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Working paper

Community COVID-19 Vulnerability Index in India

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Abstract

The population over age 50 and those suffering from chronic diseases are at a higher risk for severe infections and deaths due to Covid-19. The population of the elderly has increased in India since the census 2011 and more so in urban areas. Lack of sanitation and handwashing facilities compounded with congestion at homes makes it difficult to follow social distancing and maintaining proper hygiene and sanitation. Given the population size of the elderly, prevalence of co-morbidities, proportion of the population lacking basic water, sanitation and hygiene facilities, education level and the media exposure among household with at least on elderly, some areas of India are more vulnerable than the others. In this paper, we estimated several of these indicators for 640 districts of India using publicly available data and computed a community Covid-19 vulnerability index (CVI). We show that some areas of India are more at risk of severe infection and deaths than others. Identification of these areas at the lowest administrative level will help the government to define targeted interventions and campaigns and to be ready for the worst. We recommend the central and state governments to reach the vulnerable population through the vast network of local-level governments by empowering them to protect the community in their respective constituency.

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Introduction

The coronavirus disease (Covid-19) caused by novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was declared a public health emergency of international concern on 30th January by World Health Organization (WHO). At the time of writing this paper, 14th May, WHO reported more than 4.5 million cases of Covid-19 infections and more than 300 thousand deaths globally (WHO 2020c). Countries with most cases are the US, Spain, Russia, the UK, and Italy, globally, and Turkey, Iran, China, and India in Asia.

Since the first reported case in late February 2020 in India, the government announced a nationwide lockdown from 25th March to stop the population mobility and increase social distancing. The government has taken stringent initiatives through the state machinery such as police, armed forces, including medical staff and ground-level sanitization workers. In the fight against Covid-19 medical and public health workers are at the frontline focusing on the cure, prevention, and contact tracing. The public is adhering to the policies of social distancing and lockdowns. However, the infections and deaths in India have increased to 74,925 and 2,552, respectively (13 May 2020; https://www.covid19india.org/), and have spread to the majority of 733 districts in India (Perappadan 2020).

One of the most crucial components concerning prevention is to identify the vulnerable population and protect them through social distancing and isolation. Knowing the scale and geographic scope of vulnerability will help reduce the impact of a disaster in the making as the government could define targeted interventions, campaigns, and be ready for the worst. At the same time, knowing the risk at the local level will help in the preparedness and readiness of the medical services, including procuring ventilators and arranging for ICUs, for the worst-case scenario.

In this regard, the Health Ministry has categorized districts into three zones (Ministry of Home Affairs 2020; Perappadan 2020), namely, red (130, highest risk), green (319, low risk), and orange (284, moderate) zones, to identify hot spots and allocate strategies accordingly. This categorization is based solely on the number of cases and does not account for socio-demographic, health status, and hygiene and sanitation components of the vulnerability. In this paper, we identified a few potentially important sources of community vulnerability to Covid-19 and proposed an index to complement the government's effort of identifying the risk zones.

Globally, the risk of severe infection and the case fatality is increasing with age with a median age of 51 years (WHO 2020a, Dowd et al. 2020). In India, 75% of the COVID-19 related deaths occurred among patients aged 60 years and above (India Today 2020). Moreover, the severity and recovery time is longer for older adults (WHO-China 2020). Therefore, identification of vulnerable areas with a focus on older adults is needed as older adults are more at risk of the severe infection and deaths due to both ageing and social reasons.

