

To Determine the Effect of Healthcare Policy Implementation on the Covid-19 Pandemic

Aaroosh Mishra¹ and Ravi Mishra[#]

¹Waubonsie Valley High School, Aurora, Illinois, USA

[#]Advisor

ABSTRACT

As the Delta variant of SARS-CoV-2 has spread across the USA, some states have been impacted in different ways than others. This is due to factors such as the implementation of public health guidelines, primarily mask usage, and vaccination rates. With the Delta variant already causing much damage and with newer variants mutating, it is imperative to understand the spread of the Delta variant of SARS-CoV-2. The study examined five states - Minnesota, Iowa, Missouri, Arkansas, and Louisiana - and their respective Covid-19 cases. Data on these states were collected from the US Census Bureau and the CDC. The data was then compared between each state as well as to the USA. Finally, the data were analyzed and visualized using statistics software. First, Covid-19 cases were normalized by dividing by population in millions to get a standard measure, Daily Cases Per Million (DPCM), to compare the five states. Next, we used the CDC data to create a timeline, which was used to compare case data between states. Additionally, the CDC data was used to compare states concerning non-communicable disorders. Our analysis showed that the vaccination rate reduced while the masking mandates were interrupted for more than two months, with a rapid rise in delta variant of Covid-19 virus. Thus, from the study, it can be concluded that vaccines and mask usage are the most critical factors in preventing Covid-19 transmission.

Introduction

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) originated in China in December 2019 (Lopez-Leon et al., 2021). This coronavirus disease 2019 (Covid-19) has caused more than 175 million cases and more than 3.8 million deaths (Lopez-Leon et al., 2021). The current Delta variant wave of the Covid-19 in the USA is again causing a rise in death and disability. Although much research and work have been done to control a pandemic, the implementation of public health guidelines varies from region to region. This variation has led to the emergence of newer strains of the virus and increased spread in public.

Currently, the Delta variant of Covid-19 accounts for most of the cases in the USA. As a result, public health officials have promoted safe practices like mask-use, social distancing, hand washing, vaccines, testing, and tracking. However, there is still a variety of opinions on the spread and management of the SARS-CoV-2 virus. Moreover, some citizens do not believe in the use of masks, vaccines, and other health practices. In addition, with the opening of schools and colleges in mid-August, the interaction of people in closed spaces has increased. Moreover, the Covid-19 vaccine has not been approved for children below 12 years old. Therefore, with the combination of increased interactions, unvaccinated children, and opposition to safe practices, the pandemic wave has reemerged.

Due to recurrent waves of this pandemic, it is imperative to understand the spread of the Delta variant of SARS-CoV-2. In this paper, we would like to analyze the central region of the USA to see the progressive changes over time of Covid-19 and explore the factors that affect this new pandemic wave.

Methods

This paper aims to determine the effect of the Delta variant of the SARS-CoV-2 virus in the USA. We selected five states across various latitudes, socio-economic differences, political ideologies, health administration, infrastructure, Health & Human Services (HHS) regions, underlying sicknesses, prevention measures, and understanding and attitude towards public health practices. Using these factors, we can understand this effect adequately.

The study period was approximately five months, from Apr 1, 2021, to Aug 27, 2021 (total 149 days). This study period was selected to see the pandemic changes around a significant decision by CDC, especially the recommendation to use the mask in indoor settings.

Population-specific data was gathered from US Census Bureau (USCB). Specifically, census data as of Apr 1, 2020, was used for analysis. Other data gathered from this site included race and poverty.

Covid-19 data was collected from the CDC (CDC). First, Covid-19 cases were normalized by dividing by population in Millions to get a comparable number, Daily Cases Per Million (DPCM), to compare five states. Next, we used the CDC data to create a timeline, compare cases data between states, and compare states using census data and non-communicable disorders (Collaborators et al., 2018).

