Review Article

Factors influencing COVID-19 case burden and fatality rates findings from secondary data analysis of major urban agglomerations in India

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ABSTRACT

In December 2019, SARS COV-2 which originated in the Chinese city of Wuhan achieved pandemic proportions and spread rapidly to countries through International air traffic causing acute respiratory infection and deaths. Presence of International airports, demography, health financing and human developments factors were assumed to influence COVID-19 cases burden and case fatality rate (CFR). So, this study was undertaken to find a association between these factors and COVID-19 cases and deaths. The study used 48 districts using purposive sampling as proxy for cities and used secondary data analysis. Data was obtained for various variables like demographic, Health Financing, Indices and Testing infrastructure, COVID cases burden and case fatality from trusted sources. Descriptive statistics correlational statistics using Pearsons coefficient students T was used to describe, correlate and find significant difference in the data. The analysis found a significant difference between COVID cases burden in districts with International Airports (p<0.039) and those without it. Positive correlation of population density (r=0.65) with COVID-19 case burden and negative correlation of case fatality rate with NITI Aayogs health index (r=-0.12), human development index (HDI) (r=-0.18), per-capita expenditure on health (r=-0.072) and a correlation of r=0.16 was observed for gross state domestic product. Decongestion of cities through perspective urban planning is the need of the hour. Stricter quarantine measures in those districts with international airports can help reduce the transmission. Negative correlation of HDI and NITI Aayogs health index with CFR emphasizes the importance of improvements in social determinants of health.

Keywords: COVID-19, Urban area, Case fatality, Population density, Per capita health expenditure, Human development index

INTRODUCTION

In December 2019, a novel corona virus designated as SARS COV-2 originated in the Chinese city of Wuhan achieving pandemic proportions and subsequently spreading rapidly across major continents by international air traffic causing acute respiratory infection and death.[1,2]

As the pandemic spread, countries in different continents were overwhelmed by COVID-19 cases and deaths, which were more than the carrying capacity of their health system. The COVID-19 death defined by WHO is death resulting from a clinically compatible illness in a probable or confirmed COVID-19 case, unless there is a clear alternative cause of death that cannot be related to COVID disease (e.g. trauma).[3] In this regard, the case fatality rate (CFR) is an important indicator not only of disease severity but also of the Strength of the health infrastructure capacity of a system a measure of proportion of all individuals diagnosed with a disease who will die from that disease.[4]

It is observed that high-density urban agglomerations though having sustainable economies are defenseless in times of such unprecedented disease outbreaks like the ongoing COVID-19 pandemic because of the sheer density of the population which provides an ideal environment for infections to erupt, and multiply fast.[5] In a country like India's where urban population grew from 25,851,873 in 1901to over 377,000,000 in 2011 the process of urban planning and resource management has failed to match population growth thus resulting an increasing number of people live in informal settlements making them vulnerable for disease infection.[5]

Countries facing increasing numbers of COVID-19 cases, have mostly attributed it to regular international flight connections with China, making decisions to restrict air traffic from heavily affected countries challenging.[6,7]

Data on how population densities, health infrastructure and health financing and various human development and their association with COVID-19 case burden and case fatality is scare, so in the present study, the authors made an attempt to demonstrate an association between Location of International airports and case burden. The authors also attempted to demonstrate how demographic factors like population density, slum density, indices like NITI Aayogs health index and human development index (HDI), specific health financing indicators like% gross state domestic product (GSDP), per capita health expenditure and testing infrastructures are corelated with cases burden and case fatality rates in major urban agglomerations of India.

METHODS

The present study is a secondary data analysis. The unit of observation in the present analysis is a district.

Description of data sources

As per census of India 2011, there are 53 class 1 urban agglomerations (UA) in India.[6] Class 1 urban agglomerations defined as those with population more than 1 million The authors obtained Data for class 1 urban agglomerations and their population from Ministry of Housing and Urban affairs, Government of India website.[6]

COVID-19 case load and fatality rates of these urban agglomerations was extracted from various sources like state health bulletins, state Twitter updates, states coronavirus dashboards.[8] Data regarding locations of International airports was obtained for airports authority of India website.[9] Demographic data on population density and percentage of slum population of these agglomerations was obtained from the census of India 2011.[10] Data on indicators like percentage of gross domestic product (GDP) on health, per capita health expenditure was sourced from National health profile 2019.[11] Data on health index of NITI Aayog's was

sourced from its publication 'healthy states and progressive India report on the rank of states and Union territories'.[12] Data on HDI for states was obtained from "sub-national HDI - area database - global data lab".[13,14]

Data for tests conducted per million for each states was collected.[15] Data for testing infrastructure both in public and private laboratories was collected from ICMR bulletin.[16]

The NITI Aayog's health index is a weighted composite Index based on 23 indicators grouped into the domains of health outcomes, governance and information, and key inputs/processes and each domain has been assigned weights based on its importance and has been equally distributed among indicators.[17]

The HDI is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. It is a statistical tool used to measure a country's overall achievement in its social and economic dimensions.[18]

Testing infrastructure includes Laboratories reporting to ICMR. This include labs conducting Real-Time RT PCR for COVID-19: 471 (govt. 308 and private 163), true NAT test for COVID-19: 115 (govt. 109 and private 06) and CBNAAT test for COVID-19: 55 (govt. 28 and private 27).[16]

Selection of study units

Out of the 53 class 1 urban agglomerations in India we selected 48 class 1 urban agglomerations namely Mumbai Delhi, Chennai Ahmedabad, Pune, Indore, Jaipur, Kolkata, Surat, Bhopal, Aurangabad, Jodhpur, Hyderabad, Nashik, Vadodara, Agra, Nagpur, Kota, Meerut, Amritsar, Lucknow, Kanpur, Bangalore, Chandigarh, Faridabad, Ghaziabad, Madurai, Patna, Jabalpur, Srinagar, Kannur, Ludhiana, Varanasi, Coimbatore, Ranchi, Gwalior, Visakhapatnam, Rajkot, Allahabad, Malappuram, Tiruchirappalli, Kozhikode, Kollam, Thiruvananthapuram, Kochi, Thrissur, Dhanbad and Raipur using non-probability sampling. We selected their corresponding districts as unit of Observations as city wise data was not available for majority of these agglomerations. Data of NITI Aayogs's health index, HDI, percentage of GSDP allocation on health (%) and per capita health expenditure (INR) for the state was used as a proxy for the district due to non- availability of district level data in public domain for the purpose of analysis.