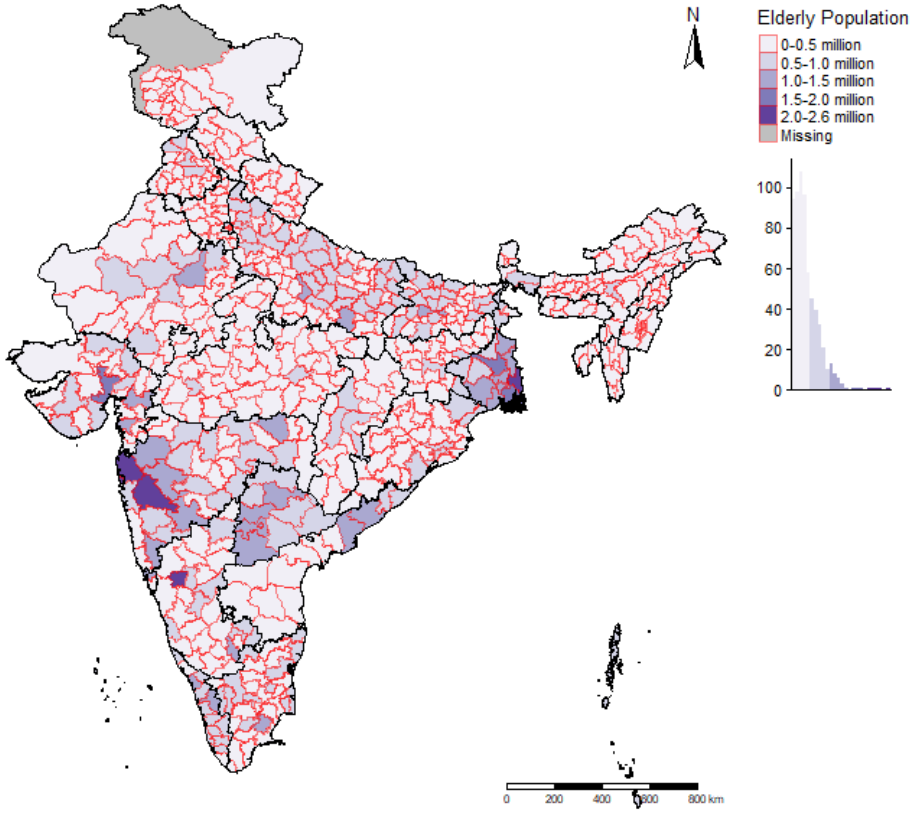
Data

In this paper, we focus on older adults aged 50 years and above (for ease of reading referred to as "the elderly" in this paper) to assess the vulnerability of the population and used available data from the Census 2011 for 640 districts of India (ORGI 2011), nationally representative household surveys such as National Family Health Survey (NFHS-4) (IIPS & ICF 2017) and National Sample Survey (NSS) (Ministry of Statistics and Program Implementation 2018), and existing population projection (KC et al. 2018) for projected population by age and sex from 2011 to 2020.

Results

Our projection shows that the population of the elderly in India has increased by 34% (192 million in 2011 to 258 million in 2020). The increase has been higher in older ages, e.g., among age 70+ by 46%, from 40 million to 58.4 million. The concentration of the elderly population (Figure 1 and Appendix Table A for 640 districts, and Table 1 for States and Union Territories) is high in certain areas in and around big cities (e.g., Kolkata, Mumbai, Pune, Chennai, Delhi, and Bengaluru). Data shows that males are more vulnerable than females to the risk of severity and deaths due to Covid-19 (Jin et al. 2020). In India, there are more females aged 50+ years than males, with a projected sex ratio of 98 males per 100 females in 2020. Moreover, the sex ratio is lower in older ages, e.g., among 70+ years old, the sex ratio is 87 males per 100 females due to better mortality conditions for females. However, 115 districts (18%) have more elderly males than females and these areas might be at a higher level of community vulnerability to Covid-19.

Figure 1. Distribution of projected population aged 50 years and above in India[1] (2020)

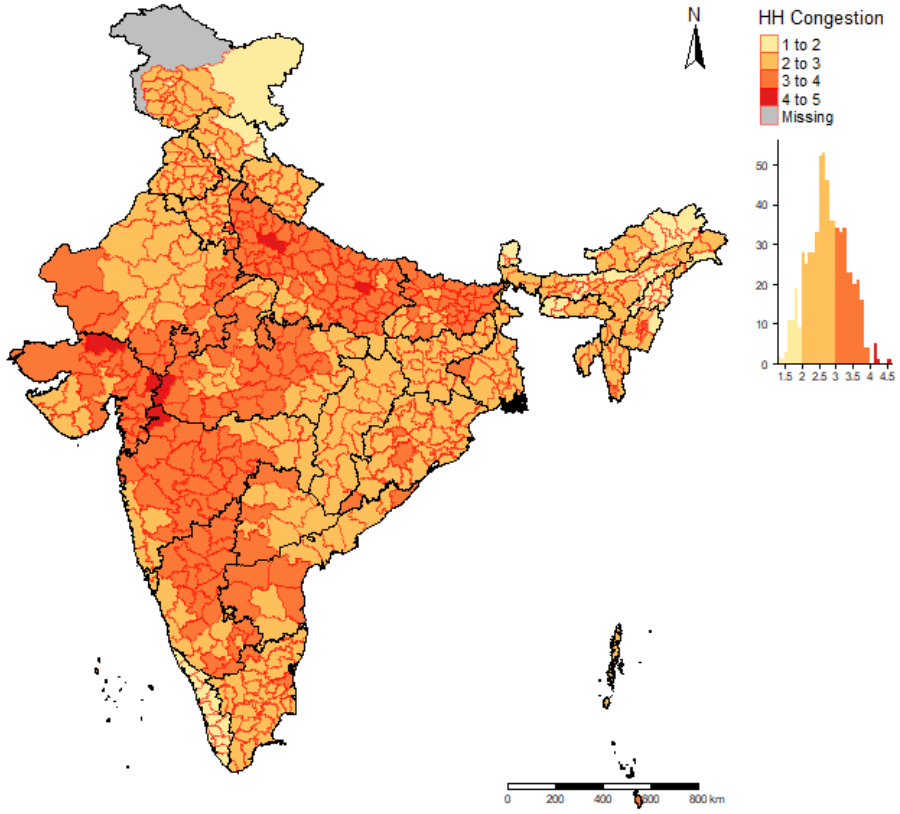


Furthermore, the elderly living in crowded houses and institutions are at a higher risk of getting infected. To take this into account, we estimated household congestion ratio, defined as persons per sleeping room, for households with at least one person aged 50+ years using data from the NFHS-4 (2015-16). Overall, in India (Figure 2), the average household congestion ratio was three per sleeping room. Maharashtra, Madhya

