Lockdown: The Most Effective Preventive Measurement of Corona Virus Pandemic Disease through Social Distancing

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ABSTRACT

Purpose: *The lifestyle of people throughout the world has been affected exceptionally due to the severity of COVID-19 pandemic disease. Different steps to prevent this pandemic disease have been taken to protect the entire nation by the government of the affected countries. Several research works are going on to forecast on the different cases of the disease like new affected cases, new death cases. But the researchers have not worked for the Stringency Index on which transmission of the virus mostly depends till now.*

Objective: *Decision of maintaining strict lockdown and partial lockdown are the most effective preventive measure to resist this pandemic disease by breaking the cycle of transmission through social distancing.*

Methodology: *In our proposed work we have introduced the reality. Data from various sources on this disease for most affected countries like India have been collected by the authors. They have started an experiment on that data and ultimately have prepared a mathematical model to correlate between basic reproduction rate and the stringency index.*

Results: *The authors have calculated average new infected cases, maximum new infected cases and minimum new infected cases which are highly associated with the stringency index. Average death cases, maximum death cases, and minimum death cases are also been calculated as these are also associated with the stringency index.*

Conclusion: *Depending on the result of experiment of our work government of India as well as World Health Organization can take a decision for maintaining an effective lockdown to protect the entire nation from this deadlier disease.*

Keywords: Correlation, Stringency Index, Reproduction Rate, Corona Virus, Lockdown,

1. INTRODUCTION :

In India the first evidence of corona virus disease was detected in India on 30th January, 2020 after travelling of a university student from Wuhan, China in Kerala[1-2]. “Janata Curfew” [2-3] was the beginning of the long battle against corona virus disease. Nation wise lockdown was first started on 24th March, 2020 to control the out breaking of this deadlier virus through maintaining the social distance. The duration of the lockdown was 21 days and the main goal of lockdown was to restrict the movement

of entire nation of India [4-5]. Different exigency services, carrying of necessary goods, fire, police etc. were completely free from lockdown. But other services like schools, colleges, universities, businesses and hospitals were deferred during this period [6]. As per decision from MHA other essentials like food store, banking services, ATM services, petrol stations were free from the restrictions of the lockdown [6-7].

As per the reports from various observers the growth rate of the transmission of the virus had been reduced by the effect of lockdown and by 6th April, 2020 the double growth rate was observed in every six days [8] and by 8th April,2020 the same growth rate was observed in every 8 days[9].Though the decision of the first phase of lockdown was 21 days but extension of lockdown was recommended by state governments and other advisory committee of India to break the cycle of the spreading of the deadlier virus [10]. The second phase of lockdown was started in India from 15th April, 2020 as a decision taken by government of India [11] but there was some relaxations for the regions where the transmission rate was minimum. From May, 2020 extension of the nationwide lockdown was initialized and the duration of this third phase of lockdown was two weeks. All districts of India were splitted into different sectors like red, green and orange based on the severity of the out breaking of the virus and some relaxations were applied according to the severity of the virus [12].

As per the decision of government authority fourth phase of lockdown was started from 18th May, 2020 in India and it was extended for two weeks again [13]. Though the growth rate of transmission of the virus was reduced due to strict lockdown but the entire country faced severe economic slowdown due to suspension of several industries [14-16]. They were worried about their unpredictable future. The minimum GDP growth rate was noticed in India from April, 2020 to June, 2020 and it was -23.9 [16]. The growth rate for manufacturing industry was -39.3%, for mining industry growth rate was -23.3% [16]. The growth rate for Tourism industry was -47% and for construction industry the growth rate was -50% [16].

Thousands of people became jobless [17] and had been emigrated out of different cities [17] due to closing of different factories and workplaces [18,19], the people who went to different places of India for job from their home town faced the problem of loss of job, food deprivation [18,19]. Keeping these concepts in mind government of India took the decision to reopen some industries phase wise. Unlock 1.0 was started from 8th June, 2020 [20]. Shopping malls, places of worships for all religions, hotels, and restaurants were allowed to reopen but any form of crowd were strictly restrained [21].

Travelling in interstate level was allowed. It was decided to reopen the educational institutions in July during unlock phase II. It was decided to relieve restrictions on international flights, metro rails, and some recreational activities like gymnasiums and yoga centres was decided in August, 2020 [21]. But educational institutions would remain closed. Lockdown was maintained in the confinement zone till 30th September, 2020 during unlock phase IV. Some activities were relieved from restrictions outside the containment zone. As per decision of government of India from 7th September, 2020 metro rail service was allowed to be resumed. In any social gathering maximum 100 people were allowed. In meeting places, organizations and face coverings/face shields were made compulsory in transport.

