COVID-19 in King County, WA Population Dynamics

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DATA 512

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Motivation

1. After numerous surges of COVID-19, the analysis of mitigation strategies such as vaccination efforts and mask usage were of high interest to see how they reduce transmission of COVID-19 within the local community.

2. Create a model with flexibility that can adapt to other scenarios

Problem

1. Looking into more feasible mitigation strategies for COVID-19

2. Identifying large influential factors of COVID-19

Why is this human centered?

- Based on the possible outcomes of the model, this can highly impact the decisions relating to COVID-19 prevention efforts made for the community which ultimately affect the lifestyle of these individuals.
- Furthermore, this can affect decisions and behaviors individuals themselves make for the benefit of their health.
- The model is flexible and the data and computations used are fully transparent.

Methodology

- Utilizing an SVEIR compartment model for disease transmissions[1]

Research Question

1. How does the introduction of vaccines affect behaviors of disease dynamics in King County, WA during the COVID-19 epidemic from February 2020 to October 2021?

2. Does adding a masking proportion rate lower the rate at which individuals become infected?

Hypothesis

1. The introduction of a vaccine with a vaccination level of at least 30% of the population, in a closed system, will decrease the disease death count by at least 2%.

2. Adding a masking proportion of at least 40% of the population will slow the spread of the disease by about 10 days.

[1] Brauer F. Compartmental Models in Epidemiology. Mathematical Epidemiology. 2008;1945:19–79. doi: 10.1007/978-3-540-78911-6_2. PMCID: PMC7122373.

Data & Parameters

Data sources are mainly used to compute these parameters.
(if relevant, data computation was limited to be between Feb. 2020 – Oct. 2021)

John Hopkins University COVID-19 Data
- Infectious rate

New York Times mask compliance survey
- Mask usage proportion

King County COVID-19 Health data (kingcounty.gov) [3]
- Vaccination rate
- Disease Induced Death

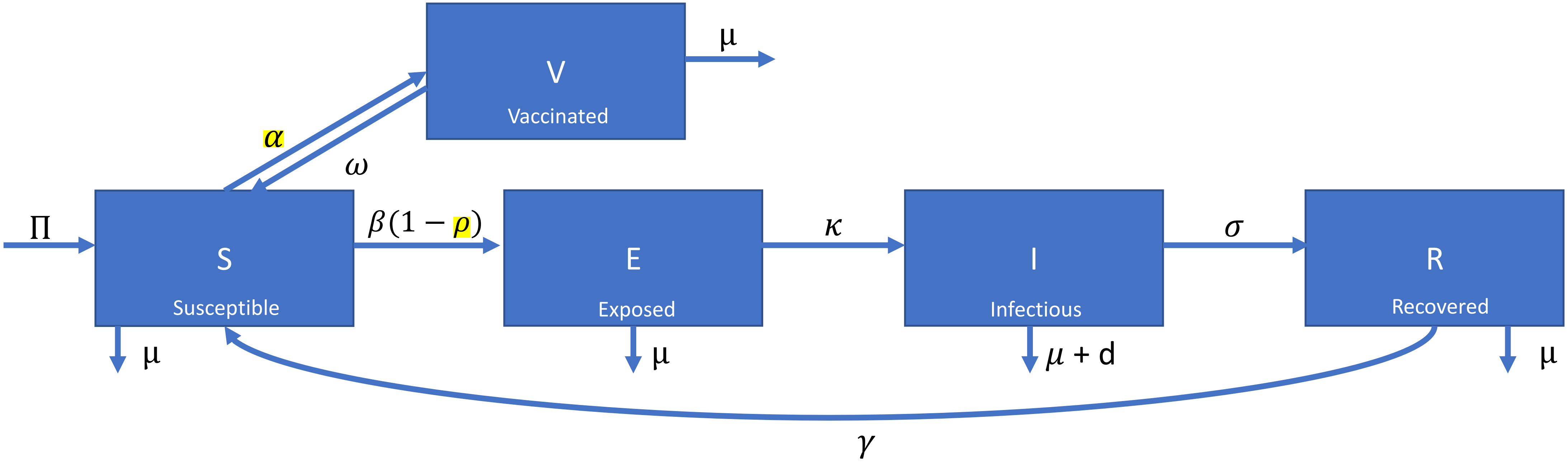
Washington Department of Health [4]
- Birth Rate
- Natural Death Rate
- King County Population value (2019 and 2020)

