data agencies ensure gender data, which should be available, analyzed, and actionable on a larger scale.

## CONCLUSION

Significant gender-related differences were present in the occurrence of COVID-19 in the Karnataka state considered in this study. Besides a wide range of factors that may influence the outcome, gender should be one criterion for selecting the appropriate measures. Indeed, given the differences in lethality between the two genders, we believe that studying gender differences will help find suitable interventions for all patients and help policymakers frame better policies to reduce the spread of COVID-19. Only extensive studies considering all factors concerning gender differences may explain why males tend to have a higher risk of severe infection and mortality in general and why females suffering from comorbidities like diabetes and hypertension were at higher risk of mortality due to COVID-19 than their male counterparts. Therefore, it is recommended that for all COVID-19 patients, gender-disaggregated data with some critical socioeconomic determinants must be recorded during diagnosis and treatment and made available to the researchers for analysis. It will enhance the research scope to determine the root causes of the gender differentials in the COVID-19 pandemic in the country.

### LIMITATIONS

The study analysis could not be extended to all Indian states due to the unavailability of gender-wise information on the given source. Additionally, in the case of symptoms, the study is limited to three symptoms: fever, breathlessness, and cough, and could not consider some other COVID-19 symptoms, such as tiredness, headache, diarrhoea, loss of taste and smell, etc. because of the unavailability of data. The study is also time-bound and analyzed the cases between 09th March 2020 to 05th September 2020.

### AUTHORS' CONTRIBUTORS

SR contributed to the data curation, analysis, and writing. AK added literature search, data interpretation and writing. RT conceptualized and visualized the study design and contributed to the analysis. All authors contributed equally to the final manuscript review, provided edits, and approved it.


### CONFLICT OF INTEREST STATEMENT

We declare that there are no competing interests.

### ROLE OF FUNDING SOURCE

There is no funding involved for this study.


### ETHICS COMMITTEE APPROVAL

As all data used in this research is available in the public domain, no ethics clearance has been required for this study.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