From the article [22] it was observed that swimming pools were allowed to open for training purpose, cinema halls were opened from 15th October,2020 with 50% seating capacity, some tourists' spots were opened for tourists during the different phases of unlock down. No new changes have been added in the existing guidelines of unlock phase 5.0 and as per the advice of MHA unlock phase 6.0 had been started from November, 2020 and it was extended up to 30th November, 2020 [23-25]. More activities outside containment zones were allowed for some states and these states announced partial reopening of schools [26]. The international flights were banned till January 31, 2021 [27] as per decision of government of India. As a consequence of the lockdown more than 350 deaths were reported as of 10 May due to food deprivation, different kinds of rail and road accidents, suicides and delay of getting medical care [28-34].

Figure 1 shows the daily confirmed deaths due to covid-19 disease per million people in India for 8th November, 2021. Comparatively in India daily death rate is lower than other countries. From this study the authors have come to the decision that maintain social distancing along with mass immunization through vaccination is the most effective preventive measurements for protecting the entire nation from this deadlier disease.

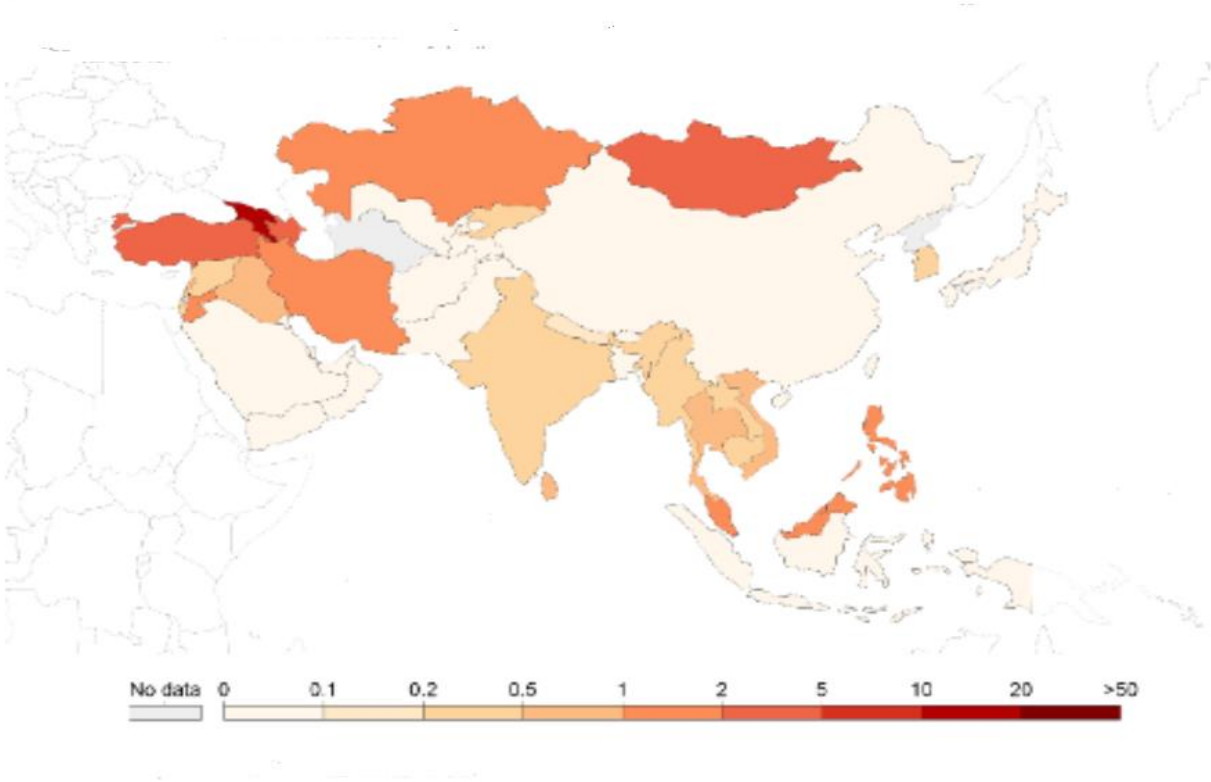

Fig. 1: Daily confirmed deaths per million people in India

The main goal of our present research work has come into picture and popular Correlation coefficient function has been introduced. This model has been used in our work to receive more accurate value in the relationship between basic stringency index and other factors of corona virus pandemic disease which are highly dependent on stringency index for India. This paper has collected data about confirmed COVID-19 cases, death cases, vaccinated cases, basic reproduction number, stringency index for India from January, 2020 to November, 2021 from worldometer [35] and has calculated correlation coefficient between Stringency Index and other factors which are highly associated with the corona virus pandemic disease. The authors of this paper have analysed these correlation coefficient [36] to make a decision on the effectiveness of strict and partial lockdown along with the effectiveness of mass immunization through vaccination [37]. No research works have been considered for analysing the future trends of the deadlier disease for worldwide due to strict and the partial lockdown, so we can propose the reality of our work in this paper. The outline of our research work is as follows:

Correlation: In statistics the degree of association between more than one variable from collected dataset is called correlation. It is also important in Data Science also. The properties of every data point from the dataset is observed.

In our proposed research paper, we have considered the basic reproduction rate, total confirmed Covid cases, new infected cases, new death cases and stringency index as features of the dataset. The authors have arranged the next section of the paper as follows:

The detail analysis of collected data for correlating different features regarding corona virus pandemic for the period of August, 2021 to August 2022 has been done in the section-2 after the introduction part of section-1. The proposed methodology for correlating total corona virus affected case, new infected cases, death cases with stringency index have been discussed in section 3. Section 4 shows the empirical results with comparisons and evaluates the performance of the research work. Different suggested policies for controlling the pandemic disease have been discussed in section-5. The conclusion and future orientations have been discussed in the last section.

