CovidML – an operational tool to moderate the pace of the COVID-19 epidemic

Team Alpha

1 INTRODUCTION

During the COVID-19 pandemic, varied strategies have been adopted from lockdown, to social distancing, to herd immunity. Policymakers face difficult choices, as the extent of mobility restraint may save or cost thousands of lives. In almost all reopening plans, it is critical to provide continuous and accurate estimates of infection cases and health system demand. This is a problem not only of data collection but also predictive analytics. While most reopening plans consider extensive testing and monitoring of population mobility, there is a scarcity in controls that dynamically moderate the feedback loop (Figure 1). The feedback loop could help adjust the level of mobility restraint given the continuously evolving health system capacity and virus activity.

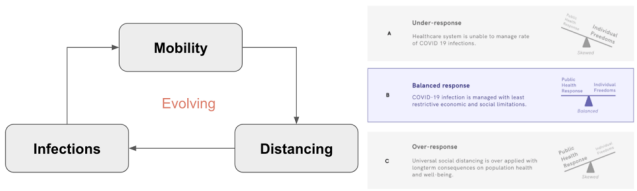

Figure 1: Dynamic feedback cycle of COVID-19 pandemic.

2 PROBLEM DESCRIPTION

The core problem is quantifying the impact of mobility change on the number of COVID-19 hospitalization to provide informed suggestions of safe degrees of mobility. We are aiming to build a model that forecasts whether the anticipated infection prevalence in each state will overload local health systems given multi-department mobility indexes. Coupling tolerable transmission estimates with daily assessments of mobility and testing statistics could help regulate phases of transmission, and alert the need of suppression measures in time.

3 BROAD APPROACH

We aim to develop a dynamic approach of data collection, analysis, and forecasting to inform policy decisions in real time and deliver public health recommendations for re-opening given measurements of mobility and virus activity to avoid unmanageable hospital surges (Figure 2). Aspects like time lags and sensitivity need to be addressed before such data can be used reliably. With reliable tracking and benchmarking in place, we can calculate infection prevalence, daily growth and transmission rates, which is essential for determining if the mobility level is desired.

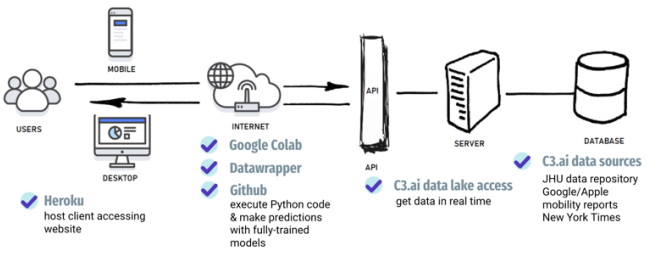

Figure 2: CovidML workflow

4 TECHNICAL DETAILS OF APPROACH

Maintaining adequate hospital capacity while simultaneously allowing freedoms can be a balancing act. Delays are inevitable even with perfect reporting. For example, new cases today may be infected over a week ago, which depends on social distancing interventions from days earlier. We derived these delays empirically from the lag correlation analysis, and established a set of proxy measures such as test positivity rates, fatalities, etc that are indicative early in the process.

Our prediction targets are daily COVID incidence in the US. To understand the relationships between limited mobility and the spread of COVID-19, we analyzed

the mobility changes between March and October (Figure 3). Ongoing mobility tracking can identify potential spikes of transmission rates. As we are interested in measuring the actual changes in the rate of the spread, we employed one of the most popular endemic models, the SIR model. Besides looking at the case and fatality data, we investigated the relationship between the parameter changes of the SIR model and the changes in mobility indexes.

Operationally, we used daily mobility data to capture real-time trends in movement patterns for each US state, and used these data to generate a social distancing metric. We used epidemiological data to compute the COVID-19 growth rate ratio for a given state on a given day (Figure 4). Using these metrics, we evaluated how social distancing, measured by the relative change in mobility, affected the rate of new infections and excess mortality in the US by fitting a statistical model for each state.

