Comparison of Health and Economic Values of SARS-COV2 Vaccination with Preventive Measures (Stay-at-Home, Mask and Hand Sanitizer) in California

*Somya Shubhra Pal, 2 Samir Kumar Pal
1 Department of Economics and Statistics, California State University, Los Angeles, 5151 State University Drive, Los Angeles, CA 90032, USA
2 Department of Chemical, Biological and Macromolecular Sciences and Technical Research Centre, S. N. Bose National Centre for Basic Sciences, Block JD, Sector III, Salt Lake, Kolkata, West Bengal 700106, India
Email: spal6@calstatela.edu

Received on: 15th June 2021; Published on: 30th June 2021

Abstract
The first line of defense against COVID-19 pandemic was recommended to adopt physical distancing alongside use of face masks and hand sanitizers in early 2020. Vaccines against SARS-COV2 came around early 2021. We have carefully studied the temporal behaviour of the COVID-19 suspected and confirmed infection in various hospitals in four major cities namely in California. Our observation revealed the limitation of the standard SIRD model to simulate the full pandemic episodes in California. We also investigated the additional economic value of the immunization program compared to physical distancing in four major cities in California considering the number of homeless people as one of the microeconomic markers to gain insights and opportunity about possible future scenarios in a post-vaccination era.

Keywords
COVID-19, Health Economics, Vaccination Program in California, Impact of Local Economics, Preventive Measures versus Vaccination Program

Introduction
The novel coronavirus (SARS-CoV-2) has spread over the world at an incredible rate since its discovery at the end of 2019 and has been deemed a pandemic. At the time of this article's submission, the outbreak had afflicted more than 170 million people and claimed the lives of more than 3 million people [1] the data has been obtained from CEIC Global Economic Database. The first aim in most countries is to “flatten the curve” so that local health systems can handle the growing number of patients who require hospitalisation and acute care. Closures of schools, non-essential retail, hospitality venues, and workplaces were among the physical distancing measures implemented, as were ordered to stay at home and maintain a distance of 1–2 metres between individuals from different households, restrictions on mass gatherings and movement (including public transportation), and isolation of symptomatic cases and quarantining of exposed individuals [2]. Although, since the starting of the year 2020, the whole world is facing a challenge due to an outbreak of an unprecedented COVID-19 pandemic owing to a novel coronavirus, in recent times, several models including susceptible infected recovered dead model (SIRD) and its modified forms have been used to analyse the time series data of the pandemic in various countries [3] However, in the works, either pandemic infection for a limited period [4] was chosen or countries were chosen to have perfect matches with a particular model [5]. Considering the particular nature of the COV2 infection and unknown origin [6], a unique model to explain all the temporal patterns of the pandemic is sparse in the literature. Here, we have chosen California as the place of our interest for the following reasons. Firstly, a precise data set of COV2 hospital infection day-wise starting from early 2020 till the date of the submission of the manuscript (second week of June) is reported on the government website [7]. Secondly, the interesting nature of the temporal pattern of confirmed infection consisting of three clear waves with different amplitudes in various cities of the states and its comparison with lower numbers of suspected cases in the hospital may be indicative of several parameters including the willingness of a person to pay for health in accordance to the WTP procedures which could provide insights into the monetary value of health gains (as measured by instruments in the QALY field) and hence can be estimated [8][9]. This can also be combined to get a monetary value for health gain and health state utility. Most importantly, lack of literature which reports the fitting of the temporal patterns with a particular model to date.

We have also considered the impact of the pandemic on the local microeconomics in terms of unoccupied homes in the counties (an indicator of homeless people). Data from Deloitte, USA on homelessness from key economies in the developed world suggests key parameters of economies. In the United States alone, point-in-time estimates by the Department of Housing and Urban Development (HUD) for a single day in January 2018 put the country’s number of homeless at 552,830. In 2020 the number is 580,466 which is a significant fraction of the total US population (0.2 percent). In the midst of extraordinary vulnerability, the worldwide economy is projected to develop 5.5 percent in 2021 and 4.2 percent in 2022. The 2021 estimate is amended up 0.3 rates directly relative
toward the past conjecture, reflecting assumptions for an immunization fuelled fortifying action later in the year and extra strategy support in a couple of enormous economies as indicated by International Monetary Fund (IMF). Here, we have discussed the temporal behaviours of confirmed COV2 infected cases and compared with that of the suspected in the hospital setting in four major cities in California namely: Los Angeles, San Francisco, Santa Clara, and San Diego- from April 2020 till the second week of June 2021. We have noted that the third wave even after the preventive measures in the state is significant and decreases after the pharmaceutical intervention (vaccination) in the state. The corresponding number of unoccupied homes in the cities in the said time period is also projected as the temporal pattern of the microeconomics. We have numerically fitted the rising and decreasing trend of the third wave in various cities in the state and compared with the numerical parameters of the temporal pattern of the cumulative vaccination in the state. Albeit ongoing vaccine endorsements have raised any desires for a turnaround in the pandemic in the not-so-distant future, restored waves and new variations of the infection present worries for the standpoint.

Materials and Methods
Here we discuss COVID-19 time series data for four major cities in California, United States namely: Los Angeles, San Francisco, Santa Clara, and San Diego. The data have been obtained from California Health and Human Services Open Data Portal.

Numerical Model:
As the mechanism of spread is through the contact of an infected person with a susceptible population, the growth rate of infection in the third wave (biggest). We have compared the temporal data of the third waves in different cities of California for the cumulative number of infected people in the hospitals with the sigmoidal function (growth/decay) as given below

\[ y(t) = A_1 + \frac{A_2 - A_1}{1 + e^{(t - t_0)}} \]  

(1)

Where \( A_1 \) and \( A_2 \) denote the initial and final infected population. While we have defined \( A_1^- \) and \( A_2^- \) during increasing infection trend, \( A_1^+ \) and \( A_2^+ \) are denoted for decreasing infection trends. A similar convention is followed for \( k \) and \( X_0 \).

