Effectiveness of masks in the suppression of COVID-19 cases during the ongoing pandemic in India

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ABSTRACT: Perhaps the worst predicament faced by humanity in the twenty-first century is the COVID-19 pandemic, which is caused by the SARS-CoV-2 virus. Most parts of the world, including India, went into lockdowns for some period because of the massive increase in cases throughout 2020. Face masks became an important countermeasure for protecting the populace, health professionals, and medics, particularly during the period prior to the mass availability of vaccines.

This study intends to evaluate the effectiveness of face masks in limiting the spread of the virus. The data for the number of COVID-19 cases was analyzed from January 1, 2022 to May 31, 2022, using Python programming. This timeframe involved face mask mandates and no mask requirement, and hence was considered to be ideal for analyzing the usefulness of face masks. A decline in cases during the mandate was observed, while the opposite occurred without the mandate. The outcome of the research showed that face masks are effective additional measures against the spread of SARS-CoV-2. This study elevates the value of personal protective equipment (PPE), such as face masks, made with nonwovens and other fabrics, as lifesavers in the case of airborne diseases such as COVID-19 and other pulmonary disorders.

Application: This study shows that extra precautions like wearing face masks helped stop the spread of SARS-CoV-2 along, with vaccinations.

Face masks are textile materials that have gained prominence during the current COVID-19 pandemic. Earlier during the pandemic, due to the unavailability of nonwoven three-ply surgical masks, many different cloth masks evolved, which are generally referred to as face coverings. A simple categorization of the face masks that evolved includes: 1) filtering facepiece respirators (FFRs), commonly known as N95 masks; 2) surgical masks; 3) face covers; and 4) face covers with enhanced filtration called FISORS [1]. The FFRs and surgical masks have different nonwoven components in them. Surgical masks today have electrically charged meltblown webs and spunbond fabrics. The FISOR mask combines a cloth face covering with a nonwoven (spunbond-meltblown-spunbond) three-ply surgical mask [2]. Prior to the mass availability of vaccines, face masks played an important role in saving lives. Face masks serve as a valuable countermeasure in controlling the spread of virus. This paper endeavors to highlight the usefulness of face masks in reducing the number of daily COVID-19 cases in India from January 2022 to May 2022 [2]. As the purpose of this study was to understand the face mask mandate's effect on reducing the COVID-19 cases in India, the efficacy of the type of face mask on the spread of SARS-CoV-2, the mask's structure, and other factors are beyond scope of this paper.

As of September 21, 2022, the COVID-19 outbreak has spread to 228 countries and territories worldwide, with 610,393,563 confirmed cases and a death toll of 6,508,521 [3]. There were 44,547,599 cases and 528,403 deaths confirmed in India, making it the country with the second-highest number of cases and deaths [4]. The disease is mainly transmitted through ejected respiratory droplets (>5 μm) [5], smaller aerosols (<5 μm) [6], and direct contact with an infected person [7], and it can be spread by asymptomatic, pre-symptomatic, and symptomatic patients [8,9] through coughs or sneezes. Since the SARS-CoV-2 virus spreads through air, the drop in reported cases could be attributable to the reduction in aerosol concentrations in the air during the initial lockdown in India on March 24, 2020 [10]. Physical distancing has also proven to be an effective strategy in the fight against spread of the virus. One can avoid catching and transmitting COVID-19 by having adequate airflow. People should maintain distance between one another to decrease the likelihood of transmitting the virus; therefore, avoiding crowded situations is recommended [11]. Despite social distancing being widely adopted and face masks being used to prevent the spread of the virus, there is still some doubt that lingers in the minds of the populace regarding the usefulness of using face masks. The N95 respirators or similar high-quality masks have

