Effects of Social Distancing and Stay at Home Orders on the COVID-19 Growth Rate in the United States

Grant Gambetta and Guangpeng Ren

Introduction

- The COVID-19 pandemic originated in Wuhan, China in December of 2019, and since then, the virus has spread to most countries around the world
- Many countries have experienced more severe pandemics than China has, and the US is one of those countries
- US has the greatest number of COVID-19 cases and deaths out of any country worldwide
- As of May 5, the US had roughly 1.23 million cases and 71,532 deaths
- Number of COVID-19 cases began to increase exponentially in the US in early to mid-March
  - This led to social distancing and stay at home orders being implemented to contain the virus and reduce the amount of exposure people have with it

Background on the Dataset/source

- Since the first case of COVID-19 was discovered in Wuhan in December 2019, the Johns Hopkins University (JHU) Center for Systems Science and Engineering has been conducting extensive collection of COVID-19 data
- JHU acquires the data from a variety of sources, such as the World Health Organization (WHO) and the US Centers for Disease Control and Prevention (CDC)
- Dataset used for this project is a time series that consists of the number of deaths each day since 1/22, in every country that has a confirmed death from COVID-19

Confirmed Deaths vs Confirmed Cases

- Why use the number of confirmed deaths data instead of the number of confirmed cases data?
- The confirmed cases data depends heavily on the availability of testing in each country
- Since countries have had varying levels of testing capabilities, this has led to a lot of uncertainty regarding the actual number of COVID-19 cases
  - Many people could have had COVID-19 without showing any symptoms and have not been tested

Project Overview

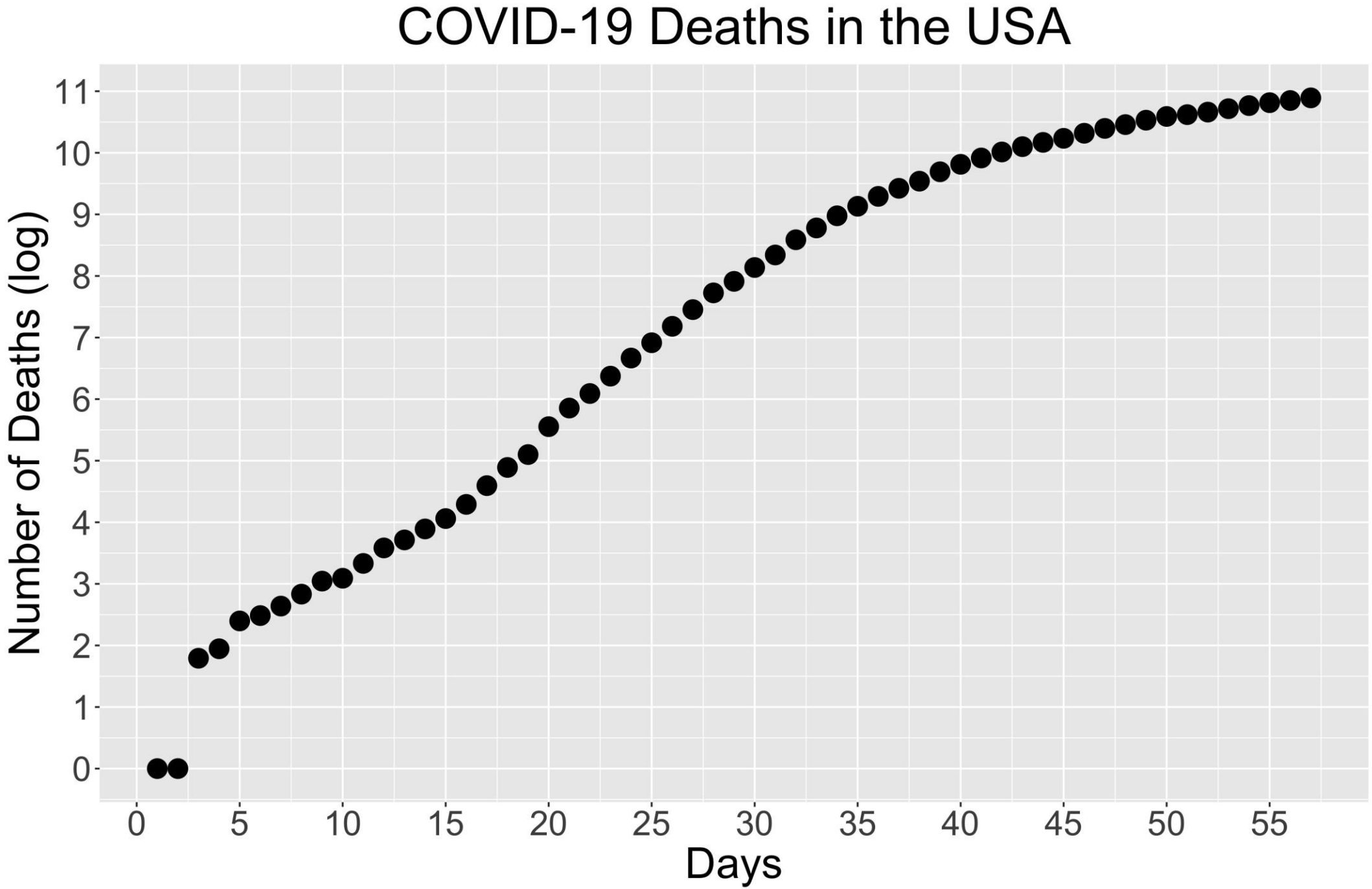
- **Goal:** To determine whether the social distancing and stay at home orders implemented in the US have had a significant effect on the growth rate of COVID-19
- **Null Hypothesis:** The COVID-19 growth rates before and after social distancing and stay at home orders were implemented in the US are not significantly different
  - In other words, the social distancing and stay at home orders have not caused a change in the COVID-19 growth rate in the US

