Managing the COVID-19 pandemic: does social infrastructure matter?
Evidence from India

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Abstract

Purpose – The COVID-19 pandemic elicited extraordinary policy responses globally, including in India, to flatten the infection-growth curve. The trajectories of infections, recovery, and deaths vastly differed across Indian states. The purpose of this study is to investigate whether persistent investments by states in critical social sectors, such as health and education, explain their preparedness and hence better management of the pandemic.

Design/methodology/approach – This study uses secondary data on the number of infected, recovered and deceased due to COVID-19, along with data on population and income across 302 districts in 11 major states in India. Data on health and education indices are collected at the state-level. Linear regression models that also control for heteroskedasticity are applied.

Findings – This study finds that higher investments in health care and education reduce the propensity of the infection spread. Further, states with persistent investments in health care and education exhibit a higher rate of recovery. This study also finds that death rates are significantly lower in states with higher investments in education.

Research limitations/implications – The findings support the conjecture that states that have consistently invested in social sectors benefited from the associated positive externalities during the crisis that helped them manage the pandemic better.

Originality/value – This study will help policymakers understand the underlying social forces critical to the success in the fight against pandemics. Apart from improving preparedness for future pandemics, the evidence provided in the paper may help give better direction and purpose to tax-financed public spending in states where social sector development has hitherto received low priority.

Keywords Education, India, Health, Sub-national, COVID-19, Social infrastructure

Paper type Research paper

1. Introduction

COVID-19, first reported in Wuhan, the People’s Republic of China in December 2019, assumed the form of a pandemic in a very short time. The rapid global transmission of the
Sars-Cov-2 virus initially happened via international air routes, and subsequently spread across major urban agglomerations around the world, primarily through contact-intensive economic activities (Dahab et al., 2020).

In about seven months since the first case was reported in China’s Hubei province, the disease spread to at least 220 countries and territories around the world (World Health Organisation, 2020a), resulting in a massive loss to lives and livelihoods. The rapid spread of infections and fatality [1] caused by the deadly virus has overwhelmed public health systems. Since early May 2020, Southeast Asian countries, including India [2], have shown a rapid increase in the number of cases (Ministry of Health and Family Welfare, 2020; World Health Organisation, 2020a). As of August 13, the total number of cases in India exceeded 2.3 million, the third-highest in the world in the cumulative number of cases, accounting for more than one-tenth of total cases globally. The World Health Organisation (WHO) has classified transmission in India as “clusters of cases” that is characterized by cases “clustered in time, geographic location and/or by common exposures” (Figure 1).

The public health emergency triggered by the pandemic has educed extraordinary policy responses globally (Visvizi and Lytras, 2020). Consistent with the approach adopted elsewhere in the world, the Indian government also enacted a complete lockdown policy from 24 March 2020, when the total number of cases was only 519. The lockdown policy was initially enacted to limit the movement of India’s 1.3 billion population with an aim to flatten the infection-growth curve. The policy was protracted over five months in several phases, with progressively varying degrees of relaxation on mobility and economic activity (Government of India, 2020).

While the lockdown policy was enacted across India, one can observe a wide disparity in the extent to which the policy served the objectives of prevention and containment at the sub-national level (Figure 1). Although almost all states showed exponential growth in the number of confirmed cases, the trajectories vastly differed across states (Figure 2). States such as Maharashtra, Andhra Pradesh, Karnataka, Delhi and Tamil Nadu were the worst-hit ones, recording more than 100,000 cases as of end-July, 2020. However, states such as Kerala, Punjab, Chattisgarh, Himachal Pradesh, Uttarakhand and most North-eastern states reported less than 25,000 cases in the same period. The spatial disparity in outcomes could be observed at all three levels – infections, recovery and deaths, which merits deep reflection about the plausible reasons.

Figure 1.
Spatial pattern of COVID-19 infections, recoveries and deaths as on July 31, 2020

Sources: Ministry of Health and Family Welfare (2020); NITI Aayog (2019). Map created by Authors
In particular, despite remaining under the purview of common rules governing the nationwide lockdown, why have some states achieved better outcomes on all aspects than others? Could it be attributed to a better and decentralized health-care infrastructure that perfectly supplemented the aggressive testing strategy adopted by the better-performing states? Could it be attributed to the states’ sustained investments in social infrastructure (in particular on health and education)? Because that not only ensures better preparedness in meeting the myriad challenges thrown open by the pandemic but also effectively engages the more-informed individual and local communities to enact the lockdown protocols in letter and spirit.

It is in the above context that this paper undertakes a preliminary empirical analysis to understand the underlying determinants of divergent outcomes of infection, recovery and deaths at the sub-national levels – across 21 states and 302 districts (across 11 major states) in India. Specifically, the study investigates whether persistent investments by some states in critical social sectors such as health and education explain their preparedness and hence better management of the COVID-19 pandemic than others.