1. Different types of masks worn by the Indian public: (a) surgical mask, (b) N95 mask, and (c) cloth mask.

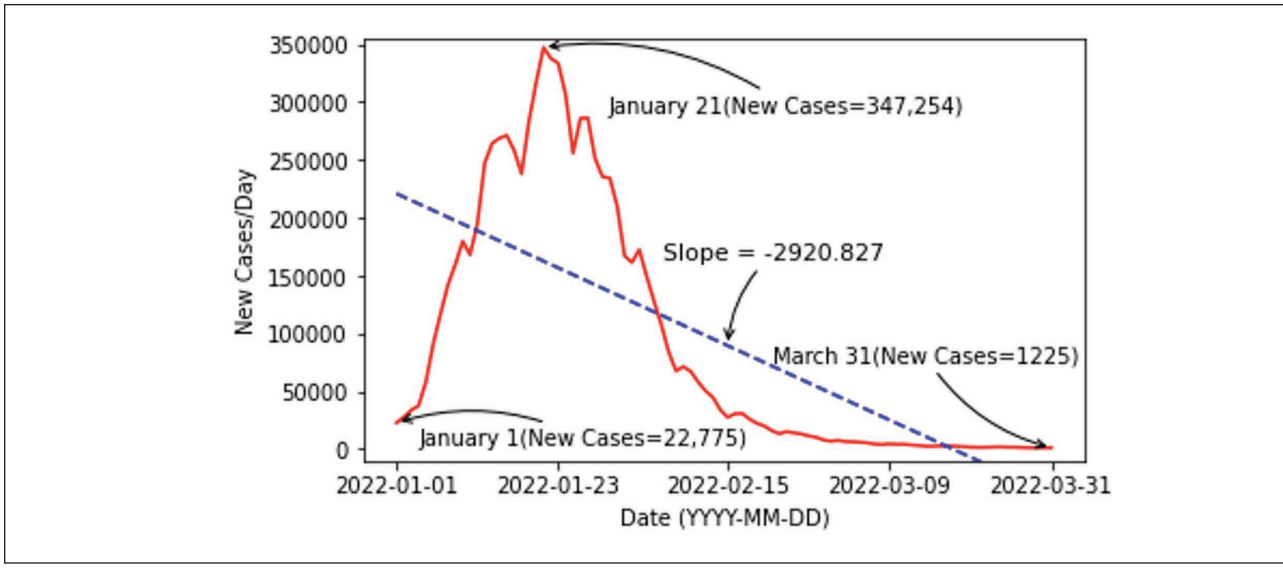
been recommended for wear by health care professionals caring for patients with suspected or confirmed SARS-CoV-2 [12]. However, masks must be used to provide a proper fit and seal against the face of the person using it [13]. Also, in India, three-ply medical masks and N95 respirator masks are recommended for those working in hospitals, quarantine centers, clinical laboratories, and primary health care/community settings [14], whereas the civilian population commonly uses surgical masks (**Fig. 1a**), N95 or KN95 (Fig. 1b) masks, and cloth masks (Fig. 1c), with the majority using surgical-type masks made with polypropylene nonwoven fabrics.

Face coverings made of different household fabrics provide protection based on the number of layers [15]. Sterilization or washing is recommended based on the microbial load in the case of repetitive use of cloth face coverings [16]. Recent research looked at incorporating functional properties to face mask components to enhance their protection capabilities against microbes [17].

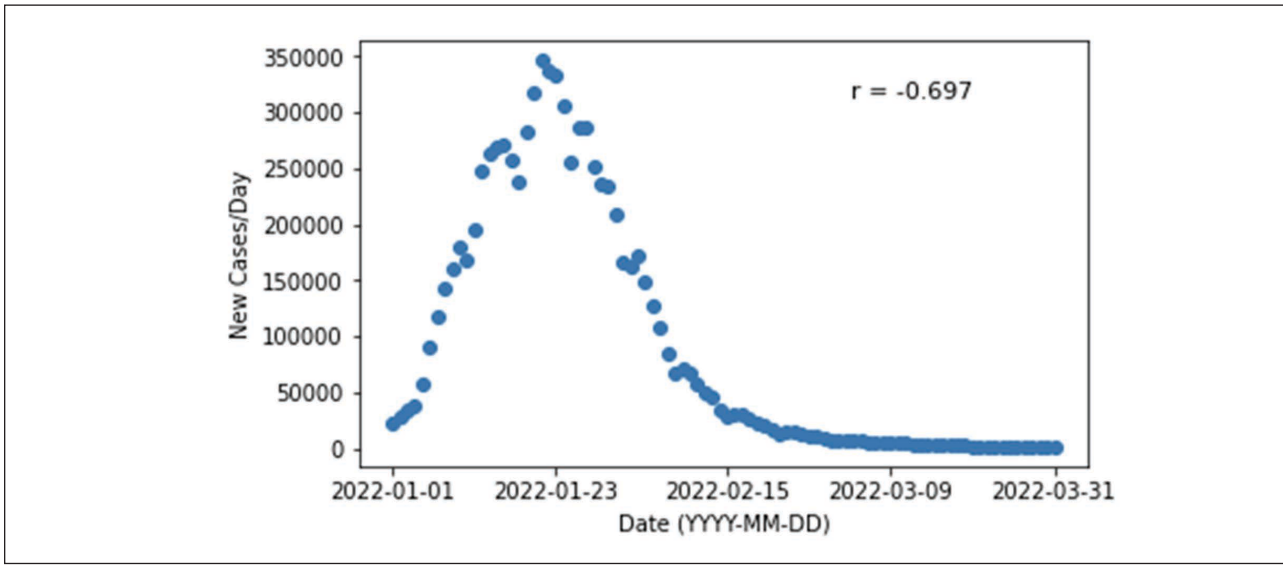
While there have been developments in countermeasures against SARS-CoV-2, relative roles of contact vs. airborne transmission pathways in the COVID-19 pandemic are not fully understood [18,19]. The effectiveness of face coverings in preventing the spread of COVID-19 has been investigated in the United States [20]. Analysis has been carried out using mathematical and/or empirical modeling approaches [21,22], simulation experiments [23], and participatory surveys [24]. In the current study, actual confirmed case data were used in the analysis. We examined the efficacy of face coverings as a preventive measure by evaluating new daily cases and cumulative cases in India from January 2022 to May 2022, and the rate of new cases was compared between the time period of the mask mandate (January 1, 2022 to March 31, 2022, and April 24, 2022 to May 31, 2022) and the time period without the mask mandate (April 1, 2022 to April 23, 2022).