Centers for Disease Control and Prevention (COVID-19 guidelines) [5]
- Recovery rate
- Loss of Immunity
- Wanning rate of vaccine

Symbol	Parameter	Value
Π	Birth rate [constant value]	66
β	Infectious rate	.0000005785
κ	Incubation rate/period	1/4
σ	Recovery Rate	1/14
γ	Loss of immunity	1/90
d	Disease Induced death	0.0321
α	Vaccination rate	0.00236
ω	Wanning rate of vaccine	1/120
μ	Natural death rate	0.0000165
ρ	Mask usage proportion	0.724

[3] King County COVID-19 publicly available data, https://kingcounty.gov/depts/health/covid-19/data/about-data.aspx, compiled from various sources – open government data
[4] Washington Department of Hleath, https://doh.wa.gov/data-and-statistical-reports/washington-tracking-network-wtn, - open government data
5 Centers for Disease Control and Prevention, https://www.cdc.gov/coronavirus/2019-ncov/index.html,

Compartment Model



Ordinary Differential Equations

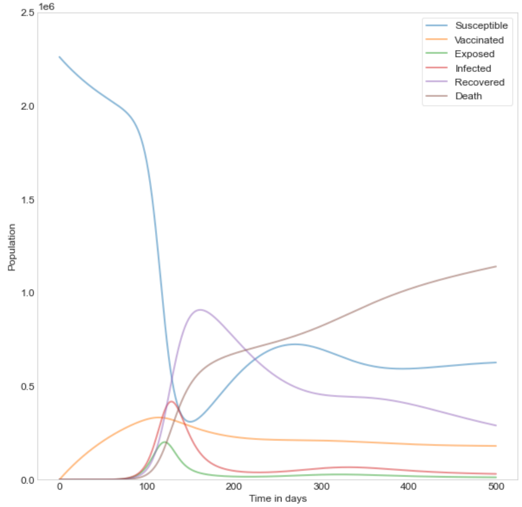
$$\frac{dS}{dt} = \Pi + \omega V + \gamma R - (\mu + \alpha)S \ - \beta(1-\rho)SI$$