For statistics, daily cases from states were used to determine the difference of means. ANOVA on Ranks, with Tukey modification, was used to compare means between groups and within groups to measure statistical significance ($p < 0.05$). Sigmaplot software, version 14 (Systat Software, Inc.), was used to analyze and create graphs.

Results

The states included in this study, from North to South, were Minnesota (MN, HHS 5), Iowa (IA, HHS 7), Missouri (MO, HHS 7), Arkansas (AR, HHS 6), and Louisiana (LA, HHS 6).

Table 1: Covid19 Cases	Minnesota	Iowa	Missouri	Arkansas	Louisiana	5 States
Population (Apr, 20) (USCB)	5,706,494	3,190,369	6,154,913	3,011,524	4,657,757	22,721,057
Cases (Apr, 21 – Aug, 21) (CDC)	124,661	51,726	194,881	116,032	234,399	721,699
Cases per Million	21,845	16,213	31,663	38,529	50,324	31,763
Cases percentage	17	7	27	16	32	100
Cases in Children % (08/19/21)	18.80	11.20	11.60	15.30	14.00	

As shown in Table 1, during the study period from April 1, 2021, to August 27, 2021, there were 8,130,402 cases of Covid-19 in the USA. As the USA's population is 331,449,281 (USCB), the USA's rate is 24,530 cases per million.

Locally, in the study group of five states, there were 721,699 cases during the study period. Therefore, the combined population for these five states is 22,721,057. As shown in Table 1, the highest percentage of cases was in Louisiana (32%), and the lowest percentage of cases was in Iowa (7%). The remaining three states (Minnesota, Missouri, and Arkansas) were between these percentages (17%, 27%, and 16%, respectively).

To normalize the cases, we divided the total cases by the total population during the study period. This gave us the total cases per million (CPM). Louisiana has the highest CPM at 50,324 cases per million. Iowa has the lowest CPM million at 16,213 cases per million. Although Minnesota and Arkansas have similar case percentages, Arkansas had 38,529 CPM, whereas Minnesota had 21,845 CPM. Just as Iowa had the lowest case percentage, it also had the lowest CPM at 16,213.

According to the American Academy of Pediatrics (AAP), total cases in children accounted for about 14.6% in the USA as of Aug 19, 2021. This accounted for about 4.5 million cases of Covid-19 cases in Pediatrics since the beginning of the pandemic. Among the states reporting to AAP, children accounted for about 1.6 to 3.6% of the total

accumulated hospitalizations. Death in pediatric patients is less than 0.3% of all Covid-19 deaths. Among the five states being studied, Minnesota reported the highest number of pediatric cases at 18.8%, whereas Iowa and Missouri reported the lowest pediatric cases at about 11.2 to 11.6%.

