Original Article

Variation in COVID Mortality with Different Demographic Factors in Districts of India

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Background : Descriptive data suggests significant disparity in the COVID-19 related deaths across different demographic zones. Several studies have examined these factors at the intra-country or intrastate level. Our study analyzed the data at a District level.

Methods : This cross-sectional study analyzed the association between Socio-demographic factors and COVID-19 Mortality at a District level using Univariate and Multivariate linear regression models. Data for sixty randomly selected Districts was collected and compiled from free sources available in the public domain. Linear regression models were built and factors that were found to be significant were used in the model.

Results : Univariate analysis revealed that COVID Mortality has a positive correlation with the literacy rate and a negative correlation with the percentage Rural population of the District. No significant relation was found with primary Health Center accessibility, Sex Ratio and the percentage of chronic illness. On Multivariate analysis, it was negatively correlated to only the percentage of the Rural population.

Conclusion and Relevance : Our study concluded that as the rural population increased in a district, COVID 19 mortality decreased. There was no significant association with other sociodemographic variables.

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Key words **: Demographic Factors, COVID-19, Mortality, India.**

More than a year has passed by since COVID-19 was declared to be a pandemic by the World Health Organization and the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus continues to disrupt public life[1]. Many countries, despite implementing strict measures such as lockdown, social distancing and travel restrictions struggled to control the spread and contain the death toll[2].

The number of deaths and the Case Mortality Rate (CMR) varied enormously across the Globe during the pandemic across different geographical regions[3]. This can be due to numerous reasons, including the measures taken to control the spread and access to Healthcare facilities. Underlying demographic variations, prevalence of comorbidities and socio-economic development also played a major role[4].

Most of the studies studying the Demographic Factors affecting the transmission and Mortality of this disease were carried out at an International, National or state level. These studies are limited in their strength and design to account for the variation between geographical areas. A District level study done in England indicates that healthcare accessibility is negatively related to COVID Mortality whereas joblessness has a positive correlation[5]. An Indian study identified that at the district level population density was positively correlated with higher chances of COVID-19 infection and the ratio of elderly to the total population signified a greater mortality risk[6].

Editor's Comment :

- Our study helps in understanding the Demographic factors that affected the Mortality of COVID-19 at the District level in India. COVID mortality was negatively correlated to the percentage of Rural population in the District.

In this study, we explored the relationship of various socioeconomic factors that operate at the micro-level with the COVID mortality rate in a district to understand the huge disparity that exists across India. Identifying such factors allows us to not only understand the spread of the virus but will also help us take appropriate policy decisions for subsequent waves or emerging infections (Fig 1).

Material and Method

Study Design :

We conducted a cross sectional analysis wherein linear regression models were developed to study the

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Fig 1—Map of India showing the selected districts for the study
[Google maps was used to plot the selected sixty districts]

variation in COVID Mortality rate in a District with Socio-demographic factors.

Research Data :

We gathered the data for our study from the datasets available for free in the public domain. Data for deaths due to COVID-19 deaths was available on the website of Integrated Disease Surveillance Program (IDSP) under the National Centre for Disease Control (NCDC)[7] and was taken on 27th March 2021. The number of total Corona case for each district was available on the district wise corona tracker for India on 27th March, 2021[8].

The District wise population, Sex ratio, Literacy rate, and percentage Rural population was available for 2011 from the data of the Census 2011[9]. The prevalence of Chronic illnesses and percentages villages in the district with a PHC within 10 Km from the District Level Health Survey-4 (DLHS-4) (2012-2013) on the website of NITI Aayog[10]. The number of functioning Primary Health Centers was taken from the Rural Health Statistics (RHS) 2018-19[11].

Selection of Districts :

There are 718 Districts in India as of 2021[12]. However, for our study we considered the 640 Districts that were present in 2011 and hence their data of our interest was available from the Census 2011[9].

