Projection of Covid-19 Pandemic in the United States

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1 Introduction

Much of the year 2020 has been featured with grief and challenges as the governments and scientists around the world continue to study how to battle the current Covid-19 pandemic and restore citizens' hopes from the enduring health crisis. The outbreak of novel coronavirus that initially began in Wuhan, China, has spread rapidly around the world throughout the first half of 2020, with more than 10 million cases now confirmed in at least 188 countries and territories (Guan et al, 2020; Jazeera, 2020). On January 20, 2020, the Centers for Disease Control and Prevention confirmed the first U.S. coronavirus case in Snohomish County, Washington (Holshue, et al, 2020).

As infections escalate dramatically with sustained transmission, it has become increasingly clear that the public health crisis is affecting the country with profound impacts. The United States declared a national emergency on 13 March as the pandemic had spread to 49 of the country's 50 states (Tanne, 2020). The calculations based on the C.D.C.'s estimation in March suggested that 2.4 million to 21 million people in the U.S. could require hospitalization, potentially crushing the nation's medical system, which has only about 925,000 staffed hospital beds (Fink, 2020). Various forms of mathematical models have also been developed to better understand the global spread and the transmission dynamics of COVID-19 (Röst, 2020; Moghadas, 2020). This paper is going to provide an epidemiological and statistical analysis of the COVID-19 outbreak in America, and use a decomposable graph model to explore possible future scenarios for different demographic characteristics and government responses.

2 Epidemiological Report

Currently, the total positive coronavirus cases in the United States have exceeded 2.5 million with more than 120,000 deaths. The situation is still evolving quickly as some states have experienced sharp increases in newly diagnosed cases since June. The data that this paper primarily employs is collected from [sources].

Several key variables of our compiled dataset can be traced as far back as January 22, the beginning of the outbreak. The pattern of the cumulative incidence of Covid-19 infection and related death are illustrated in a series of figures below. Figure A1 reveals a

steady increase of cases in America until now. In contrast to the federal and state governments' gradual reopen schedules since May, Figure A2 suggests that there is no clear sign that the number of daily increases is getting smaller. The new daily positive cases even show significant surges after June, instead of being effectively contained. It is noticed that the report of daily increase seems to follow a weekly pattern, where from Monday to Friday there are relatively more cases reported, the number often goes down over the weekend, and then goes back up during the next week.

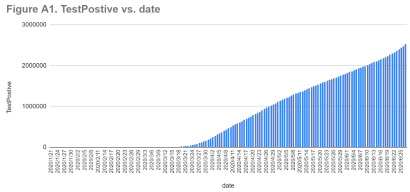

Figure 1: Total Positive Cases v.s. Date

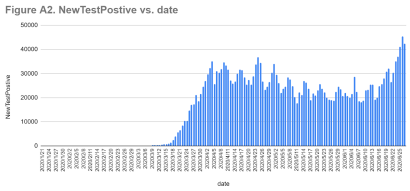

Figure 2: New Positive Cases v.s. Date

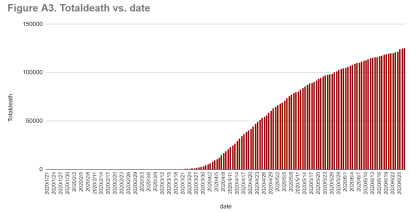

Figure 3: Total Deaths v.s. Date

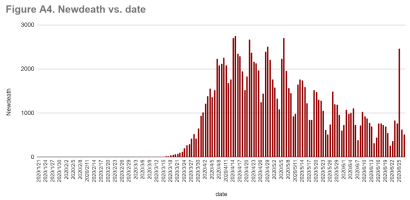

Figure 4: New Deaths v.s. Date

It is widely acknowledged that age plays a vital role in a person's chance of contracting and overcoming the coronavirus. Overall, the middle age group makes up the majority of the infected cases. But it is observed that a higher portion of the deaths are from the older age group (Table 1). Similarly, the crude fatality rate shows an upward trend that is positively related to the patients' ages, suggesting the vulnerability of older age groups.

Age Group	Case Count	Death Count	Mortality (Percentage)
0 - 4 Years	23296	476	2.04
5 - 17 Years	75780	25	0.03
18 - 29 Years	324648	391	0.12
30 - 39 Years	318259	1107	0.35
40 - 49 Years	316698	2742	0.87
50 - 64 Years	472646	13962	2.95
65 - 74 Years	182977	19129	10.45
75 - 84 Years	115278	24095	20.90
85+ Years	97282	29318	30.14
Unknown	2848	53	4.73

Table 1.

3 Transmission Model

$$P(C, A, L, G, I, H, O) = P(C) \cdot P(A) \cdot P(L|C, A) \cdot P(G) \cdot P(I|L, G) \cdot P(H|I) \cdot P(O|H)$$

joint probability is also equal to $\dfrac{P(C) \cdot P(A) \cdot P(C, A, L) \cdot P(I, L, G) \cdot P(H, I) \cdot P(O, H)}{P(C, A) \cdot P(L, G) \cdot P(I) \cdot P(H)}$

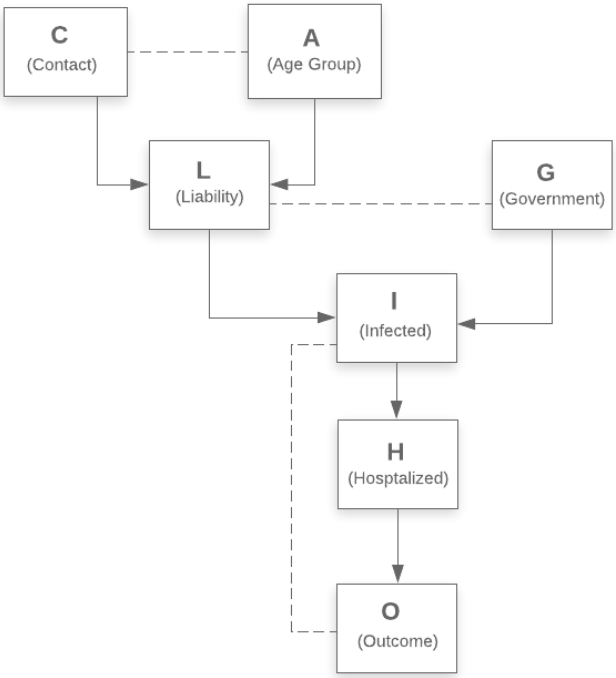

Figure 5: Covid-19 Casual Model

Parameter Specification:
C_1 :Self-isolation, C_2 :Stay with family, C_3 : No Isolation;
A_1 : 0-20 years old (Children), A_2 : 20-40 years old (Young), A_3 : 40-65 years old (Middle), A_4 : Over 65 years old (Old);
L_1 :High liability, L_2 :Low liability;
G_1: Strict Regulation, G_2: Mild Regulation, G_3: No Regulation;
I_1: Severely Infected; I_2: Mildly Infected; I_3: No infection;
H_1: Normally Hospitalized; H_2: Treated in ICU; H_3: Stay Home;
O_1: Recover/healthy; O_2: Dead.

4 Discussion

5 Conclusion

6 Reference

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