[1] The district boundaries in the map is as per the Census of India, 2011

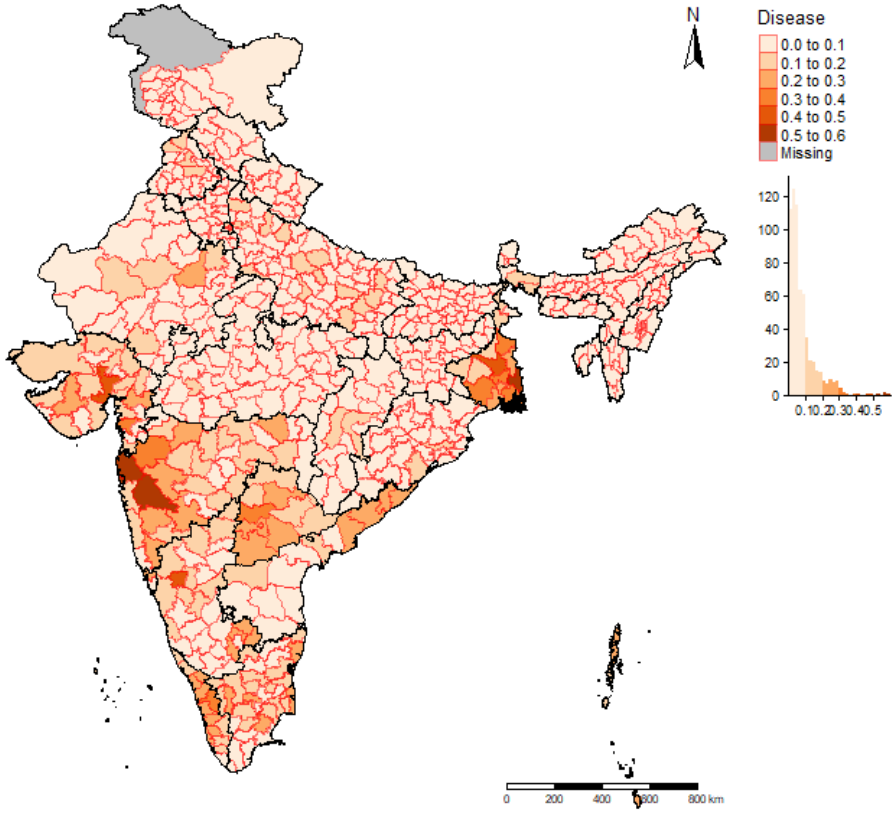
Pradesh, Gujarat, and Uttar Pradesh have the highest household congestion, whereas states from the Northeastern regions have the lowest household congestion ratio. At the district level in a household with at least one elderly, the average household congestion ranges from 1.3 to 4.5 members per sleeping room. The results indicate the difficulty in isolating the elderly in India.

Figure 2. Average Household Congestion, persons per sleeping room, in households with at least one person above age 50 or above, 2015-16



Also, people with existing medical conditions, such as cardiovascular diseases, diabetes, hypertension, or respiratory system diseases, are more vulnerable to the adverse effects of Covid-19 (WHO 2020b; Yang et al. 2020). The recovery rate and duration of recovery are longer among patients with co-morbid conditions (WHO-China 2020). Households with elderly suffering from either of the ailments are two times more vulnerable (Blocker 2020) than the average household as younger members during their outdoor activities could accidentally get infected and spread it within the household. Also, due to the enforced lockdown, the health of ailing elderly might deteriorate due to the absence of medicine or regular checkups and make them more vulnerable to Covid-19. In India, 86% of Covid-19 related deaths had these pre-existing medical conditions (India Today 2020).

Figure 3. Prevalence of cardiovascular, hypertension, diabetes, and respiratory-related morbidities at the district level of India in 2018

