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Evaluation of Interrelationship Between COVID-19 Spread in SAARC Region and Socio-Economic Indicators using Multivariate Regression Analysis

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Abstract
Around one fourth of world population who reside in countries of SAARC region witnessed critical social as well as economic implications due to the spread of global pandemic COVID-19. Since the spread of disease is erratic in nature, there is ambivalent knowledge about it and its interrelationship with socio-economic indicators. While impacts of the disease has been widely assessed, there is dearth of researches that specifically address the interrelationship between the spread and socio-economic indicators in SAARC region. This research work is an attempt to contribute in filling the voids. Through literature review and expert opinion, a conceptual framework is formulated. The socio-economic indicators are selected on the basis of precision, relevance, ability to be measured and means of verification. Multivariate regression analysis is performed first with daily COVID infection to test percentage and next with daily infection incremental rate as dependent variables. The analysis reveals that literacy, Universal Health Coverage (UHC), Human Development Index (HDI), Health Expenditure Per Capita (HEPC) and stringency index have influence in the spread of COVID-19 disease in context of SAARC countries. The governments of respective nations have to prioritize to promote these factors as preparedness for new pandemics like this in posterity. Advanced research in the topic could lead to further evidences and pave the way for new findings.

Keywords
COVID19 Spread, Socio-economic Indicators, Multivariate Regression Analysis, SAARC Region

1. Introduction

1.1 Background

COVID-19, spreading throughout the globe, has impact on public health, but this outbreak is likely to have more significant economic consequences and will cause a negative supply shock to the world economy [1]. The extreme uncertainty about the path, duration, magnitude, and impact of the pandemic has caused wide spread social and economic repercussions [2].The economic and social disruption caused by the pandemic is devastating: tens of millions of people are at risk of falling into extreme poverty, while the number of undernourished people, currently estimated at nearly 690 million, has increased by up to 132 million by the end of the year 2020. [3] The case of countries in South Asian Association for Regional Cooperation (SAARC) which constitute about one fourth of humanity was no different.

In order to come up with accurate predictions, understanding of natural progression of disease is very important. A disease generally progresses because of the exposure to the infection. Because of this exposure to infection hosts are formed. Hosts refer to the group of people who are more susceptible to get affected. When an infected host comes in contact with more people then disease starts to spread [4].

Along with the virological structure it has been concluded that socio- economic factors such as economic status of country, occurrence of social contacts, occupancy of confined space and population density could be the reasons for the difference in spread of the virus . Epidemiological studies have

suggested the impact of environmental factors like, temperature and humidity along with international travel and lack of proper social consciousness for isolation as causes of the global spread of COVID 19 [5].

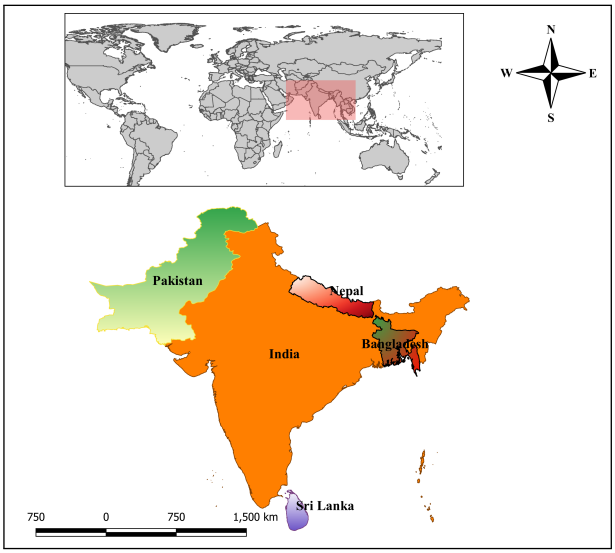

Figure 1: Selected Countries of SAARC Region

Since COVID-19 is a novice pandemic with an erratic global implications, scientists, academicians, and researchers are not much familiar with it. Moreover, there are fewer literature that address the relationship between the spread of disease and socio-economic indicators and quantitatively assess it.