2. DATA ANALYSIS :

Correlation between basic reproduction rate and stringency index will help government to take right decisions for maintenance of strict and partial lockdown. The authors have collected dataset for the

period of January, 2020 to August, 2021 from worldometer and based on that dataset they have researched for the trends of the pandemic disease. The dataset is maintained by a team of researchers who are working internationally. These statistics has been reviewed by several researchers for continuing their research on coronavirus disease. The authors have used numbers of daily new coronavirus infected cases, daily rate of fatality, daily basis total infected cases, and daily recovery rate as specifications for analysis and forecasting of transmission rate of the disease and impact of vaccination on it. Pearson correlation function [38] has been utilized to examine the correlation between variables from the dataset.

3. PROPOSED METHODOLOGY :

Correlation

In statistics the degree of association between more than one variables from collected dataset is called correlation. It is also important in Data Science also. The properties of every data point from the dataset is observed.

Three different forms of correlation:

(1) **Negative correlation:** In this interrelation one variable increases as the other interrelated variable decreases.

(2) **Weak or no correlation: In this interrelation, there is no as such clear inclination between the interrelated variables.**

(3) **Positive correlation:** In this interrelation one variable increases as the other interrelated variable increases.

Pearson Correlation:

Correlation between more than one sets of data is a measurement of association. In statistics Pearson Correlation (**Pearson Product Moment Correlation (PPMC))** is the most common measurement of association. Linear relationship between two sets of data can be determined by using this correlation function.

The authors have used CORREL function which is basically a statistical function in Excel. It has been used to find the correlation coefficient of two interrelated variables.

The CORREL formula in Excel is used to find out the correlation coefficient between two variables. Authors have used ARRAY1 and ARRAY2 for two datasets and the CORREL function returns the correlation coefficient of these two arrays. Basically ARRAY1 and ARRAY2 are the required specifications for CORREL function. ARRAY1 is the compulsory set of independent variable and ARRAY2 is the set of dependent variable.

CORREL Formula in Excel

= CORREL(ARRAY1,ARRAY2)(1)

CORREL Formula in Excel has two compulsory parameters, i.e., **ARRAY1, ARRAY2.**

The formula for calculation of correlation coefficient is:

$$Correl(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{\sqrt{\sum (x-\bar{x})^2 \sum (y-\bar{y})^2}} \quad (2)$$

where $\bar{x}$ and $\bar{y}$ are the sample means and calculated by average (array1) and average (array2).

The value of the correlation coefficient (r) is nearest to +1, it indicates a strong **positive correlation**, and if r is nearest to -1, it indicates a strong **negative correlation**.