Data Preprocessing and Filtering

- Substantial amount of data manipulation and preprocessing was required to obtain only the relevant data needed for creating the general linear models
- A subset of the original JHU dataset was created that consisted of only US data, and all days with no confirmed deaths were filtered out for simplicity
- US data was observed for the most linear parts before and after the social distancing and stay at home measures were implemented
- A factor variable was added to the filtered US data categorize the data before (days 15 to 30) and after (days 40 onward) the measures were implemented
  - 0 denotes the data from March (before measures were implemented) and 1 denotes the data from April and early May (after measures were implemented)
- Final dataset used in analysis consisted of three columns: days, number of deaths in US on log scale, and group (0 or 1)

Statistical Analysis Overview

- Created two general linear models (GLM), denoted model 1 and model 2
- Applied a log transform to the number of confirmed deaths in the US
- Model 1 was created to analyze the relationship between the number of deaths (dependent) and days 15 to 30 and 40 to 57 (independent), with group as a factor variable
- In model 2, the dependent and factor variables remain the same as model 1, but the independent variable consists of days 15 to 30 and 40 to 65
  - Used to determine if there was a difference in the results from model 1 due to the addition of extra data


COVID-19 Deaths in the USA
Number of Deaths (log)
11
10
9
8
7
6
5
4
3
2
1
0
0
5
10
15
20
25
30
35
40
45
50
55
Days