In order to ensure a representation of Districts from all over India, stratified random sampling of the Districts was done. The states were divided into 6 groups based on the Zonal Councils of India. 10 Districts were then randomly selected out of each of these 6 groups of states using Excel function.

Variables of Research :

In order to study the Mortality associated with COVID-19 infection, we chose Mortality per million; defined as the number of deaths due to COVID-19 per million population in the District as the dependent variable. The Independent variables were selected under the following themes:

- **Socio-economic Status :** The percentage of Rural population, Sex ratio and Literacy rate were considered under this.
- **Health Facility Accessibility :** We devised a Novel indicator - Primary Healthcare Center (PHC) accessibility defined as the number of functioning PHCs per unit recommended population in India (25000). This was calculated by dividing the number of functioning PHCs in the District by its population and multiplied by the recommended population.
- **Morbidity Profile :** The prevalence of Chronic illness in the District. Any person suffering from symptoms for a period of more than one month is said to be suffering from Chronic illness under the District Level Health Survey (DLHS-4).

Statistical Analysis :

Stata version 16 (Stata Inc, USA) was used for analysis. Linear regression models for COVID Mortality rate were developed to explore the association with the independent variables. Covariates found significant on Univariate and Multivariate analysis were included in the model (Table 1).

Observations and Results

Univariate linear regression models were built using Stata software to predict the change in COVID Mortality per million in the District based on variation in Sex ratio, Literacy rate, Percentage of rural population, PHC accessibility and prevalence of Chronic illness. The COVID Mortality per million was positively correlated to Literacy Rate and negatively correlated to the percentage rural population in the district. Thereafter, Multivariate linear regression model was built for these variables and only a negative correlation was found

Table 1 — *Summary statistics of explanatory variables*

Variable	Mean ± SD	Range (Min- Max)
CFR	8.2 ± 51.4	0 - 399
MPM	121.5 ± 190.9	0 - 952.8
Sex Ratio	947.1 ± 51.9	787 - 1087
Literacy rate	73.3 ± 11.5	36.1 - 93
%Rural population	68 ± 25	0 - 95.7
PHC accessibility	0.5 ± 0.5	0 - 2.4
%Chronic Illness	7.9 ± 4.7	1.2 - 24.2

SD- Standard Deviation, Min.- Minimum, Max.- Maximum, CFR- Case Fatality Rate, MPM- Mortality Per Million, %Chronic Illness- Prevalence of chronic illness in the District, %Rural Illness- Percentage of Rural population in the District

with the percentage Rural population.

Table 2 represents the result of this analysis.

Table 2 — *Linear regression analysis for factors affecting COVID Mortality Rate*

Variable	Model 1 in Univariate analysis		Model 2 Multivariate analysis	
	Coefficient (95% CI)	P value	Coefficient (95% CI)	P value
Sex Ratio	0.5 (-0.5- 1.4)	0.32	0.4 (-0.4- 1.2)	0.29
Literacy rate	7.9 (4.1- 11.8)	0.00*	0.9 (-3.4- 5.2)	0.67
%Rural population	-5.9 (-7.2- -4.6)	0.00*	-6.5 (-8.3- -4.7)	0.00*
PHC accessibility	-93.9 (-197.2- 9.4)	0.07	-1.1(-74.1- 72.0)	0.98
%Chronic Illness	-0.75(-12.7-11.2)	0.90	3.0 (-4.7-10.7)	0.43

Dependent variable -Covid Mortality Rate, Independent variable – modeled as confounders, CI- Confidence Interval, %Chronic Illness- Prevalence of Chronic Illness in the District, %Rural Illness- Percentage of Rural population in the District

* Significant association with fast change (P value <0.05)

Discussion

On Multivariate linear regression analysis, a negative correlation was found between COVID-19 Mortality and the percentage of Rural population in our study. People living in Rural areas tend to practice social distancing while those in Urban areas find it difficult to practice social distancing due to the crowded environments. Urban areas tend to have better reporting systems as well while many cases and deaths in villages might go unreported (Table 3).