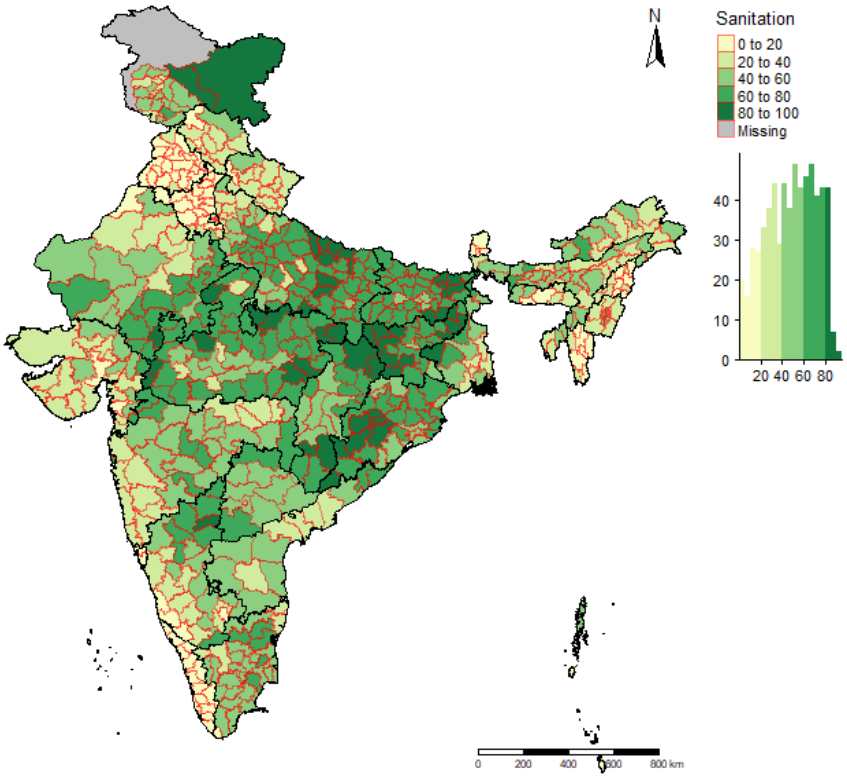


Using the NSS data, we estimate about 11.7 million (6.05 million men and 5.63 million women) older adults aged 50+ years, in India, have at least one of the diseases, namely, cardiovascular (hypertension/heart), diabetes, or respiratory-related co-morbidities (acute upper respiratory infections, bronchial asthma/cough with sputum), indicating a high-risk factor to Covid-19 related severity and deaths (Ministry of Statistics and Program Implementation 2018). Among the elderly, we estimated the percentage of elderly suffering from cardiovascular diseases (29.1%), diabetes (21.6%), and respiratory diseases (9.1%). The prevalence of at least one of these diseases was 57.5% and was higher among males than females. To estimate the prevalence at the district level among the elderly, we applied the age and sex-specific prevalence of these diseases at the appropriate higher level (e.g., the states) to the projected population of the districts within the states. The district-level map (Figure 3) of the diseases shows that the elderly population from Maharashtra, Gujrat, Kerala, Telangana, Tamil Nadu, and West Bengal are at a higher risk of having at least one of these diseases.

With no vaccine or drugs to cure the new infection, maintaining social distance, and adopting the best hygiene and sanitation practices is the first line of defense (WHO 2020b). Unfortunately, the water and sanitation situation in India is already bleak. We estimated using NFHS-4 (2015-16) that most of the households with at least one elderly (51.6%, 128 million) in India lack toilet facilities within households and use unimproved sanitation provisions (IIPS & ICF 2017). This implies only 48.4 % of the households have

coverage of basic sanitation[2] facilities in India in 2015-16 (Croft et al. 2018). The analysis carried out for households with at least one person aged 50+ years showed 48.2% coverage of basic sanitation in India. Figure 4 shows a disproportionate spatial coverage of unimproved sanitation at the district level. All districts in Kerala have better access to improved sanitation, and the coverage was more than 95% for households with at least one elderly. The coverage of improved sanitation was also higher in Goa, Punjab, Sikkim, Mizoram, Nagaland, and Union Territories (UT) - Chandigarh, Lakshadweep, Pondicherry, and Delhi.
On the other hand, several districts in Madhya Pradesh, Uttar Pradesh, Jharkhand, Bihar, Chhattisgarh, and West Bengal have inadequate coverage of basic sanitation, on average, 40% of the households lack basic sanitation provisions. Furthermore, five districts in Tamil Nadu, seven in Maharashtra, and eight in Karnataka have less than 30% coverage of the basic sanitation facility. Exposure to unimproved sanitation can raise the risk of infection among households with the elderly, especially among those who are using shared sanitation provisions.

Figure 4. Percentage of households with "Unimproved Sanitation" facility, 2015-16



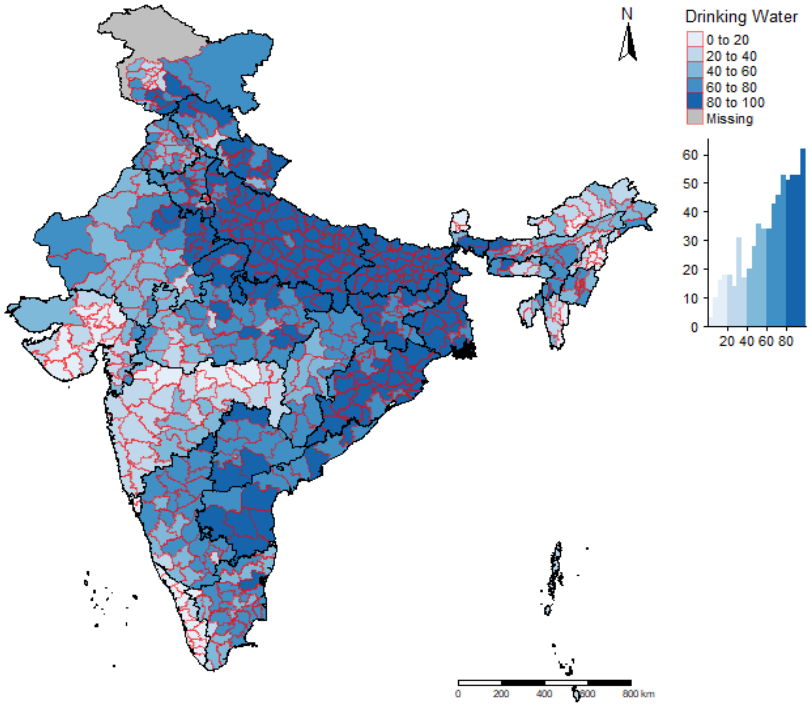
Besides, lack of access to safe basic water[3] within household premises, yard or plot, and more importantly, the availability of soap and water at the place of handwashing also plays a crucial role in reducing the exposure to the risk of infections (WHO & UNICEF 2020). In India, about 89.9% (233.3 million) of the households have access to an improved source of water, and 88.2% (219.1 million) have this access within

[2] WHO & UNICEF (2000) defined Basic sanitation as use of improved sanitation facilities which are not shared with other households.
[3] By Safe Basic water authors refer to scenario where households have coverage of improved source of water within household premise or within 30 minutes fetching time and water collected is treated before use (Croft et al. 2018).

the household premises (NFHS-4). Still, 29.3 million households lack coverage of basic water, and nearly 157.8 million (62.3 %) households do not treat water before use. Though there is no evidence on linkages between utilization of safe water and Covid-19 infections (WHO & UNICEF 2020), conventional methods of water treatment and hygienic practices would have an impact on the inactivation or removal of virus causing Covid-19 (WHO & UNICEF 2020; Centers for Disease Control and Prevention 2020).