This study is important because it may help policymakers in India and across the world, to understand the underlying forces that enable viral infection to spread even during lockdown. Given the detrimental effects of lockdown on economic well-being, no country can afford to continue lockdown for a substantially long duration. Thus, it is essential to understand what social and health capabilities and capacities of states, that are to some extent autonomous under the federal system of government in India, are critical to the success of lockdown, and in turn, in the fight against the pandemic. Such an understanding can not only help improve preparedness for future pandemics but may help give better direction and purpose to tax-financed public spending. In this context,
The rest of the paper is organized as follows. Section 2 presents the theoretical framework and states the hypotheses. Section 3 describes the data and methodology. Section 4 presents the findings of the empirical investigation. Section 5 discusses the results and implications of the study. The final section concludes the study while also mentioning the limitations and scope for future research.

2. Theoretical framework and hypotheses
The extant literature has placed profound importance to system preparedness in terms of health infrastructure, individual preparedness in terms of health-seeking behaviour (Kruk, 2008; Hanvoravongchai et al., 2012) and community (and individual) preparedness in terms of basic education (literacy and awareness) (Marshall et al., 2009), to effectively meet the challenges of public health emergencies. Welfens (2020) argues that it is crucial to link health expenditure with other macroeconomic variables while modelling for a pandemic such as COVID-19. Indeed, as Deaton (2020) notes, greater investments in public health systems involving sanitation and disease surveillance, which grew from the awareness that germs cause disease, played a more significant role in improving life expectancy than gains in income. However, there exists a significant disparity among and within nations when such social sector investments are compared, including in India (Costa-Font and Pons-Novell, 2007; Behera and Dash, 2018).

In India, the underinvestment in social sectors, particularly on health and education, is indicated by the fact that India’s general government expenditure on health care as a share of GDP was only around 0.96% in 2017, placing it at 165th position out of 186 countries in terms of public spending on health care (World Health Organisation, 2020b). Even in terms of total health-care spending (public plus out-of-pocket) as a share of GDP, India (3.6%) compares unfavourably with the OECD average of 8.8%. It records the least amount of spending among BRICS countries in 2018 (OECD, 2020). Likewise, India’s expenditure on education was only around 3% of its GDP in FY19 (Government of India, 2019), placing it at 62nd position in total public expenditure on education per student and measures of the quality of education according to the IMD World Talent Ranking 2019.

The above macro numbers notwithstanding, health being a state subject and education being in the concurrent list in India, there exist substantial differences at the sub-national level when it comes to social sector spending as a share of the gross state domestic product (GSDP). The wide disparity in social sector expenditure patterns has resulted in different outcomes for states with high and low focus, as reflected in the relative rankings of states according to the health and education parameters (Pai and Alathur, 2019).

The spread of infections during the lockdown and the unlock phases may reflect the effect of preparedness, in terms of social awareness and health infrastructure, as discussed earlier. The rate of infection spread is a function of the general health of the residents, the way people adhere to the social-distancing norms and maintain basic hygiene practices. However, the mortality and recovery rates are functions of the health infrastructure at the district and state level, coupled with the social awareness that people show to get tested and admitted (once they are infected).

This study conjectures social awareness proxied by the school education infrastructure of the states, and the health infrastructure of the states proxied by performance in health care constitute the key elements of the system, community and individual preparedness in the fight against a public health emergency such as COVID-19. They can potentially explain
why some states have managed the pandemic better than others. Both performances are measured through indices prepared by the Government of India (Government of India, 2019). This paper assesses the impact of health and education indices on the performance of Indian states in managing the COVID-19 pandemic, controlling for the levels of gross sub-national incomes.

Higher and sustained investment in health care by the states should have a positive impact on the management of pandemic due to several reasons. First, it creates more resources in terms of hospital beds, equipment and health-care professionals at all three tiers of the health-care delivery system – primary, secondary and tertiary. Increased capacity and efficiency of those resources become useful, particularly in times of a health-care crisis. Second, higher investment in health care by states increases the efficiency of primordial (generalized lifestyle modifications), primary (definitive preventive measures such as immunization) and definitive (treatment) health care. Third, it increases the health-seeking behaviour of the population that compels them to adhere to the social-distancing and hygiene norms strictly and take other proactive preventive measures (such as testing and seeking medical attention) during pandemics such as COVID-19. The recovery and mortality rates are directly linked to the treatment provided to the affected, both in terms of quality and promptness. To improve the recovery rate and reduce the mortality rates, greater and more uniformly distributed capacities and capabilities, therefore, becomes critical for providing access to timely and efficient health-care services to the infected. Thus, the first set of hypotheses may be written as:

H1A. Better health-care system leads to a lower rate of infected cases.
H1B. Better health-care system leads to a higher rate of recovered cases.
H1C. Better health-care system leads to a lower rate of deceased cases.