RESULTS AND DISCUSSION

Following the drop in the rate of daily cases, the Indian government called for a removal of the mask mandate, with over 43.03 million people infected in the country and 831.24 million being fully vaccinated as of March 31, 2022, which is one of the prime reasons for the decline in cases. COVID-



2. Graph showing daily new cases during mask mandate for the period January 1, 2022 to March 31, 2022.

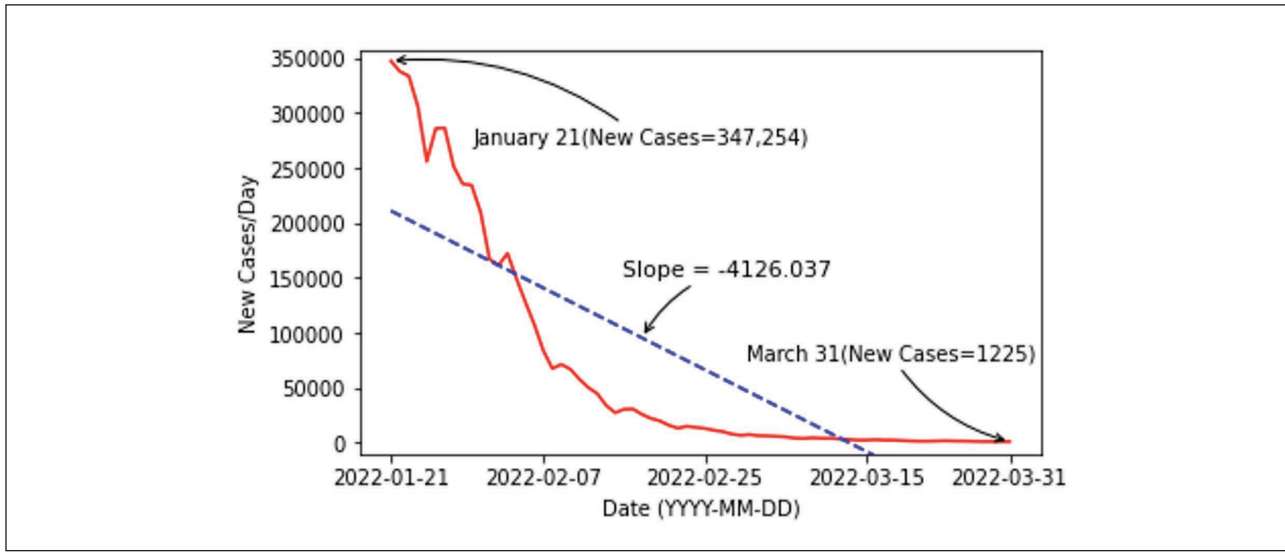


3. Scatter plot showing the correlation between the number of daily new cases vs. time (January 1, 2022 to March 31, 2022). The plot shows a negative Pearson's correlation of -0.697.