In addition to that, while impact of COVID-19 in SAARC is studied but there is dearth of researches that projects the required interrelationship in the region. So there is necessity to build a robust framework that could accomplish the task. The study of interrelationship between spread of COVID-19 in SAARC region and socio-economic indicators helps to expand the institutional knowledge about pandemics, their impacts, preventive measures, and response activities. It paves the way for the governments to establish a well built and robust mechanism to face the pandemics and reduce its impacts. This is helpful for researchers, policy makers, planners, students, and general public.

1.2 Objectives and Limitations

The objective of this research is:
To evaluate the interrelationship between socio-economic indicators and COVID-19 spread in SAARC region.

The limitations of this research work are as follows:

- The research is mainly focused in the context of SAARC countries.
- Afghanistan, Bhutan and Maldives have been excluded due to less availability of data.
- Since there were fewer data in earlier months of the year 2020, analysis is done using the data starting from April 2020 to December 2020 for infection to test percentage and from May 2020 to December 2020 for daily incremental rate.

2. Methodology

The formation of conceptual framework acts as the foundation for the selection of indicators. The degree of spread of pandemic such as COVID-19 and its disastrous threat in any nation is likely to be determined by the the level of preparedness and the ability to effectively respond to it. This can indeed be characterized by prevalent healthcare infrastructure, economic performances, socio demographic factors and strong institutional capacity of the government [Refer Table 1].

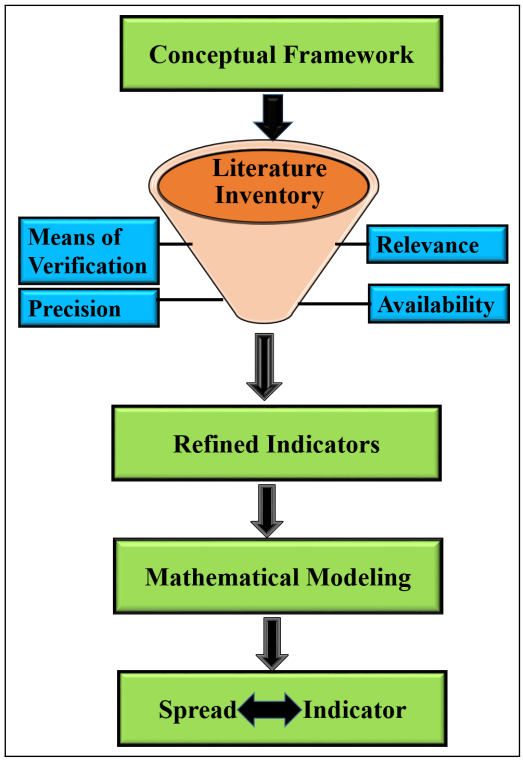

Figure 2: Research Framework

The strong interrelationship between the rate of spread and indicators is largely affected by the choice of the latter. Indicators ought to be chosen on the

Table 1: Selected Socio-economic indicators for assessing COVID-19 spread

Criteria	Sub-Criteria	Description	Relevance in COVID19
Health Infrastructure	UHC	Average coverage of essential services based on tracer interventions that include service capacity and access to fundamental health facilities	Addresses preparedness and response
	HEPC	Expenditure by a nation in health sector per capita	Addresses preparedness and response
Economic Performance	Gini Coefficient	Measure of the distribution of income across a population and used as gauge of economic inequality	Addresses preparedness and response
	GDP Per Capita	Gross Domestic Production measured per unit capita	Addresses preparedness
Socio-Demography	HDI	composite index of life expectancy, education and per capita income indicators	Addresses preparedness and response
	Literacy Rate	Percentage of population able to read and write	Addresses response
	Population Density	Number of People Living per unit square kilometers	Addresses response
Institutional Capacity	Governance Index	Effectiveness of a government to frame and implement pro people policies	Addresses preparedness and response
	Stringency Index	Measures the degree of strictness adopted by the government to impose lockdown	Addresses response

basis of their relevance and ability to be measured. However relevant an indicator may be, after all as we intend to quantify the data, thus it must be measurable and should have strong means of verification. With the assistance of literature review important indicators were extracted out of big set of indicators on the basis of precision, transparency, fairness and means of verification [15].

