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Evaluating the Effect of Wearing Face Masks by the General Population on Mitigating the Spread of COVID-19

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Commentary

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Abstract

COVID-19 has emerged as a global pandemic that is affecting nations worldwide, with the number of global confirmed cases growing exponentially since March 2020. To mitigate the rapid spread of COVID-19, governments of many countries implement public health intervention. While these public health interventions have been recognized as effective measures to control the epidemic, there has been much debate about the usefulness of face masks in preventing further dispersal of COVID-19. We utilized the functional canonical correlation analysis (FCCA) method to analyze face masks intervention for the general public, and proposed an auto-encoder method to forecast the trend of the spread of COVID-19 for countries with and without face masks interventions. Our analysis showed that countries who implemented face masks interventions for the general population demonstrated statistically significantly better results for mitigating virus spread in terms of confirmed cases of COVID-19. Additionally our forecasting result indicated that if countries implement the wearing of face masks for the general population, the trend of COVID-19 will slow down and the end time of the pandemic will be sooner.

Keywords: COVID-19; Face Masks; Canonical Correlation Analysis, Transmission Dynamics; Forecasting, Auto-Encoder

Abbreviations: FCCA: Functional Canonical Correlation Analysis; FPCs: Functional Principle Components; AI: Artificial Intelligence.

COVID-19 has emerged as a global pandemic that is affecting nations worldwide, with the number of global confirmed cases growing exponentially since March 2020. To mitigate the rapid spread of COVID-19, governments of many countries enforced nationwide stay-at-home orders, which includes cancelling public gatherings and sports events, closing schools and transferring to remote learning and working, to encourage social distancing. While these public health interventions have been recognized as effective measures to control the epidemic, there has been much debate about the usefulness of face masks in preventing further dispersal of COVID-19. WHO stated that "there is no specific evidence to suggest that the wearing of masks by the mass population has any particular benefit", and thus face masks are only recommended for people infected by COVID-19 and those who look after them. However, recent studies discovered a significant portion of asymptomatic but infected individuals who demonstrated transmitting capabilities before developing symptoms. On April 3, 2020, the U.S. CDC recommended the use of cloth face coverings to further prevent human-to-human transmission, especially in areas with serious community-based transmission. Whether

general public should wear face masks or not during the COVID-19 pandemic is a controversial question. As a result, there is a strong need to evaluate the effect of wearing face masks by the general population on curbing the spread of COVID-19 [1].

We utilized the functional canonical correlation analysis (FCCA) method to analyze face masks intervention for the general public, and proposed an auto-encoder method to forecast the trend of the spread of COVID-19 for countries with and without face masks interventions. Our analysis showed that countries who implemented face masks interventions for the general population demonstrated statistically significantly better results for mitigating virus spread in terms of confirmed cases of COVID-19. Additionally our forecasting result indicated that if countries implement the wearing of face masks for the general population, the trend of COVID-19 will slow down and the end time of the pandemic will be sooner.

We categorized countries into two groups: first group is countries where the general public wears face masks such as China, South Korea, Japan and Singapore and the second group is all other countries. Based on our analysis, the shapes of the case-time curves of COVID-19 between the two groups differ, and further statistical tests indicates significant difference in the spread of COVID-19 between countries where the general population wears face masks and those in absence of face masks.

Data on the number of confirmed cases from January 22 to April 2, 2020 were obtained from WHO (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports). We randomly generated a 260 × 9 dimensional matrix Y_1 for the first group and a 11440× 9 dimensional matrix Y_2 for the second group Each row of the matrices Y_1 and Y_2 was randomly selected for a 9-day consecutive time series period of the cases without replacement from the nations in the first group and second group, respectively. Then, we randomly selected 260 rows from the matrix Y_2 and appended to the matrix Y_1 to 520×9 generate a dimensional matrix where the first 260 rows of the matrix Y3 were from the matrix Y_1 and the second 260 rows of the matrix Y_3 were randomly selected from the matrix Y_2. Each element of the vector took two values: 1 and 0. The value 1 indicated that its corresponding row in the matrix Y_3 was from the first country group and value 0 indicated that its corresponding row was from the second country group [2].

The functional principle component (FPC) analysis method was used to reduce the time series data to several functional principle components (FPCs). The Chi-square test was then used to test the canonical correlation between the FPC scores and the indicator variable[1]. The test was repeated 1,000 times and showed that the number of cases was highly associated with the wearing of face masks by the general population (maximum of P-values over 1,000 tests <1.68×10-6, which was the most conservative P-value).

