Scholarly Research Journal for Interdisciplinary Studies,
Online ISSN 2278-8808, SJIF 2021 = 7.380, www.srjis.com
PEER REVIEWED & REFEREED JOURNAL, JAN-FEB 2023, VOL- 10/75
10.21922/srjis.v10i75.123028

ASSESSMENT OF COMPARABILITY INDEX OF COVID-19 CASES: A STUDY OF URBAN AREAS OF INDIA

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Paper Received On: 25 FEBRUARY 2023

Peer Reviewed On: 28 FEBRUARY 2023

Published On: 01 MARCH 2023

Abstract

India is one of the worst hit countries from SARS-COV-2 since its inception. There have been two major COVID-19 waves that India has faced, one in the mid of 2020 and the other in the beginning of 2021. Although the second wave was much worse than the first as it had high transmissibility rate and mortality rate. In this paper a comparative analysis is done for COVID-19 cases in the urban areas of India. These urban cities have gaps when it comes to economic level and urban development. Using the Comparability Index (CI), the study found a correlation between the selected variables namely Population Density, Economic level, Housing occupancy and the number of COVID-19 cases in each city for both the COVID-19 waves.

Keywords: *COVID-19, Economic Level, Housing occupancy, Population Density, Urban cities.*

INTROUCTION

The world today is facing the biggest threat in the form of COVID-19. It began from the city of Wuhan, China in early Dec 2019 after which it spread to other countries within no time. Since then, it has been said to have mutated causing respiratory and other problems. In February 2020, the WHO formally designated this outbreak as the Corona virus disease COVID-19 (where Co-corona, Vi-virus D-disease, and 19-2019 the year it began). Recent years have seen an increase in the social and environmental elements that cause pandemics, such as ecosystem damage, meat eating, urbanization, and connectivity between cities and countries. Pathogens may move from

animals to people as a result of changes in land use and meat intake. The growth of urban areas, as well as the networks of international trade and travel, raise the possibility that such zoonotic epidemics would eventually spread to become pandemics. Kerala, India's first instance, was reported on January 30, 2020. A total of 143788 suspected cases were reported on May 8th,2020 (ICMR). In May Maharashtra, Delhi, Gujrat were reported to be Hotspots of COVID-19. Till now India has witnessed two waves of COVID-19 with high Reproduction number indicating the high transmissibility of the virus. First wave was majorly spread in the months of May, June, July, August and September with cases peaking inSeptember. Government imposed social distancing the 'JANTA CURFEW' on march 22nd 2020. After this there were many lockdowns that the government had imposed time and again and lifted it gradually. In November and October, the first wave appeared to be receding. There was a drop-in positivity rate and death rate also dropped. Even after major government restrictions India could not manage to save itself from the brunt of second wave of covid -19. This wave hit India even harder. In the middle of march 2021, second wave started and highest number of cases were registered in April. India this time had to grapple with the healthcare system too, with hospitals struggling to cope. This wave was different than the first wave in the sense that it had higher mortality rate and transmissibility rate. The peak started receding in June and further more in July. One major reason for the second wave to be so deadly was that India had let down its guard after the first wave also the health care lacunae came into limelight. Not only this but it led to many mental health issues. Psychological responses were seen during the spread and even after the outbreak. Many people showed malefic behavior, emotional stress, anxiety, mood disorders and much more. The study also revealed that these responses were more prevalent in children and women (Cullen et al.).

India is a culmination of rural and urban setting. Even though the Rural- Urban distribution: 68.84% & 31.16% the level of urbanization increased from 27.81% in 2001 Census to 31.16% in 2011 Census in the proportion of Rural population declined from 72.19% to 68.84% (*Census of India 2011*). This urban setting is imposing further challenge to the spread of COVID-19. Some studies have already shown the effectiveness of social distancing policies in those countries with high population densities (Jawad, 2020). Indeed, those studies evaluated data from different countries in terms of density and compared it with the number of infection cases registered (Auerbach and Thachil; Abouk and Heydari).