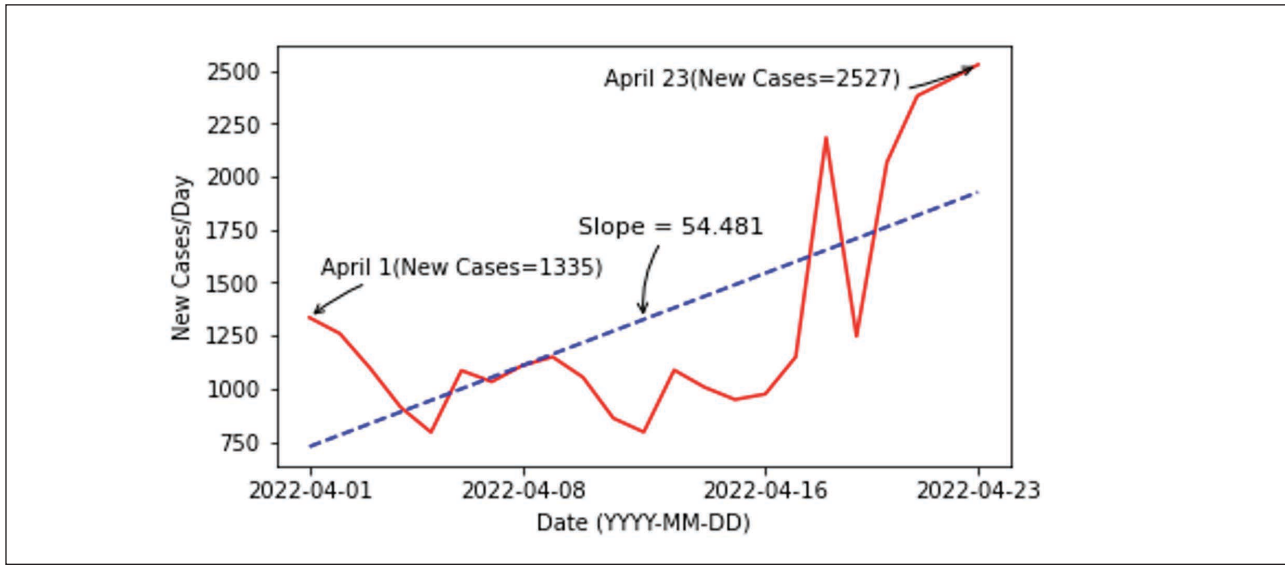
19 vaccines that provide immunity were understood to reduce the magnitude of potential infection waves. Significant reduction in mortality occurs when prioritizing individuals over 60 years old, but all vaccination strategies result in appreciable gains compared to no immunization [25]. As a result, states like Delhi, Maharashtra, and Telangana ultimately removed the requirement of masks in public starting April 1, 2022 [26, 27]. However, due to the mutating nature of the SARS-CoV-2 virus, there was an apparent increase in the number of daily new cases and the growth rate of cumulative cases across the nation. While vaccinations prevented severe infections and hospitalizations, other countermeasures such as face masks and enhanced hygiene helped with curtailing spread of the virus.

Mask mandate timeframe (January 1, 2022 to March 31, 2022)

As is evident from **Fig. 2**, after plotting the new daily cases during this time period, the slope came out to be -2920, which is an average decline of about 2920 cases per day for the three-month period (January 1, 2022 to March 31, 2022). Considering this time period, a statistically significant ($p<0.001$) negative Pearson's correlation of -0.697 (**Fig. 3**) was observed between the date and the number of daily new cases. The result indicates that the number of new cases decreased during this timeframe. During the early days in January 2022, even though the face mask mandate was in effect, the rise in cases could have been attributed to the incubation period of up to 14 days for the