Timeline of Covid-19

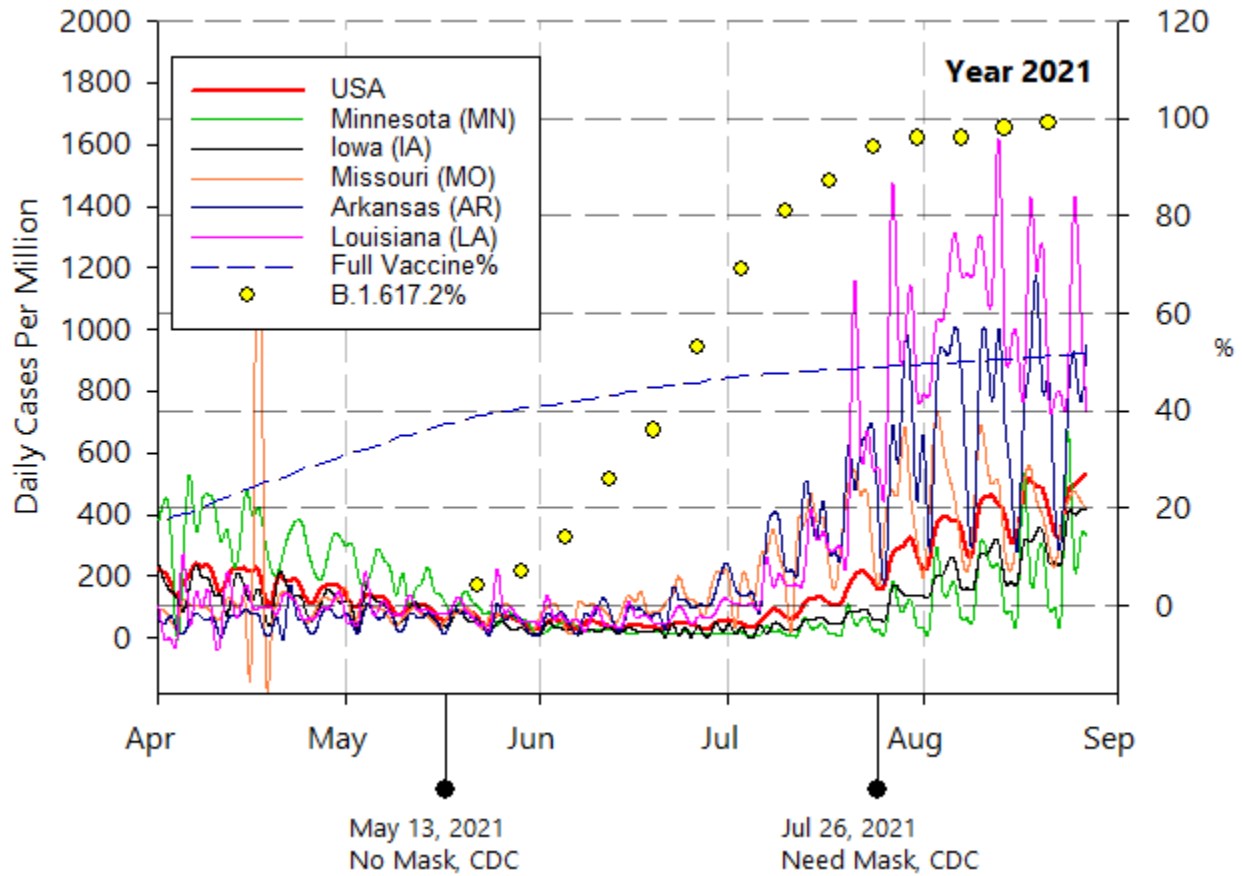


Figure 1. Timeline of Covid-19 Cases.

Figure 1 shows the timeline of Covid-19 Daily Cases Per Million (DCPM) in the USA and the five states from Apr 1, 2021, to Aug 27, 2021 (149 days). As shown in the graph, all the states showed a gradual decline in Covid-19 cases from April to the lowest point at the beginning of June 2021. However, beginning July, the cases gradually increased to a peak reaching during mid of August. As of Aug 27, 2021, it is hard to predict whether the peak for this wave has reached or not.

In the USA, the DCPM was around 200. This number declined to ~75 at the beginning of June and has increased to ~400 by August. However, individual states show a wide variation in the DCPM. For example, northern states such as Minnesota and Iowa have had a lower increase in DCPM than southern states such as Missouri, Arkansas, and Louisiana.

According to the CDC (CDC), people are considered fully vaccinated two weeks after the second dose in a two-dose series, such as the Pfizer or Moderna vaccines, or two weeks after a single dose vaccine, such as Johnson & Johnson's Janssen vaccine. Looking at the timeline in Figure 1, the fully vaccinated rate (blue-dashed line) increased rapidly from 20% to 40% from the beginning of April to mid-May of 2021. After this period, there has been a modest increase of 10% over the next three months.

As the Delta variant emerged around mid-May, it made up 4% of total cases. By the end of August, it had increased rapidly to 99% of total cases. The most dominant strain is B.1.617.2 (Delta group), almost entirely replacing

the other dominant strain of B.1.1.7 (Alpha group). The CDC's indoor mask mandate for fully vaccinated people was discontinued on May 13, 2021 (during the study period). However, due to the increase in Covid-19 cases, the CDC reinstated the indoor mask mandate on July 26, 2021(during the study period).