Asirvatham, *et al* studied the variation of state level adjusted case fatality rate with the Socio-economic and Health indicators of the population in 30 states and Union territories of India in June, 2020[13]. Data was collected from free access public domain sources and fractional regression analysis was performed. Higher percentage of Urban, Geriatric population and the prevalence of Diabetes, Hypertension, Cardiovascular Diseases and any Cancer was associated with an increased case fatality rate in the state whereas a high literacy rate and a high proportion of women were associated with a reduced case Fatality Rate. In our

Table 3 — *Comparison of published literature on the demographic factors affecting COVID Mortality*

Title	Geographical regions considered	Dependent variable	Explanatory Variable	Results	Statistical Analysis
1) Factors affecting COVID-19 mortality: an exploratory study[1]	184 countries	CMR	Per capita income, education, availability of doctors per thousand population, life expectancy at birth, urbanization, the proportion of the population over the age of 65 and obesity	The estimated results suggest that obesity, the proportion of the population over the age of 65 and urbanization as a measure of density had a statistically significant positive effect on the COVID-19 mortality rate. Per capita income, however, had a negative and statistically significant effect on the COVID-19 mortality rate.	A cross sectional study was done. Quantile regression test was used
2)Population Risk Factors for COVID-19 Mortality in 93 Countries[2]	93 countries	CMR	Chronic diseases and GDP per capita, unemployment, age over 65 years, urbanization, population density, and socio-demographic index]	Significant association between chronic respiratory diseases and Alzheimer's. Lower Socio-economic development and crowding was not associated with mortality	The data was analyzed in three steps: correlation analysis, bivariate comparison of countries, and finally, multivariate modelling.
3)Early trends of socio-economic and health indicators influencing case fatality rate of COVID-19 pandemic[3]	Countries reporting a minimum of 50 cases as on 14.03.20 were chosen	CFR	GDP per capita, POD 30/70, HCI, life expectancy, medical doctors per 10,000, median age, current health expenditure per capita, number of confirmed cases and population in millions.	GDP per capita, POD 30/70, HCI, GNI per capita, life expectancy, medical doctors per 10000 population, negatively corelated with CFR	After selecting from univariate analysis, the indicators with the maximum correlation were used to build a model using multiple variable linear regression with a forward selection of variables and using adjusted R-squared score as the metric.
4)Demystifying the varying case fatality rates (CFR) of COVID-19 in India: Lessons learned and future directions[4]	30 states and UT of India	aCFR	Urban population %, Population > 60 years%, Literacy Rate %, Gender ratio (Females/1000 Males), Per capita state domestic product, State health system performance %, Public health expenditure % , COVID19 tests per million COVID19 cases per million, CVD %, Hypertension & Diabetes % and Any Cancer %	High proportion of urban population and population above 60 years were significantly associated with increased aCFR (p=0.08, p=0.05), whereas **high literacy rate and high proportion of women were associated with reduced aCFR**(p<0.001, p=0.03). The higher number of cases per million population (p=0.001), prevalence of diabetes and hypertension (p=0.012), cardiovascular diseases (p=0.05), and any cancer (p<0.001) were significantly associated with increased aCFR.	Fractional regression analysis was done
5)Spatial inequalities of COVID-19 mortality rate in relation to socioeconomic and environmental factors across England[5]	Local Authority district level of England	CMR	Percent of females, percent of Asians, Percent of Blacks, Percent of households in poverty Unemployment rate (%), Density of population (unit: 1000 persons per km^2), Density of hospital (number of hospitals per 1000,000 persons), Annual mean PM 3-month mean relative humidity (%) and 3-month mean range of air temperature (°C)	-Although global spatial association of COVID-19 mortality and non-COVID-19 mortality is positive, local spatial association of COVID-19 mortality and non-COVID-19 mortality is negative in some areas. -hospital accessibility is negatively related to COVID-19 mortality rate. -Percent of Asians, percent of Blacks, and unemployment rate are positively related to COVID-19 mortality rate. -relative humidity is negatively related to COVID-19 mortality rate.	Two newly developed specifications of spatial regression models were established successfully to estimate COVID-19 mortality rate (R2=0.49and R2= 0.793).
6)Impact of population density on Covid-19 infected and mortality rate in India [6]	600 districts of India	CMR, Infection rate	Population density	We find moderate association between Covid-19 spread and population density.	Correlation and regression analysis was used
7)Hierarchical Modelling of COVID-19 Death Risk in India in the Early Phase of the Pandemic[7]	Districts of 11 states of India	CFR, Infection Rate	-Individual variables - District level (Age 65+ population, Migration, Obesity%, Underweight%)	COVID-19 deaths in north and central India were higher in areas with older and overweight populations, and were more common among people with pre-existing health conditions, or who smoke, or who live in urban areas.	Regression model (Hierarchical model) was developed and used

