Using Mathematical Modeling to Compare and Predict Trends Between Daily COVID-19 Total Cases and Deaths in New York, New Jersey, and Illinois

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Abstract

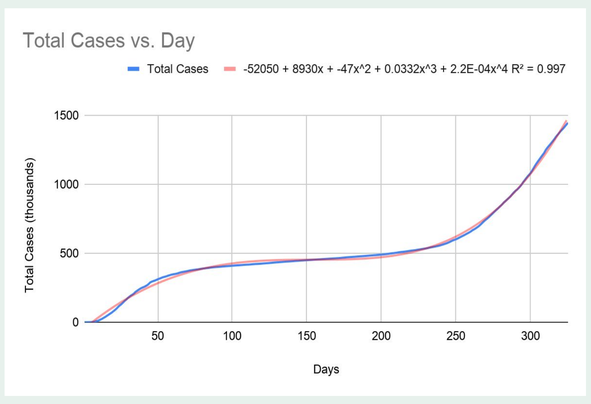
In this paper, we aim to explore the coronavirus case data from three states, New York, New Jersey, and Illinois with the appropriate lockdown factors to predict the number of cases in the future using a variety of mathematical models. We subsequently use a variety of functions, including linear, quadratic, and polynomials to predict the association between virus cases and days from lockdown. After the introduction of widespread vaccination efforts in December of 2020 across the US, we included data from January to analyze the impact of said vaccination efforts on the number of total cases and deaths in each state.

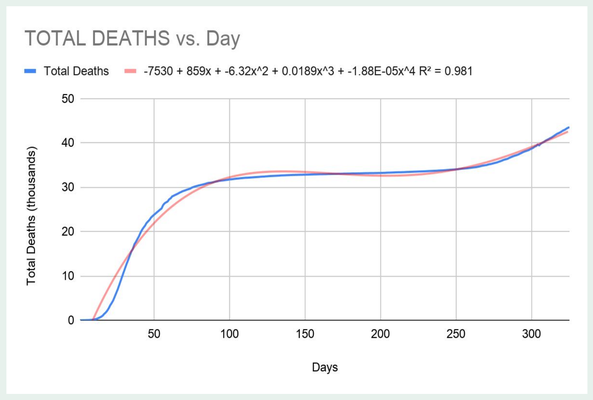
Introduction

In this paper, we aim to explore the coronavirus case data from three states, New York, New Jersey, and Illinois with the appropriate lockdown factors to predict the number of cases in the future using a variety of mathematical models. Analyzing the data with the regressor and using variable "t" as the number of days after lock-down, we are able to gain an accurate picture of how the lockdown has affected case numbers across these three states, holding other variables constant. We subsequently use a variety of functions, including linear, quadratic, and polynomials to predict the association between virus cases and days from lockdown. In the state of New York, it was found that total cases and deaths both increased from March to May of 2020, then slowed down between June and October due to lockdown policies taking effect, and surged again from November to January. However, in 2020, our total case predictions by the end of the year (December 31st), were far surpassed. In New Jersey, there was a general trend where the number of total cases rose dramatically from March 12 to approximately May 2nd 2020, where social distancing and restrictions were at their maximum. However, the number of cases flattened out until November or early December, where the number of cases grew exponentially. This stark increase, however, was most likely a result from the emergence of other common respiratory viruses, like the common flu, and the start of winter. Then, we can confidently state that New Jersey's government introduced effective regulations to contain the COVID-19 virus. In comparison to other states, in Illinois, there are less COVID-19 cases, likely due to the smaller population. Over time, from March 12th to August 23rd 2020, there has been a steady increase in cases. It was shocking that when Illinois had revoked their stay at home order (on May 29th), there was no large surge in cases. Thus, from this, it is recognized that Illinois is handling the coronavirus pandemic safely (social distancing, and use of masks). We are able to make the association with relative confidence because the correlation between the data and the regression line is very close, and we make reasonable assumptions that help us control for extraneous variables in the three states.

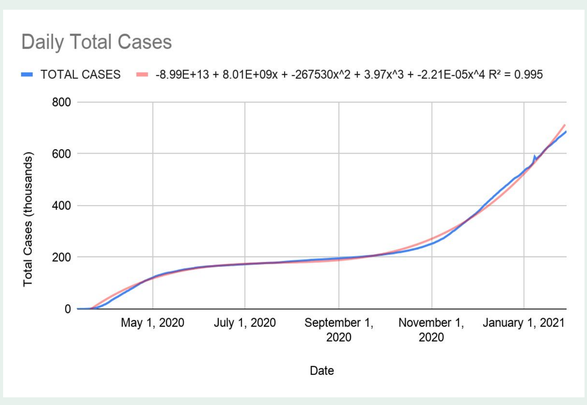
Total Cases/Deaths and Future Predictions