4. Graph showing daily new cases during the mask mandate for the period January 21, 2022 to March 31, 2022.



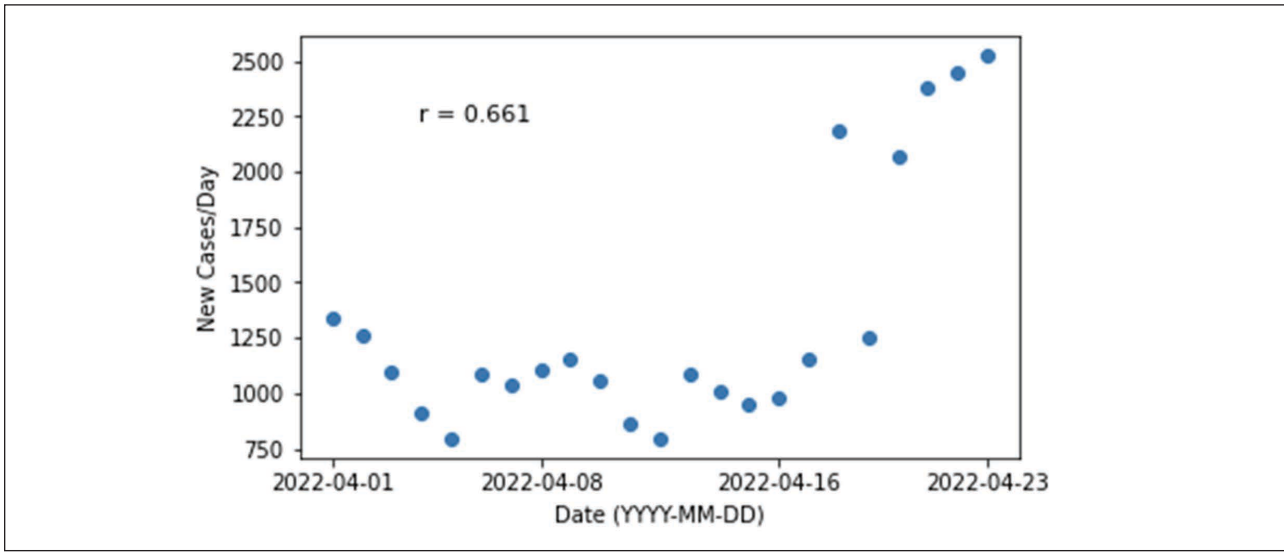
5. Graph showing daily new cases by date after the removal of the mask mandate from April 1, 2022 to April 23, 2022.

mutating virus, which started spreading prior to the beginning of the new year [28]. Following the incubation period, actual cases were reflected as peaking after about two weeks. After peaking, with the face mask mandate in place, cases/day started falling, indicating the usefulness of extra protection measures such as face masks, as social distancing could not be strictly practiced due to no lockdowns.

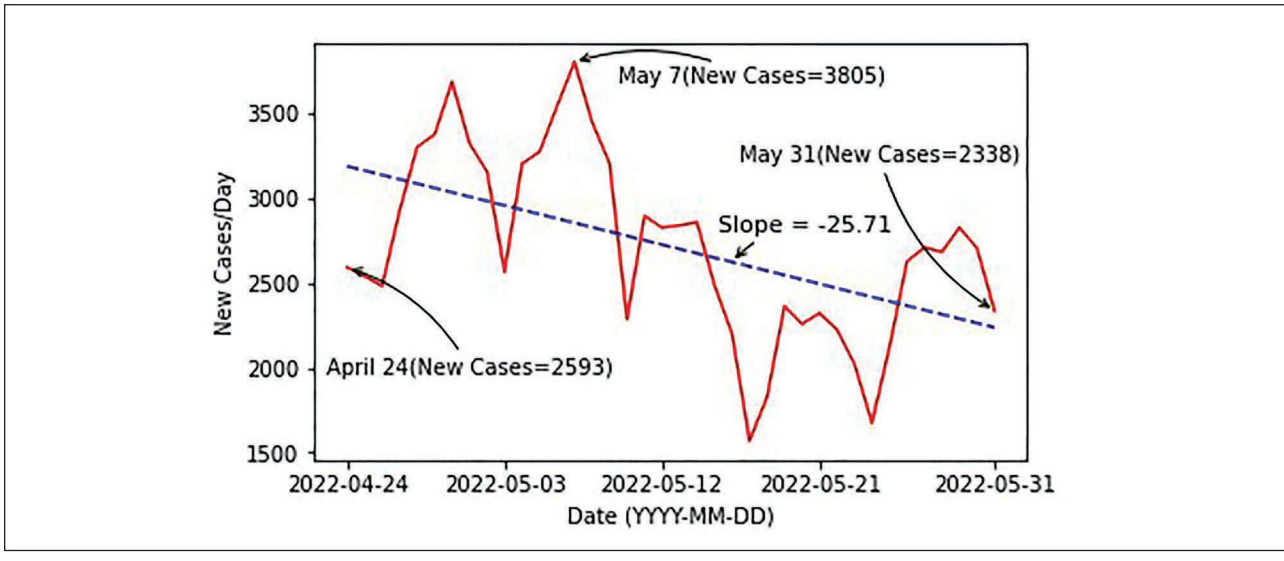
Figure 4 gives a clear indication of the influence of additional protection measures like face masks in reducing the daily new cases. Once the face mask mandate was in full swing, the effect was visible in about 2 to 3 weeks' time, as is evident from the negative slope of -4126 as compared with the negative slope of -2920 for the period starting from January 1, 2022. Given that there is negative slope in the period when the face mask mandate was in effect, this fact supports the hypothesis that face masks have a positive influence on curbing spread of the virus.