Results of Model 1

Group 0 is days 15 to 30

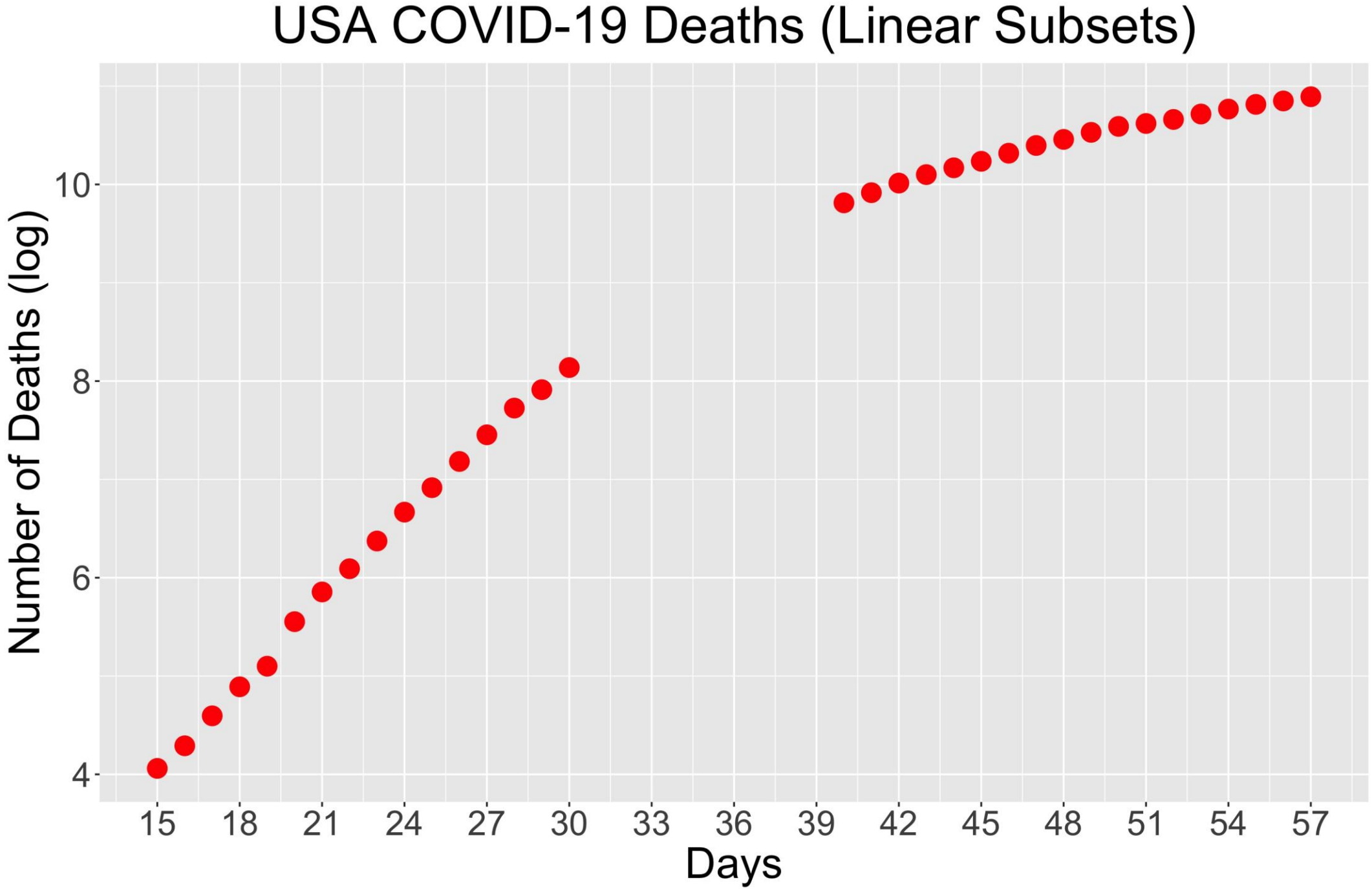
Group 1 is days 40 to 57

Parameter	Estimate	P-Value	95% CI Interval Lower Bound	95% CI Interval Upper Bound
Group 0 (baseline)	-0.1066	0.166	-0.2599	0.0466
Group 0 * Days (baseline)	0.2792	< 2e-16	0.2725	0.2859
Group 1	7.5326	< 2e-16	7.2198	7.8454
Group 1 * Days	-0.2171	< 2e-16	-0.2258	-0.2084

Actual Growth Rate of Group 1 * days = 0.2792 + (-0.2171) = 0.0621

R Squared: 0.9993

$$Y = -0.1066 \cdot Group_0 + 0.2792 \cdot Group_0 \cdot Days + 7.5326 \cdot Group_1 - 0.2171 \cdot Group_1 \cdot Days$$


USA COVID-19 Deaths (Linear Subsets)
Number of Deaths (log)
10
8
6
4
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
Days

Interpretation of Model 1

- Group 0 is days 15 to 30
- Group 1 is days 40 to 57
- Growth rate of COVID-19 before social distancing: 0.2792 (baseline), p-value less than 0.05
- Growth rate of COVID-19 after social distancing: 0.0621, p-value less than 0.05
- P-values are less than 0.05, so we can reject the null hypothesis and conclude there is a difference in the growth rate of COVID-19 before and after social distancing and stay at home orders were implemented