Data analysis

The data was entered into Microsoft Excel and analyzed using SPSS version 21 for descriptive statistics like mean, Standard deviation, maximum, minimum to and correlational statistics by calculating Pearson's

correlation coefficient (r) to test the relationship between case fatality rate and factors like HDI, health index, per capita health expenditure, percentage of GDP on health population of density/sqkm and tests per million. Appropriate test of significance was applied test the significance between the confirmed cases and presence of international airport.

All the charts in the present analysis were prepared using data wrapper.[19]

DEMOGRAPHICS AND RELATION TO INTERNATIONAL AIRPORTS

In the present analysis, the total confirmed cases of 48 class 1 urban agglomerations and their corresponding districts was 1,09,779 which were 60.3% of all the confirmed cases in India till 31st May 2020.

In the present analysis, mean confirmed cases were 2287 (SD=6153), mean population density of 3,914 (SD=6590.7) and mean percentage of slum population was 20% (SD=14.03) (Table 1).

The present analysis observed that total reported confirmed cases from the 26 districts with an international airport were 1,00,926, which was 55,4% of all the confirmed cases (1,81,860) of COVID-19 in India on 31st May 2020.

The analysis observed that districts with International airports has significantly a greater number of confirmed COVID-19 cases than those without International airports) (p=0.039) (Figure 1).
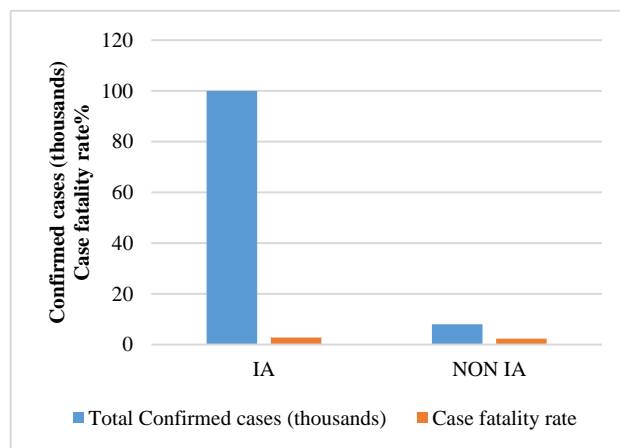

Figure 1: Comparison of confirmed COVID-19 cases and case fatality in districts.

IA: international airports, NON IA: non-international airports p<0.039.

The confirmed cases showed a positive correlation with Population density per sq. km (r=0.65) (Figure 2), and a correlation of r=0.20 with percentage of slum population in the district.
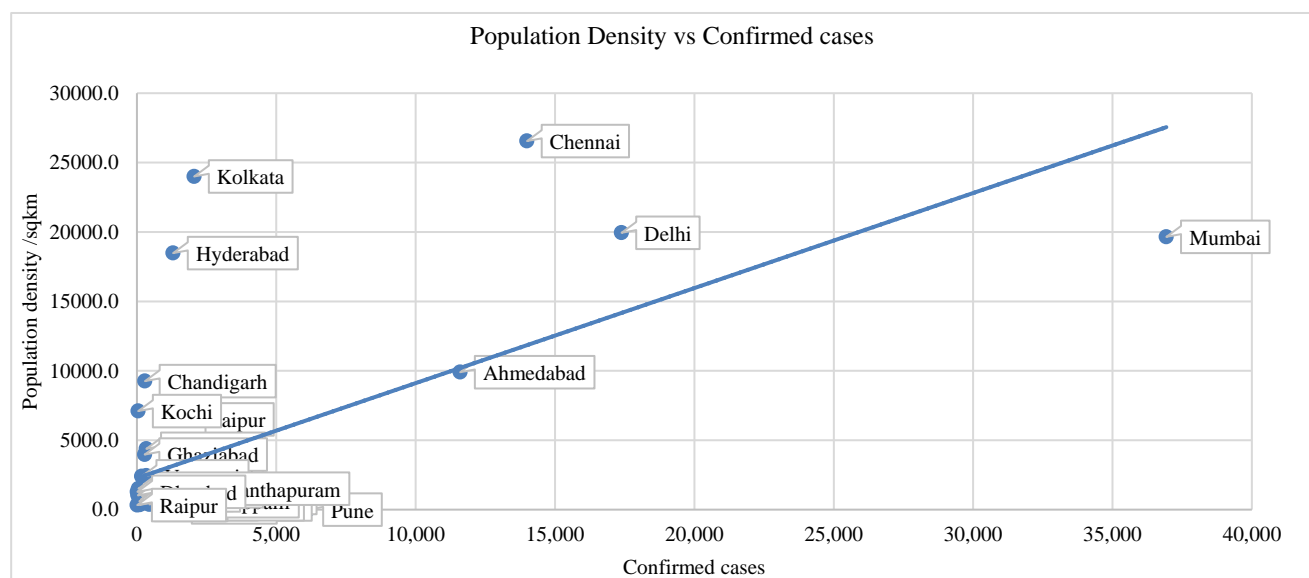

Figure 2: Correlation of population density and confirmed cases (r=0.65).