No mask mandate timeframe (April 1, 2022 to April 23, 2022)

As is evident from Fig. 5, during the period from April 1 to April 23, 2022, when the mask mandate was not in effect, the rate of cases saw a spike, with the slope being 54.481 (i.e., a rise of about 54 new cases a day). A scatter plot of the daily number of new cases from April 1, 2022, until April 23, 2022, shows that the removal of the mask mandate on April 1, 2022, could be the reason for the increase in the number of cases. Cases peaked on or about two weeks after the mandate was in effect. In Fig. 6, the dates were placed on the x-axis of the graph and the y-axis indicates the number of new cases per day, and the Pearson's correlation be-



6. Scatter plot showing a correlation between the number of new cases daily vs. time (April 1, 2022 to April 23, 2022). The plot shows a positive Pearson's correlation of 0.66.



7. Graph showing daily new cases by date after the reinstatement of the mask mandate from April 24, 2022 to May 31, 2022.

tween the two variables was calculated. In examining the data, a positive Pearson's correlation (0.661) was found, suggesting that the days without the mask mandate directly contributed to the daily increase in cases (Fig. 6). Analysis also showed statistical significance ($p<0.001$).

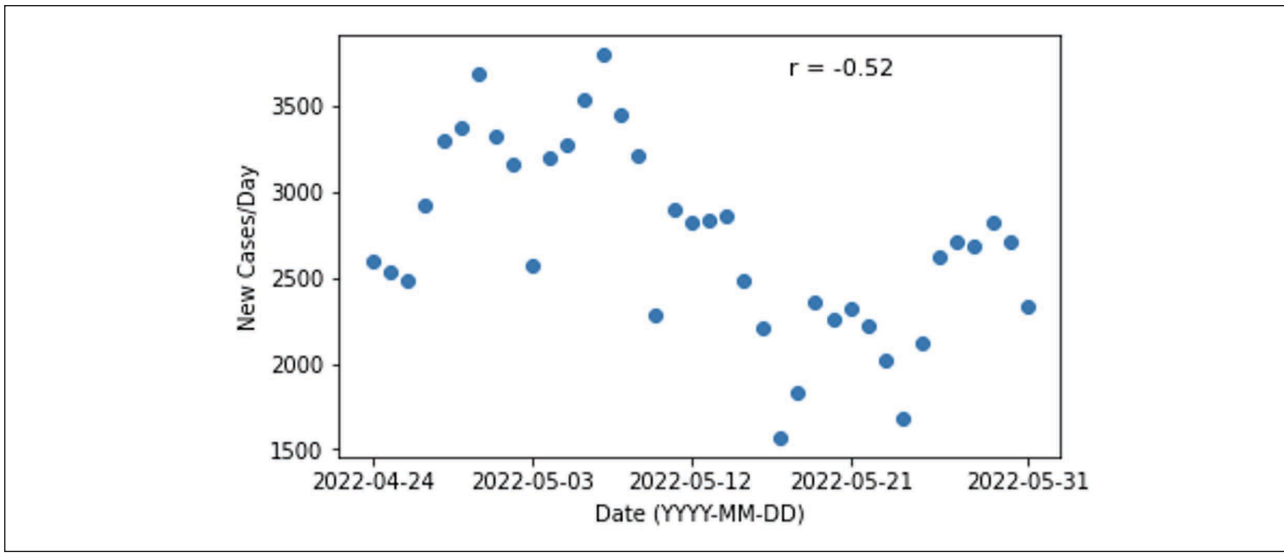
Reinstatement of mask mandate (April 24, 2022 to May 31, 2022)

As is evident from **Fig. 7**, after reinstatement of the mask mandate on April 24, 2022 [29], the number of cases from April 24, 2022 to May 31, 2022, saw a drop, with a negative slope of 25.71, indicating a drop of almost 26 cases each day. However, the initial two weeks still saw spikes in cases due to the transition timeframe [30]. It is evident that the mask mandate contributed to a decrease in cases, leading to its reinstatement on April 24, 2022.