Compare States for Covid-19

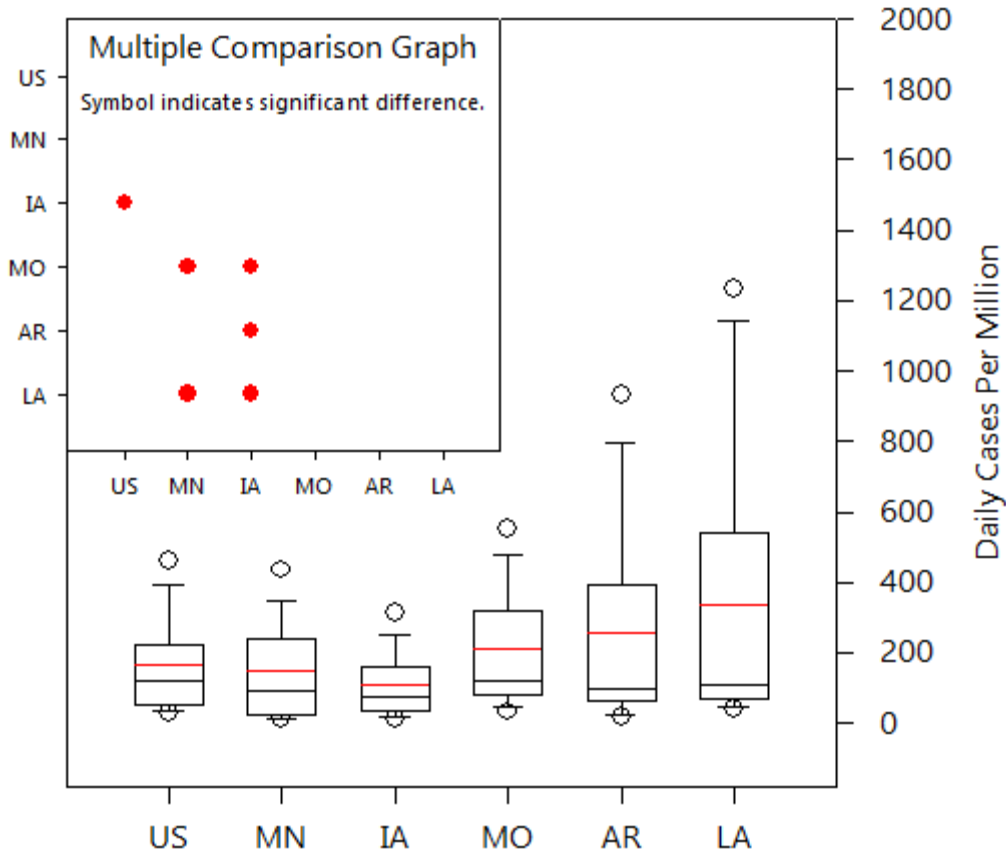


Figure 2. Comparison of Covid-19 Cases Per Million (CPM) in the five states. The box and whisker plots show each state's data, with the 5th and 95th percentile for data spread. All outliers are not shown. The red line shows the mean for each box. The black line shows the median for each box. The inset shows multiple comparisons between each state and the USA, showing statistically significant differences using a red dot. The test used was ANOVA on Ranks, with Tukey modification

The Daily Cases Per Million (DCPM) data from the period (149 days) were summarized and compared within each state and compared to the United States data. One way analysis of variance test was used to perform the comparisons. The data failed the (Shapiro-Wilk) normality test ($p < 0.05$), and hence "Kruskal-Wallis One Way Analysis of Variance on Ranks" was used.