Results and Discussion
Figure 1 shows a single peak in the total number of people infected by SARS-CoV-2. As the number of days is increased, the total infected population flatlines in accordance with the SIRD model.

The total population susceptible to disease decreases over the time period until eventually closing down to zero. Death rates stabilize as the total number of recoveries increases. From this model what we observe is just a single peak; which according to actual data is not the case. There, limiting our interpretation to hypothetical situations which can only be obtained from very specific conditions and hence cannot be used to calculate large data arrays. It has to be noted that a number of COV2 infection waves are evident in most of the places including, justifying the limitation of the model to the realistic prediction of the pandemic.
Figure 2: Temporal Trends of Confirmed COV2 Infected and Suspected Population in Hospital Setting in Various Major Cities of California, USA.

Figure 2 shows temporal trends of confirmed COV2 infected and suspected population in hospital settings in various major cities of California, USA. The existence of several peaks in the temporal trends is found to be a limitation of the existing model as shown in figure 1. It is observed that the different counties of the state are hiked by peaks at different times based on how quickly the people instituted stay-at-home orders or other social distancing rules. Differences between suspected and confirmed cases may be explained from the aforementioned parameters and a person's willingness to invest in accordance with the Modern Portfolio Theory (MPT) in the context of healthcare and to avail the same [10].

Economic Impact of COVID-19 in California (House Occupancy as Marker)

Figure 3: Temporal Trends of Unoccupied Homes in Major Cities of California during COVID-19 Pandemic Episode.
Figure 3 shows House occupancy (HO) as a marker of socio-economic repercussions during the pre and post-vaccination period within a time frame of 14th April 2020 to 8th June 2021 and we studied the relation of the HO within the time frame keeping in mind that several policies were implemented by the government in the event of various waves. We took 4 major economic hotspots in California. In Los Angeles (a) we can see that although the total number of HO was declining at a decreasing rate after day 100 we see it increase at a decreasing rate which was the approximate time period of the third wave in the city. This could imply that even after various strategies implemented by the government including stay-at-home order the total number of cases continued to increase until vaccines were implemented; in turn signaling a failure of the same. In the case of San Francisco (b) we see the total number of HO to initially reduce along the 75th day then increase at an increasing rate before coming to a standstill both before and after vaccines were administered. A similar outcome was observed with the data recorded in Santa Clara as well as recorded in San Francisco. In San Diego, the total HO kept reducing regardless of the implementation of the vaccinations which would, in turn, mean that other socioeconomic strategies implemented by the government were sufficient. A further detailed economic analysis would be made by the authors in their following paper with regards to the HO issue at length.

![Figure 3: House occupancy (HO) as a marker of socio-economic repercussions during the pre and post-vaccination period within a time frame of 14th April 2020 to 8th June 2021.](image)

Pharmaceutical Remediation of COVID-19 in California (Vaccination)

![Figure 4: (a) Temporal Trend of Vaccination (Cumulative) in California. (b) Numerical Parameters of Third Waves of the COV2 Infection in Various Cities of California are shown.](image)

The curative rate of vaccination is figure 4 (a). Figure 4(b) shows the numerical parameter of the vaccination from the fitting of the data using equation 1. The table also depicts the rate of increase and decrease of the infected cases in various major cities. In a recent report [11] as of November 2020, the Phase 3 clinical trial data of the messenger RNA (mRNA) vaccine shows that 14 days after the second vaccination, it is effective in preventing the symptomatic severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is 94.1. Seven days after the second dose of BNT162b2 vaccine (Pfizer), mRNA-1273 (Moderna) 1 and 95 efficacy. Since the results of these trials were published, the number of diseases caused by Coronavirus 2019 (Covid-19) has increased nationwide. With the emergence of the more infectious SARS-CoV-2 variant, the US Food and Drug Administration has granted emergency use authorization for these two mRNA vaccines, and vaccination has begun in all US states.
From December 16, 2020, to February 9, 2021, a total of 36,659 health care workers received the first dose of vaccine, of which 28,184 (77%) received the second dose. Among the vaccinated health care workers, 379 unique individuals tested positive for SARS-CoV-2 at least 1 day after vaccination, and most of these individuals (71%) were in the first 2 days after the first vaccination. Detected positive within a week. After the two vaccines, 37 health workers tested positive; of these workers, 22 tested positive 1 to 7 days after the second vaccination. Between 8 and 14 days after the second vaccination, only 8 health workers tested positive, and within 15 days or more after the second vaccination, 7 health workers tested positive.

Conclusion
From an economic and epidemiological standpoint, this present research provides early insights into possible future post-vaccination scenarios. The limitation of the existing models to simulate the temporal behaviours of the pandemic in various major cities in California is also highlighted. It may help both, Governments, and persons to consider health as an investment instead. Individual ‘investment’ in self-care and preventive health yields returns by lowering the need for, and spending on curative care. In addition to improving the population's well-being, government investment in health has a substantial multiplier effect throughout the economy. In our following research work, we are currently working on the implication of both the WTP procedure and the MPT in the current socio-economic scenario- in the state of California.

Acknowledgments
We thank Mr. Tuhin Kumar Maji, S. N. Bose National Centre for Basic Sciences for his kind help in the preparation of the figures and careful reading of the manuscript.

Conflicts of Interest
The authors disclose no conflict of interest.

References