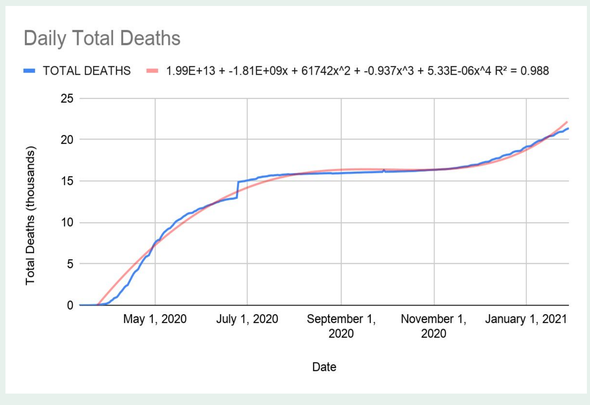
New York



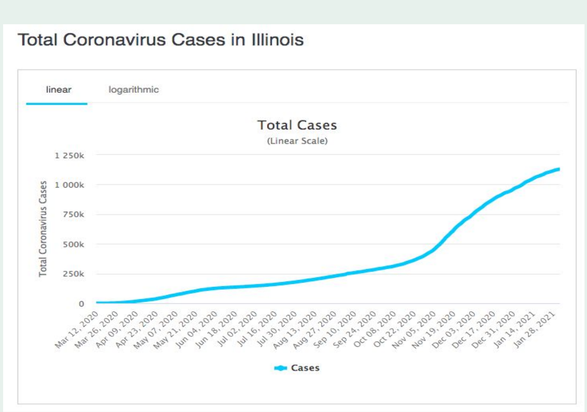


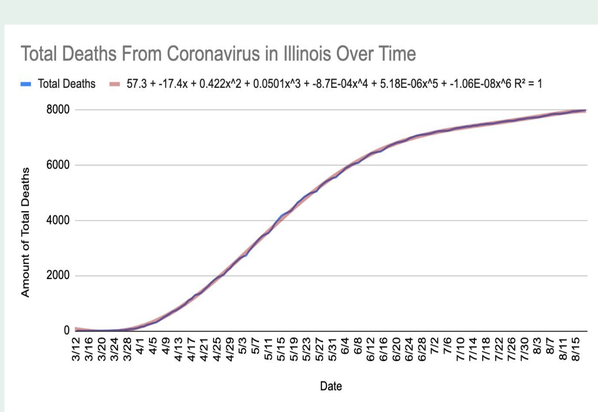
New Jersey





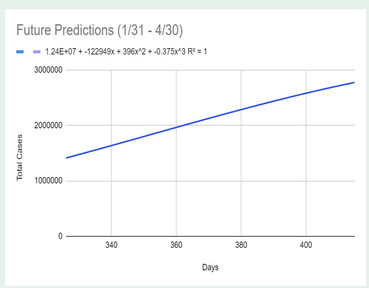
Illinois



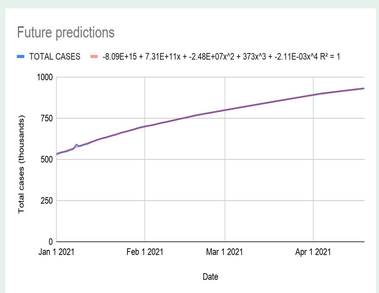


Predictions

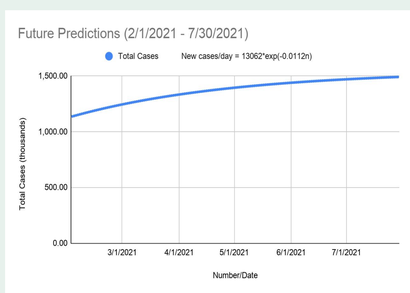
New York



New Jersey



Illinois



Future Prediction: Polynomial Regression

New York: Since the completion of the COVID-19 vaccine late last year, New York has seen a significant decrease in the amount of daily new cases and new deaths. By examining the trends of the total cases, new cases, total deaths, and new deaths data sets, we were able to predict the future outlook for the state of New York regarding COVID-19. Our models imply that the coronavirus curve will be flat by the end of April 2021, which is around the time that the majority of Americans will already have been vaccinated.

New Jersey: With the introduction of vaccines to combat the increasing number of new cases, New Jersey has seen a significant drop in daily new cases. Since the slope of the total cases graphs has been decreasing, we can conclude that the COVID-19 vaccine has had a great impact by decreasing the number of daily new cases. Our model suggests that the graph of total cases will almost be flat by the end of April. This shows that when the majority of the United State's population receives vaccines (the majority of the vaccines will arrive in Summer), the number of daily new cases will drop significantly and will level off approximately between late summer and early fall or winter.

Illinois: The prediction shown exhibits a gradual decline in total cases over the span of just over a month (from August 19th to September 21st). This shows that The extrapolation does not work well for future predictions after August 26th since the total number of cases could not decrease. Thus, in order to make more accurate predictions, we need to split the data up. Then, the data on the total amount of coronavirus cases was split into three sections based on when the stay at home order was placed and revoked for more accurate curves of best fits during different circumstances. Additionally, predictions reaching 3 weeks ahead were created for each of these three sections. Predictions for the first two sections were compared with the actual data collected at the time of those predictions to measure accuracy. The prediction generated from the last section is used for a future prediction on the total amount of coronavirus cases.