The median DCPM from the USA was 120 (54-224) with the range of 25 to 75th percentile. The Median (25%, 75%) DCPM for various states were as follows: Minnesota 90 (24-240), Iowa 74 (33-160), Missouri 119 (83-319), Arkansas 96 (66-392), and Louisiana 108 (69-543). The differences in medians were statistically significant ($p < 0.001$). To further evaluate, all pairwise multiple comparison procedures using the Tukey test were done to clarify the statistically significant difference.

As shown in the "inset box" in figure 2, Iowa and Minnesota had significantly lower cases concerning other states. There was no difference between Iowa and Minnesota. Iowa had statistically significant ($p < 0.05$) lower cases

than the USA, Missouri, Arkansas, and Louisiana. Minnesota had statistically significant ($p < 0.05$) lower cases than Missouri and Louisiana.

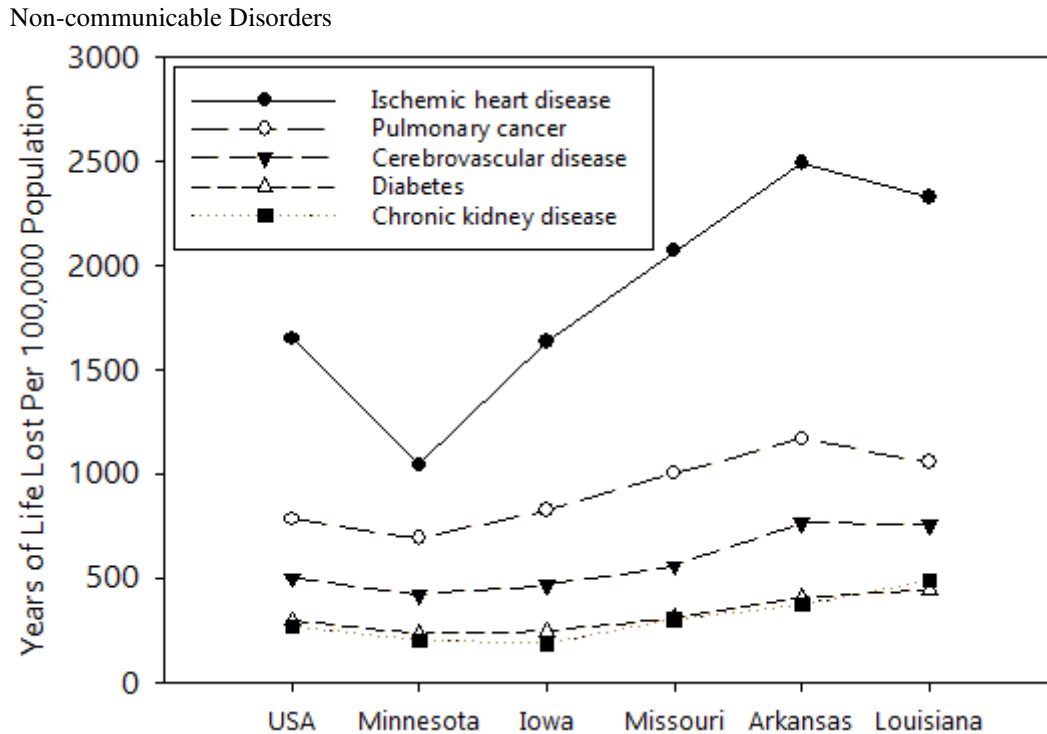


Figure 3. Non-communicable diseases in different states.

Noncommunicable Disease (NCD) is defined as chronic conditions that do not result from an infectious process and hence are “not communicable.” NCD diseases usually have a prolonged course that does not resolve spontaneously and for which a complete cure is rarely achieved. NCD usually predominates in the lower economic strata of society. Globally, it is supposed to cause over 25 million deaths in lower-income countries, vs. less than ten millions deaths in high-income countries.

With compared to the USA as a benchmark, southern states have s higher rates of NCD. For example, Louisiana has significantly higher rates of all the five NCD studied here, including Ischemic Heart Disease, Pulmonary Cancer, Cerebrovascular Disease, Diabetes, and Chronic Kidney Disease. On the other hand, Minnesota is among the healthiest states with the lowest incidence of all five NCD.