4. EXPERIMENTAL RESULTS AND DISCUSSIONS :

The transmission of the corona virus has been affected by many factors. A dynamic transmission model has been established based on these different estimated factors. This model will make the whole population along with government of India aware of the trend of this pandemic disease and will also help the government authorities to take decisions on lockdown. In figure-2 the authors have analysed the relationship between new infected cases and new death cases on daily basis in lockdown phase in 2020.

For India it has been noticed that during strict lockdown phases in 2020 the number of new infected cases have been increased on daily basis but death cases have not been increased in the same fashion. The initial of lockdown had been started in India from March 24, 2020 and it was extended up to April 14, 2020. From April 15, 2020 to May 3, 2020 second stage of lockdown started. So we can come to

an end that maintenance of strict isolation is very fruitful for decreasing the transmission rate of corona virus. In India as per the advice of MHA 3rd stage of isolation had been started from May 4, 2020 and it was extended up toMay17, 2020.Similarly 4th stage of lockdown had been started from May 18, 2020 and it was extended up to May31, 2020.In these phases though the stringency index has been reduced but we follow the same nature in the curve. So the authors can conclude from this figure that during this period due to the reduction of stringency index death rate is not as higher as new infected cases. The nature of the graph for new death cases is slightly increasing at the end of fourth phase of lockdown.

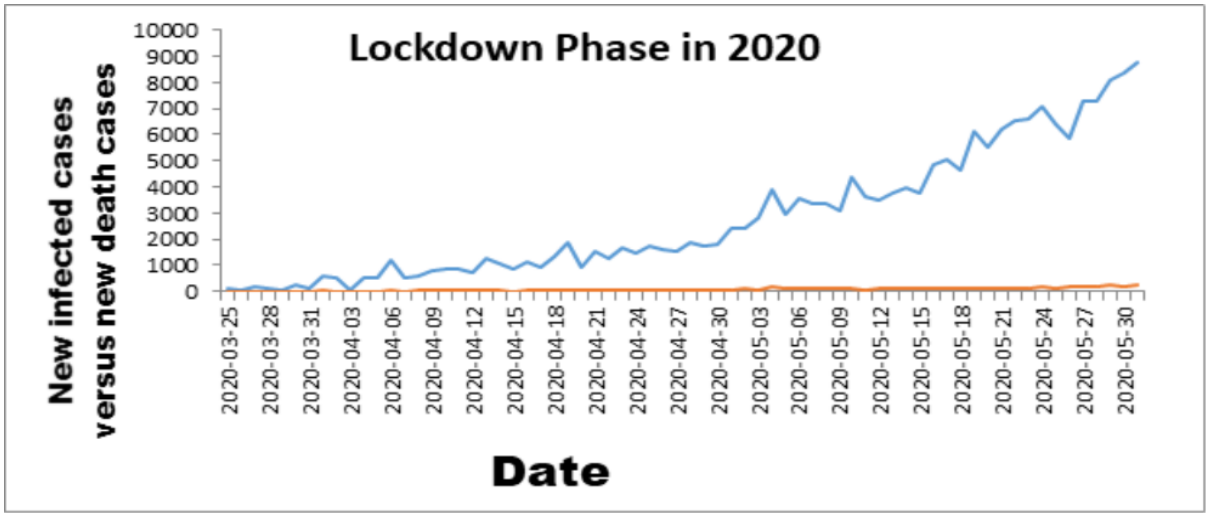

Fig. 2: Relationship between new infected cases and new death cases during lockdown phase

Though lockdown is the most important preventive measurement to decrease the infection rate of deadlier corona virus but as a consequence of maintaining strict home isolation and social distancing millions of people have lost their jobs. India has faced a severe economic slowdown due to this phase wise lockdown decision. So from June, 2020 some new guidelines have been issued by MHA for lockdown. Lockdown restrictions were only to be imposed in containment zones, while activities were permitted in other zones in a phased manner. In figure 4 the authors have depicted the relation between total infected cases and death cases during the unlock phase 1.0 and unlock phase 2.0. In India as per the advice of MHA the unlock phase 1.0 has been started from 1st June, 2020 and unlock phase 2.0 has been started from 1st July, 2020. It was decided that to reopen the different sectors like shopping malls, religious places, hotels, and restaurants from 8th June,2020 that is during the unlock phase 1.0. Phase 2.0 of unlock started from July, 2020. Most activities were permitted except the containment zone. In India phase 3.0 of unlock has been started from August, 2020, phase 4.0 of unlock has been started from September, 2020, phase 5.0 of unlock has been started from October, 2020 and phase 6.0 of unlock has been started from November, 2020.