As is evident from **Fig. 8**, the analysis showed a negative Pearson's correlation (-0.52) between the rate of cases with the passage of days, which is statistically significant ($p<0.001$). This demonstrated that the number of daily new cases decreased with days when face masks were used.

Prediction of cases vs. actual cases

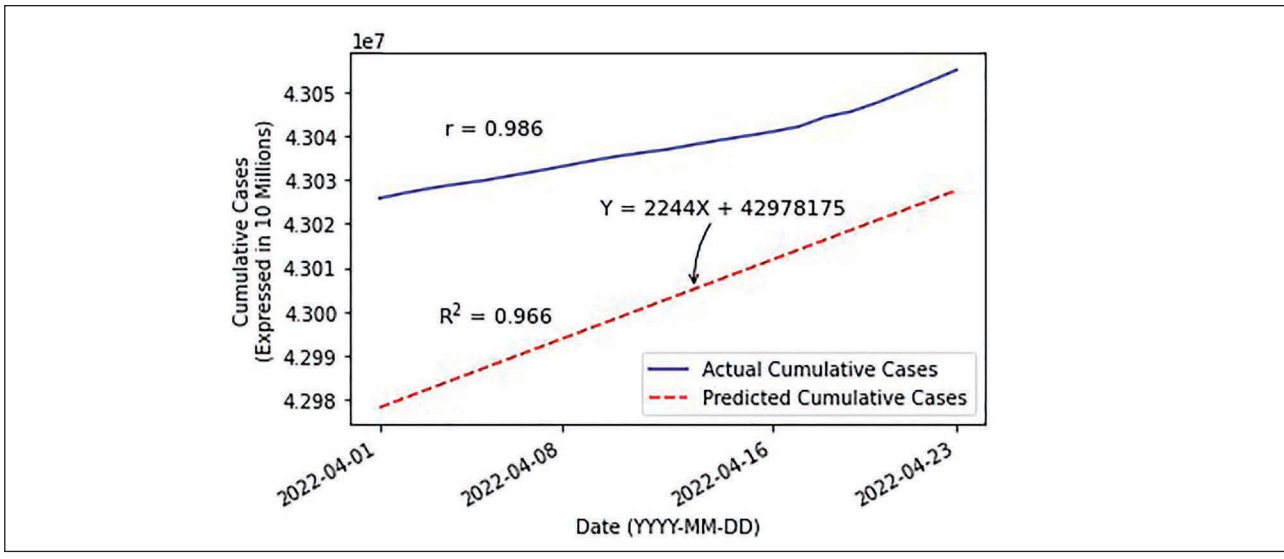
The number of cumulative cases for March 2022 was considered to predict the number of cases during April 2022 (**Table I**). The linear regression prediction of the number of cases was much less than the actual number of cases during April. However, the coefficient of determination (0.966) for the date vs. cumulative case count graph (**Fig. 9**) is very high, affirming the accuracy of the prediction. The maximum difference between the predicted value for the cases and the actual values was about 47,599. Furthermore, re-



8. Scatter plot showing the correlation between the number of daily new cases vs. time (April 24, 2022 to May 31, 2022) since the reinstatement of the mask mandate. The plot shows a negative Pearson's correlation of -0.52.

Date	Actual Cumulative Cases	Predicted Cumulative Cases
2022-04-01	43,025,775	42,978,175
2022-04-02	43,027,035	42,980,419
2022-04-03	43,028,131	42,982,664
2022-04-04	43,029,044	42,984,908
2022-04-05	43,029,839	42,987,152
2022-04-06	43,030,925	42,989,397
2022-04-07	43,031,958	42,991,641
2022-04-08	43,033,067	42,993,885
2022-04-09	43,034,217	42,996,130
2022-04-10	43,035,271	42,998,374
2022-04-11	43,036,132	43,000,618
2022-04-12	43,036,928	43,002,863
2022-04-13	43,038,016	43,005,107
2022-04-14	43,039,023	43,007,351
2022-04-15	43,039,972	43,009,596
2022-04-16	43,040,947	43,011,840
2022-04-17	43,042,097	43,014,084
2022-04-18	43,044,280	43,016,329
2022-04-19	43,045,527	43,018,573
2022-04-20	43,047,594	43,020,817
2022-04-21	43,049,974	43,023,062
2022-04-22	43,052,425	43,025,306
2022-04-23	43,054,952	43,027,550

I. Table giving daily new cases and rate of increase of cumulative cases in India for the time period from April 1, 2022 to April 23, 2022, when the mask mandate was not in effect.