The authenticity of any research work is corroborated by the accuracy of available data. All the data regarding confirmed cases of COVID-19 and tests performed in a given date in the selected countries are extracted from online portal 'ourworldindata'. Data of indicators have been sourced from various reports of international organizations and verified online platforms. The data of the socio-economic indicators for the selected nations are listed in Table 2.

After extraction of daily COVID-19 data , the percentage of infection to test as well as daily incremental rate is calculated for each day. An average of the percentage is reckoned for each month.

$$\text{Infection per Test} = \frac{\text{New cases in a given day}}{\text{Number of new tests}} \times 100 \tag{1}$$

$$\text{Rate} = \frac{\text{Cases in a day- Cases the day before}}{\text{Cases the day before}} \times 100 \tag{2}$$

Using SPSS, stepwise multivariate linear regression separate analysis is performed using the average value of rate for each month as dependent variable and the selected indicators as independent variables. Thus interrelationship between the indicators and the spread of virus is evaluated.

3. Results and Discussion

i) Infection per test percentage:

For this modeling, infection per test percentage is considered dependent variable and all the selected

Table 2: Socio-economic indicator data of the selected nations

Indicator/Nation	Nepal	Pakistan	India	Bangladesh	Sri Lanka	Remarks	References
UHC	48	45	55	48	66	0-100	[6]
HEPC	57.85	42.87	72.83	41.9	157.46	US	[7]
GDP Per Capita	3586	5160	6284	5139	13114	US $	[8]
Gini Coefficient	0.71	0.67	0.83	0.69	0.7	0-1	[9]
HDI	0.602	0.557	0.645	0.632	0.782	0-1	[10]
Literacy Rate	67.9	59.1	74.4	73.9	91.71	0-100	[11]
Population Density	200.72	276	411.48	1181	332.31	0-100	[12]
Governance Index	-1.05	-0.68	0.17	-0.74	-0.11	-2.5 to 2.5	[13]
Stringency Index	80.05	65.1	77.05	80.92	55.52	0-100	[14]

socio-economic indicators are taken as independent variables. From stepwise regression analysis, UHC and literacy rate are found to be significant. The summary of equations obtained in each model when using infection to test percent as dependent variable is as follows:

Table 3: Summary of Regression Analysis

Model	Equation
First	y = 30.79-0.43UHC
Second	y = 28.723-1.176UHC+0.56 literacy rate

y= Average infection to test percentage

Table-3 presents the resultant model obtained after multivariate regression analysis.From model summary of Table 4, Universal Health Coverage (UHC) and literacy rate have been identified as the key indicators that have interrelationship with infection to test ratio.

Table 4: Summary of Model

Model	R	R Square
First	0.487[a]	0.220
Second	0.576[b]	0.331

a. Predictors: (constant) , UHC
b. Predictors: (constant) , UHC, Literacy Rate

The significance for ANOVA test is .001 for first model. Likewise for the second model which has both UHC and literacy rate, the value is .000.This proves that Universal Health Coverage (UHC) which covers the access of an individual to health service does have impact in the outcome of COVID infection to test ratio. At the same time literacy rate which is associated with the ability of an individual capable of reading and writing, also influences the dependent variable. It is to be noted that the coefficient for UHC is negative which means it has inverse relation with the output variable.