Simultaneously, an effective school education system creates more responsible citizens, both in terms of their social awareness and social as well as individual health-seeking behaviour. Therefore, the states with sustained spending records in education, resulting in better educational infrastructure and quality are likely to have more residents who will adhere to the social-distancing norms, individual and family hygiene norms, equally during the lockdown and the unlock phases. They will also be more aware of the symptoms, more likely to undergo diagnostic tests and admit themselves or their kin in case they are symptomatic or infected, thus reducing the chance of mortality and increasing the chance of recovery. Thus, the second set of hypotheses may be written as:

H1D. Better quality of school education leads to a lower rate of infected cases.
H1E. Better quality of school education leads to a higher rate of recovered cases.
H1F. Better quality of school education leads to a lower rate of deceased cases.

All these hypotheses are tested using state- and district-level data, as described in the next section.

3. Data and methodology
3.1 Variables
The dependent variables for the study are the district-wise numbers of confirmed, recovered and deceased cases. District-specific and state-specific factors are used to explain the incidence of COVID-19 infections, recoveries and deaths. At the district-level, gross district
domestic product (GDDP) and total population are controlled [3]. GDDP is used to control for district-level development that can cause potential endogeneity. The unavailability of GDDP data restricts the sample to 302 districts across 11 major states [4]. However, as these 11 states exhibit a wide dispersion in the income levels and are also spatially dispersed across the country, the sample is a representative one.

As proxies for the states’ preparedness for the epidemic in terms of persistent investments in health and education sectors, the composite health index and school education quality index (SEQI) published by NITI Aayog (2019) are used. State-wise health index is calculated by NITI Aayog based on several indicators under three broad domains – health outcomes, governance and information and main inputs/processes [5]. Similarly, SEQI is based on indicators that measure the overall effectiveness, quality and efficiency of the Indian school education system [6]. Using composite indices rather than using metrics such as health and social sector expenditure gives an advantage in terms of better capturing the health and educational performance, as well as to address the endogeneity issues. For example, higher education and health expenditure may also be indicators of more developed states that experienced a spurt of initial infections.

The other state-level control variables are the number of days since the 10th case and the total tests conducted. Both variables control for the epidemiological characteristics. The first one primarily caters to the exponential shape of the infection-growth trajectory. In the case of a pandemic of this scale and contagiousness, proactive testing of citizens is one significant way of restricting the spread by quarantining the infected (Binnicker, 2020). Thus, the number of tests for SARS-CoV-2 conducted by the states is used as another control variable.

India is a country of vast diversity. The states are created based on the language and ethnographic divide of the people. The COVID-19 pandemic is a novel pandemic, and all the determinants of its spread of infection and mortality rates are still unknown. Whether the spread of infection and mortality depend on genetic and ethnographic predispositions are uncertain. Some preliminary research on COVID-19 indicates a possible link between Bacillus Calmette–Guérin (BCG) vaccine immunization and the lower chance of contracting severe symptoms (Miller et al., 2020). The immunization data across India are not available. Hence, state-specific dummies are used in the regression to reduce the omitted variable bias.

3.2 Data sources
This study uses secondary sources of data for the empirical analysis. Information on the district-wise total number of confirmed, recovered and deceased cases, as well as the total tests conducted by the states as of 31 July 2020, have been collected from various state websites [7]. The GDDP data for the year 2012–2013 (latest available) are sourced from the open government data (OGD) platform of India [8]. District-level population data are obtained from the Census 2011. Data for health index and SEQI have been sourced from NITI Aayog (2019). For the illustration of the growth trajectory, state-level data has been collected from Ministry of Health and Family Welfare (2020).

3.3 Methodology
This study performs the empirical analysis in two parts. In the first part, state-level infection, recovery and death rates due to COVID-19, as compared to health and education indices of the state, are presented graphically (Figures 3 and 4). In the second part, information from 302 districts of India is used to fit linear regression models to understand the impact of health and education investments on COVID-19 confirmed cases, recoveries and deaths. State-level variables – total tests, health index, SEQI and days since the 10th
Case – are replicated for all districts in a state across 11 states since district-wise data for all states are unavailable.

The following specification of the regression model is used to measure the impact of health and education variables on COVID-19 incidence at the district level.