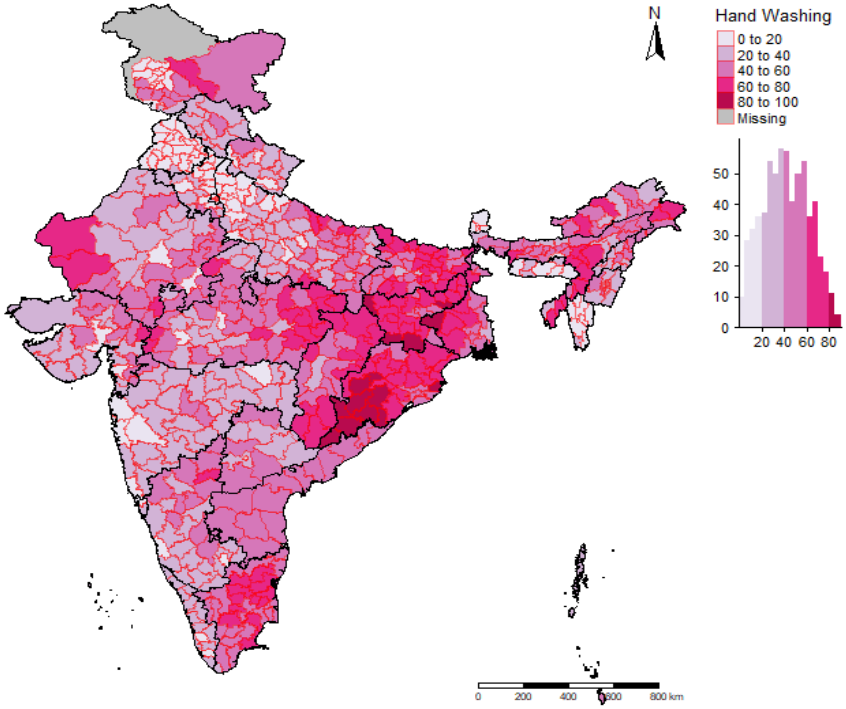
A large proportion of households with at least one elderly (64.5%) do not have coverage of safe water management (Figure 5). The situation in "Empowered Action Group" (EAG) states such as Bihar, Uttar Pradesh, Jharkhand, Madya Pradesh, Uttarakhand, Chhattisgarh, Odisha, Rajasthan, and West Bengal posed serious challenges concerning the utilization of basic drinking water. The situation in a few districts in Andhra Pradesh, Telangana, and Tamil Nadu is as poor as the EAG states. On average, 60% of the households with at least one elderly in these states do not have access to safe basic water. At the same time, states like Sikkim, Goa, Kerala, Maharashtra, and Gujarat are relatively better off with the availability of safe basic water.

Figure 5. Percentage of households lacking access to safe basic drinking water, 2015-16



Hand hygiene is crucial in the prevention of Covid-19 infections (WHO &UNICEF 2020). In India, 97% of the households have designated place for handwashing in their households in 2015-16. However, only 60% (149.5 million) households had both soap and water at the location of hand washing (IIPS & ICF, 2017). In this study, we have used the definition of DHS to evaluate the coverage of basic hand washing facilities in households with at least one elderly (Croft et al. 2018). We find a significant deviation in coverage of the basic hand washing across 640 districts. About 41.7% of households with the elderly lack the basic hand washing (Figure 6) facilities. The access to the basic handwashing severely lacked in majority districts in Odisha, Bihar, Chhattisgarh, West Bengal, and Jharkhand, where more than 60% of the households with elderly do not have the basic hand washing provisions. We find a similar situation in 17 districts in Tamil Nadu and 11 districts in West Bengal. On the other hand, coverage of basic hand washing is prominent in Sikkim, Punjab, Kerala, Mizoram, Meghalaya, and UTs - Daman and Diu, Delhi, Chandigarh, and Pondicherry.

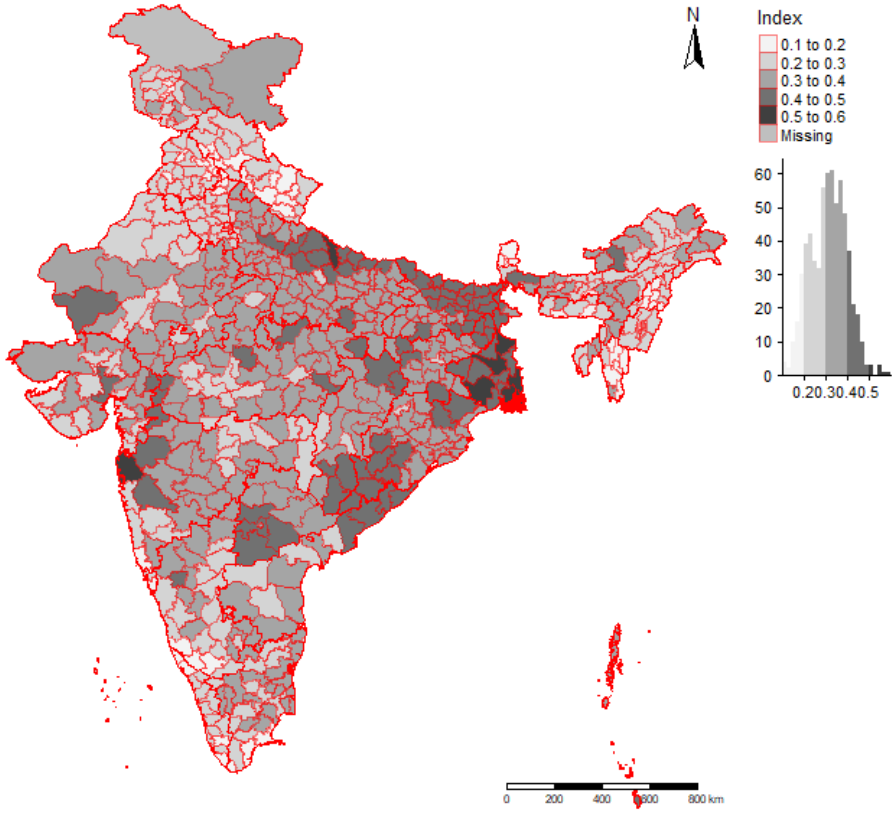
Figure 6. Percentage of households lacking basic hand washing provisions, 2015-16