CFR

In the present analysis, mean CFR in the study districts was 2.8 (SD=2.17) (Table 1). The CFR showed a correlation of r=0.17 with population density (Figure 3) and r= 0.47 with percentage of slum population (Figure 4).

The CFR showed negative correlation with NITI aayogs health index (r=-0.12) (Figure 5) and HDI (r=-018) (Figure 6).

The CFR also showed negative correlation with per capita health expenditure (r =-0.072) (Figure 7) and a correlation of (r =0.16) (Figure 8) with percentage of GSDP on health.
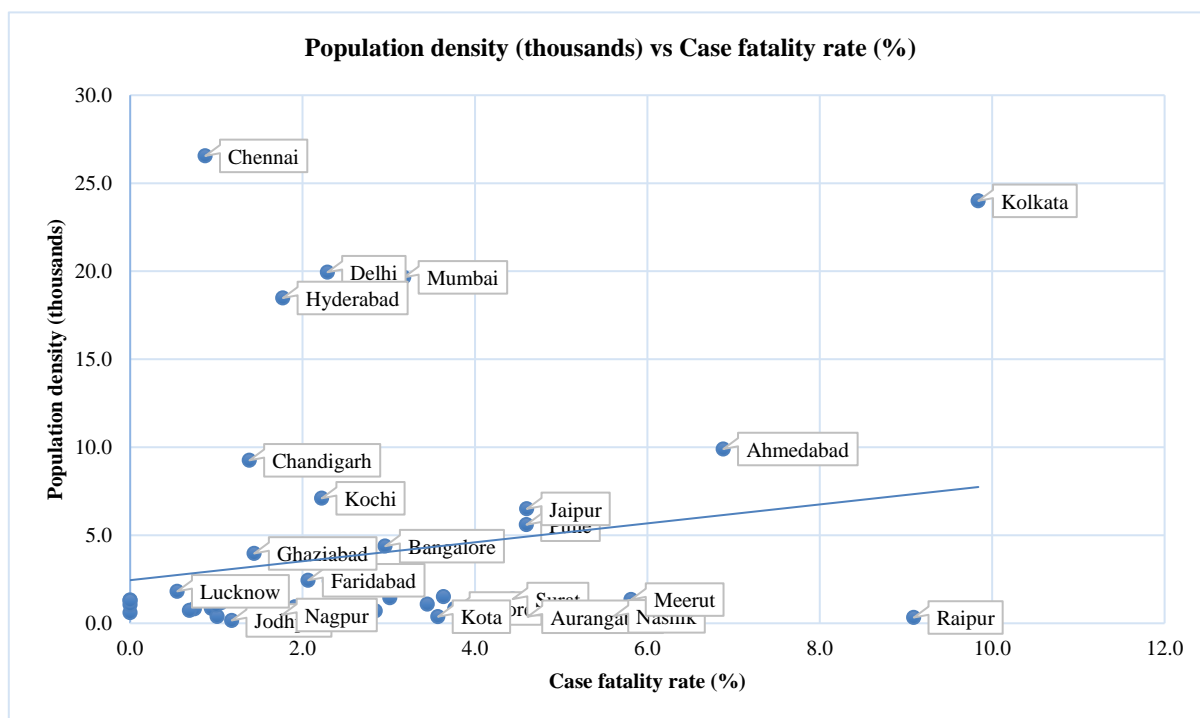
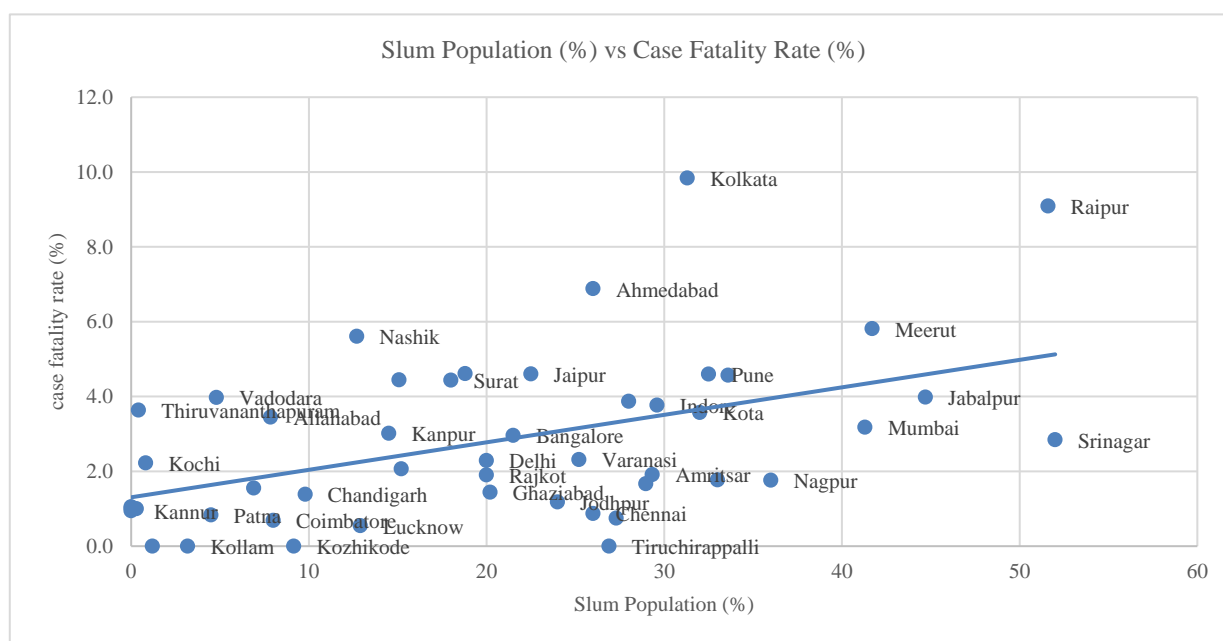**Figure 3: Correlation of population density and CFR (r=0.17).**

Figure 4: Correlation of percentage slum population and CFR (r=0.17).

