

Role of Health Infrastructure in containing the pandemic – Decoding the Stigma

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Abstract

Covid-19 has affected the entire world, but not alike. Perception is that a country's health infrastructure greatly impacts its ability to contain the spread of various diseases. But is it so? This study aims to identify the role of health infrastructure in creating a variation in the impact of the Coronavirus across countries. The main objective of our study is to identify any relations between the pandemic related fatality rate and health infrastructure of a country as the usual stigma is.

Methodology: In this study, a few key components of health infrastructure were identified and a suitable criterion for the selection of 12 nations for this study was followed. The data metrics, such as population density, deaths, cases, hospital beds, nurses, physicians, tests and current expenditure on health, were extrapolated through linear regression and an aggregate score of the health infrastructure of each country was arrived at using a formula based on WHO standards of a particular data metrics. The countries were grouped into different categories through the use of a matrix on basis of their respective scores and case-fatality rates.

Results: Results show that highly developed countries like the USA and Australia have very good health infrastructures whereas Russia, though not so developed, stands amongst them in terms of infrastructure. On the other hand, India, which is still a developing country, has a poor infrastructure. All the European nations, studied here, have a moderate infrastructure. There is no definite relationship of this classification on the corona-case-fatality rate. India, apart from having poor infrastructure, has a lower fatality rate and Canada, despite great infrastructure has a high fatality rate.

Conclusion: All the analysis points towards the stigma being wrong and tells us that there is no whatsoever correlation between Health infrastructure and Corona fatality rate. Also, the scope of this study limits itself to comparative analysis of the data collected and further extrapolated. Health infrastructure is not the sole factor in

Key words: covid-19, coronavirus, health infrastructure, population density, case-fatality rate.

Received : 02 .09.2020

Revised : 07.10.2020

Accepted : 11.10.2020

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studying the varying impact of the virus on different nations but studying it exclusively has provided some insights into the vastness and depth of this sector alone.

Literature Review

Author	Title	Source	Findings
Shahbaz A. Shams, Abid Haleem, Mohd Javaid	Analysing Covid-19 pandemic for unequal distribution of tests, identified cases, deaths, and fatality rates in top 18 countries.	Elsevier	The results show that health infrastructure is a key factor in containing the losses from the pandemic alongside certain other factors like economic status, income levels, government response, etc.
Michelle L. Holshue, M.P.H., Chas DeBolt, M.P.H., Scott Lindquist, M.D., Kathy H. Lofy, M.D., et al., for the Washington State 2019-nCoV Case Investigation Team	First case of 2019 Novel Coronavirus in the United States	The New England Journal of Medicine	This paper traces the cause of the first case of the virus in the US, establishing the person-to-person transmission as the cause. It provides detailed analysis of the origin of the virus in Wuhan and studies its transmission dynamics.
Kenneth McIntosh	Coronaviruses	UpToDate	The study presents a detailed analysis of the coronaviruses, studying in depth their types, causes, treatment, prevention and summarises each aspect, forming a base for the purpose of our research.
Shuja Asrar	Covid-19: What are the reasons for low fatality rate in India?	The Times of India	The results show that India has a lower case-fatality rate when compared to other nations, the reasons for which may be timely government response, large young population, or lesser population density.
Linda Luxon	Infrastructure- The key to healthcare improvement	Future Healthcare Journal	The paper examines different components of health infrastructure and proposes new approaches for healthcare efficiency.
Shima Hamidi	High population density in India associated with the spread of Covid-19	Medical Research News	The results show that population density is positively related to virus infection rates in India, even though the same is not true

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			for the US.
Prachi Singh, Shamika Ravi, Sikim Chakraborty	Is India's health infrastructure equipped to handle an epidemic?	Brookings	The article underpins the need to quickly revamp the supply of health equipment in India, highlighting the poor infrastructure of the country.
Aaron Kandola	Coronavirus cause: origin and how it spreads	Medical News Today	The article delves into the basics of the virus, right from its origin to causes, symptoms and prevention, stressing upon person-to-person transmission of the disease.
	Public Health Infrastructure	HealthyPeople.gov	This article provides insights on what health infrastructure is, underscoring its importance and services along with emerging trends in the same.
Navdeep Yadav	10 most-affected countries with the highest number of cases	Business Insider India	The results show that the USA tops coronavirus cases, followed by India, then Brazil, Russia, Colombia and continues till the ten most affected countries, forming one of the bases of selection of countries for our study.