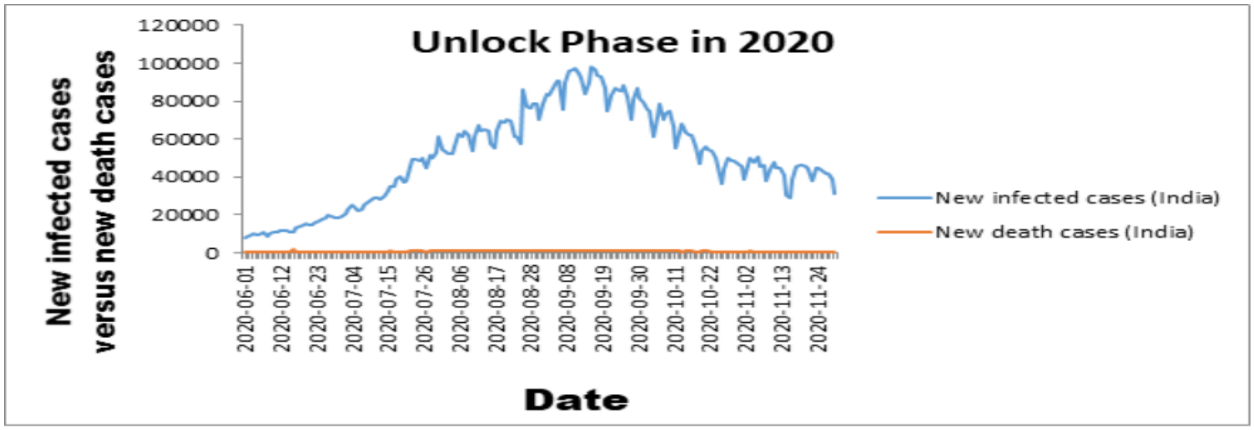

Fig. 3: Relationship between new infected cases and new death cases during unlock phase

The nature of the graph has been depicted by authors in figure 3. As per the advice of MHA third phase of unlocking has been started from 1st August, 2020, fourth phase of unlocking has been started from September 1, 2020, fifth phase of unlocking has been started from October 1st, 2020 and sixth phase of unlocking has been started from 1st November, 2020. During unlock phase 1.0 to 3.0 the new infected cases have been increased slowly but during unlock phase 4.0 the rate of new infected cases is highest. Again from October, 2021 though the stringency index is much lower than the stringency index maintained during lockdown phase 2020 but the rate of new infected cases has been decreased gradually up to November, 2020. From figure 2 and figure 3 it is clear that the impact of strict lockdown, isolation and social distancing is a very fruitful preventive measurement to reduce the transmission rate of corona virus. So inverse proportion between reproduction rate and stringency index has been observed in different phases of unlock in India up to March, 2021 after maintenance of strict lockdown.

The authors have analysed the data from January, 2021 to April 2021. The rate of infection is very less during the period January, 2021 to March, 2021. The stringency index is also very less during this period that means lockdown has not been maintained strictly. But this infection rate has been gradually increased from 28th March, 2021 and it is highest on 27th April, 2021. Government of India has decided to maintain strict and partial lockdown again on the basis of severity of the disease. So it has been concluded that stringency index which is directly dependent on lockdown is the best preventive measurement to protect the nation from this deadlier disease.