Table 1: Descriptive statistics of the 48 districts.

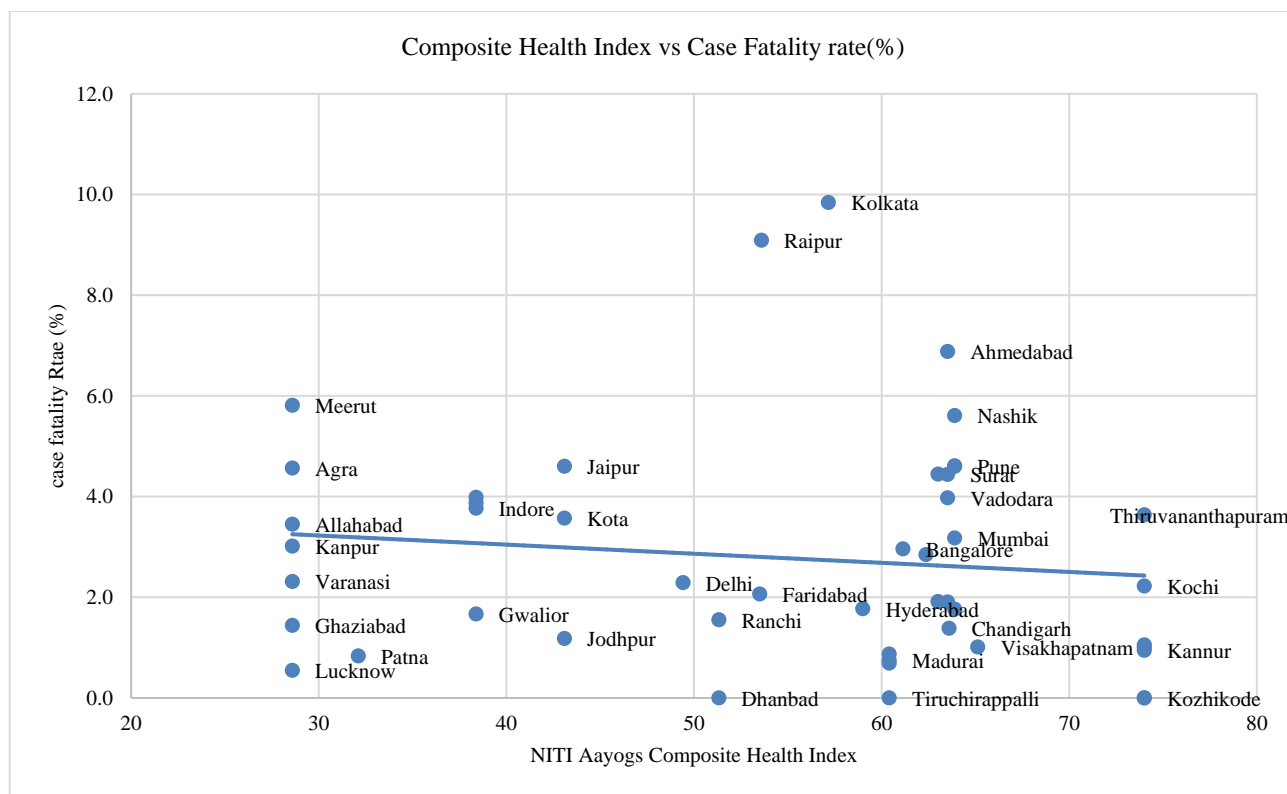|	Confirmed cases	Case fatality rate (%)	Population density	Slum population (%)	Test/million (no)	Health index	HDI	Labs (no)	GSDP (%)	PCHE (INR)
Mean	2287	2.8	3913.9	20.2	2330	54.2	0.67	34.6	1.12	1155.5
SD	6153	2.2	6590.7	14.0	1743	14.9	0.07	22.0	0.35	380.8
Max	36932	9.8	26553.0	52.0	10778	74.0	0.82	78.0	2.46	2359.0
Min	11	0.0	161.0	0.0	55	28.6	0.58	3.0	0.69	491.0

PCHE: per capita health expenditure.