Introduction

Coronavirus

Coronavirus Disease 2019 (COVID – 19) is an infectious disease originated in the Wet market of Wuhan, Hubei, China in November 2019, thereby earning this name on 11th February 2020. From that day onwards this disease has proliferated throughout the world and it was declared Pandemic by WHO on 11th March 2020. Every country in the world, no matter developed or underdeveloped, is using every possible way to contain this pandemic which has taken above 7 lakh lives around the world. (Till 7th August, 2020; Source: [WHO](#)).

With the rising fatality rate in the countries, a perception formed in everyone's mind that fatality rate is indirectly proportional to health infrastructure in the country. Does this perception hold truth? Invigorated by this question, we decided to research the health infrastructure of meticulously selected 12 nations; their health infrastructure and fatality rate and tried to find a correlation between health infrastructure and the Corona fatality rate which could prove the role of health infrastructure in containing the pandemic. This paper provides you a thorough journey of research methods we

used and conclusion. But first, we need to understand what health infrastructure is and what it includes.

Health Infrastructure

Public health infrastructure provides communities, states, and the Nation the capacity to prevent disease, promote health, and prepare for and respond to both acute (emergency) threats and chronic (ongoing) challenges to health. Infrastructure is the foundation for planning, delivering, evaluating, and improving public health. Health infrastructure includes all health-related infrastructure that a country possesses ([HealthyPeople.gov](https://www.healthypeople.gov)). Be it advance machines, number of physicians, number of nurses, number of beds, expenditure on health or other such paraphernalia. An advanced health infrastructure provides the country an edge over countries with less advanced infrastructure in preventing diseases, better standard of living and low mortality rate. Health infrastructure lays the foundation of planning and strategizing to face any kind of health situation in the country.

In order to keep the health infrastructure relevant to our study, we decided to take on the factors that affect the situation of pandemic in our country i.e. no. of beds (per 1000 person), no. of physician (per 1000 person), no. of nurses (per 1000 person), Density (P/Km²) and tests (per 1000 person).

Next, we will have a look at the objective of our research.

Objective

This study aims at articulating the role of health infrastructure in containing the pandemic by drawing out a comparison between countries on the basis of their Health infrastructure, mainly comprising of Hospital beds (per 1000), Current Expenditure on Health, Nurses (Per 1000), Physicians (Per 1000), Density (P/KM²) and Tests (Per 1000); all these are the factors that affect rate of recovery of patients, rate of Infection etc. This comparison allows us to identify the countries that lagged behind despite having the best resources and countries with poor resources who managed to keep the situation in check.

Criteria for Choosing the Countries

This research paper looks at the trajectory of the effects that COVID-19 has had on different countries with different parameters of health services. By gauging the level and quality of healthcare departments of countries, the paper draws and detects the correlation between the health infrastructure of a country in terms of COVID-19 and its effect. The countries have been chosen consciously; keeping in mind the necessity to cover a large range. Thus, spanning from developed superpowers to countries which are still developing, the paper has manifested all possibilities in a nutshell. Moreover, countries which are/were worst affected by the virus have been given place to further enlarge the prospects of the paper. In terms of hospital beds, emerging European countries like Germany, Spain, France, and Italy have been taken into consideration, some of which were badly affected by the COVID-19 in economic and social terms. Australia, an island country, has also been added for greater representation. Not forgetting the hegemonic power of the US and competing nation Russia, the paper includes developed countries on one and stifled countries on the other. For instance, terror-stricken Iran.

Asian countries like Singapore and India have been included as these are one of the worst affected countries. India being the growing economy as it is, its place marks an important role. A close observation portrays how less India spends on its health sector compared to how large its population is. It was also important to keep in the list, a geographically large country like Canada. Our erstwhile colonizer, the United Kingdom gets a spot too, for the rapid rise in their number of cases caught international attention.

Research Methodology

The requirements of this research recommend a promising methodology to fulfill its objective: identifying key components and countries to explore, pinning down data requirements, collection of data, maneuvering it as per the need and probing into the output yielded.

The data for the research purpose has been collected from the official sites of WHO, World Bank, OECD and many other sources which collect their data from the countries themselves, hence secondary data has been used extensively.

Six major factors have been chosen for study and relevant data has been collected, these are as follows:

1. Number of hospital beds (per 1000).
2. Number of physicians (per 1000).
3. Number of nurses and midwives (per 1000).
4. Population density (per square km).
5. Current expenditure on health as percentage of GDP.
6. Number of tests for corona, as on August 4, 2020.

