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Excess COVID-19 Infections, Mortality, and Economic Development in India

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Abstract: *The main purpose of the research is to estimate the extent of excess Covid-19 cases and mortalities in India and examine its relationship with the degree of economic progress in various parts of the country especially given the uneven nature of the impact of the pandemic throughout the nation. The main hypotheses of the study were: 1) in areas with a high level of income per capita, the death rate per 100,000 population will be lower; 2) areas with a high level of income per capita tend to be more urbanized, economically active, and therefore quite densely populated, which increases the probability of morbidity and mortality. The object of research is over 20 million Covid-19 cases and over 370,000 deaths in 31 States and Union Territories (UTs) in India beginning in the first months of the pandemic and going through the middle of 2021. The methodological tools of the conducted research were the methods of regression analysis. The study of a relative measure of success in pandemic management (less than one-half of the median death rate as the relative threshold for measuring success) empirically confirms and theoretically proves that India had at least 16.6 million excess Covid-19 cases and over 228,000 excess COVID-19 deaths as of June 18, 2021. The paper presents the results of an empirical analysis of the relationship between excess deaths of the population from Covid-19 and state-level per-capita income (as an explanatory variable), which testified that about 60% of actual and excess deaths can be explained by the per-capita income alone. According to the results of the analysis, it was proved that actual and excess deaths are both higher in richer states. Poorer states did considerably well in keeping Covid-19 mortality low compared to their more affluent counterparts. The positive relationship between Covid-19 mortality and per-capita income does not go away even after controlling for the caseloads used as a proxy for the spread of the pandemic. This augmented model explains about 80% of the actual and excess deaths from the Covid-19 pandemic in India. After controlling for caseloads, a thousand Rupees increase in per-capita income contributed to about 15 additional deaths per 100,000 population. The article presents the results of an empirical analysis of the relationship between economic development (as measured by the per-capita income) and excess mortality from COVID-19, which proved a positive relationship between them and proved a potentially adverse impact of economic progress on human immunity, especially if population density, living conditions, and food security moderate that relationship.*
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JEL Classification: I14, I15, I18.

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Introduction

The Covid-19 pandemic has affected over 200 countries worldwide, infecting over 640 million individuals and resulting in the death of over 6.5 million people. India, the world's largest democracy, has already experienced over 44 million cases and well over half a million deaths from Covid-19. By the second quarter of 2020, the Indian economy shrunk by 7.5%, while about 140 million people lost their jobs at the pandemic's peak. Significant progress has been made since 2020 following the Indian government's massive support package of over $266 billion, which was about 2% of India's GDP (Schmall, 2021). Despite the progress, the ripples of the pandemic are still felt in the country and will remain in the public consciousness and drive policies for generations to come. While the drivers of the pandemic remain active areas of research, this article makes a modest effort to understand the key contributors to the disparate nature of the pandemic's impact, especially towards the first phase of the disruptions.

Considerable global worries persist concerning the ferocity of the Covid-19 pandemic in recent months. The highly transmissible Delta variant wreaked havoc in India and remained a dominant risk to many countries in Europe and North America for a considerable period, even through 2021. The true extent of the spread of the pandemic and the human cost of the same remains vigorously contested. However, the emerging consensus suggests that India might have significantly undercounted the number of cases and deaths (Gettleman, J. et al., 2021). The undercounting problem is more than just India. It may be a more widespread challenge than previously thought (Felter, 2021). Mortality from Covid-19 in India remained far below compared to the Western countries. (Jain, Iyengar, Vaish, and Vaishya, 2020). However, experts have questioned India's low mortality numbers given the country's relatively unsophisticated state of vital information registration. (Chatterjee, 2020).

Efforts to understand the effect of the pandemic by using indirect data have produced several interesting insights. Electricity consumption and nighttime light intensity data suggest that while electricity consumption dropped by 50% in some states, many others remained virtually untouched. While this observation could be partly explained by the prevalence of energy-intensive manufacturing and return migration of seasonal workers, nighttime light intensity was negatively related to Covid-19 infections pointing to the strong negative impact of COVID-19 infections on the Indian economy. (Beyer, Franco-Bedoya, Galdo, 2020) The choice of this innovative methodological tool is particularly interesting given the close positive relationship between energy consumption and economic activities in virtually every modern sector.