Sources: Ministry of Health and Family Welfare (2020); NITI Aayog (2019)
Figure 4.
State-wise pattern of SEQI vs COVID-19 infections, recoveries and deaths

Sources: Ministry of Health and Family Welfare (2020); NITI Aayog (2019)
\[
\ln (Y_i) = \alpha + D\beta + X\gamma + \varepsilon
\]  

(1)

where \( Y_i \) represents different COVID-19 outcome variables in district \( i \) – the number of confirmed, recovered and deceased cases. The number of cases is multiplicative data. It forms the base for the number of recoveries and number of deceased. Thus, logarithmic transformation of the confirmed cases, recoveries and deaths is used to adjust for skewness in the data across districts. As there are many “0 reported cases,” 0.01 is added before the data transformation. \( D \) represents the matrix of district-level variables (population and GDDP) with coefficient vector \( \beta \), and \( X \) is the matrix of state-level variables (health index, SEQI, total tests, and days since 10th case) with coefficient vector \( \gamma \). Population, GDDP and total tests are log-transformed. In contrast, days since 10th case is not, to capture the exponential nature of infection-growth trajectory. Health index and SEQI are state indices and primary variables of interest. Being indices, they follow a Gaussian distribution and thus are not log-transformed as well. Heteroskedasticity is found to be present once ordinary least squares is used to estimate the models. Hence, heteroskedasticity-consistent standard errors and covariances are used following White (1980). The presence of endogeneity is checked through analysis of the correlation between variables of interest, the health index and SEQI with the model residuals (Table 3).

4. Results

4.1 State-level analysis

Figure 3 presents the state-wise graph of health index and COVID-19 infection, recovery and death rates [9]. Panel A shows that infection rates are lower in the states with higher health index, for example, in Andhra Pradesh, Punjab and Kerala, except for Maharashtra. Similar patterns are observed for recovery and death rates among the states (Panels B and C). States with better health index such as Kerala, Tamil Nadu and Goa reported lower death rates due to COVID-19. The findings support the underlying argument that states which have consistently invested in health infrastructure, leading to better health outcomes, performed better in managing the pandemic.

In Figure 4, the state-wise graph of SEQI and the COVID-19 variables (infection, recovery and death rates) are plotted. The rationale behind the same is to understand whether states that have had better record on education index managed to lessen the spread of the disease through better information-management regarding COVID-19, better sanitation practices and better awareness and understanding of the importance of lockdown by the population at large. With few exceptions such as Maharashtra, Delhi and Gujarat, lower infection rates are found in states with higher SEQI scores (such as Andhra Pradesh, Assam, Goa, Kerala and Odisha). The recovery rate (Panel B) was also found to indicate a strong association with SEQI. Thus, states with better outcomes on education quality such as Andhra Pradesh, Haryana and Kerala showed higher recovery rates. For death rates, however, no specific pattern with educational index is noticed.

4.2 District-level regression results

4.2.1 Summary statistics Table 1 shows the summary statistics of the variables used in the analysis. The maximum incidence of COVID-19 is reported in Mumbai, making the district the worst-hit in India. Kerala emerged as the best-performing state, both in health (76.55) and education (82.17) indices. The worst-performing state according to the health index was Uttar Pradesh (33.69), and in SEQI was Bihar (37.2).
4.2.2 Regression results  The results for district-level regression specified in equation (1) are reported in Table 2. Three outcome variables are considered in the study – the total number of confirmed, recovered and deaths due to COVID-19.

All three outcome variables are estimated using two models in each case. The spread of COVID-19 infection is estimated using the number of confirmed cases. Model 1 includes only district income (GDDP), while in Model 2, the squared GDDP is also considered. While modelling log of confirmed cases, log population is controlled (Table 2, Models 1 and 2).

The results (Table 2, Models 1 and 2) reveal that the states that had better health index have a significantly fewer number of confirmed cases (validating hypothesis H1A). The education index does have a significant negative impact on the number of confirmed cases (validating hypothesis H1D). The results signify that better social awareness (proxied by the better quality of school education), and investment in health by the states (proxied by health index) lead to a decline in the spread of the pandemic. The coefficient for GDDP levels in Model 1 shows that the number of confirmed cases increased in the districts with higher incomes, arguably due to greater contact-intensity in economic activities. However, when the squared GDDP is considered in Model 2, results suggest that the number of confirmed cases actually declines with an initial increase in income levels. Then, the propensity of infection spread increases quadratically with higher levels of income. Results also indicate that higher the number of tests, lower is the spread of infection. The number of tests conducted by a state signals the focus of the state on health care.

In Models 3 and 4 (Table 2), the log of the number of confirmed cases is used as the control variable, instead of the population. The determinants of recovery explain more than 94% (Adjusted \( R^2 = 0.94 \)) in the variation in recovery rates across the 302 districts in India. Interestingly, the health index emerges as a significant determinant for the recovery rate (validating hypothesis H1B). The quality of school education, however, has no impact on the recovery rate (rejecting hypothesis H1E). It is a confirmation to the pattern observed in Figures 3 and 4.