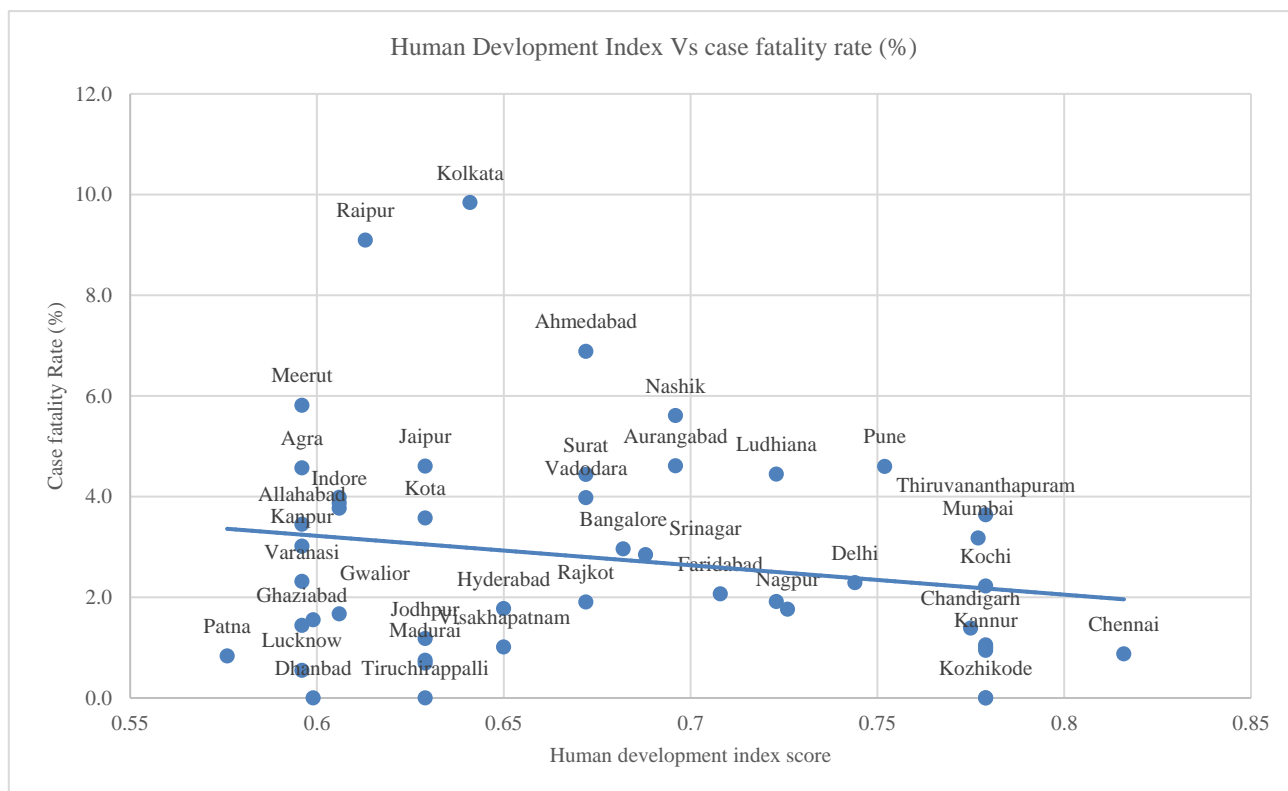**Figure 5: Correlation of composite health index and CFR (r=-0.12).**

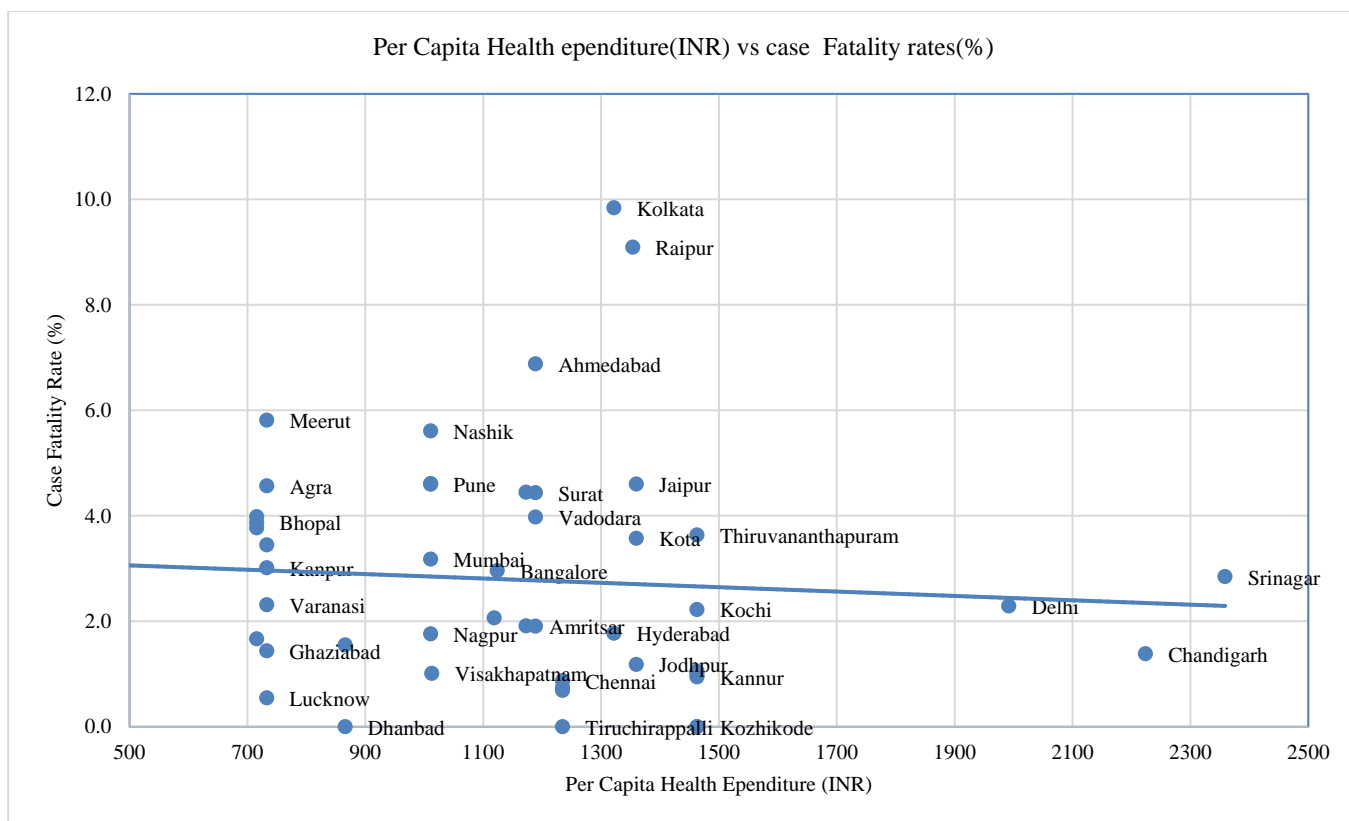**Figure 6: Correlation of human development index and CFR (r=-0.18).**

Figure 7: Correlation of per capita health expenditure and CFR (r=-0.072).