India is the world’s second most populous country. Pandemics like Covid-19 have significant implications on the country's prosperity as it contributes to about 6.8% of the global GDP and 11.8% of the emerging market GDP. India's economic woes are equally important for matters of global consequence. At the same time, pandemics like these pose an urgent challenge for meeting the healthcare needs of a country with one of the highest out-of-pocket health expenditures. A sharp downturn in the Indian economy could have led to a significant negative impact on the world economy (Biyani, 2021). Furthermore, the human toll of the Covid-19 pandemic may ripple through many future decades as the Covid orphans face painful trauma, family dislocation, resource scarcity, and trafficking risks raising important challenges for human capital accumulation and economic progress for generations to come (Thiagarajan, 2021).

It may be noted that Covid-19 has affected only some parts of India equally. Cases and mortality per thousand population vary widely from one state to another. These states are also quite different regarding their economic progress as measured by their per-capita incomes. Prior research (Santiago, Wadsworth, & Stump, 2011) has suggested a close relationship between poverty, low income, and chronic stress. Economic limitations (low economic development) may significantly contribute to high stress. Furthermore, Parchley (2020) raised the importance of stress in Covid-19 outcomes in that higher stress may lead to poor outcomes from the pandemic. We study this aspect rigorously in our research. If the low socioeconomic status is a risk factor for enhanced stress and if enhanced stress is a risk factor contributing towards higher Covid-19 mortality, then states that are richer are expected to have lower mortality controlling for other mitigating factors.

Our study contrasts with the research done for the more advanced nations. In developed countries like the USA, poorer communities have suffered disproportionately from Covid-19 (Finch & Hernández Finch, 2020).

We explore if the same pattern carries over to an emerging economy. If similar patterns exist between a developed and a developing country, one expects the poorer states to perform worse than the wealthier states regarding the excess spread of the infection and its death toll. As we document below, our results are opposite to that intuition. We find that the richer states have performed significantly worse than their poorer counterparts both in controlling the pandemic and saving lives from the disease. In other words, poorer Indian states seemed to have achieved lower mortality rates and disease burdens than their richer counterparts. We exploit a relative performance measure in this research by centering the neutral performance around the median mortality. Viewed this way, states with mortality below the median are treated as better performers than their peers on the other side of the median.

Literature Review

The relative performance of Indian states is hard to establish, especially in the presence of non-trivial concerns about data quality. According to Jha, P., Deshmukh, Y., Tumbe, C., et al. (2022), undercounting cases in India could be as high as 29%. Taking the interstate variations as focal points of estimation, Leffler, C. T., Das, S., Yang, E., & Konda, S. (2022) posits that undercounting of deaths from Covid-19 in India may be as high as 3.57 million or, about seven times than what the currently available reports seem to suggest. Bhadra, A., Mukherjee, A., & Sarkar, K. (2021) finds a moderate relationship between population density and Covid-19 death rates in India. This result is significant and can provide a rational explanation for our results in that economically richer states in India are also some of the most populated ones. Therefore, if population density is positively related to death rates and per capita income is positively related to population density, one would expect that the richer states with higher population density might perform worse compared to their poorer and less rich counterparts.

Given the complexity of socioeconomic responses to the Covid-19 pandemic, deaths from other causes might have also been affected. For example, Bhargava, A., & Shewade, H. D. (2020) estimates that Covid lockdowns might have adversely affected food security and worsened nutrition among a particular section of the population, leading to increased death rates from tuberculosis. Lewnard, J. A., Mahmud, A., Narayan, T., Wahl, B., Selvavinayagam, T. S., & Laxminarayan, R. (2022) notes a significant increase in excess mortality, especially among the disadvantaged community in the Southern parts of India. This finding closely mimics the excess disease burden in disadvantaged communities in the USA, as in Finch & Hernández Finch (2020). Interestingly, Covid-19 lockdown-driven improvements in air quality might have contributed to decreased mortality as in Karuppasamy, M. B., Seshachalam, S., Natesan, U., Ayyamperumal, R., Karuppannan, S., Gopalakrishnan, G., & Nazir, N. (2020) and Ray (2021).