$$\frac{dV}{dt} = \alpha S \ - (\omega + \mu)V$$

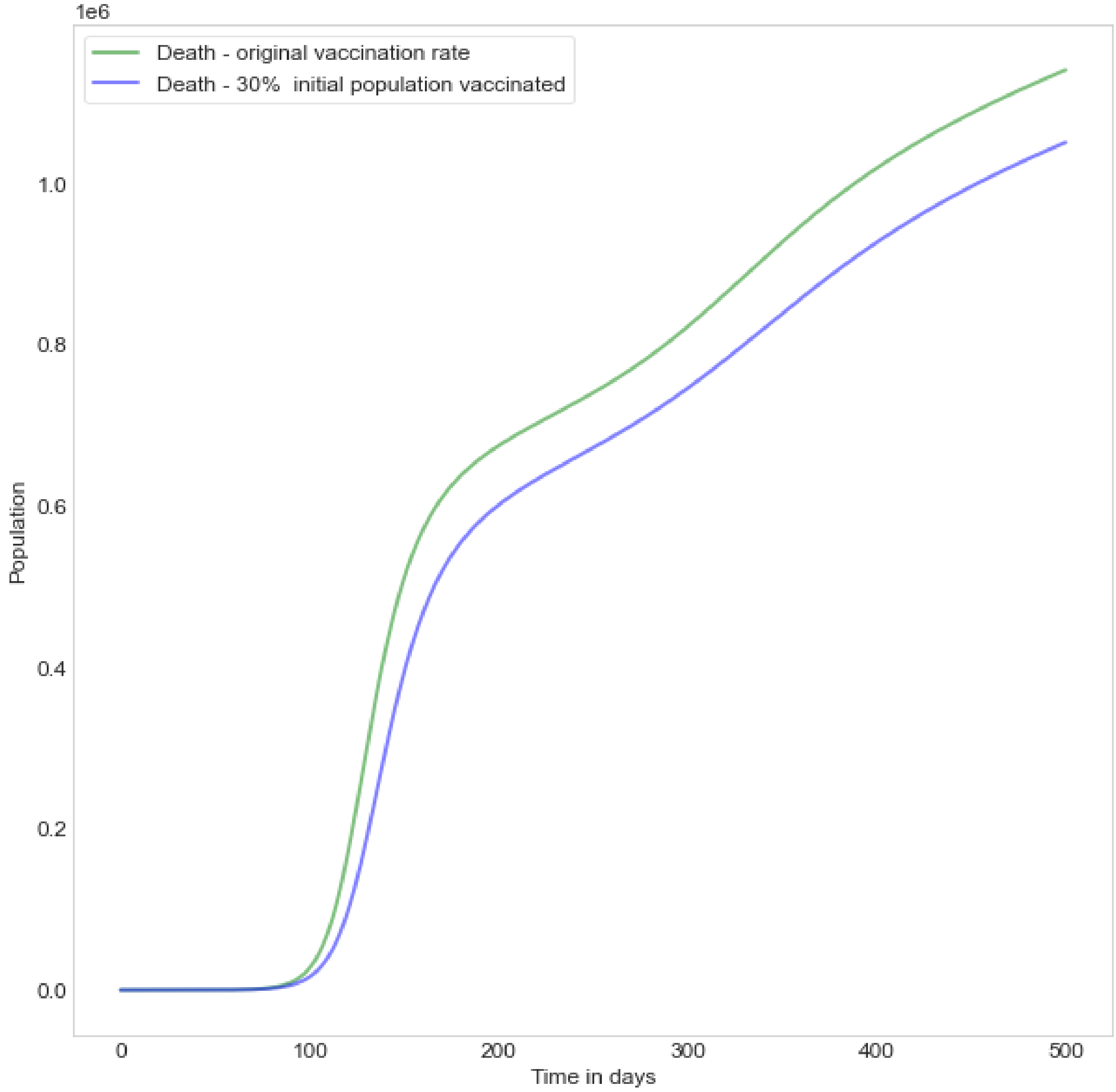
$$\frac{dE}{dt} = \beta(1-\rho)SI \ - \kappa E \ - \mu E$$