Health care disparity

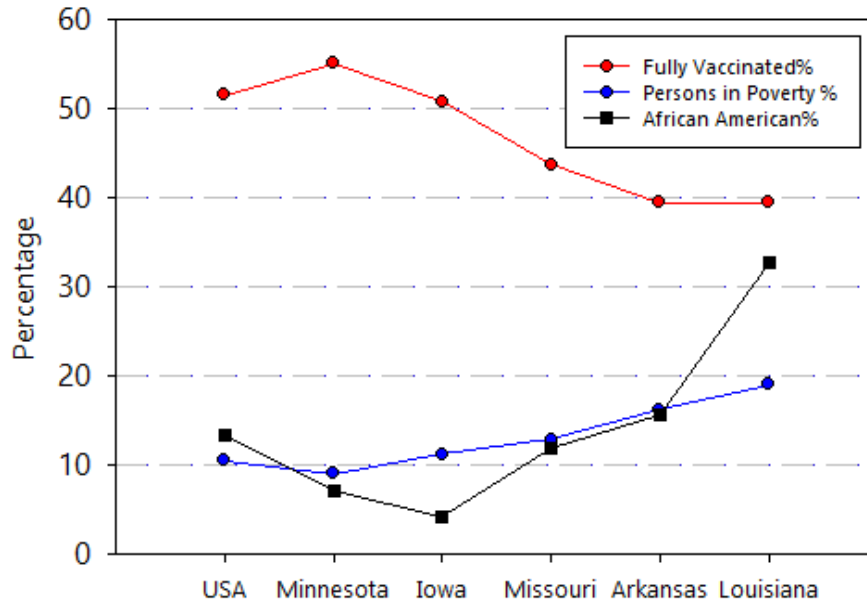


Figure 4. Health care disparity in different states

Regarding socio-economic factors, Southern states have higher rates of African American populations and lower economic security, specifically higher unemployment, and lack of access to healthcare. Additionally, Southern states have lower vaccination rates due to various factors such as vaccine access, personal beliefs regarding the vaccine, and political motivations.

Having a prevalence of non-communicable diseases (NCDs) is significant as recent research has highlighted that preexisting NCDs worsen the effect of COVID-19. Moreover, NCDs such as hypertension, diabetes, and obesity interact in ways that increase auto-inflammation and injury, leading to severe injury or death.

Considering the under-resourced healthcare systems and preexisting NCDs of southern states, especially Louisiana, these states are prone to worse outcomes of the COVID-19 pandemic.

Discussion

Covid-19 viruses are RNA viruses belonging to the family coronaviridae, with four genera (alpha, beta, gamma, and delta) and multiple strains. The crown-shaped structure consists of an inner core of RNA and an outer membrane with spikes-shaped proteins (see Figure 5). The coronavirus genome contains about 26 to 32 kilobases, as compared to three billion bases in humans. The virus causing the current pandemic is SARS-CoV-2, which originated in December 2019 in Wuhan, Hubei Province in China. Currently, the origin of Covid-19 remains inconclusive (Maxmen, 2021), with two competing theories persisting: i.e., natural infection vs. lab-originated virus.