The interactions between poverty and the Covid-19 pandemic are varied and nuanced. While the pandemic and resultant shutdowns and economic dislocations contributed to increased poverty and higher mortality, the presence of higher poverty at the starting point exacerbated the problem in a non-trivial way. Decerf, B., Ferreira, F. H., Mahler, D. G., & Sterck, O. (2021) The complex and nuanced relationship between poverty, inequality and Covid-19 outcomes has been extensively studied in Spanish regions, Asia and Latin America. Palomino, J. C., Rodríguez, J. G., & Sebastian, R. (2022) and Bargain, O., & Aminjonov, U. (2021). The extent of poverty might have also moderated the level of compliance with various Covid-19 restrictions, including but not limited to the shelter-in-place directives. Wright, A. L., Sonin, K., Driscoll, J., & Wilson, J. (2020) Elsewhere, the relationship between poverty, food security, and Covid-19 outcomes has also shed important lights evolution of the pandemic. Laborde, D., Martin, W., & Vos, R. (2021).

Methodology and Research Methods

Our research covers the period from the pandemic's beginning to June 18, 2021. We collected Covid-19-related data from https://www.covid19india.org/. We augmented the Covid-19 data by population and per-capita Income of respected Indian states and Union Territories (UT) collected from the Ministry of Statistics and Program Implementation's data publicly available at https://www.mospi.gov.in/. We used the population to compute the caseload, deaths, and excess deaths per 100,000 population for each of the Indian states. To calculate the *excess cases and deaths*, we derived a threshold based on the relative spread of the pandemic in Indian states and Union Territories (UTs).

First, we found the medians of the cases of deaths per 100,000 population. We took one-half of those medians as the cutoff point to divide geographical units into two *mutually exclusive* categories. Our choice of one-half of the median is akin to the relative poverty measure used by the OECD, where the poverty line

is defined as *one-half of the median income*. (OECD, 2019) This relative threshold is adopted to ensure that the States and UTs are compared with their peer groups within the nation as opposed to geographical units from other parts of the world with whom they share very little to no political, economic and cultural similarities. Furthermore, by being in the same nation and governed by the same Central administration, the national policies (like vaccine availability, shelter-in-place, cash transfers, food security, etc.) affected all the constituent units, similarly, leaving the only state and UT level differences as the key drivers of performance disparities.

We do not differentiate between the first and second waves of the spread of the pandemic. The data has been considered in a cumulative manner that begins towards the beginning of the pandemic and spans to the cutoff date. It is reasonable to assume that the pandemic did not spread symmetrically across different states and UTs of the nation. However, taking a longer period allows us to take a more macro view of the performance of various units. In this structure, states and UTs with at least one-half of the median number of cases and deaths are poorly performing with excess disease burden. On the other hand, States and UTs below one-half of the median threshold are assumed to have *no excess cases or excess mortality*.

In parallel to the relative poverty line, individuals below one-half of the median income are considered poor. Our approach is the mirror image of that widely adopted concept of relative poverty. We assume that the States and UTs above one-half of the median threshold are worse (poor). For the states and UTs above one-half of the median mark, we calculated the difference between the reported number and the counterfactual value; they had one-half of the median for the corresponding variable. States and UTs below the median were considered to have no excess cases or death. Although the States and UTs below one-half of the median threshold may differ, we ignore that difference and treat all equally successful.

We have two distinct but related hypotheses that we test in our research. These are

H1: The relationship between excess death per 100,000 population and per capita income of states & UTs. *This hypothesis relies on the observation that areas with high per capita income are typically more urbanized and offer more economic opportunities. Therefore, excess death per 100,000 population shall be lesser for states & UTs with higher per capita income.*

H2: The relationship of excess death per 100,000 population and per capita income of states & UTs after controlling for the number of cases per 100,000 population. *This hypothesis relies on the observation that areas with high per capita income are typically more urbanized and economically active while also being quite densely populated. While increasing the probability of transmission, this dense population distribution does not fully mitigate the effect of income on mortality.*

Finally, we model the excess cases and death per 100,000 population by simple regression models, controlling for per-capita income and caseloads as a proxy for the contagiousness of the diseases and its spread in a state. The regression models estimated are given by

$$\text{Excess Death} = \beta_0 + \beta_1(\text{Per Capita Income}) + \varepsilon \quad (1)$$

$$\text{Excess Death} = \beta_0 + \beta_1(\text{Per Capita Income}) + \beta_2(\text{Cases}) + \eta \quad (2)$$

In these regression models, Excess Death refers to Excess Death Per 100,000 Population, and Cases refer to Cases Per 100,000 Population. At the same time, the per capita income is measured in thousands of Indian rupees. It may be noted that our unit of observation is at the state level, and we do not adjust for the population density by looking at the ratio to the population to the area of the state.