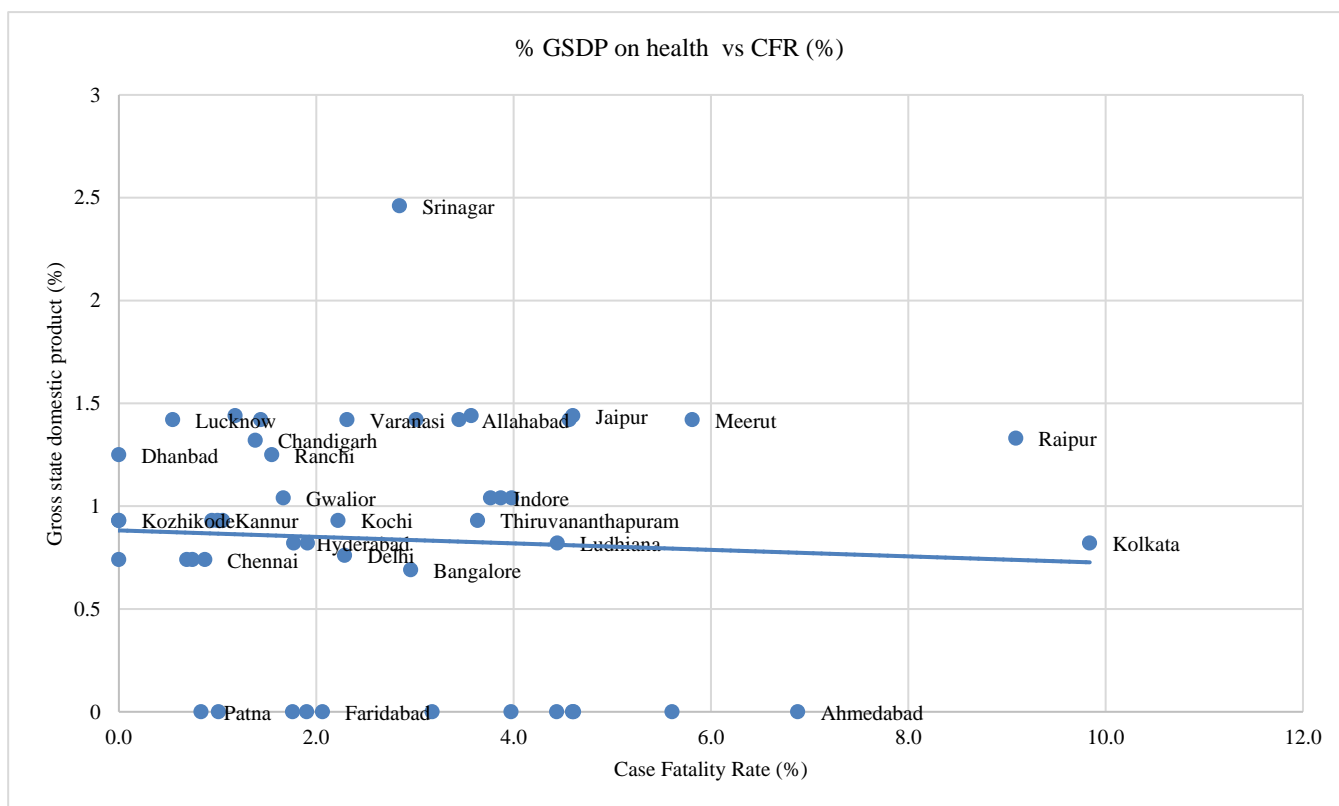

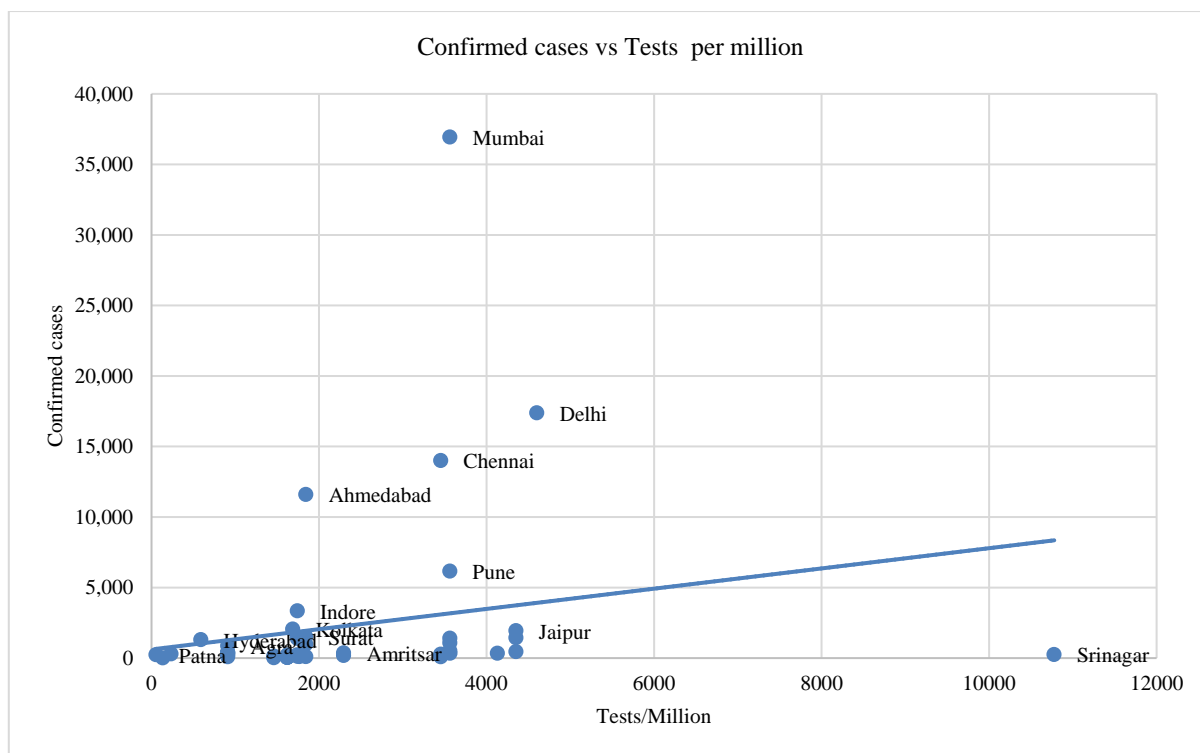**Figure 8: Correlation of GDSP percentage and CFR (r=0.16).**