The official sites and online articles publish the latest data of 2018 for the 1st five factors, therefore in order to compare the data with the cases in 2020; the data for 2020 has been extrapolated using LINEAR REGRESSION (In statistics, linear regression is a linear approach to model the relationship between a scalar and one or more explanatory variables; we have used Microsoft excel as a tool to model the relationship between year and data for the factors) . The data for the number of tests was available and hence no further extrapolations were done to it.

In order to calculate the case fatality rates, the number of deaths due to the virus has been divided by the total number of cases.

Following tables; Table 1 shows the data for each parameter for each country for year 2020 along with a benchmark standard for each parameter and Table 2 presents us the fatality rate for each country.

Table 1

Countries	Hospital beds (per 1000)	Current expenditure	Nurses (per 1000)	Physicians (per 1000)	Density (P/KM ²)	Tests (per 1000)
Australia	3.883	9.731	13.881	3.842	3.202	149.059
Canada	2.394	10.770	10.280	2.576	4.037	100.348
Germany	7.806	11.503	13.945	4.464	237.016	90.535
Spain	2.929	8.865	5.808	4.176	93.105	76.136
France	5.796	11.542	12.102	3.300	122.578	49.247
United Kingdom	2.346	10.710	8.087	2.854	272.898	133.364
India	0.482	3.743	2.158	0.846	450.419	13.551
Iran, Islamic Rep.	1.800	9.998	2.561	1.397	49.831	20.505
Italy	2.938	8.902	6.088	4.003	205.859	51.709
Russian Federation	7.961	5.664	9.383	1.781	8.823	188.053
Singapore	2.867	5.251	6.873	2.728	7915.000	93.052
United States	2.596	17.575	20.264	2.691	35.608	164.545
Standard	5.000	9.864	4.000	1.000	50.100	91.794

Table 2

Countries	Total deaths per million	Total cases per million	Fatality rate
Australia	8.67	718.36	1.21
Canada	237.06	3100.43	7.65
Germany	109.28	2521.74	4.33
Spain	608.96	6353.45	9.58
France	464.11	2930.67	15.84
United Kingdom	680.70	4502.00	15.12
India	28.22	1344.74	2.10
Iran, Islamic Rep.	207.22	3715.01	5.58
Italy	581.62	4105.55	14.17
Russian Federation	97.35	5867.46	1.66
Singapore	4.62	9068.02	0.05
United States	469.49	14240.26	3.30

Further, countries have been allotted scores taking WHO standards as the benchmark. More details are presented in the SCORING section. Using the derived scores and case fatality rate, a matrix has prepared, and all the 12 countries have been classified into different categories for comparison.

Scoring

For the purpose of allotting scores to the countries for each factor, the collected data has been sorted country-wise and factor-wise.

Benchmarking was found to be the most suitable technique to allot the marks to the countries. In this technique, a benchmark is set as standard and then something else is evaluated against that standard. We further have allotted scores to the standard and a country's score is proportionate to the difference in the standard and data for that country for that particular parameter. For ex- Standard set is 5 for a particular parameter and score allotted at this standard is 5. The country X's data for this particular parameter is 8, so the score for that parameter for country X will be $(8*5)/5 = 8$ (Formula is explained in the following paragraph).

The WHO standards for each factor taken have been set as benchmark, and in case of Current expenditure and Number of tests, where the standard was not available; the median of the data of all countries has been taken as benchmark.

The score at the benchmark has been set equal to 5 and maximum score has been set equal to 10 and the following formula has been used to calculate score:

$$(\text{Extrapolated data (2020)} \times \text{Score at the benchmark}) / \text{Benchmark}$$

In order to calculate the scores for population density, it has been taken into consideration that unlike other factors, the lesser the numerical value for population density, the better the score will be. Hence, the following formula has been used:

$$10 - (\text{Extrapolated data (2020)} \times \text{Score at the benchmark}) / \text{Benchmark}$$

The scores of all factors have been added for each country on the assumption that all factors have equal weightage and hence, a composite score has been obtained.