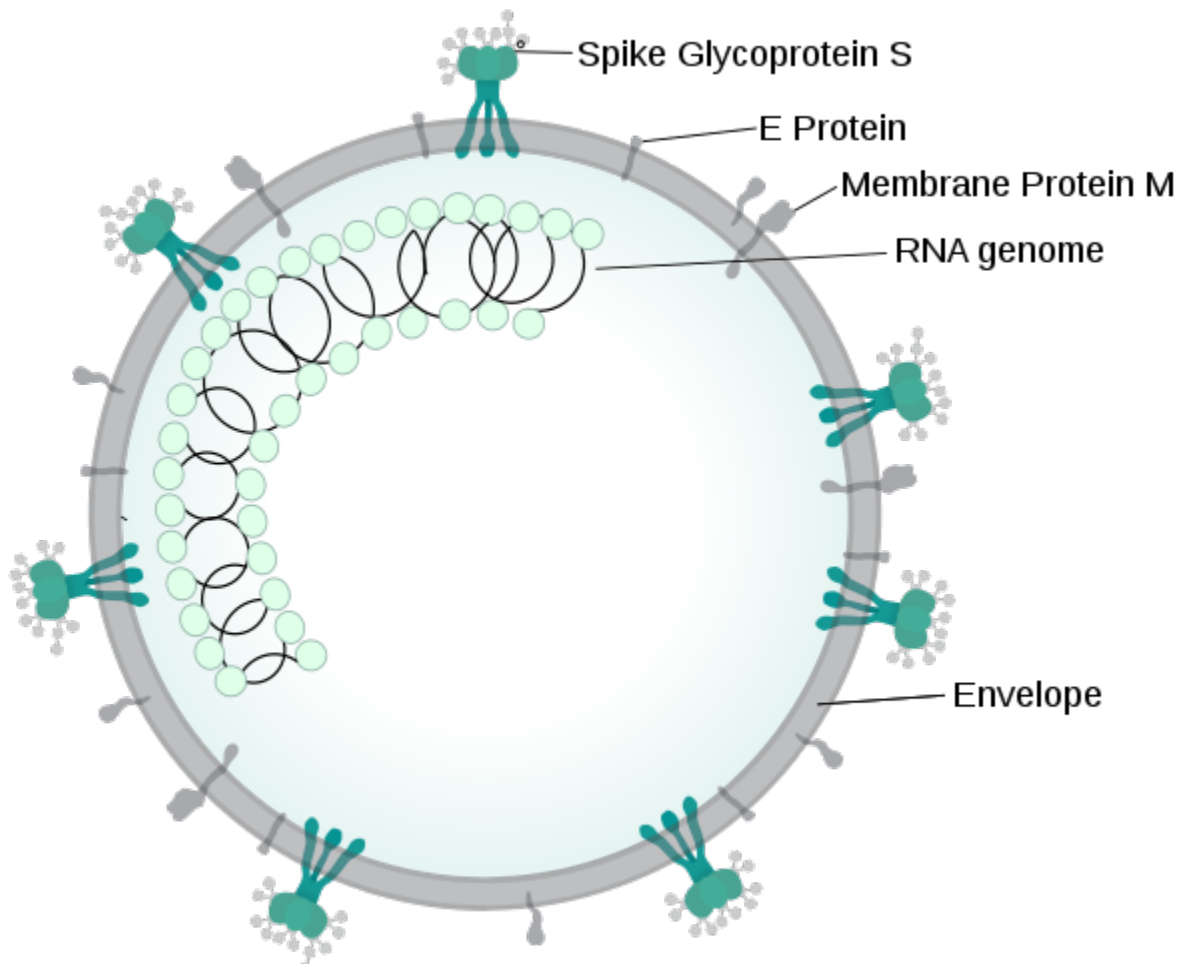


Figure 5. Structure of Coronavirus, with RNA core, and spike proteins on surface.

(Source: By SPQR10 - Own work, CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=88349537>)

The most common variant causing the current wave of the Covid-19 pandemic is the Delta variant (CDC). According to the CDC website (CDC), the Delta variant is twice as contagious as previous variants. In addition, in unvaccinated people, the Delta variant may cause more severe illness than previous variants. Hence, the risk is very high for unvaccinated people. Fully vaccinated people can have breakthrough infections but are protected from severe disabilities and death. However, they can still acquire and transmit this virus to other individuals.