Income levels of the districts negatively impact the recoveries, indicating that wealthier districts do not necessarily have better health infrastructure. The finding reiterates the nexus between growth and development. It implies that unless higher incomes are channelized towards welfare-enhancing social spending, individuals and societies shall continue to remain vulnerable when exigencies such as COVID-19 strike. It also conforms to

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs.</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirmed cases</td>
<td>302</td>
<td>3,205.67</td>
<td>10,677.24</td>
<td>40</td>
<td>1,14,284</td>
</tr>
<tr>
<td>Recovered cases</td>
<td>302</td>
<td>1,806.99</td>
<td>6,615.86</td>
<td>12</td>
<td>87,074</td>
</tr>
<tr>
<td>Deceased</td>
<td>302</td>
<td>73.67</td>
<td>419.78</td>
<td>0</td>
<td>6,353</td>
</tr>
<tr>
<td>Total tests(^a)</td>
<td>302</td>
<td>13,37,532</td>
<td>7,60,915.30</td>
<td>3,16,127</td>
<td>23,25,428</td>
</tr>
<tr>
<td>Health index(^a)</td>
<td>302</td>
<td>50.12</td>
<td>13.55</td>
<td>33.69</td>
<td>76.55</td>
</tr>
<tr>
<td>SEQI(^a)</td>
<td>302</td>
<td>53.17</td>
<td>9.94</td>
<td>37.20</td>
<td>82.17</td>
</tr>
<tr>
<td>Days since 10th case(^a)</td>
<td>302</td>
<td>133.45</td>
<td>7.87</td>
<td>119</td>
<td>150</td>
</tr>
<tr>
<td>GDDP (in Rs. billion)</td>
<td>302</td>
<td>8,691.16</td>
<td>140.73</td>
<td>3.42</td>
<td>1,679.14</td>
</tr>
<tr>
<td>Population</td>
<td>302</td>
<td>25,26,943</td>
<td>16,41,431</td>
<td>3,12,164</td>
<td>1,10,60,148</td>
</tr>
</tbody>
</table>

Table 1. Summary statistics

Note: \(^a\)Data is replicated for all districts for a state, across 11 states

Sources: Ministry of Health and Family Welfare (2020), NITI Aayog (2019); Census of India 2011
<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Ln (Confirmed cases)</th>
<th>Ln (Recovered cases)</th>
<th>Ln (Deceased)</th>
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<tbody>
<tr>
<td></td>
<td>Model 1</td>
<td>Model 2</td>
<td>Model 3</td>
</tr>
<tr>
<td>Health index</td>
<td>−0.0276*** (0.0083)</td>
<td>−0.0221*** (0.0077)</td>
<td>0.0065*** (0.0024)</td>
</tr>
<tr>
<td>SEQI</td>
<td>−0.0413* (0.0226)</td>
<td>−0.0385* (0.0214)</td>
<td>0.0061 (0.0052)</td>
</tr>
<tr>
<td>Ln(Total tests)</td>
<td>−0.8749* (0.4236)</td>
<td>−0.8727** (0.4078)</td>
<td>0.1131 (0.0839)</td>
</tr>
<tr>
<td>Ln(Confirmed cases)</td>
<td>−1.0084*** (0.0191)</td>
<td>−1.0079*** (0.0203)</td>
<td>1.0309*** (0.0647)</td>
</tr>
<tr>
<td>Days since 10th case</td>
<td>0.0369 (0.0575)</td>
<td>0.0537 (0.0556)</td>
<td>−0.02467*** (0.0109)</td>
</tr>
<tr>
<td>Ln(Population)</td>
<td>0.4031** (0.1649)</td>
<td>0.4839*** (0.1611)</td>
<td>−0.0805 (0.1987)</td>
</tr>
<tr>
<td>Ln(GDP)</td>
<td>0.1474*** (0.0263)</td>
<td>−1.7790*** (0.5093)</td>
<td>−0.0655*** (0.0290)</td>
</tr>
<tr>
<td>Ln(GDP)^2</td>
<td>0.8466*** (0.1413)</td>
<td>0.1474*** (0.0263)</td>
<td>0.00089 (0.0118)</td>
</tr>
<tr>
<td>State dummy</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Constant</td>
<td>4.1167 (2.8996)</td>
<td>11.8414*** (2.8905)</td>
<td>1.1929* (0.6353)</td>
</tr>
<tr>
<td>Observations</td>
<td>302</td>
<td>302</td>
<td>302</td>
</tr>
<tr>
<td>F-stat</td>
<td>72.35</td>
<td>81.81</td>
<td>662.74</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td>0.7238</td>
<td>0.7490</td>
<td>0.9430</td>
</tr>
</tbody>
</table>

**Notes:** *Refer to 10% significance level. **Refer to 5% significance level. ***Refer to 1% significance level. Heteroskedasticity-consistent standard errors (White, 1980) are reported within the parentheses.