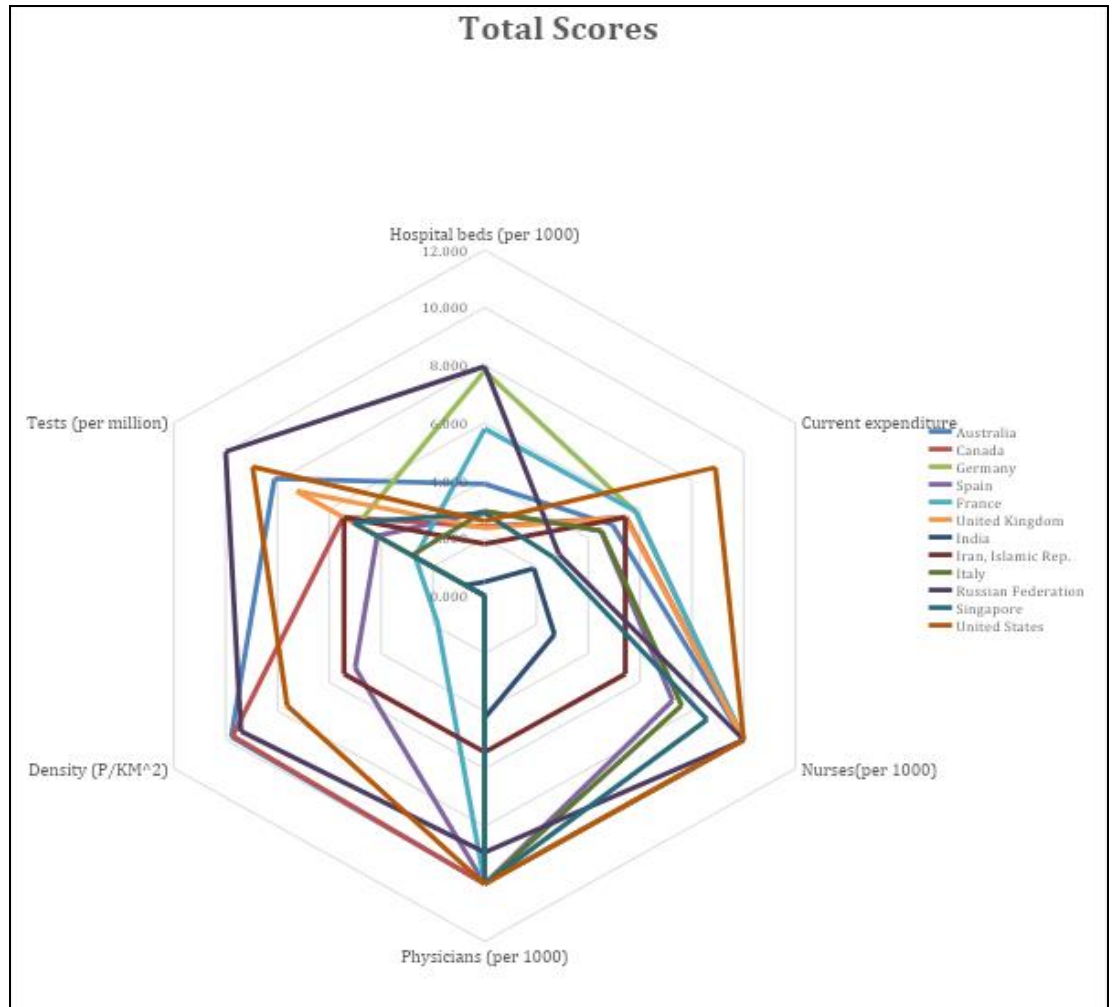
Table 3 shows calculated individual score according to the formulas written above and total score for every country.

Table 3

Countries	Hospital beds (per 1000)	Current expenditure	Nurses (per 1000)	Physicians (per 1000)	Density (P/KM ²)	Tests (per 1000)	Total Score
Australia	3.883	4.932	10.000	10.000	9.787	8.119	46.721
Canada	2.394	5.459	10.000	10.000	9.731	5.466	43.050
Germany	7.806	5.830	10.000	10.000	0.000	4.931	38.568
Spain	2.929	4.494	7.260	10.000	5.000	4.147	33.829
France	5.796	5.850	10.000	10.000	1.828	2.682	36.158
United Kingdom	2.346	5.429	10.000	10.000	0.000	7.264	35.040
India	0.482	1.897	2.697	4.229	0.000	0.738	10.043
Iran, Islamic Rep.	1.800	5.068	3.202	6.986	6.678	1.117	24.850
Italy	2.938	4.512	7.610	10.000	0.000	2.817	27.877
Russian Federation	7.961	2.871	10.000	8.907	9.412	10.000	49.151
Singapore	2.867	2.662	8.591	10.000	0.000	5.069	29.188
United States	2.596	8.908	10.000	10.000	7.626	8.963	48.093

Following is the Radar chart showing the individual scores of each country (represented by a colored line) on the basis of each parameter. To see how to read the radar chart, [Click here](#).