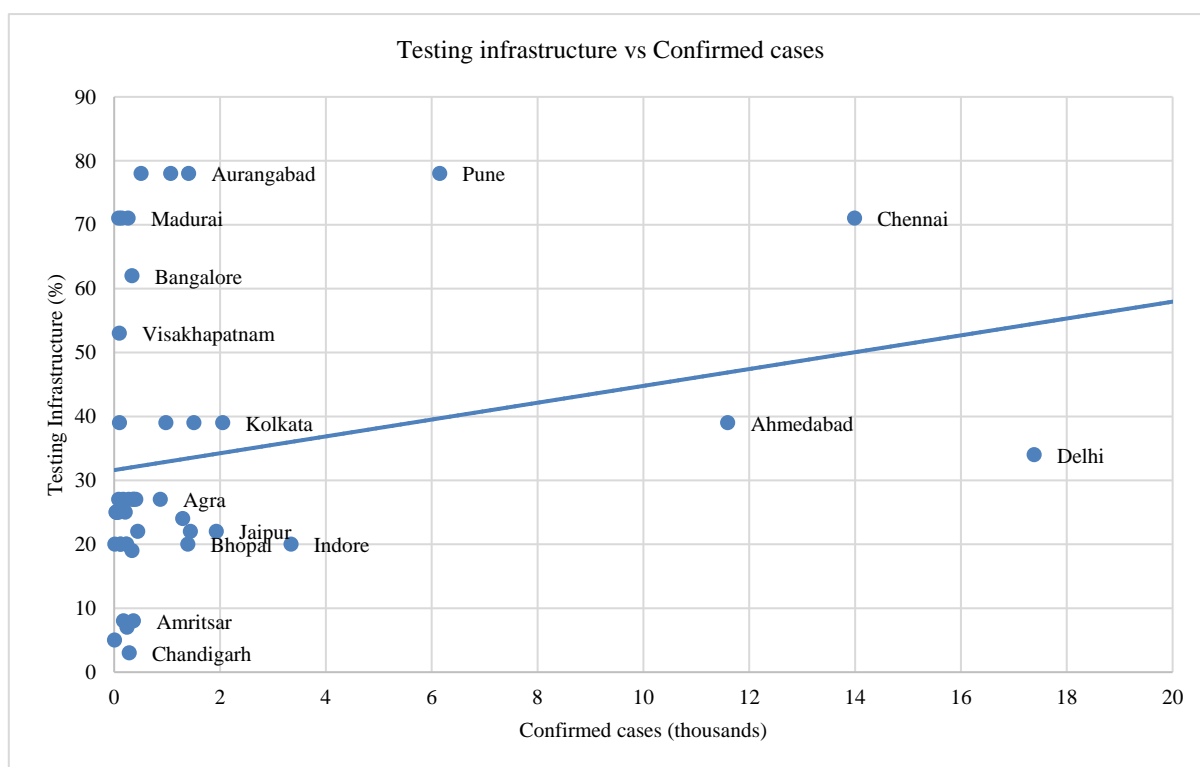**Figure 9: Correlation of tests per million confirmed cases (r=0.20).**

Figure 10: Correlation of no. of testing laboratories and confirmed cases (r=0.36).

TESTING INFRASTRUCTURE

In the present analysis, mean test conducted per million population and testing infrastructure were 2330 (SD=1742), 34 labs per districts (SD=22.0) (Table 1).

The present analysis showed relationship of r=0.20 (Figure 9) and r=0.36 (Figure 10) of tests per million and testing infrastructure with confirmed cases respectively.

DISCUSSION

Paucity of data from the various geographical locations didn't allow the authors to make more generalized comparisons. The present analysis is an attempt to gain an insight into the relationship between COVID-19 cases and deaths with selected factors like Geographical distribution, demographic factors like population density and percentage of slum population, health financing parameters like percentage of GSDP, per-capita health expenditure and testing infrastructure.

Secondary data analysis done in the present study seem to concur with media reports from the city of New York which have indicated a link between the region's density and confirmed cases.[20] In data analyzed for London, as of 27 April, the UK reported over 157,000 positive cases, nearly a fourth of which were in London with one-fifth deaths which could be attributed to London's population density.[21,22]

Analysis done by Desai concluded that high degree of disparities in the population densities of the different boroughs makes London an ideal case to study how the highly skewed population distribution within the diverse city areas acted as 'clusters' for the spread of the virus.[5] The present analysis also concluded that COVID-19 cases are more in cities /districts with high densities.