**Source:** Authors' estimation
the stylized fact that COVID-19 infection spreads more in the affluent regions of the society due to their higher connectedness (Dahab et al., 2020).

Models 5 and 6 present the determinants of the death rate (Table 2). Once a person is infected and diagnosed, the availability and access to better health-care infrastructure and services become critical. Contrary to the hypothesis $H1C$, it is found that a higher health index significantly increases the percentage of people dying after contracting COVID-19. The result for health index appears to be counter-intuitive. However, it should be kept in mind that failure to flatten the infection curve to a desirable degree has put a considerable strain on the tertiary health-care system. In most of the populous states, health care with inadequate capacity was, thus, overwhelmed by the large number of patients as time progressed. The result for income levels is similar to that of the number of confirmed cases (Models 1 and 2).

However, the quality of education is found to be significantly decreasing the death rate (validating hypothesis $H1F$). Proper monitoring of the infected patients at home, preventive monitoring and isolation of members of the vulnerable age-groups and timely hospitalization are critical factors determining COVID-19 mortality rates. The negative relationship reflects the positive spillovers that investments in education can bear on health outcomes. States with a better quality of school education can create more responsible individuals, which manifest through better awareness and health-seeking behaviour at the individual and community levels.

Table 3 presents the correlation of the variables of interest – health index and SEQI – with the residuals of all six models. In none of the cases, the residuals are found to be significantly correlated with the variables. Thus, it can be said that the results are not biased by endogeneity. Further, as indicated in the methodology section, to counter heteroskedasticity that is present in the district-level data, heteroskedasticity-consistent standard errors and covariance estimates (White, 1980) were used to make the results robust.

5. Discussions and implications

5.1 Discussions

The results reported in Section 4 provide some critical insights on the role that developmental spending and concomitant outcomes play in shaping preparedness and agility of health systems in addressing the challenges posed by sudden exigencies to public health and safety, as the current case of the COVID-19 pandemic presents.

For example, the state of Kerala has a larger share of international migrants (emigrants) and an ageing population compared to other states across India (Oommen, 2008). Nevertheless, by responding proactively and swiftly, the state has been able to contain the spread effectively. The state has also reported a high rate of recovery and a low rate of mortality related to COVID-19, which underlines the long-term focus of the state on health and education (Sulaiman et al., 2020). Kerala has made continued investments in universal health care and literacy (Nikarthil, 2015). Today, every village has a health centre, with doctors, nurses and paramedics, delivering quality health care (including preventive health-care services). Coupled with a high level of literacy and awareness, it has resulted in a very different kind of health-seeking behaviour among the population. In the case of COVID-19, while the state governments had taken proactive steps to strictly follow the epidemiological protocols recommended by the WHO (test, trace, isolate and support), it would have been hardly possible without the high levels of discipline and awareness among the population. Earlier, it had managed to counter the Nipah virus outbreak in 2018 with great success. Repeated success in managing health emergencies is hardly possible without the
<table>
<thead>
<tr>
<th>Variable of interest</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Residuals</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health index</td>
<td>$-9.75 \times 10^{-9}$((-1.69 \times 10^{-7})$</td>
<td>$1.36 \times 10^{-8}$((2.35 \times 10^{-7})$</td>
<td>$9.44 \times 10^{-10}$((1.63 \times 10^{-8})$</td>
<td>$8.17 \times 10^{-9}$((1.41 \times 10^{-7})$</td>
<td>$1.59 \times 10^{-8}$((2.74 \times 10^{-7})$</td>
<td>$-9.31 \times 10^{-9}$((-1.61 \times 10^{-7})$</td>
<td></td>
</tr>
<tr>
<td>SBQI</td>
<td>$-1.19 \times 10^{-8}$((-2.05 \times 10^{-7})$</td>
<td>$1.62 \times 10^{-9}$((2.80 \times 10^{-8})$</td>
<td>$-4.96 \times 10^{-9}$((-8.58 \times 10^{-8})$</td>
<td>$4.46 \times 10^{-9}$((7.71 \times 10^{-8})$</td>
<td>$-4.08 \times 10^{-9}$((-7.05 \times 10^{-8})$</td>
<td>$-1.32 \times 10^{-8}$((-2.29 \times 10^{-8})$</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** $t$-stat is reported in parentheses with null hypothesis $\text{Corr}(\mu, x) = 0$

**Source:** Authors' estimation

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**Table 3.** Endogeneity check – correlations of the health index and SEQI with the regression model residuals

Managing the COVID-19 pandemic
government’s steadfast focus on welfare and social sector development, which helps to significantly shorten the learning curve when the disaster strikes (Sinha Roy and Babu, 2020).