Results

Our results indicate that India might have experienced over 16.6 million excess Covid-19 cases and over 228,000 excess Covid-19 deaths by June 18, 2021. Table 1 reports the number of cases, deaths, excess deaths, and cases per 100,000 population for a sample of States and UTs. Excess death is computed to be zero if the number falls below one-half of the median for deaths. Many states (like Odisha, Telangana, Rajasthan, Arunachal Pradesh, etc.) with zero excess deaths simultaneously have large excess cases. It is important to note that these states achieved very low death rates despite a high excess case burden. States like Goa, Delhi, Punjab, Maharashtra, Karnataka, etc., suffered from a very high excess burden and high excess death burden. Uttar Pradesh, Madhya Pradesh, and Bihar seem to have done best among the large states by registering zero excess cases and excess deaths per 100,000 population.

Table 1. Excess Cases and Excess Death in a Sample of Indian States and UTs

State / UT	Cases Per 100,000 Population	Deaths Per 100,000 Population	Excess Cases Per 100,000 Population	Excess Death Per 100,000 Population	Per-capita income in '000 Rupees
Odisha	1869.63	7.60	861.35	0.00	76.42
Bihar	575.88	7.63	0.00	0.00	28.67
Telangana	1548.21	8.98	539.93	0.00	143.62
Uttar Pradesh	716.21	9.26	0.00	0.00	44.42
Arunachal Pradesh	2068.38	10.06	1060.10	0.00	93.19
Madhya Pradesh	924.28	10.17	0.00	0.00	56.50
Rajasthan	1173.13	10.95	164.85	0.00	78.57
Assam	1329.66	11.53	321.38	0.12	60.70
Jharkhand	891.67	13.20	0.00	1.80	54.98
Chhattisgarh	1080.21	13.24	71.93	1.83	69.50
Tripura	1459.76	15.13	451.48	3.73	82.63
Gujarat	1286.41	15.68	278.12	4.28	153.50
West Bengal	1480.03	17.25	471.75	5.84	67.30
Nagaland	1068.63	20.71	60.35	9.31	73.28
Andhra Pradesh	3400.35	22.57	2392.06	11.17	107.24
Meghalaya	1288.26	22.81	279.98	11.41	66.22
Haryana	2718.83	32.43	1710.55	21.02	169.41
Kerala	7770.27	32.90	6761.99	21.49	148.08
Manipur	2016.56	33.03	1008.28	21.62	51.18
Uttarakhand	3004.80	37.56	1996.52	26.16	155.15
Tamil Nadu	3080.45	39.24	2072.17	27.84	142.94
Sikkim	2737.55	41.58	1729.27	30.17	242.00
Himachal Pradesh	2679.82	45.73	1671.54	34.33	139.47
Karnataka	4130.00	49.49	3121.72	38.08	153.28
Punjab	1959.29	52.21	951.00	40.81	115.88
Chandigarh	5289.12	69.23	4280.84	57.82	235.00
Maharashtra	4827.44	94.22	3819.15	82.81	147.45
Puducherry	8061.17	120.97	7052.89	109.57	142.58
Delhi	7652.58	133.00	6644.30	121.60	269.51
Goa	10314.39	187.17	9306.11	175.77	368.69

Source: https://www.covid19india.org/; https://www.mospi.gov.in/

Table 2 presents the regression results. Per capita income alone explains nearly 60% of the variation in excess cases per 100,000 population. A thousand Rupees increase in per capita income is found to increase the excess cases per 100,000 population about 25.3. A straightforward interpretation of this result is that the richer states have fared worse in controlling the spread of the pandemic. The success of the poorer places in pandemic control may be partially driven by population density and other living conditions. It is also possible that the results are driven by better data collection where the caseloads and deaths are better captured in richer States especially with large metros. Similar results can be interpreted through the maps given below for excess cases and excess deaths.