Recent research has highlighted the fact that preexisting non-communicable diseases worsen the Covid-19 outcomes. For example, hypertension, diabetes, and obesity interact in various ways (Shah et al., 2021) to cause an increase in auto-inflammation and injury, leading to disability or death of a patient. In addition, our study has seen a predominance of NCD in southern states, especially Louisiana, with higher poverty and health care disparity and lower vaccine rates, which puts them in a precarious situation for worse outcomes after Covid-19 infections.

Long Covid-19 (Lopez-Leon et al., 2021) syndrome is prolonged symptoms after Covid-19 illness. This syndrome may persist from few weeks to several months. However, in a recent Meta-Analysis (Lopez-Leon et al., 2021), it has been to cause more than fifty long-term symptoms, including but not limited to fatigue, headaches, breathlessness, joint pains, depression, and other debilitating symptoms. This syndrome leads to poor performance at school and work, with a loss in productivity of an individual.

Currently, there is no vaccine approved for kids under 12 years of age. Therefore, the indoor transmission of the Covid-19 virus can only be mitigated by using physical barriers and limiting exposure times. The physical barriers

include plastic barriers where feasible, masks by people, and limiting physical contact, such as six feet social distancing.

To understand why the Delta variant became so harmful, it is helpful to understand its timeline. In April 2021, India suffered the worst pandemic wave, with deaths in the tens of thousands. This issue only heightened shortages in hospital bed spaces, medicine, oxygen, health care provider exhaustion, and broken families. Similar reports of an increase in Delta variants came from different European countries.

In the first weeks of May, the USA sent assistance to India regarding medicines, oxygenators, and oxygen cylinders. Unfortunately, this coincided with the emergence of the Delta variant in the USA. Although vaccine rates were rapidly improving in spring, the rate of vaccinations slowed down over the summer. After full situational awareness, CDC recommended reducing the in-door mask mandate. In addition, an increase in movement to shopping malls and indoor gatherings, increase in vacation traffic after a year of indoor work, reduction of mask recommendations, and most importantly, the individual choice concerning masks and vaccines, become a dominant factor in the current wave of Covid-19 pandemic.

Implication

The Covid-19 pandemic is not over yet. Newer variants are still evolving, which may reduce/increase this virus's transmission and disease-causing potency. The hope of herd immunity depends on a mixture of natural infection and acquired immunity by vaccines. While stimulating the immune system, direct infection puts a person at risk of death and disability, such as Long Covid-19 (Lopez-Leon et al., 2021). These increase suffering and causes substantial economic losses in lost production, compensation, and healthcare expenses.

Till then, vaccine and masking are the only definite answer to this ongoing pandemic. Moreover, the SARS-CoV-2 virus will infect people, regardless of their opinions on vaccines and masking unless stopped by some external barrier (mask) or internal barrier (vaccine). Therefore, we recommend both continuous use of masks and vaccines until further variants become endemic to the population and futures waves are small and localized to a small geographical location.

Limitations

There are many more indicators that could be tracked to study the Covid-19 pandemic. However, it is not possible as it is not a prospective controlled trial. For example, a primary indicator like mask usage is difficult to track, as even the regular user may occasionally take it off. Similarly, exact health demographics on individual-level data are not available in this study.

Conclusion

Over the last two years, the Covid-19 pandemic has caused more than 4.5 million deaths globally. Various strains of this virus keep evolving with various degrees of transmission and disease-producing potency. A recent wave of this pandemic in the USA is the Delta variant (B.1.617.2 strain), which is highly infectious to both vaccinated and unvaccinated people. This strain may cause severe illness in unvaccinated people, leading to death. In addition, the vaccinated people can have severe complications leading to Long Covid-19 syndrome.

Our analysis showed that CDC vaccine implementation had difficulties. Additionally, the CDC's guidance on removing masks may have been premature, especially in the background of severe pandemic waves in India in April 2021. In order to reduce this pandemic, two factors should be implemented aggressively while people try to open the economy and get back to school and work. They include the implementation of external barriers (masks) and

internal barriers (vaccines). Government and workplaces should issue further guidance to implement both at the earliest.

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