9. Graph showing the cumulative number of cases, broken down by day, for April 1, 2022 to April 23, 2022, when the mask requirement was lifted. The blue line represents the actual monthly cumulative cases, while the red line represents a prediction based on the previous month's data.

moving the mask mandate was associated with an increase in the daily number of cases, as demonstrated by a positive Pearson's correlation (0.986) between the daily cumulative cases and the date for the period April 1, 2022 to April 23, 2022, which was statistically significant ($p<0.001$). There is good correlation between the actual and predicted cumulative cases, as is evident from the positive Pearson's correlation (0.986).

MATERIALS AND METHODS

Data sources

The data for daily new cases and cumulative cases for the entire Indian population was obtained from the WHO data source for all countries [31]. The values for the number of single and fully vaccinated people in the country were given by Our World in Data [32].

Data analysis

Statistical analysis, including Pearson's correlation analysis and regression analysis, were performed using Python (v 3.9.13), an open-source programming language. The data was stored using the Numbers spreadsheet application for the macOS operating system from Apple. Pandas library for Python was used to import and manipulate the data for calculations and plotting. Graphs were plotted using Matplotlib library functions and Scilearn library functions in Python. The p-value for the analysis was determined at <0.001. As a case in point, we used the cumulative case data of March 2022 to predict the values for the period April 1, 2022 to April 23, 2022. We have focused on the data for April 2022 to showcase that with the lack of a supplemental protection requirement such as face masks, the number of cases increased compared to the predicted value. This again proves the hypothesis that even with vaccination, due to the mutating nature of the virus, additional countermeasures play an important role in controlling the spread of the virus.

CONCLUSIONS

Lockdowns, quarantine, physical distancing, isolation, stay-at-home orders, and shelter-in-place have all been used to slow the spread of SARS-CoV-2, with little or no debate about their effectiveness and complete compliance with these rules. However, because the use of face coverings is a contentious issue, its implementation varied greatly from one location to the next. In addition, different states in India implemented the usage of masks to varying extents. Generally, physical distance rules can be met during lockdown, quarantine, shelter-in-place, and isolation. However, since the world cannot remain in lockdown eternally, the usage of protection in the form of face masks and face coverings is essential for reducing or stabilizing infection rates.

The study considered the time period from January 1, 2022 to May 31, 2022 to prove the effectiveness of masks in mitigating the spread of COVID-19 in India. Importantly, in most of the countries, COVID-19 peaked during January 2022, while vaccinations were in full swing. This indicated the emergence of mutations and hence the need for additional safety measures.

The analysis of daily new cases during the time period January 1, 2022 to May 31, 2022 showed that the rate of daily new cases increased when the mask mandate was removed from April 1, 2022 to April 23, 2022 with a positive Pearson's correlation (0.66) and then dropped from April 24, 2022 to May 31,2022 with a negative Pearson's correlation (-0.52) after the mandate was reinstated. Analysis shows that in addition to vaccinations, additional safety measures such as the use of face masks played a role in preventing the spread of SARS-CoV-2. **TJ**

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ABOUT THIS PAPER

Cite this article as:
Ganesh, S., Khym, M., Kikanme, K., et al., *TAPPI J.* 21(10): 521(2022). https://doi.org/10.32964/TJ21.10.521

DOI: https://doi.org/10.32964/TJ21.10.521

ISSN: 0734-1415

Publisher: TAPPI Press

About this journal

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This research was carried out to observe and describe the trend of COVID-19 cases in India during and without the face mask mandate. Our previous research was on the effectiveness of face mask mandates for different states in the United States. The current research supports the finding that a face mask mandate helped in curtailing the spread of SARS-CoV-2 in India.

The most difficult aspect of this research was obtaining quality quantitative data. This was addressed using Python programming.

Our analysis shows that in addition to vaccinations, additional safety measures such as the use of face masks played a role in preventing the spread of SARS-CoV-2. It was interesting to find that the number of daily cases increased every time the mask mandate was removed.

For companies that produce PPE, such as those in the nonwovens industry, this research shows the need for increasing the efficacy of individual face coverings in a cost-effective manner. Our next step will be to examine the effectiveness of face mask mandates during the pandemic in other countries.

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