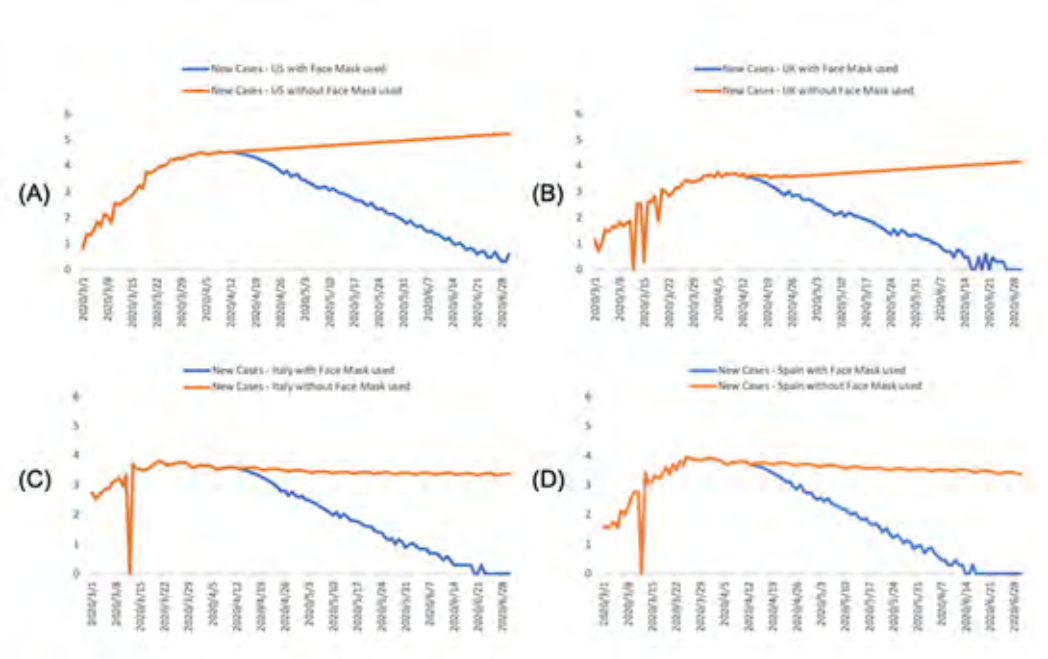

Figure 1: Figure 1 (A), (B), (D) and (C) plotted the numbers of new cases of Covid-19 over time in four countries: US, UK, Italy and Spain with or without wearing face masks by general publics, respectively. The scale of Y axis was logarithm of new cases.

To further assess the impact of wearing face masks by the general population on mitigating the spread of COVID-19, the modified auto-encoder method[2] was used to forecast the trajectory of COVID-19 with face masks intervention. The analyzed data were obtained from WHO (https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports) for January 2 to April 6, 2020. Figure 1 plotted the number of new cases of COVID-19 over time in four countries: U.S., UK, Italy and Spain with and without face masks interventions. We assume that the policy for wearing face masks is implemented on April 7, 2020. The result showed that in absence of face masks by the general population, the number of new cases of COVID-19 would increase in the U.S. and UK, and decrease very slowly in Italy and Spain. However, the numbers of new cases of COVID-19 would decrease exponentially in all four countries with the public wearing of face masks. In summary, our analysis indicated that if the policy for wearing face masks is implemented on April 7, 2020, in addition to all current public health interventions, the spread of COVID-19 in the U.S., UK, Italy and Spain will be ended on July 7, June 26, June 23 and June 17 in the year of 2020, respectively [3].

In summary, there are two approaches to investigate the impact of wearing face masks for preventing further transmission of COVID-19. One approach is to study the mechanism of the coronavirus transmission. Some researchers suggested that "masks are effective at capturing droplets, which is a main transmission route of coronavirus, and some studies have estimated a roughly fivefold protection versus no barrier alone (although others have found lower levels of effectiveness)[3]. The second approach, which is our analysis, is through real data analysis that provides direct and indirect evidence on the effectiveness of wearing face masks in slowing down the spread of the virus. We performed analysis on the number of laboratory confirmed cases of COVID-19 worldwide using an artificial intelligence (AI) approach (auto-encoder method) and functional-based canonical correlation analysis (FCCA). Statistical FCCA tests indicated that universal face mask usage is highly associated with the number of laboratory confirmed cases of COVID-19. In addition, the AI-based auto-encoder method forecasted that the number of cases would be reduced significantly if universal face masks wearing are adopted by the general public and all current public health interventions are implemented. We can expect that implementing non-pharmaceutical interventions such as stay-at-home orders, keeping social distance, closing school and cancelling non-essential activities/productions, and face masks wearing by the general public, will substantially limit the spread of COVID-19 and help bring the pandemic to a more rapid end.

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