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COVID-19 Active Case Algorithm

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General Background

Since March 30, 2020, the State of Vermont has required a 14-day self-quarantine for anyone traveling into the state in response to the COVID-19 pandemic. Effective June 8, 2020, the State of Vermont lifted the 14-day quarantine for personal auto travel to and from counties in New England and New York that have fewer than 400 active COVID-19 cases per million. Effective July 1, 2020, Vermont expanded this policy to counties in New Jersey, Pennsylvania, Maryland, Delaware, Ohio, Virginia, West Virginia, and Washington D.C. The Vermont Department of Health has determined there is a sufficiently low risk of transmission in those counties with fewer than 400 active COVID-19 cases per million to allow for safe cross-state travel between these regions.

Vermont has long prided itself on its openness and hospitality. Due to current conditions, a 14-day quarantine on some travelers is necessary to ensure the health and safety of all those living in and visiting the Green Mountain State. Vermont is open to all—the State asks only that those advised to quarantine do their part to protect themselves and others.

About the Map

The dynamic case map displayed on the Vermont Department of Financial Regulation and the Vermont Agency of Commerce and Community Development websites allows anyone to determine the current travel status of any county in the applicable travel area under Governor Phil Scott's current self-quarantine regulations. The most recent infection data is pulled once a week from Johns Hopkins University's ("Johns Hopkins") COVID-19 GitHub repository and the New York Department of Health's website, then put through a viral load algorithm to assess an estimated number of active cases per million for gauging relative risk of interstate travel. Travelers from counties colored green are exempt from the 14-day self-quarantine, while those from counties colored in yellow and red must continue to abide by the restrictions. Vermont is colored blue as the travel policy does not apply to Vermont counties. Reopening in Vermont is instead monitored by the following metrics: 1) syndromic surveillance, 2) case growth, 3) percentage of positive tests, and 4) hospital resource capacity. The python script used to run the active case algorithm and create the travel map is available here.

About the Algorithm

The Department of Financial Regulation determines which counties are above or below the 400 active cases threshold by using daily confirmed case data at the county level from Johns

Hopkins and then applying an estimated viral load algorithm. Updates are released weekly, and travel guidance is considered current until the next update.

Current research has determined that individuals are most infectious around their symptom onset date, and that their infectiousness begins to decrease within a few days after onset. Since the main concern is preventing new infections in Vermont, recently detected cases must be weighted more heavily than older cases. As such, a county with an outbreak yesterday would be deemed a greater risk to Vermonters than a county which has not had any new confirmed cases for over a week, even if they report the same number of total confirmed cases over a similar period of time.

Developing the Algorithm

In order to model how infectious someone is after a given time, the modeling team consulted a list of known transmissions between two individuals provided by the Vermont Department of Health. By looking at the time from the infector's initial symptoms to infectee's initial symptoms, it is possible to determine how long it took to pass on the virus. Consulting many "infector-infectee pairs" allows for a measure of how likely the infection is to spread at any given point. (Note: this frequency distribution is commonly known as a serial-interval distribution and is useful for calculating the effective reproduction number, or R_t, of an epidemic.)

A COVID-positive person's infectiousness over time most closely fits a gamma statistical distribution, reflecting that patients first undergo a short period of high infectiousness followed by a longer period of much lower infectiousness. Running each case along this distribution determines how infectious the patient is. A patient who tested positive 14 days ago, for example, is less than one sixth as infectious as a patient who tests positive today. While most active infection models and travel advisories would count these two cases as equal, ours can distinguish between patients that pose a significant threat to Vermonters and those that have already passed their most infectious period.[1]

After weighing each case based on the date that case is reported, our model adds them together. This number is combined with census data to determine "weighted active cases per million." The model now has the correct distribution and relative values for county infection levels but needs to be normalized to bring total values into line with known metrics. To achieve this, the algorithm multiplies its outputs by a scale factor α that has been calculated based on Vermont's epidemiological data. This returns the final value of "normalized active cases per million" in a county. It is this final number that is compared to the 400 cases per million

[1] The model uses the dates of positive diagnoses as a proxy for severity of infectiousness in aggregate. While this introduces delay between the infection of an individual and their inclusion in the calculations, such delays are assumed to be uniform and evenly distributed across the travel region. This conservative approach aims to assess relative risk rather than determine the exact number of active cases or compare individual cases, using the infections reported in each county as a proxy for current trends.

threshold. The process is then repeated for all counties in the travel region. The complete equation for active cases per million in a county is as follows:

$$Estimated\ Active\ Cases\ per\ Million = \frac{\alpha * 10^6}{P} * \sum_{x=1}^{30} \left(\left(1 - \frac{1}{\Gamma(k)} * \gamma\left(k, \frac{x}{\theta}\right) \right) * I_x \right)$$

Where I_x represents new infections x days ago as measured by the Johns Hopkins epidemiology team, P is the population of the county, k and θ are the shape and scale parameters of the gamma distribution, and α is the scale factor. The current values for these variables are $k = 1.3134$, $\theta = 6.1519$, and $\alpha = 2.4$. Variables are subject to change based on new data in order to ensure the most accurate possible estimation.

What this Map Isn't Intended to Do

As this algorithm and map are designed for the sole purpose of monitoring regional travel requirements and assessing relative risk of counties, viewers should keep a few things in mind. The map does not provide live information—updates are released weekly. Since active case counts are adjusted for population, this map also does not provide the number of total or active cases in any county.[2] The map may disagree with data put out by municipal governments due to varying definitions of "active case" or differences in reporting timeframes. Our data is drawn from Johns Hopkins University, an internationally trusted resource, to ensure that data for all counties is obtained from a single source at a single point in time. The one exception to this practice involves the five counties comprising the New York City metro area as Johns Hopkins reports combined data for these counties. We instead pull data from the New York Department of Health, which reports new daily cases for each of the five New York City counties.

Johns Hopkins occasionally differs from individual county level data—this can happen for several reasons. Many municipal governments keep records that differ from official state totals, due either to a lack of communication or breakdown in data entry. In these cases, state totals are most often preferred. There have also been several instances of states recategorizing the location of a group of infections (e.g., when a group from one county tests positive in another county). These retroactive modifications to the data can cause county totals to rise or fall suddenly when compared to previous values. Such adjustments have been observed throughout the travel region for as long as the travel map has been operational and are considered an unavoidable source of error when attempting to create a real time reflection of the pandemic's impact. In such instances when data reporting errors are detected, the modeling team will refresh the travel map as soon as possible to remedy the incongruity.

[2] The mouseover data for the map provides both the estimated active cases per million and the percent change in this value from last week. Counties with no active cases last week have undefined percent changes, and are reported as "N/A" accordingly. A disclaimer is included on percentages calculated off of fewer than 25 unnormalized cases (the average size of an outbreak in Vermont), since these low raw case counts are prone to much higher relative variability from week to week.

As Vermont's understanding of COVID-19 further develops and the State continues to collaborate with its regional and federal partners, the above methodology may be changed to better assess the risk associated with interstate travel. Any changes will be reported in the most recent version of this methodology paper hosted on the DFR website.

Please direct all questions to dfr.pubinfo@vermont.gov.