BACKGROUND

Evidently, Oxford Economics' Global cities report estimates that 17 of the 20 fastest-growing cities in the world between 2019 and 2035 will be from India. Indian cities are likely to contribute to 70% to the GDP by 2030. This can be supported by the exponential growth of the Indian cities ("The 10 Top Challenges for India - The Economic Times," n.d.). India over the next two decades are projected to have an increase of population from 282 million to 590 million people. India's towns and cities have expanded rapidly as increasing numbers migrate to towns and cities in search of economic opportunity (*Urbanization in India*). An urban area is properly defined by government of India as a place with a municipality, cantonment board, a corporation or notified town area committee (*Census of India 2011 Provisional Population Totals*). Cities are frequently hotspots for COVID-19 infections due to the large concentration of people and economic activity there. Most of the world's population lives in cities, which are also hubs of economic development and innovation. However, cities are particularly susceptible to stressors like natural and man-made disasters due to the great concentration of people and activity there. With this in mind, a large body of research on the effects of a variety of catastrophes on cities as well as the essential preparation, recovery, and adaptation steps that need to be taken to deal with those disasters has been published during the past few decades (Sharifi, 2020). Despite the fact that pandemics had impacted cities previously throughout human history, there was nothing written about them prior to the appearance of the COVID-19 pandemic ((Matthew and McDonald). To comprehend the effects of COVID-19 on cities, many researchers are finding it difficult to comprehend the dynamics of the pandemic in urban settings. We must look into the significance of urban and in response to regional governance networks issues COVID-19 presents in various jurisdictions both scales Urbanization has increased the difficulty of managing global health because of the Political influences on health-related planning and policy decisions (Fidler, 2020). This study demonstrates the negative effects COVID-19 has had on people's health a more negative influence on economies of nations with less wealth disparity. Despite this, the Overall, both the rate of economic growth and the number of COVID-19-related deaths have decreased in proportion to the country's level of income inequality. Additionally, the outcomes indicate that Countries that depended more on the service industry and nations that imposed more repressive policies (lockdowns) saw their GDP growth decrease more quickly during the first year of the pandemic timeframe The article finishes with a few crucial policy recommendations that back the function of strong institutions in sustaining economies

during pandemics ((Ghecham). For numerous reasons, income disparity can have a negative effect on economic growth reasons. As a result of income inequality, a nation's human capital can be undermined reduced monetary commitment to education by people. The connection between income disparity and economic growth is fairly significant crucial in that it can advance our scant knowledge of how health problems work influence economic expansion Despite the country-to-country correlation of health Although economic growth is generally agreed, further work is still required to explore the basic processes.

A study suggested that it's important to look at the social and spatial aspect of COVID-19 as well. To tackle COVID-19 in urban settings like Toronto, Italy it's important to have an expanded definition of care which takes into consideration the ethnography-societal-development and other complexities (Biglieri et al.). Many studies related to COVID-19 and urban density indicated that though both these variables should have strong correlation, on the contrary it is a complex phenomenon. It's important to separate urban density from internal and external connectivities. Six categories were found and impact of COVID-19 on them was identified as the gap (Teller). It was found that Economic endowments affects when and how much will people engage in distancing themselves socially (Wright et al.). A study showed that municipalities having low individual income and more income inequality will show stronger reduction in connectivity. Also, lockdown restrictions have more effect on regions with higher Fiscal Capacity (Pammolli Designed Research; G et al.). In order to examine the impact of economic factors on racial/ethnic disparities in county-level COVID-19 immunization rates, pooled ordinary least squares (OLS) with control variables were used in a longitudinal study that included all counties in the U.S that reported COVID-19 immunization rates from January 2021 to July 2021. County-level income per capita and county-level rates of unemployment were both positively linked with county-level COVID-19 immunization rates nationally. The relationships varied, though, when it came to race and ethnicity. Health care attempts to raise COVID-19 immunization rates should come into consideration and economic l factors that are related to decreased COVID-19 vaccination rates (Guo et al.). These variables separately are said to have an impact on COVID-19. The first assumption one would make is that because of the high levels of human interaction, densely populated places could turn into hotspots for the rapid spread of the pandemic. COVID-19 hs been unequal in its spread . Another paper showed that economic and social factors are related positively with COVID-19 and cultural and population density relation is low initially and higher later (Mogi