Finally, we added the educational attainment of individuals to define further the vulnerability at the community level. Educated people have a better ability to follow instructions and find solutions, including identifying symptoms and expressing it to the medical professionals, and this might well be why Kerala is showing better adherence and results (KC and Lentzner, 2010). Using the information from NFHS-4, we defined the absence of ten years of schooling and exposure to mobile and television as a proxy for the level of unawareness among the population, especially in households with elderly.

We have identified four sets of factors at the district level defining vulnerability to Covid-19, namely, a) age and sex, b) the prevalence of high-risk diseases, c) hygiene, sanitation, water availability, and household congestion, and d) education and media exposure. We did not know the relative importance of each of these components and decided to assign equal weights to each of the four sets and calculated an index following the concept UNDP's HDI index (UNDP 2018). We applied the range equalization method to the assembled data at the district by first transforming each component into a range between 0 and 1. Then these values were averaged with their respective weights within and between each set. We present community level Covid- 19 Vulnerability Index (CVI) for the population at the district level (Figure 7 and the results in the Appendix).

Figure 7. Covid-19 Vulnerability Index (CVI) for the population in districts of India, 2020



The CVI (Figure 7) indicates that the western (Maharashtra and Gujarat), eastern (Bengal and Odisha), and the southern (Telangana and Andhra) regions of the country's population are highly vulnerable to the adverse effect of the virus. The vulnerability is moderate in the northern region and low in the northeastern region. The map depicts that Mumbai, Thane, Pune, Ahmedabad, and Vadodara from the western regions are at elevated risk. Similarly, Hyderabad, Wanaparthy, and Sangareddy from Telangana, Nabrangapur, Koraput, and Ganjam from Odisha and Kolkata, Bardhhaman, North and South twenty-four Parganas, and East and West Medinipur from West Bengal are highly vulnerable districts according to the CVI.

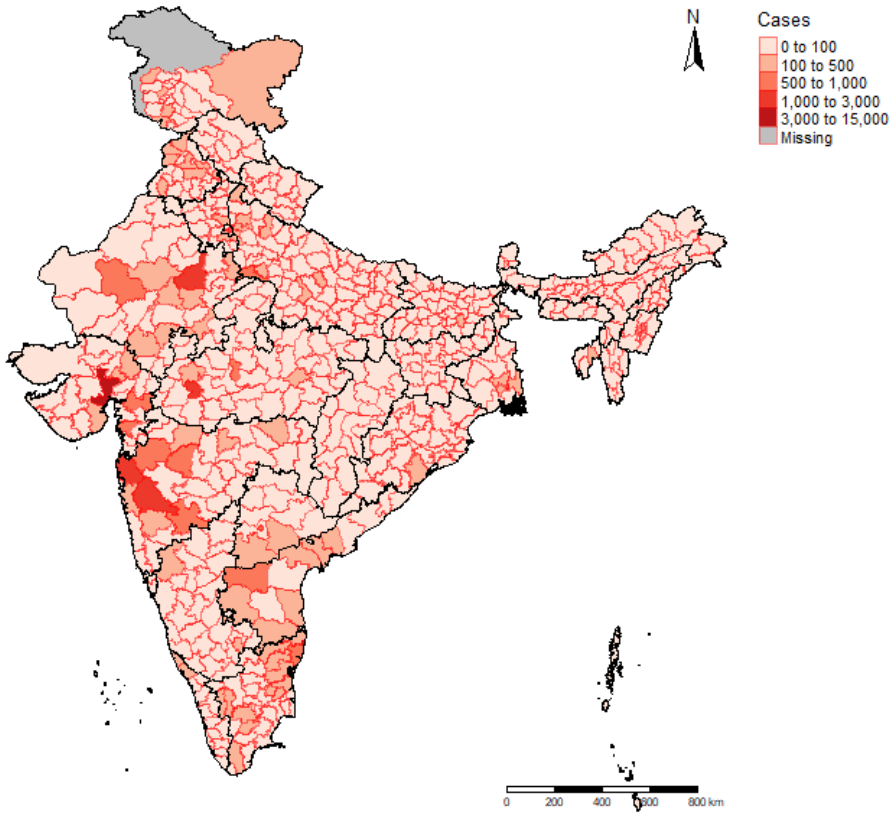
Table 1. Components of Community level Covid-19 Vulnerability Index in States and Union Territories of India