Comparisons

Based on the data of New Jersey, we can conclude that efficient governmental actions can really make an impact in the spread of a novel airborne disease. New Jersey's government's rapid and effective actions enabled a decrease in the daily cases of COVID-19 as we can see from the decrease of the slope of the function as days progress. As New Jersey entered Stage 2 of quarantine and social-distancing, daily new cases already had decreased significantly, which enabled the citizens to enjoy a comeback to most of the parts of their daily lives. Therefore, the results of the research on New Jersey's daily COVID-19 cases and deaths allows us to understand the importance of governmental actions and social cooperation; since without the government, no actions would be taken to contain the virus, and without social cooperation, all governmental actions and recommendations to contain the virus would be ignored or disobeyed. In the future, in a world where animals and humans are becoming increasingly in contact, a viral outbreak is going to be inevitable. However, with the results from this research, we can confidently state that if we learn from the mistakes done and we improve on what we have done correctly, we will be able to handle effectively the next global pandemic. From COVID-19 data for the state of New York during early stages of the pandemic, one can determine the effectiveness of government action against infection. From March to May of 2020, New York was by far the most heavily impacted state in the United States, with the case count rising rapidly and steadily, and at times with a daily increase of over 11,000 cases. By late May, when lifting of lockdowns and Stage 1 of reopening had begun, total cases for the state had already reached a staggering amount. Around two weeks after this time, approximately mid-June, it was obvious that the spread of the virus had started slowing. The policies that had been put into place in March were finally starting to take effect. However, it is arguable that the lockdowns and anti-infection policies in New York were imposed much too late, as when they were imposed, too many New Yorkers had already been infected for measures to have any significant effect on the infection rate until two months later. However, after the first stage of reopening began, the infection rate decreased and stayed relatively low. The results of data collected on the pandemic situation in New York allows us to understand the importance of both a responsive government and a cooperative society. Unfortunately, it is not uncommon for the implications and particulars for such unfortunate circumstances a pandemic provides to be heavily politicized. From this research, one will learn that the significance of government action against this biological phenomenon cannot be ignored, but we must also understand that the gravity of the situation is severe and is challenging for both state and citizens. Challenges for the government arise because they must be greatly concerned for human life, while also focused on maintaining societal and economic operations. The occurrence of pandemics in the future will still be very likely, as it was in the past. Deaths and economic destruction will be inevitable, and governments will have to choose the lesser of two evils, and choose carefully, for not only human lives will be at stake.Based on the Illinois data analysis, at the beginning of the pandemic, when people and hospitals were lacking in protective equipment such as masks and hand sanitizer, the cases were on a steady rise. When the shelter in place was first enforced, there was still a rise in cases which is likely due to people still going out to buy groceries last minute due to the sudden announcement in the shelter-in-place. Another possibility for this continued rise is due to the up to two week period which takes Coronavirus symptoms to appear, which makes cases appear later in time then people have actually contracted the disease. It is proven from this data that near the middle and the end of the shelter-in-place, the cases have greatly declined. This exhibits that Illinois contained the virus with great timing and the shelter-in-place is extremely effective towards minimizing the amount of coronavirus cases. After the shelter-in-place, the amount of the rise in cases was much lower which is likely due to people's awareness on the severity of the virus after the shelter-in-place. The shelter in place is effective in not only greatly limiting the amount of coronavirus cases, but also spreading awareness and allowing others to recognize the intensity and importance of social distancing and wearing proper safety equipment to prohibit the spread of the virus.

Conclusion

From our regression analysis across New York, New Jersey, and Illinois, we generally see a drastic uptick in virus cases within days of the lock-down restrictions, possibly due to asymptomatic patients and panic grocery sprees that exacerbated the crisis. However, the case numbers gradually stabilized and became more constant within weeks of lock-down imposition, with the state enacting the toughest, most common sense lockdown experiencing the most decline in virus cases. We found that the timing of the lock-down orders and shelter-in-place restrictions were the most significant regressors on virus cases in states. As time progressed and the case numbers normalized, states gradually enacted reopening plans to bring back aspects of the public life. The data from phase 1 and phase 2 of the re-openings are generally encouraging, as no significant spike in cases was detected upon the ease of lock-down restrictions. We attribute this to a responsive state-government as well as cooperative public that accepts some restrictions on freedom for the common good of their community.

Future Work

COVID-19 is still very much a looming threat in the United States, and, since the publishing of this paper, the daily cases in the US have shown no signs of slowing down. We believe that there is much work to be done on the monitoring and analysis of the virus trajectory in the United States. One possible area for further investigation would be the southern states like Florida, Arizona, and Texas, where state-governments hesitated to take action against the virus and the public is much less cooperative. A comparison of the southern states against the states investigated in this paper should yield interesting results as we compare and contrast the virus data.

Acknowledgements

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Selected References

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