et al.). However, reported evidence on the association between density and COVID-19 is contrasting and can be questioned. According to a study, urbanization had a cumulative impact on Hubei's economy that was first favourable, became negative over time, and then progressively increased during the COVID-19's various stages of discovery, outbreak, and subsidence. Significant industrial and urban diversity resulted from this process, which was most clearly demonstrated by costs in the tourism and catering sectors that were much higher. Similar to this, major cities took longer to heal than small and medium-sized ones. The primary cause of these discrepancies is that in regions where urbanization rates are higher, the urbanization problem is more pronounced. Future urbanization has received attention thanks to COVID-19 ((Yang et al.) In a study of over 900 US metropolitan, it was found that there's no strong positive correlation between COVID-19 infection and mortality rates and density. Surprisingly, compared with sprawling areas, they observed slightly lower virus-related mortality rates in high-density locations (Hamidi et al.). Similarly, there's no significant positive relationship between county density and infection rate in the Netherlands, which is generally highly urbanized and densely populated (Boterman) . Also, in China it was found that the percentage of the population and population density are key factors that can explain the spread rate of COVID-19. They further explored the effect of population density and did not find high spread rates in high density metropolitan regions (Lin et al.) . It means that we cannot conclusively say that any of the above-mentioned factors can individually affect the incidence of COVID-19. In European Nations it was found that it's not the population density but economic condition of a country that affects the COVID-19 death rate. It was seen that the spread dynamics does not matter as is seen in the developed Nations the death rate of COVID-19 in lower (Kozlovskyi et al.). This paper is primarily based upon the research conducted in Mexico City wherein a comparative analysis of urban development, economic development, number of COVID-19 cases was done and a correlation was found between them and COVID-19 cases (Molina-Torres et al.). Based on the relevant literature the proposed variables for the present study includes the population density, the housing occupancy index, and the income per capita.

OBJECTIVE OF THE STUDY

1. To find correlation among population density , income per capita, housing occupancy and COVID-19 cases for urban Indian cities.

2. To find out whether the selected variables influence COVID-19 cases together or/and individually for urban Indian areas.

METHODOLOGY

COVID-19 comparability index: The most important index in this study is the Comparability Index. This index tries to correlate all the above variables.

Population density PD_j (Table 1and column 3) is defined by Equation;

- ***$PD_j = P_j/S_j$; Where Pj is the population of jth city and Sj is the surface of the jth city (1)***

Per Capita (Income) PC_j (Table 2 and Column 4) is defined by Equation (2);

- ***$PC_j = I_j/P_j$; Where I_j is the total income and P_j the total population of the ith city (2)***

Now, the housing occupancy index HO_j (Table 1 and Column 5) is represented by Equation (3);

- ***$HO_j = R_j/D_j$; Where R_j is the number of permanent residents and H_j is the total number of dwellings of the jth municipality. (3)***
- $$CI\,j = (\alpha 1 PDj + \alpha 2 PCj + \alpha 3 HO\,j) * (COVID - 19) \quad (4)$$

Equation (4), defines the Comparability Index (CI) as the multiplication of the weighted average of the three variables: population density PD_j, income per capita index PC_j, and the housing occupancy index HO_j, by the number of COVID-19 cases in the jth city. The non-negative coefficients α_1, α_2, and α_3 are the weights of the variables and satisfy $\alpha_1 + \alpha_2 + \alpha_3 = 1$. In this study, the equal values $\alpha_1 = \alpha_2 = \alpha_3 = 0.333$ were chosen, as it is assumed a uniform contribution of each variable in the spread of the COVID-19 disease.