Similarly, Goa, Puducherry, Sikkim, Mizoram and other north-eastern states have controlled and contained the COVID-19 attack because of their well-developed primary health-care systems and coordinated efforts of various government agencies and local communities. Most of these states spend more than twice the national per capita average expenditure on public health (Duggal, 2020).

Had other states in India similarly invested in a robust and comprehensive primary health-care system, perhaps the contagion of the deadly virus could have been managed better. The example of Maharashtra, and in particular, the city of Mumbai is a case in point. While Mumbai may have sufficient number of beds, considering both public and private medical facilities, the deficits in human resources and supplies and meagre budgetary allocations for health care [10] have been limiting factors for the public health-care system’s response to the COVID-19 crisis. Like Kerala, Maharashtra has been affected by multiple pandemics in the past (SARS 2003 and H1N1 2009). Yet, unlike Kerala, lessons have not been learnt. While the state has become more affluent, commensurate investments in welfare-improving social spending have remained inadequate. Despite earlier experiences, adequate focus on capacity building and preparedness has remained elusive, leading to continued vulnerability. The story is similar for states such as Gujarat, Haryana and Madhya Pradesh.

5.2 Implications
The empirical analysis in this paper suggests the need for a paradigm shift in the philosophy driving growth and development in India in general and the need for higher and sustained social sector spending in particular. The challenges to public health systems posed by the ongoing pandemic have exposed the skewness of social sector spending at the sub-national level like never before. The findings suggest that as national and sub-national income grows, an increasing number of resources need to be directed towards crucial social sector infrastructures such as health and education.

India’s overall public spending on health and education amounts to a meagre 1% and 3% of the GDP (World Health Organisation, 2020b; Government of India, 2019). There is a wide disparity among states on this account as well. The consolidated spending is clearly sub-optimal and pales compared to global benchmarks (Chandwani and Dwivedi, 2015). The findings in this paper underscore the need for a more in-depth and nuanced understanding of the utility that social sector spending bears in times of exigencies. If policymakers fail to recognize the role that social infrastructure can play in improving growth, agility and in building human capability in an egalitarian way, the overall outcomes are going to be detrimental for the economy and the society when sudden external shocks emanate (Sen, 2020; Deaton, 2020).

Sustained investments in social sectors can bear significant positive externalities in terms of better awareness, discipline, personal and community responsibilities, better vision of the greater good to name a few. That, in turn, can drastically improve preparedness across all levels while facing health emergencies such as COVID-19. As the recent experience suggests, such social expenditures assume greater relevance in India where morbidities are high and increasing and unrestricted to the ageing population alone.

Inadequate and ad hoc spending, on the other hand, can have substantial negative externalities that may exacerbate the challenges for policymakers and society, as is evident
through experiences of states in the current crisis. Capacity constraints in public health infrastructure, reflective of paltry investments in the sector, can severely impact the economic activity, as the protracted lockdown indicates. The experience of the COVID-19 pandemic should, therefore, act as a wake-up call for governments at all levels, not only in India but internationally. Without higher public investments directed to improve capacity and outcomes in social sectors such as health care and education, the fruits of growth can be easily eroded for lack of system, individual and community preparedness when the next health exigency strikes.

The key findings of the paper, albeit holding true for a sub-national analysis in a single-country context, also broadly resonate with global experiences. Countries that have had a historical focus on social sector investment and infrastructure appear to be performing better in terms of recovery and fatality rates, adjusted for population size. Countries with high or medium social infrastructure (such as the USA, Central European countries, several Scandinavian countries and China) reported a high number of cases. It can be attributed to their high degree of global connectivity (which led to the initial spread of the virus), high intensity of economic activity and delayed efforts in dealing with the pandemic (GHS Index Reports, 2020). Despite the unfavourable demographic pattern (mostly with a rapidly ageing population), the per capita recovery and fatality rates in those countries have been impressive, thanks to the robust social infrastructure built over the years. Our findings are consistent with Khan et al. (2020), which confirms that greater health-care capacity is indeed related to lesser case-fatality – a conclusion arrived after examining data for 86 countries that had at least 1,000 confirmed cases.