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Comparison Chart

This comparison chart categorizes countries on the basis of their fatality rate and their scores, and each category is explained further along with the implications a particular category holds.

Fatalit y rate	Scores	Low (0-20)	Medium (20-40)	High (40-60)
	Low (0-5)	Question Marks I	Minimalists III	Stars V
High (5-20)	Accursed II	High Maintenance IV	Black sheep VI	

Box I, the QUESTION MARKS, called so because despite having low infrastructure, they have lesser fatality rate, arousing questions as to how this could have been possible. Some of the reasons that these countries were able to do so could be stringent measures taken by administration, cooperative people, effective tracking systems to track the trail of corona infected, etc. These countries could have done better in containing coronavirus for they had better infrastructure. This portion includes only India.

Box II, the ACCURSED, called so because they lack in health infrastructure and have a high case-fatality rate, rendering them the unlucky and unfortunate ones. This box represents those countries which could not do much to contain corona due to their poor infrastructure. These countries must plan to strengthen their respective health systems in order to lessen the fatality rate owing to the virus.

Box III, the MINIMALISTS, called so due to their effective control on the virus fatality rate within a moderate amount of resources, thus making the best out of little resources. These countries, with the help of their already available health infrastructure, along with some additional measures were able to keep in check the spread of virus and fatality rate. These countries can be considered the ideal types with moderate availability of infrastructure and strategic containment of the virus. This box contains Germany and Singapore.

Box IV, the HIGH MAINTENANCE, called so because they need more to accomplish something that they could not achieve with the available resources, though some other countries could with similar quantities of resources. They have moderate health infrastructure scores and high fatality rates. This box represents countries which, in case had improved their health infrastructure and opted for stringent measures and public cooperation, could have made a good deal at containing the spread of virus and low fatality rate but didn't manage to do that. The flaw, here, does not lie in the health sector only. It includes Spain, France, UK, Iran, and Italy.

Box V, the STARS, represents the countries with high health infrastructure and low fatality rate. These countries, with the help of their highest level of health infrastructure, managed to keep in check the spread of virus resulting in a low fatality rate. It includes Australia, Russia, and the USA.

Box VI, the BLACK SHEEP, called so because they failed to contain the pandemic even with the best resources at their disposal. It represents the countries with the highest level of health infrastructure score and high fatality rate. These countries had the best cards in hand but still they lost. The reason could be sudden outburst of virus, leaving little time to handle the situation, ignorance on the part of either the government or the public. It includes Canada only.

Results

From the above comparison we can analyse that India is the only country out of the 12 selected nations with very low scores in health representing poor state of the country, however, it still has a low fatality rate due to the virus. Next, America is one of the countries that has better infrastructure and low fatality rate but Canada, on the other hand, has a high case-fatality rate even though it has a good infrastructure.

From the above analysis we can infer that Health infrastructure and Corona Fatality rate does not have a correlation and Health infrastructure is definitely not the only thing that can be used to contain the pandemic.

Conclusion

The analysis of our research tells us that there is no direct relation between a country's health infrastructure and their Corona fatality rate. Our research doesn't exterminate the possibility of a correlation between these two, it just suggests that health infrastructure is not the only thing that affects fatality rate and also is not the only thing which is capable of containing the pandemic. This research also has some shortcomings due to which the results may be biased but we have tried our best to utilize the data and techniques available to us to reach a conclusion. Shortcomings are First of all, health infrastructure encompasses a large number of components, but only a few significant ones have been taken up for the purpose of research which may not have exactly represented the entire health sector. Secondly, the paper has studied the quantitative components only; however, the qualitative factors too constitute a major portion of the health sector. Thirdly, it is not only the health infrastructure that has an impact on the case-fatality rate but other provisions such as travel restrictions, lockdown measures, ability to purchase PPEs, etc. which have affected the case-fatality rate as well and are not covered under the ambit of this research.

Keeping the drawbacks of this paper in mind, it is concluded that in the situation of India, where low fatality rate despite poor infrastructure can mean effective containment of the virus within the right time through other measures. The similar can be the case with the other nations which do not strike a definite relationship between both the areas studied above. Thus, health infrastructure is not the only exclusive sector for containing the corona case-fatality rate.

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Cite This work: Gupta, A. B. (2020). Role of Health Infrastructure in containing the pandemic – Decoding the Stigma. *International Journal of Economics, Business and Human Behaviour*, 1(3), 49–61. <https://doi.org/10.5281/zenodo.4084895>