To tap the urban setting of India its major 8 urban cities has been taken to consideration. These are the cities with highest urban population. The data of population of these major cities, area square km has been taken from Census of India ,2011. Population Density from this data has been calculated and listed in Table1. Income per capita of these cities has been taken from MGSSI based on data from the United Nations and MGI (Suzuki). While data for all cities mentioned was found except for Lucknow therefore the income per capita (in million) for Lucknow was calculated from Uttar Pradesh Economic Survey (2015-16) (*UPDES*). Another important variable is Housing occupancy. Rapid urbanization combined with economic disparities has led to increasing problem of housing, overcrowding in small houses, steady growth of slums and unplanned settlements and severe deleterious effect on civic services in urban areas. Housing occupancy is another important variable to completely understand the urban setting because in India the urban dwellings are compact with 4-6 members of family living together in small compact space. In the year 2001,

many households lived in one room or two room dwelling (app 60%). Nothing much has changed in 2011 as well. (*GOVERNMENT OF INDIA MINISTRY OF URBAN DEVELOPMENT HANDBOOK OF URBAN STATISTICS*). The housing occupancy has been calculated by taking the permanent residents in a city and dividing by number of dwellings in that city using data from Census of India2011 and is mentioned in Table1. Another important variable is the COVID-19 which is the main variable to the study. The data for COVID-19 for India is available but the data per say for major cities was not that readily available. So, the data has been taken from Times of India which had data available for these urban cities. The total confirmed cases were taken for both the waves in India. For the first wave the data was taken for months of July, August, September, October, November. The data was taken from July because cases started to increase majorly after June as the cases in May and June were not much that would have been enough for the purpose of the study. Also, the cases had peaks in September and October and started to decline thereafter. Therefore, these months were taken so that a sufficient number of cases were there to conduct this study. Similarly, the months taken for second wave are March, April, May, June, July. Where the cases started to gain pace in March and peaked in April and eventually started to recede in July. So, these months were taken so that there can be sufficient number of COVID-19 cases. Column 6 in Table1. Shows the percentage of covid -19 cases in both the waves. This percentage was calculated by adding the per day cases for each city for the specific wave and then divide it by the total number of cases for these cities.

Table 1: Depicts the I and II wave of COVID-19, Column 2 shows the major urban cities, Column 3 shows the Population Density, Column 4 shows the Income per capita (in million) , Column 5 shows the Housing occupancy, Column 6 shows the percent COVID-19 cases, Column 7 shows the Comparability index.

TABLE 1: COMPARABILITY INDEX

WAVE	MAJOR CITIES	POPULATION DENSITY	INCOME PER CAPITA (mn)	HOUSING OCCUPANCY INDEX	COVID -19(%)	CI
I	DELHI	18665.05	0.31	4.77	.27	1678.83
II		18665.05	0.31	4.77	.20	1243.50
I	BENGALURU	11470	0.34	4.01	.20	764.25
II		11470	0.34	4.01	.21	811.19
I	MUMBAI	20634.11	0.39	4.47	.11	756.07
II		20634.11	0.39	4.47	.11	756.07
I	CHENNAI	26553	0.23	4.02	.09	795.96
II		26553	0.23	4.02	.08	707.52
I	PUNE	11304	0.33	4.20	.18	677.94
II		11304	0.33	4.20	.18	677.94
I	KOLKATTA	24306	0.17	4.38	.06	485.78
II		24306	0.17	4.38	.05	404.82
I	LUCKNOW	8076	0.14	5.23	.04	107.66
II		8076	0.14	5.23	.04	107.66
I	AHMEDABAD	11895	0.37	4.72	.02	79.26
II		11895	0.37	4.72	.05	198.15

Source: 1. *Population data: Census of India (2011)*

2.Income per capita: Suzuki, Y. (n.d.). INCOME LEVELS IN INDIA'S CITIES-WHEN WILL INDIA REACH CHINA'S LEVELS?