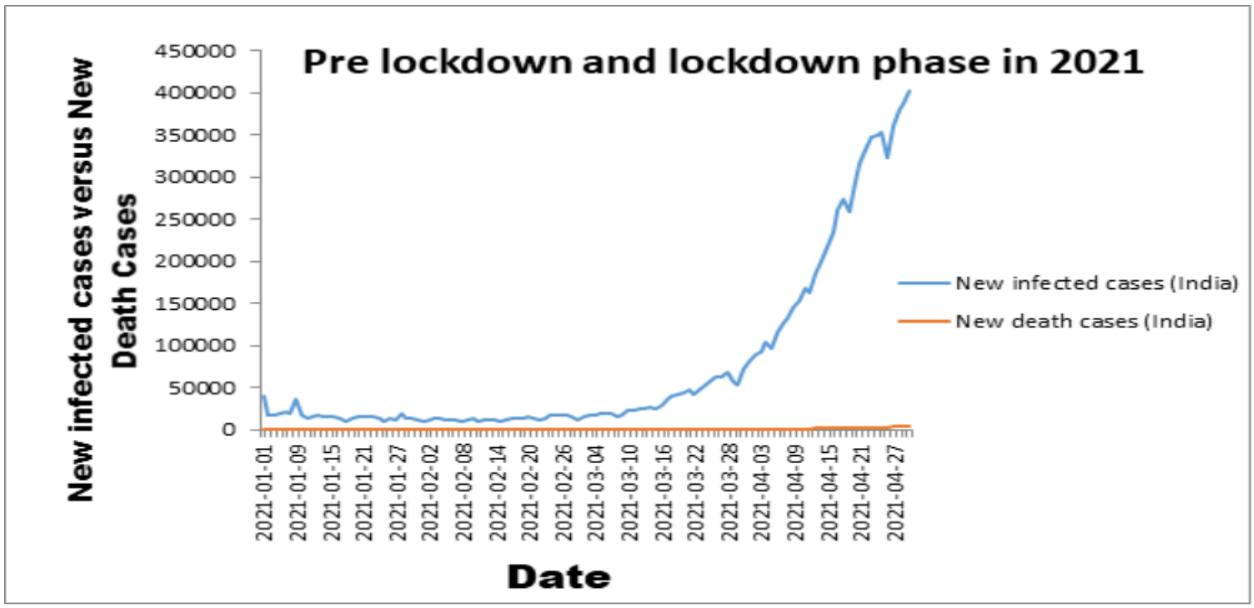

Fig. 4: Relationship between new infected cases and new death cases during pre-lockdown and lockdown phase in 2020

Immunization through vaccination has been started from January, 2021 in India. But from May, 2021 mass immunization program has been started. Authors have analysed the data from May, 2021 to October, 2021. It has been noticed from figure 5 that at the beginning of May, 2021 the rate of new infected people was high but it has been decreased gradually from time to time and in the last week of August,2021 the rate of infection is minimum. So it can be concluded that higher the stringency index lower the infection rate. So mass immunization through vaccination as well as maintaining strict lockdown are the best preventive measurements to protect human being from this deadlier virus.

The second wave of the pandemic disease has been started from end of February 2021 in India. State wise different phases of lockdown has been started in India from April, 2021. The authors have calculated correlation coefficients by using Pearson Correlation Function between stringency indexes with different factors of corona virus disease. Table 1 shows the empirical result for correlation coefficients between Stringency index and total number of infected cases, stringency index and number of new infected cases, stringency index and number of death cases and stringency index and reproduction rate during different phases from 2020 to 2021. Positive correlation has been noticed between stringency index and different factors of corona virus disease during the period when lockdown has not been started.

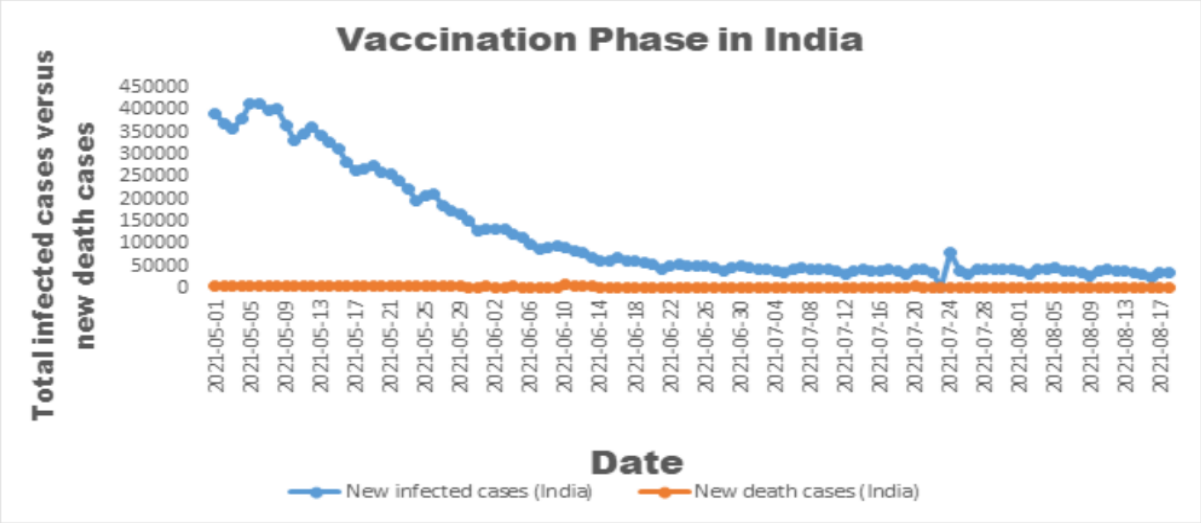

Fig 5: Relationship between new infected cases and new death cases during mass immunization phase in 2021