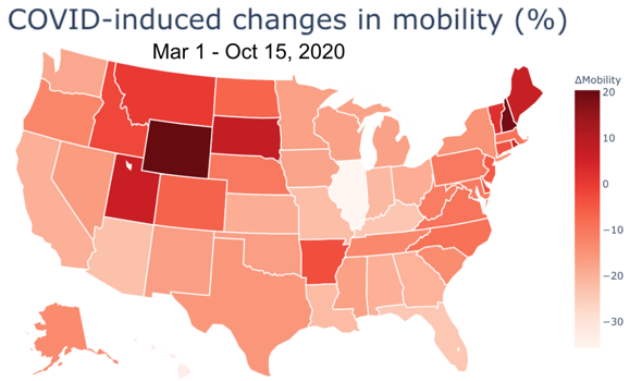

Figure 3: Percent changes of Google mobility index from Mar 1 to Oct 15, 2020 across the US.

5 RESULTS

We found that human mobility explains the early spread of COVID-19, and mobility patterns are strongly correlated with decreased COVID-19 case growth rates for the most affected states in the USA. As activity trends in the US increased, COVID-19 cases grew (Figure 5). Reduction in public transport usage was obvious before June. After easing of the measures, previous levels of mobility were reached again for over half of the 50 states. Excess deaths actually due to coronavirus are affected by demographics, their health condition, the availability of ICU units and healthcare system, all of which generally vary across regions.

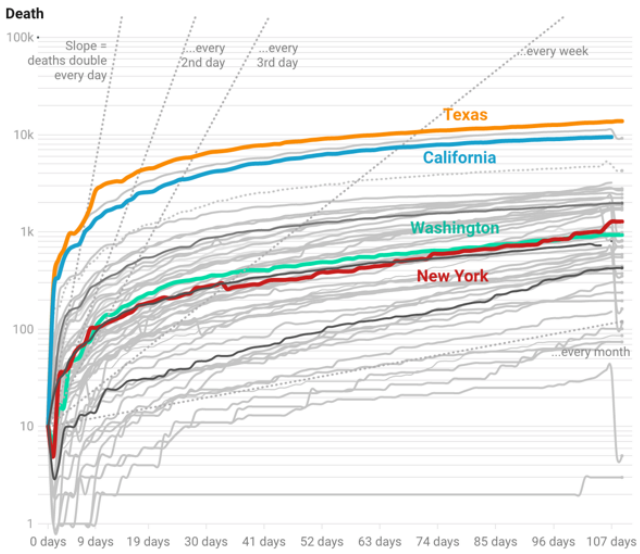

Figure 4: Latest trend of daily new COVID-19 deaths.

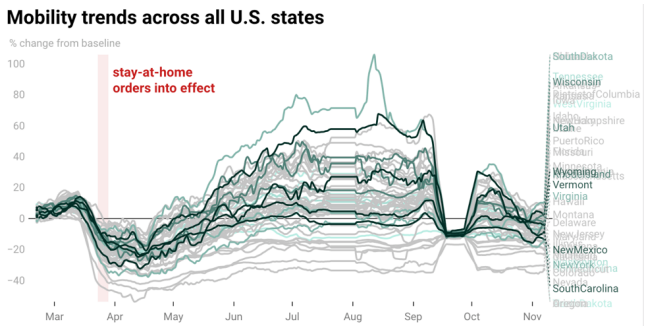

Figure 5: Time series of mobility indexes across all US states.

6 IMPACT

The timing of implementing and easing social distancing greatly affects the number of COVID-19 cases. CovidML is designed to leave valuable lead time for policymakers and citizens to plan interventions and optimize decisions by forecasting the emerging pandemic in real time in a data-driven manner leveraging rich heterogeneous data signals including mobility. Continuously analyzing current mobility as well as infections and projected health system capacity can allow us to set up an early warning system that intelligently balance public health and economic needs.