3. Housing occupancy: Census of India (2011)

4. COVID-19 cases: Times of India

DISCUSSION

The CI is depicted in Table1. The CI result shows that there exists a correlation between the three variables: Income per capita, Population Density and Housing occupancy. The result has been calculated for both the waves and will be discussed simultaneously for both the waves. In both the waves, if income per capita was the only variable for covid -19 cases, its expected that a

a city with high -income will have CI which is low compared with a city with low-income. But this is not true, as Mumbai has the highest income per capita and has second highest CI too. Similarly, Lucknow has the lowest income per capita but stands at the second lowest CI too. Though it can be said that for Ahmedabad that it has the second highest Income per capita and it has the lowest CI. Similarly, for both the waves, if High Population Density would have the highest CI, then Chennai would have had the highest CI followed by Mumbai and Lucknow having the lowest Population Density should have had the lowest CI which is not the case. Finally, if in both the wave, High Housing occupancy was the case then Lucknow would have had the highest CI and Bengaluru having the lowest Housing occupancy should have the lowest CI. Therefore, it can be concluded that it is the correlation of these variables that is High Population Density, Low per Capita and High Housing occupancy that will together affect the CI as is the case with Delhi which among all the cities that we have taken has comparatively high Population Density, low Income per capita and High Housing occupancy and hence highest CI. It clearly states that its not only one factor among the three that affects the CI and COVID-19 cases but it has to be a correlation of all the three factors for having a high CI and hence high correlation with covid 19 cases. This is clearly depicted in Figure 1. The graph clearly indicates a clear relationship between the COVID-19 cases in these cites and the comparability index confirming that the city with the highest comparability index is the one with the highest number of COVID-19 cases as well.

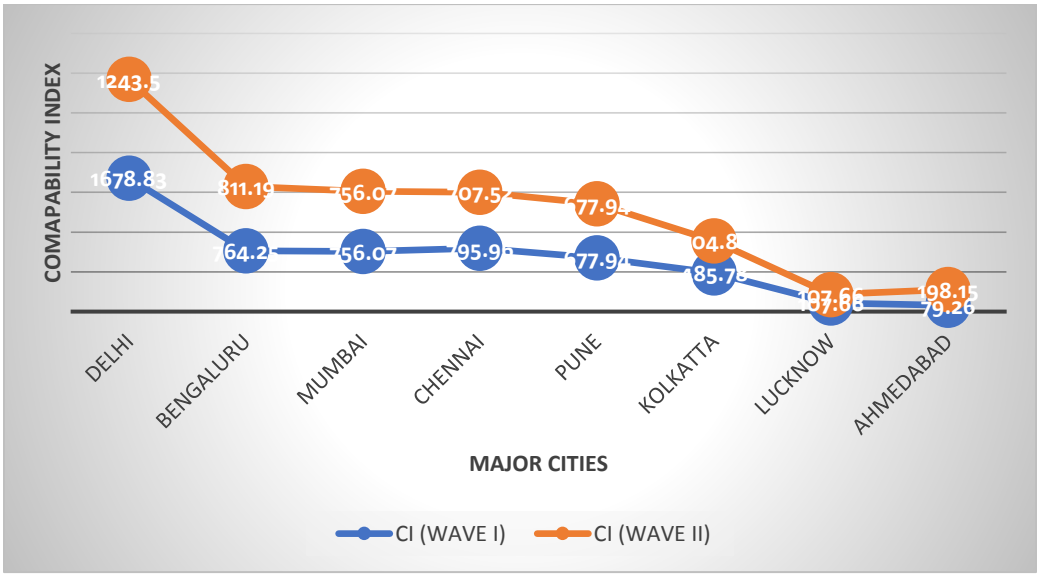

Figure 1. *This graph illustrates the relation between Comparability Index and the Number of COVID-19 cases in the urban regions of India.*

CONCLUSION

This study shows that in Indian context the selected variables play a role in determining the COVID-19 cases. Majorly 8 urban Indian cities were taken which have different urban levels and different comparability Index correlating three different variables. Comparability Index is the average(weighted) of the three variables into COVID-19 cases. Here it was assumed that all the three variables have equal weightage hence the value 0.333 for all the three variables. To see more detailed impact the study can be carried out at a micro level too taking into account individual houses. This CI clearly showed that DELHI with comparatively high Population Density, Low Income per capita and High Housing occupancy has the highest Comparability Index and hence it has more rate of infections.

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