States/Union Territories	Number of Districts	Population (in million)	Reported Number of Covid-19 cases*	Congest-ion (persons per sleeping room)	Disease prevalence at least one cardio-vascular, diabetes, and respiratory	Un-improved sanitation	Lack of provision of basic drinking water	Inadequate basic hand washing facility	Sex ratio (males per 1000 females)	Household with absence of Mobile/TV (%)	Education: Below secondary (%)	Average^ Covid-19 Vulnerability Index
India	640	258.00	67619	2.768	0.081	48.15	64.56	41.74	985	6.30	53.51	0.315
Andaman & Nicobar	3	2.29	33	2.42	0.196	23.46	28.38	28.28	1205	5.77	56.03	0.367
Andhra Pradesh	13	7.26	2137	2.95	0.135	46.19	81.23	47.95	895	3.82	54.05	0.336
Arunachal Pradesh	16	0.23	1	2.01	0.002	38.86	37.35	47.60	1161	12.38	58.09	0.290
Assam	27	5.84	66	2.06	0.033	46.77	58.24	52.20	1038	9.26	54.04	0.293
Bihar	38	18.30	879	3.16	0.040	70.97	95.38	61.37	1065	7.22	67.19	0.405
Chandigarh	1	0.23	187	2.51	0.043	8.25	40.15	6.54	1144	0.60	33.50	0.180
Chhattisgarh	18	5.11	54	2.61	0.052	68.03	64.74	62.57	943	16.17	58.51	0.354
Dadar & Nagar Haveli	1	0.05	1	3.11	0.010	61.71	67.35	51.68	1116	4.60	48.40	0.300
Daman & Diu	2	0.04	0	2.51	0.004	20.40	32.88	20.72	1158	1.45	40.10	0.175
Delhi	9	3.56	788	2.71	0.074	17.29	51.76	13.21	1086	0.52	37.49	0.224
Goa	2	1.47	7	2.21	0.192	15.20	12.56	18.98	919	0.30	26.30	0.200
Gujarat	26	13.10	8904	3.29	0.142	38.45	30.13	36.21	972	5.05	50.40	0.304
Haryana	21	5.20	766	2.58	0.044	16.49	75.62	22.06	994	1.07	46.92	0.227
Himachal Pradesh	12	1.68	66	2.07	0.033	25.42	63.24	31.30	940	0.98	42.58	0.198
Jammu Kashmir	22	2.44	976	2.40	0.026	49.26	57.60	28.28	1079	2.46	51.06	0.255
Jharkhand	24	6.23	172	2.60	0.038	75.93	82.02	70.47	992	12.65	61.37	0.372
Karnataka	30	15.20	923	3.09	0.124	45.05	63.67	35.60	920	2.42	44.14	0.289
Kerala	14	11.10	525	1.76	0.221	1.89	13.27	29.48	840	0.94	37.61	0.217
Lakshadweep	1	0.70	0	2.17	0.182	0.72	24.35	33.24	1017	0.40	23.00	0.210
Madhya Pradesh	50	13.70	3986	3.13	0.045	65.83	68.44	47.65	994	11.32	59.76	0.349
Maharashtra	35	26.20	24386	3.21	0.187	47.05	31.20	26.67	970	5.71	46.08	0.324
Manipur	9	0.59	2	2.11	0.010	41.33	67.37	34.14	965	4.72	47.58	0.227
Meghalaya	7	0.44	13	1.95	0.010	32.20	55.01	16.26	966	8.10	60.50	0.239
Mizoram	8	0.21	1	2.87	0.004	14.74	32.32	6.69	996	6.13	48.05	0.190
Nagaland	11	0.33	0	1.68	0.005	19.10	24.63	39.05	1115	5.76	50.92	0.207

States/Union Territories	Number of Districts	Population (in million)	Reported Number of Covid-19 cases*	Congest-ion (persons per sleeping room)	Disease prevalence at least one cardio-vascular, diabetes, and respiratory	Un-improved sanitation	Lack of provision of basic drinking water	Inadequate basic hand washing facility	Sex ratio (males per 1000 females)	Household with absence of Mobile/TV (%)	Education: Below secondary (%)	Average^ Covid-19 Vulnerability Index
Odisha	30	9.46	538	2.73	0.055	69.08	84.41	73.01	989	15.59	56.88	0.384
Puducherry	4	3.34	12	2.30	0.213	22.23	44.70	37.41	862	2.95	52.48	0.310
Punjab	20	6.70	1914	2.55	0.074	14.00	59.82	11.38	982	0.72	45.11	0.216
Rajasthan	33	12.80	4212	3.04	0.068	53.97	63.22	42.78	969	4.03	61.51	0.323
Sikkim	4	0.12	0	1.71	0.005	6.21	4.08	3.65	1184	1.73	47.28	0.160
Tamil Nadu	32	13.80	8714	2.46	0.120	49.16	58.77	57.73	938	2.08	44.90	0.291
Telangana	10	9.17	1321	2.97	0.222	49.19	77.50	42.00	909	4.63	56.36	0.395
Tripura	4	0.82	154	2.28	0.031	38.68	43.01	59.16	1024	9.10	50.80	0.275
Uttar Pradesh	72	37.20	3653	3.40	0.071	62.98	92.15	33.63	1038	5.15	59.65	0.368
Uttarakhand	12	1.91	71	2.38	0.021	30.70	77.50	27.33	943	2.68	47.74	0.213
West Bengal	19	21.20	2157	2.55	0.247	46.02	85.66	54.88	1058	8.74	54.92	0.457