During lockdown phase 1 from 25th March, 2020 to 15th April, 2020 negative correlation between stringency index and basic reproduction rate has been observed that means the transmission rate of the virus has been decreased during this time period. A negative correlation between stringency index with different factors on which the current trend of corona virus disease depends like total infected cases, new infected cases and death cases during second isolation phase from April 15, 2020 to May 3, 2020 have been observed from Table 1. During third isolation phase from May 3, 2020 to May 17, 2020 negative correlation between stringency index with new death cases have been observed. Similarly, negative correlation between reproduction rate and stringency index has also been observed during phase 4 from 17th May, 2020 to 31st May, 2020. From these sets of observations authors have come to the point that during lockdown phases in 2020 maintenance of strict lockdown, social distancing was the only way to decrease the rate of transmission of the virus. Even during different unlock phases from June,2020 to November,2020 negative correlation between stringency index with different factors like total cases, new infected cases, mortality rate and basic transmission rate has been observed. Mass immunization through vaccination has been started from 16th January, 2021 in India. Health care workers and frontline workers got immunized during that period. The basic transmission rate of the virus was below 1 during that period. But from February, 2021 the basic transmission rate of the virus has been increased gradually and the highest reproduction rate has been observed during April, 2021. Again government of India decided to maintain lockdown in different affected zone strictly. The stringency index is higher than the period from January to March, 2021. From May, 2021 though the stringency index was higher and the transmission rate of the corona virus disease was decreasing gradually up to August, 2021.

Table 1: Empirical Result after using Pearson Correlation Function

Different Phases of Lockdown and unlock down		**Total Cases**	**New Cases**	**Death Cases**	**Reproduction Rate**
Before lockdown		0.90425904	0.78198801	0.5332441	0.93080457
Lockdown phase 1		0.22672	0.267087	0.243575	-0.09784
Lockdown Phase 2		-0.71543	-0.47654	-0.58936	0.906254
Lockdown phase 3		1.37924E-16	0	-2.51088E-16	4.19925E-15

Lockdown phase 4	**Stringency Index**	3.00662E-16	2.37382E-16	2.12334E-16	-0.369689621
Unlock phase 1, phase 2 and phase 3		-0.886566685	-0.830652135	-0.668754564	0.93455209
Unlock phase 4, phase 5 and phase 6		-0.82323	0.666258	0.782226	-0.2726
Lockdown phase 1 2021		0.564305	0.584909	0.528203	-0.41487
During Vaccination phase		0.841891	-0.7506	0.206203	-0.85459

5. CONCLUSION :

Stringency index is very essential to resist this deadlier disease in India. This research work is able to determine the stringency index which is totally dependent on lockdown correlated with different parameters for corona virus pandemic and will be useful to abolish this disease. Also, consequence of stringency index suggests that social distancing, home isolation should be promoted as it would decrease the spreading of this contaminated disease. The authors have analysed three stages of out breaking of corona virus in India: the new infection rate increases drastically from different stages of lockdown, but basic reproduction rate has been gradually decreased after maintenance of strict lockdown. Our current study has determined correlation coefficient of different parameters of Covid 19 disease with stringency index. From our analysis it has been noticed that maintaining strict lockdown, social distancing and home isolation are the major causes to decrease the growth rate of the deadlier corona virus disease. But after maintaining four phases of strict lockdown economic recession has been noticed in India. So lockdown is not the only solution to prevent the deadlier disease. Vaccination program in India to immunize the entire nation from this deadlier disease has been started from 16th January, 2021 and India got hit by second wave of the disease in April, 2021. But from May, 2021 onwards the rate of transmission of the disease has been decreased. So we can conclude that mass immunization through COVID-19 vaccine is also the long-term remedy to protect people from getting infected from the virus.

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