Public policies concerning health and education are more inclusive in developed countries compared to developing countries. Like India, social infrastructure in other developing countries exhibit a wide regional variation and is similarly plagued with inadequate per capita investment in the social sector due to limited fiscal headroom. The implications of this study that governments need to rationalize unproductive expenditures to find the necessary fiscal space for investing in welfare-augmenting social infrastructure, thus building more resilience into economic systems rendered vulnerable during the current pandemic, may therefore be instructive to other developing countries, especially in South Asia.

6. Conclusion
The study suggests that while the overall number of infections, recovery and deaths continues to rise at a rapid pace in India, the pattern is not uniform across states. A disaggregated analysis at sub-national levels (state-wise and district-wise) reveals that while the growth in infections follows the law of natural progression, higher and persistent investments in health care and education by the states reduce the propensity of the infection spread. Further, the higher the investment in health care and education, the higher is the rate of recovery. Higher investment in education also reduces the death rate. The results further suggest that high levels of income may not necessarily lead to better preparedness and management of health emergencies unless states make consistent investments in social development and welfare and redirect resources to social sectors that bear significant positive externalities when handling shocks such as COVID-19.

This study will help policymakers to understand the underlying social forces critical to the success in the fight against pandemics. Apart from improving the preparedness for future pandemics, the evidence provided in the paper may help give better direction and purpose to tax-financed public spending in states where social sector development has hitherto received low priority. The broader implications of the study can be extrapolated to developing countries where similar skewness in social sector spending is observed.
6.1 Limitations and scope of future research
This study uses state-level data on health and education infrastructure due to the unavailability of more granular data for India. A study done in some other country with district-specific infrastructure and outcome data on health and education, where available, may further substantiate the results of this analysis. Further, the immediate responses by the government (Hale et al., 2020) and the attitudes of the public towards these responses remain an important aspect for managing the spread of a pandemic. Studies show that stringent government responses with income support also helped in reducing the cases overall (Ashraf, 2020). The study can be extended by quantitatively measuring and analyzing how the attitudes and responses of the government could help explain the efficacy of pandemic management in a cross-country setting. Once the pandemic is over and more reliable as well as comprehensive data sets are made available by the governments or other multilateral organizations, such studies can be undertaken.

Notes
1. World Health Organisation (2020a) has reported 17,106,007 cases and 668,910 deaths worldwide, as on July 31, 2020. Americas have the leading number of confirmed cases and mortality with 9,152,173 cases and 351,121 deaths. Europe follows with 3,333,300 cases and 212,520 deaths. Eastern Mediterranean has reported 1,553,357 cases and 39,661 deaths. South East Asian countries so far have reported 2,009,963 cases with 44,031 deaths while countries in Western Pacific are the least affected with 306,052 cases and 8,330 deaths.
2. World Health Organisation (2020a) classifies India under Southeast Asia.
3. While large body of research argues that increases in income levels will lead to better health outcomes (Preston, 1975; Pritchett and Summers, 1993) and social well-being (Anand and Ravallion, 1993; Dollar and Kraay, 2002), concerns have been made towards whether only increasing GDP per capita is enough for better public health (Biggs et al., 2010). Rajan et al. (2013) found no statistical evidence for income levels to be associated with better health outcomes in Indian states.
4. The states are Assam, Andhra Pradesh, Bihar, Chhattisgarh, Karnataka, Kerala, Maharashtra, Odisha, Punjab, Uttar Pradesh and West Bengal. These 11 states account for almost 60% of India’s GDP and population and are responsible for most of the COVID-19 cases in India (MoHFW, 2020).
5. For detailed information on each indicator under these three domains, please visit http://social.niti.gov.in/health-index
6. The domains under SEQI includes learning outcomes, access outcomes, infrastructure and facility for outcomes, equity outcomes and indicators covering student and teacher attendance, teacher availability, administrative adequacy, training, accountability and transparency.
7. The individual state websites report the data in a homogenous format that specifically mention the confirmed, recovered and deceased cases.
8. The OGD platform is a joint initiative of the Government of India and the US Government under National Data Sharing and Accessibility Policy (NDSAP). In this platform, NITI Aayog (formerly Planning Commission of India) contributes district-wise GDDP data.
9. Infection rate is defined as the percentage of confirmed cases in total tests performed. Similarly, recovery rate and death rates are defined as the percentages of recovered and deceased cases in total confirmed cases, respectively.
10. Until 1991, the expenditure on health by the Brihanmumbai Municipal Corporation (BMC) was between 25% and 30% of its budget. In recent times, it is down to 10% to 12% of its budget (Duggal, 2016). This is reflected in the poor capacity of the BMC health infrastructure to deal with normal health-care issues, let alone a public health crisis.
References


Sen, A. (2020), Overcoming a pandemic may look like fighting a war, but the real need is far from that, The Indian Express, April 8.


Further reading

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