Legend: CFR – Case fatality rate (Number of deaths from the COVID 19/ Total population infected), CMR – Case mortality rate (Number of deaths from the COVID 19/ Total population infected x1000000), aCFR – Adjusted CFR (the number of deaths on a given day / the cumulative number of patients with confirmed COVID-19 infection 8 days before which is the average time-lag between diagnosis and deaths , GDP – Gross domestic product , POD - Probability Of Dying Between Age 30 And Exact Age 70 From Any of Cardiovascular Disease, Cancer, Diabetes or Chronic Respiratory Disease , HCI – Human capital index , GNI – Gross national income

study, the Mortality was negatively corelated to the percentage of Rural population but unlike this study, no significant association was found with the prevalence of Chronic illness, Literacy rate or the Sex ratio. The reason for this disparity between the results could be the consideration of state-level data by them while we considered District level data.

Sun, *et al* studied the variation of COVID mortality Rate with Socio-economic and environmental factors across England at the Local Authority District level[5]. They found no association between COVID Mortality and the percentage of females in the District which is in line with our study. They found a significant negative association of Mortality with hospital accessibility while we didn't find any association with Primary Health Center accessibility. The reason for disparity in results can be due to the Cultural, Ethnic and Socio-economic differences among the study population from England and India.

Upadhyaya, *et al* conducted an exploratory study of factors affecting COVID Mortality using data from 184 countries in June, 2022[14]. They found out that COVID Mortality was positively correlated to Urbanization in the country. This finding is not in line with our study as we found that the percentage Rural population was positively corelated to COVID Mortality. The difference can be due to the fact that we studied the variables at the District level and not country level.

Our study analyzed data at a District level while most other studies have considered data at the Country or State level. These studies fail to take account of the intra-country or the intra-state variations of the Socio-demographic factors.

However, our study had some limitations. The latest data for Literacy rate, Sex ratio and percentage Rural population of the district available was from the Census 2011. The population of the District was a projection of 2011 for 2021 and not the actual number. Other data was taken from Annual Health Survey (AHS) (2012-2013), DLHS-4 (2012-2013) and RHS (2018-2019) which comprised the latest data available for the demographic parameter. The difference in the timeline of the data was significant and could've hampered the results of the study. All 718 Districts were not present in Census 2011 and hence they were excluded from the study. Even the selected Districts had some gaps in the data of interest. Data for all variables that are recorded at the state and national level could not be accessed for the District level and hence could not be taken into consideration. The future studies can improve the methodology by addressing these limitations.

Conclusion

The evidence generated in our study helps in understanding the demographic factors that affected the Mortality of COVID-19 at the District level in India. Our study concluded that as the rural population increased in a District, COVID-19 Mortality decreased. There was no significant association with other Socio-demographic variables.The findings of this study add to the existing studies conducted at the state and country level.

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