$$\frac{dI}{dt} = \kappa E \ - (\sigma + d + \mu)I$$

$$\frac{dR}{dt} = \sigma I \ - (\gamma + \mu)R$$



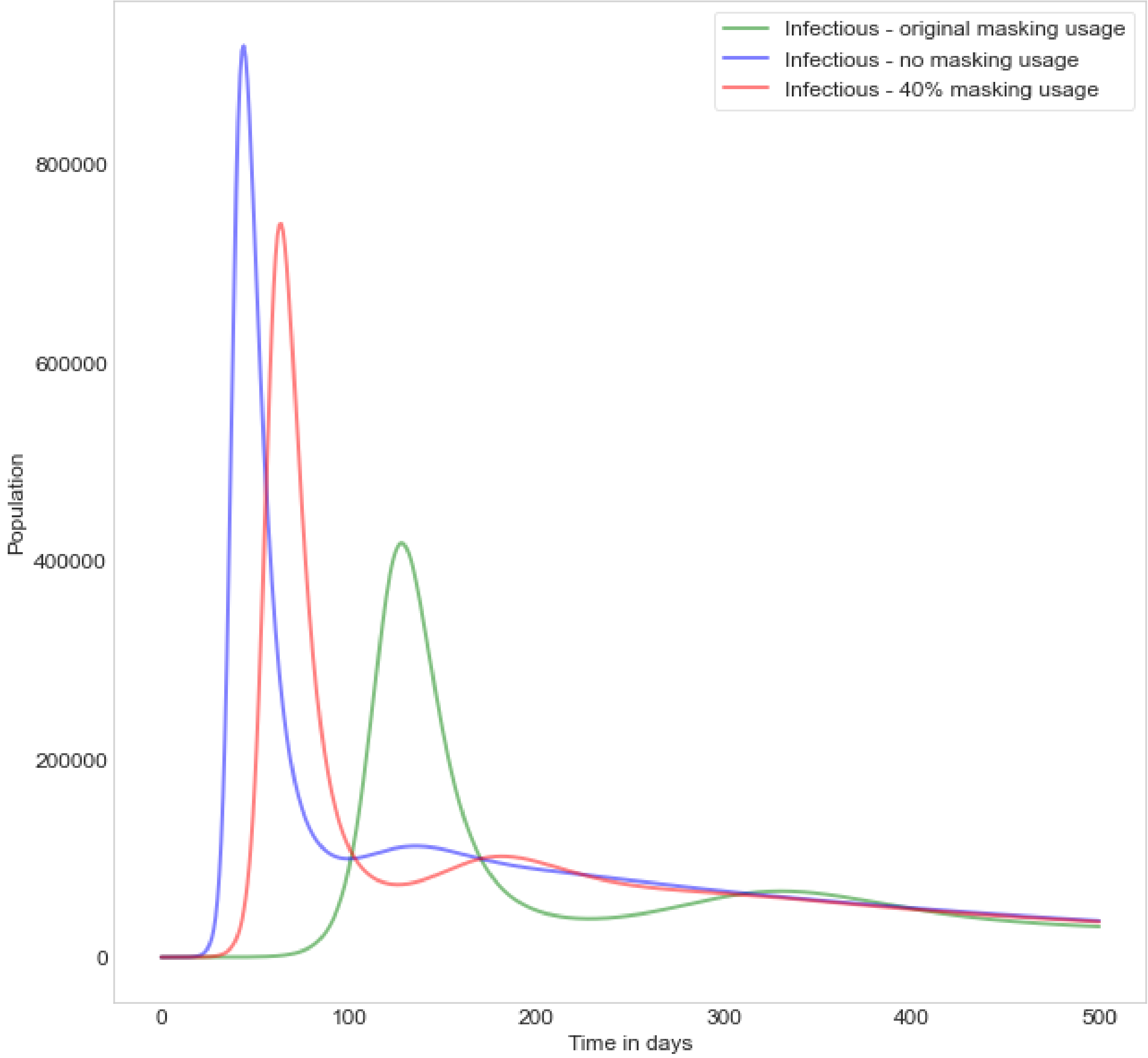
COVID-19 Deaths over time



Original vaccination rate: $\alpha = 0.00236$

Vaccination rate if 30% of population was initially vaccinated: $\alpha = 0.00366$

Infectious Individuals over time



No mask usage: $\rho = 0$

40% mask usage: $\rho = 0.4$

NY Times survey predicted mask usage: $\rho = 0.724$

Discussion/Limitations

This analysis consists of multiple assumptions. First, **we assume that the entire population is susceptible and equally susceptible.** We know that this is not entirely true as COVID-19 behaves differently with different age groups and those with underlying health conditions. We also assume that this is a **closed system and that no other factors play a role into these dynamics**; we certainly know that restriction level and good hygiene practices played an important role in the prevention of COVID-19 at the individual level. In this modeling scenario, we simply only look at the interactions of specific populations and not any other prevention strategy, such as quarantine or education level.

Why do these results matter?

Models like these can estimate the outcomes of COVID like illnesses.

1. The results show how vaccination and mask usage, to include the various levels of vaccination and mask usage, affect the transmission of COVID-19 within the local community.
   a. Compared to other mitigation strategies, vaccinating and masking are more feasible prevention approaches.

2. The results, also, show desired outcomes to a certain extent.

3. The model can be modified and extended further to include several other mitigation strategies (such as quarantine) and influence decision making to incorporate what would be the best, optimal solution.
   a. Application of Game Theory

References

- Brauer F. Compartmental Models in Epidemiology. Mathematical Epidemiology. 2008;1945:19–79. doi: 10.1007/978-3-540-78911-6_2. PMCID: PMC7122373.

- King County COVID-19 publicly available data, https://kingcounty.gov/depts/health/covid-19/data/about-data.aspx

- Washington Department of Hleath, https://doh.wa.gov/data-and-statistical-reports/washington-tracking-network-wtn

- Centers for Disease Control and Prevention, https://www.cdc.gov/coronavirus/2019-ncov/index.html

- John Hopkins University COVID-19 data, https://www.kaggle.com/datasets/antgoldbloom/covid19-data-from-john-hopkins-university

- New York Times mask compliance survey, https://github.com/nytimes/covid-19-data/tree/master/mask-use