Note: *Cases of the Covid-19 do not include unknown cases and cases with foreign country name; ^mean district level CVI within the state

Figure 8. Confirmed Cases of Covid-19 in India by Districts (Source: https://www.covid19india.org/ by 13 May 2020)



The reliability of the index (CVI) was assessed using Cronbach's alpha (0.75) and shows a higher-level association between the indicators considered to compute the index. The geographical distribution of confirmed cases (Figure 8) shows that most of the high-risk zones (red zones) match to the Covid-19 vulnerable districts (Figure 7). The districts, with most of the cases, are highly vulnerable according to the vulnerability index. Although West Bengal, Odisha, and Telangana have higher CVI (more vulnerable) values, they have not reported a higher number of cases till now. It should be noted here that if the government fails to manage increasing migration flows effectively, these areas can turn out to become emerging hot spots of Covid-19 cases.

Discussion and conclusion

To complement the government's approach of defining high-risk districts (zones), we present the index for community-level Covid-19 vulnerability index (CVI) for 640 districts of India. The CVI includes demography, health status, socio-economic, services (water and sanitation availability), and hygiene (handwashing), educational level, and media exposure. This index does not predict who will get the infection but anticipates the scale of risk at the district level. Our work could help the government to understand the priority regions for prevention and preparedness.

While we show the vulnerability at the district level among aged 50+ years, further analysis within a district and to the lowest level of administration needs to be carried out. This exercise will need data at the lowest

level, and the government can facilitate identifying and exploiting the vast governmental databases, e.g., *Aarogya Setu App* and the health management information system (HMIS).

We recommend improving the current vulnerability index by adding factors, such as income/wealth, religious practice (e.g., congregation), the governmental system of service delivery (state and local), labor force status, migration flow and readiness of the health care system to cope with the future spread of the virus. Furthermore, there is a need to replicate this type of research targeting vulnerable groups, such as pregnant women and infants needing special maternal and childcare. One caveat in the reported CVI, for 2020, is that the indicators for NFHS (2015-16) and NSS (2018) are from different times, but since it is a gap of a few years any drastic changes are not anticipated. While at the final stage of completing this paper, other researchers have published similar work on the community vulnerability for India (Bhattacharya et al. 2020; Singh and Aditi, 2020). These parallel efforts could be beneficial in further refinement of the proposed CVI.

We identified relevant sources in defining vulnerability to Covid-19. While certain factors cannot be changed (age, sex, chronic disease status), other factors related to WASH, such as the improved provision of water, supply of soaps, and targeted awareness campaigns, can be done. Who should do this? The local bodies, 7,091 urban blocks, and 255,528 rural panchayats need to be mobilized and strengthened as they are the closest elected representatives to the people. Shreds of evidence suggest that community-based approaches have proved productive resistance in diminishing transmission of the pandemic (Qualls et al. 2017; Cash and Patel 2020).

The 73rd and 74th Constitutional amendments mandated devolution of governance power to the local bodies "Urban Local Bodies" (ULB) in urban areas and panchayats in villages. Since the amendment of the Act in 1992, these local bodies received enormous funding and capacity building training about essential obligatory functioning. These functions include the distribution of sufficient drinkable water, construction, and cleaning of public streets, places and sewers, maintenance of public hospitals, and so on, including the birth and death registrations. It is noteworthy to mention that Covid-19 infection is closely associated with the essential obligatory functioning of these local bodies.

The local bodies can play a crucial role in identifying households and communities at higher risk and enforcing segregation of sanitation and the provision of water and soap. Also, local bodies are well situated in accounting for the migration flows, both internal and international and help implement the government's policy of quarantine and isolation. We have not accounted for the migration aspect, yet, in the CVI, though, it has a notable impact on the transmission of infections. However, the places of vulnerabilities concerning WASH and household congestions dissected out in this study coincides with the location of out-migration in Bihar, Uttar Pradesh, West Bengal, Rajasthan, Odisha, Chhattisgarh and Jharkhand and Madhya Pradesh (Prasad et al. 2020). This may amplify the risk of infection among vulnerable households, especially those with at least one elderly. Therefore, it becomes imperative as well as challenging to manage government directives against COVID-19 at the sub-regional level, especially where lack of WASH and high household congestion exists.

We recommend that the central and the state government empower the local bodies to take the lead in their area by bringing in local population research centers and public health workers stationed in more than 180 thousand stations, including auxiliary nurse midwives (ANM), Anganwadi (AWW) and Accredited Social Health Activist (ASHA). State governments are already using the network of ANM, ASHA and AWW for screening and containment measures. Besides, private health facilities and NGOs could be engaged in the capacity building of the local bodies at the war footing. We recommend creating local containment zones with the help of nearby public and private health facilities. Also, including the local bodies in the management of specialized

medical equipment and provisions along with medical and paramedical personnel could be beneficial for more vigorous implementation of government directives.

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Appendix

Table A. Community level Covid-19 Vulnerability Index in 640 districts of India (Supplemental Excel File, http://pure.iiasa.ac.at/id/eprint/16481)