In table 4, it is observed that single indicator UHC has R square value of 0.220. It implies that the first model can only explain 22% of fitted data.Whereas in second model when UHC and literacy rate both are taken as indicators, the value of R square is 0.331. It can be said that this model is able to explain 33.1% of fitted data.Thus it is found out that the model that has both UHC and literacy rate is better model than the one involving only UHC.

Table 5: Values of Coefficient

Model	Parameter	Coefficient	Sig.
First	Constant	30.79	.000
	UHC	-0.43	.001
Second	Constant	28.723	.000
	UHC	-1.176	.001
	Literacy Rate	0.56	.020

ii) Daily Infection Incremental Rate:

For second analysis, daily incremental rate is considered dependent variable and all the selected socio-economic indicators are taken as independent variables. Stepwise regression analysis is performed and found out that HDI, Health Expenditure Per Capita and Stringency Index are significant.

The summary of equations obtained in each model when using daily infection incremental rate as dependent variable is as follows:

Table 6: Summary of Regression Analysis

Model	Equation
First	y = -30.46+56.74*HDI
Second	y = -40.61+60.14*HDI+0.10*HEPC
Third	y=-92.42+92.80*HDI+0.103*HEPC + 0.374* Stringency Index

y= daily incremental rate

From model summary of Table 7, it can be concluded that Human Development Index(HDI), Health Expenditure Per Capita and Stringency Index have influence in the rate of daily increment of COVID infection.

Table 7: Summary of Model

Model	R	R Square
First	0.37[a]	0.137
Second	0.485[b]	0.235
Third	0.641[c]	0.411

a. Predictors: (constant) , HDI
b. Predictors: (constant) , HDI, HEPC
c. Predictors: (constant) , HDI, HEPC, Stringency Index

In first model it is observed that HDI as a single indicator has R square value of 0.237.It implies that the model could explain only 23.7 % of the fitted data. Likewise in second model, HDI and Health Expenditure Per Capita in combination contribute to R square value of 0.35.The value is increased than that of single indicator. It means 35% of the fitted data could be explained by the second model. When stringency index is added in the combination, the value of R square becomes 0.411 which is higher than that of first and second model. This implies that 41.1% of fitted data is explaiend by the the third model. It is to be noted that the incremental rate of COVID-19 does not seem to have significant interrelationship with other selected parameters such as HDI,governance, UHC, population density and GDP per capita.

Table 8: Values of Coefficient

Model	Parameter	Coefficient	Sig.
First	Constant	-30.46	.049
	HDI	56.749	.19
Second	Constant	-40.613	.010
	HDI	-60.142	.001
	HEPC	0.063	.036
Third	Constant	-92.422	.000
	HDI	92.804	.001
	HEPC	0.103	.001
	Stringency Index	0.374	.002

Stringency index having stronger interrelationship with incremental COVID-19 rate strongly point out the fact that the governmental interventions such as strict lockdown, closure of offices, educational institutions,etc do have the strength to influence the rate. Similarly, the investment of state in the health sector as well as improvement in HDI also seems to play the role to cause the variation in the spread of the disease.

For the first the significance for ANOVA test is .019. Likewise for the second model which has HDI and Health Expenditure Per Capita, its value is .007. Finally for third model with HDI, Health Expenditure Per Capita and Stringency it is .00.

4. Conclusion

This study has revealed that socio economic indicators such that literacy rate, Universal Health Coverage (UHC) have interrelationship with daily covid infection to test percentage and Human Development Index (HDI), Health Expenditure Per Capita and Stringency Index have influenced the daily incremental rate of infection of COVID-19 in the selected nations of SAARC region. Due to limitations, it is necessary to interpret the finding of the study with proper caution.

Despite the findings, it has not been clear to what degree each variable could play the role to impact the spread. The daily incremental rate is very sensitive for there could be exponential increase within a single day. In such a case the rate is suitably replaced after performing interpolation. Similarly, infection or test data for some of the nations were unavailable or missing or was zero for certain days. Further advanced research with mobilization of better resources by incorporating other possible variables could lead to more findings in the study.

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