Results of Model 2

Group 0 is days 15 to 30

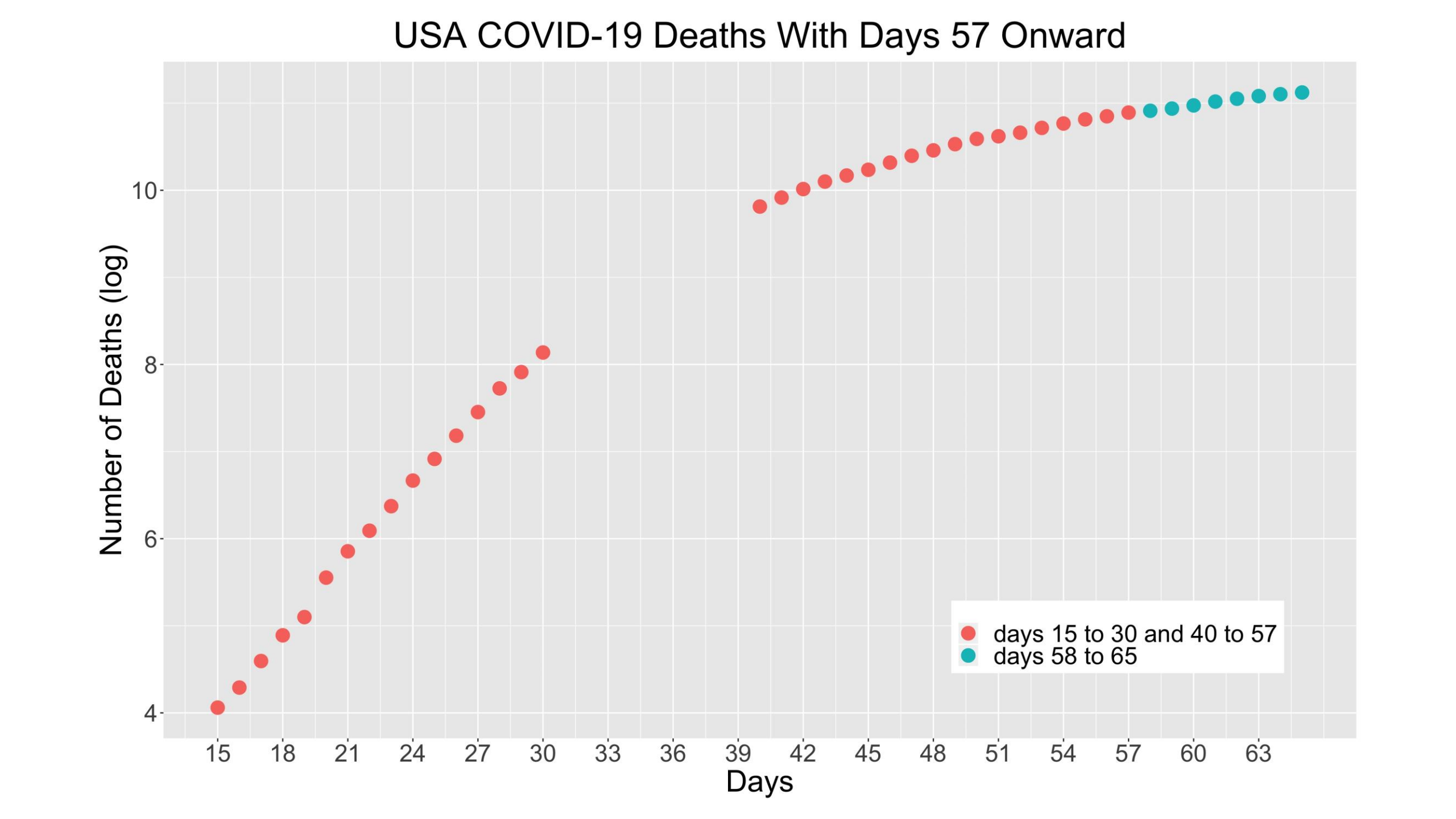
Group 1 is days 40 to 65

Parameter	Estimate	P-Value	95% CI Interval Lower Bound	95% CI Interval Upper Bound
Group 0 (baseline)	-0.1066	0.262	-0.2963	0.0831
Group 0 * Days (baseline)	0.2792	< 2e-16	0.2709	0.2875
Group 1	8.0762	< 2e-16	7.7923	8.3601
Group 1 * Days	-0.2286	< 2e-16	-0.2379	-0.2196

Actual Growth Rate of Group 1 * days = 0.2792 + (-0.2286) = 0.0506

R Squared: 0.999

$$Y = -0.1066 \cdot Group_0 + 0.2792 \cdot Group_0 \cdot Days + 8.0762 \cdot Group_1 - 0.2286 \cdot Group_1 \cdot Days$$


USA COVID-19 Deaths With Days 57 Onward
Number of Deaths (log)
10
8
6
4
15
18
21
24
27
30
33
36
39
42
45
48
51
54
57
60
63
Days
days 15 to 30 and 40 to 57
days 58 to 65

Interpretation of Model 2

- Group 0 is days 15 to 30
- Group 1 is days 40 to 65
- Growth rate of COVID-19 before social distancing: 0.2792 (baseline)
- Growth rate of COVID-19 after social distancing: 0.0506
- 8 days of added data made the growth rate drop 0.0115, about 20% decrease from 0.0621
  - Social distancing and stay at home orders are making a huge difference in the growth rate of COVID-19

Conclusion

- Reject the null hypothesis that social distancing and stay at home orders have no significant effect on the COVID-19 growth rate in the US
- These measures are clearly helping to reduce the number of COVID-19 cases in the US
- Assuming these measures are kept in place, we should expect to see the number of COVID-19 cases begin to decrease in the near future