A study conducted by Lau et al in China to study the association between international and domestic air traffic and the coronavirus (COVID-19) outbreak, suggested that the total number of COVID-19 cases of regions shows a correlation with the current air passenger volume.[7] In the present analysis, the authors found that number of COVID-19 cases being higher in those agglomerations with international airports than those without international airports.

A weak and negative association as observed in the present analysis between number of tests per million and testing infrastructure respectively with number of confirmed cases is probably a reflection of India's testing policy.

Negative correlation of case fatality rates with HDI and NITI Aayog's Health index makes a strong case for using development indicators for a more comprehensive assessment of proximal and distal determinants of disease causation.

Limitations

The conclusions of the present analysis have to be viewed in the context of limitations like, non-availability of city wise data and use of district data as a proxy for cities. Use of state level data as proxy for districts will also limit the generalizability of the present analysis.

CONCLUSION

The present analysis throws light on the importance of decongestion of cities through perspective urban planning as population density appears to play role in determining the case load due to COVID-19. Presence of international airports, appears to play role in determining the case load and thus calls for stronger quarantine measures in these agglomerations to reduce the possibility of transmission into the neighboring districts. Negative correlation of HDI and NITI Aayogs health index with case fatality rate emphasizes the importance of focusing on improvements in social determinants of health.

REFERENCES

1. WHO. Coronavirus disease (COVID-19) outbreak; 2020. Available at: https://www.who.int/emerg-encies/diseases/novel-coronavirus-2019. Accessed on 30 May 2020.
2. Epidemiology Working Group for NCIP Epidemic Response, Chinese Center for Disease Control and Prevention. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China. Zhonghua Liu Xing Bing Xue Za Zhi. 2020;41(2):145-51.
3. WHO COVID-19 Situation reports. Available at: https://www.who.int/emergencies/diseases/novel-coronavirus 2019/situation-reports/ Accessed on 08 May 2020.
4. Ruan S. Likelihood of survival of coronavirus disease 2019. Lancet Infect Dis. 2020;20(6):630-1.
5. Desai DD. Urban Densities and the Covid-19 Pandemic: Upending the Sustainability Myth of Global Megacities. ORF Occasional Paper No. 244, 2020.
6. Class 1 Urban agglomerations. Available at: http://mohua.gov.in/cms/number-of-cities--towns-by-city-size-class.php. Accessed on 29 May 2020.
7. Lau H, Khosrawipour V, Kocbach P, Mikolajczyk A, Ichii H, Zacharski M, et al. The association between international and domestic air traffic and the corona virus (COVID-19) outbreak. J Microbiol Immunol Infection. 2020;53(3):467-72.
8. Covid-19 Status Update. Available at: https://www.covid19india.org. Accessed on 30 May 2020.
9. Airports Authority of India. Available at: https://www.aai.aero/ Accessed on 30 May 2020.
10. Population density & slum population. Available at: https://censusindia.gov.in/2011-Common/Census Data2011.html. Accessed on 29 May 2020.
11. National health profile. Central Bureau of health intelligence publication. MOHFW. Issue 14. Available at: https://www.cbhidghs.nic.in/index1

.php?lang=1&level=1&sublinkid=75&lid=1135 Accessed on 29 May 2020.

12. NITI AAYOG. Healthy States Progressive India Report on the Ranks of States and Union Territories. Available at: http://social.niti.gov.in/ Accessed on 29 May 2020.

13. "Sub-national HDI - Area Database - Global Data Lab". Available at: https://globaldatalab.org/shdi/shdi/IND/?levels=1%2B4&interpolation=0&extrapolation=0&nearest_real=0.Accessed on 30 May 2020.

14. Sub national Huna development index. Available at: https://qphs.fs.quoracdn.net/main-qimg-9f57b25 5c4d971c9cd579d7a6f2dc70f. Accessed on 31 May 2020

15. Testing Laboratories in various states. Available at: https://www.thehindu.com/data/article31254727.ece/inline/ Accessed on 30 May 2020.

16. Total Operational (initiated independent testing) Laboratories reporting to ICMR. Available at: https://www.icmr.gov.in/arcctestlab.html. Accessed on 30 May 2020.

17. Niti Aayogs Health Index. Available at: https://pib.gov.in/PressReleasePage.aspx?PRID=157 5588#:~:text=The%20Health%20Index%20is%20a, been%20equally%20distributed%20among%20indic ators. Accessed on 03 June 2020.

18. Human development index definition. Available at: https://economictimes.indiatimes.com/definition/human-development-index. Accessed on 03 June 2020.

19. Data Wrapper. Available at: https://app.datawrapper.de/mycharts/. Accessed on 31 May 2020

20. Bump, Philip, "New York City Is the Epicentre Of Coronavirus in The U.S. – Is This Due to Density Or Testing?", The Washington Post, 2020. Available at: https://www.washingtonpost.com/politics/2020/03/19/new-yorkcity-is-epicenter-coronavirus-us-is-this-due-density-or-testing. Accessed on 29 May 2020

21. Official UK Cases & Deaths – Accurate as of April 27, The Sun, 27 April 2020, Available at: https://www.thesun.co.uk/wp-content/uploads/2020/04/GLUK- CORONAVIRUS-MAP-DEATHS-IN-OUT-27-APRIL-1730.jpg. Accessed on 29 May 2020.

22. Trust for London (2017). London's geography and population. Available at: https://www.trustforlondon.org.uk/data/londons-geography/. Accessed on 29 May 2020.