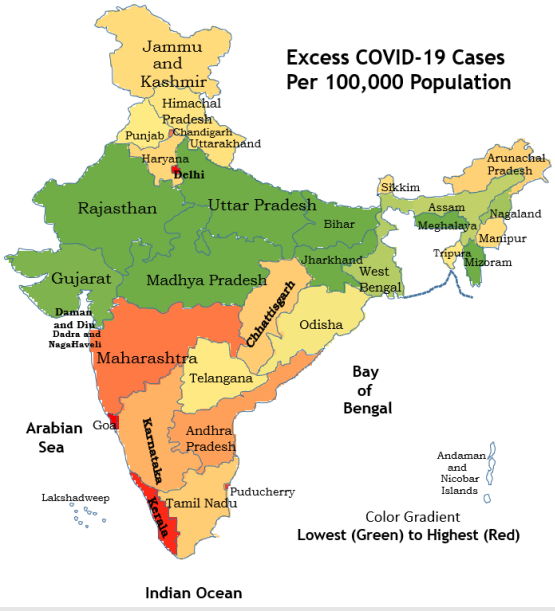

Figure 1. Visualization of Excess Cases

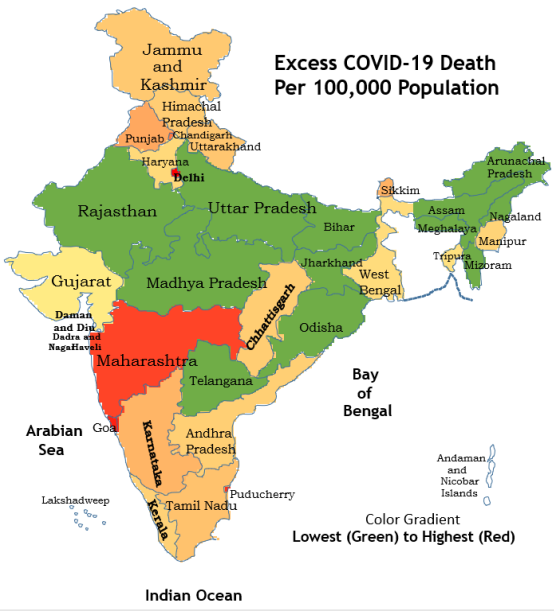

Figure 2. Visualization of Excess Deaths

Source: https://www.covid19india.org/ and https://www.mospi.gov.in/

Our results depend on the actual available numbers. Our results do not capture unreported cases and deaths. It also needs to be clarified if the extent of underreporting affected different states and UTs symmetrically. Future research on this subject may also focus on whether a more significant number of economic activities in comparatively richer states have been responsible for relatively higher mortality rates. It is important, especially in the presence of many workers in cramped living conditions with fewer opportunities to seek gainful economic employment outside their primary residence areas.

Table 2. Regression Results

Independent Variables	***Dependent variable and model***	
	Excess Death Per 100,000 Population (1)	**Excess Death Per 100,000 Population (2)**
Per-capita income in '000 Rupees	25.30*** (3.77)	0.15* (0.07)
Cases Per 100,000 Population		0.01*** (0.002)
Constant	-1,156.72** (541.35)	-22.94*** (6.48)
Observations	31	31
Adjusted R^2	0.59	0.80
Residual Std. Error	1,562.46 (df = 29)	18.64 (df = 28)
F Statistic	44.94*** (df = 1; 29)	60.61*** (df = 2; 28)
Note:	*p<0.1, **p<0.05, ***p<0.01	

Source: Authors' calculations based on the state level data collected from https://www.covid19india.org/ and https://www.mospi.gov.in/

Controlling for the cases per 100,000 population excess deaths are found to be higher in richer states. A thousand rupees increase in per capita income is found to increase the excess death per 100,000 population by about 0.15. Higher caseloads also contributed towards higher excess deaths. An increase of 100 cases per 100,000 population may have led to an additional excess death.

Conclusions

The observation that richer states have performed significantly worse compared to their poorer counterparts presents an interesting policy driver. Paradoxically, an effective pandemic control may require significantly higher deployment of scarce resources especially to the largest urban centers and richer states. The equity considerations for such a paradoxical strategy may be debatable but India stands to lose tremendously without aggressively pursuing pandemic control including vaccination in the economically rich States and urban centers. More studies are urgently required to understand the drivers behind the superior performance of the poorer and highly populous states. While population density, openness, etc. are all risk factors especially for an infectious disease like Covid-19, how the poorer parts of the country stave off raging spread in infection and controlled their death rates should be a topic of intensive studies.

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