COVID-19 Dashboard: Tracking the Regional Pandemic Trend

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ABSTRACT

The global coronavirus disease 2019 (COVID-19) outbreak has significantly impacted life since December 2019. To better monitor the changes associated with the COVID-19 pandemic, we developed an open-source visual analytics system to track the latest changes in the pandemic and keep the dataset updated daily.

Keywords: COVID-19, dashboard, visualization.

Index Terms: Human-centered computing - Visualization - Visualization application domains - Visual analytics

1 INTRODUCTION

The fast spread of Coronavirus Disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has led to a worldwide pandemic and health crisis since December 2019 [1]. To facilitate the COVID-19 data analysis, many visual dashboards have been developed to help the public and researchers to analyze the pandemic [2-4].

Due to the rapid evolution of the COVID-19 pandemic, the needs for data analysis are however continuously changing over time. Existing dashboards are designed for more complex analytical needs. It is therefore challenging for casual users to easily interpret such dashboards, particularly in terms of determining the overall trend and course of the pandemic from a multivariate perspective. Moreover, as regional factors influencing the rate of spread of the disease becomes ever more complex, particularly in the form of implementation of various public health restrictions and policies such as physical distancing, facial masking, and vaccination, there is a need for exploring and comparing how the COVID-19 outbreak evolves in different regions.

To address these challenges, we therefore propose to use visual analytic methods to explore these regional trends for the COVID-19 pandemic. The major contribution of this work is a visual analytics system (https://github.com/OHNLP/covid19tracking) based on new indicators and trend chart design, which has been released publicly and updated daily.

2 TASK ANALYSIS

We developed a dashboard for COVID-19 community surveillance operating in early 2020 and have been using this dashboard to continuously track the epidemic for our internal usage. Based on feedback from our clinicians and researchers, we continue to improve the functions and visual designs as needed to address evolving information needs, which include: 1) What's the geographic distribution of the pandemic? and 2) How does the regional pandemic change over time?

Based on these three tasks and the experience gained in developing the prototype dashboard, we identified the following design requirements: 1) exploration at varying levels of geographic granularity; 2) temporal trend exploration; 3) regional comparison; and 4) interactive exploration.

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3 DATA ABSTRACTION

As the COVID-19 pandemic spreads and the situation evolves, data, such as laboratory testing and vaccination statistics, is generated continuously. These data sources typically update daily; we therefore built an autonomous computational extraction and data transformation pipeline to reduce repetitive manual work. Our pipeline currently runs on the following data sources: (1) COVID Act Now, which provides the numbers on tests and hospitalizations from US states and territories; (2) NIH NIEHS COVID-19 data repository for pandemic vulnerability index; (3) Our World in Data for global vaccination information; and (4) Johns Hopkins Coronavirus Resource Center for international cases and deaths.

3.1 Metrics

In addition to those metrics directly collected from data sources, such as the cumulative cases, mortality rate, and positive rate, we proposed using case doubling time (CDT) to capture short-term trends. As the epidemic situation changes over time, we added a 7-day smoothed case rate per 100k capita (Cr7d100k), Cr7d100k ratio (RW_Cr7d100k), and case rate + case ratio (CrRW) status, which we define as follows:

CDT. This metric measures the number of days taken for the number of coronavirus cases to double. The CDT values for any given day are calculated based on that day's data as compared to the data of four days ago to provide more reliable estimation. The formula is as follows:

$$CDT_{day} = 4 \times \frac{\log(2)}{\log\left((N_{cases\ day} + 0.5)/N_{cases\ days-4\ days}\right)}$$

Cr7d100k. This indicator measures the increase in new cases in the last seven days and reflects the short-term regional trend of the COVID-19 pandemic. Cr7d100k is calculated based on the daily new cases for the last seven days, which reduces the impact of the frequency of data updates. The $Cr7d100k_d$ of a given day d is calculated as follows:

$$Cr7d100k_d = \frac{1}{7} \times \frac{100{,}000}{Population_{region}} \times \sum_{i=d-7}^{d} n_i$$

In the above equation, n_i is the number of new confirmed cases in a specific region on day i. Based on Cr7d100k, we propose using the ratio of two Cr7d100k from two adjacent weeks to measure the trend of COVID-19 in recent two weeks, namely RW Cr7d100k.

CrRW status. By combining Cr7d100k and RW Cr7d100k, we define the CrRW status of a region to represent the current epidemic status of the pandemic as well as recent trends with the following thresholds:

GREEN status: if Cr7d100k<15 and RW_Cr7d100k<1 for the past seven days, we consider current outlook based on trends to be positive and suggests successful management of the virus

RED status: is indicated by two-criteria. First, if Cr7d100k > 30 for the past seven days, the rate of case growth is considered extremely serious thus indicated as red. Second, if Cr7d100k > 15 and RW_Cr7d100k > 1.1 for the past seven days, suggesting that the current region may need stricter management and / or that the regional trend is concerning.

ORANGE status: covers all other cases as it tends to be an unstable transition period in either direction between green and red.

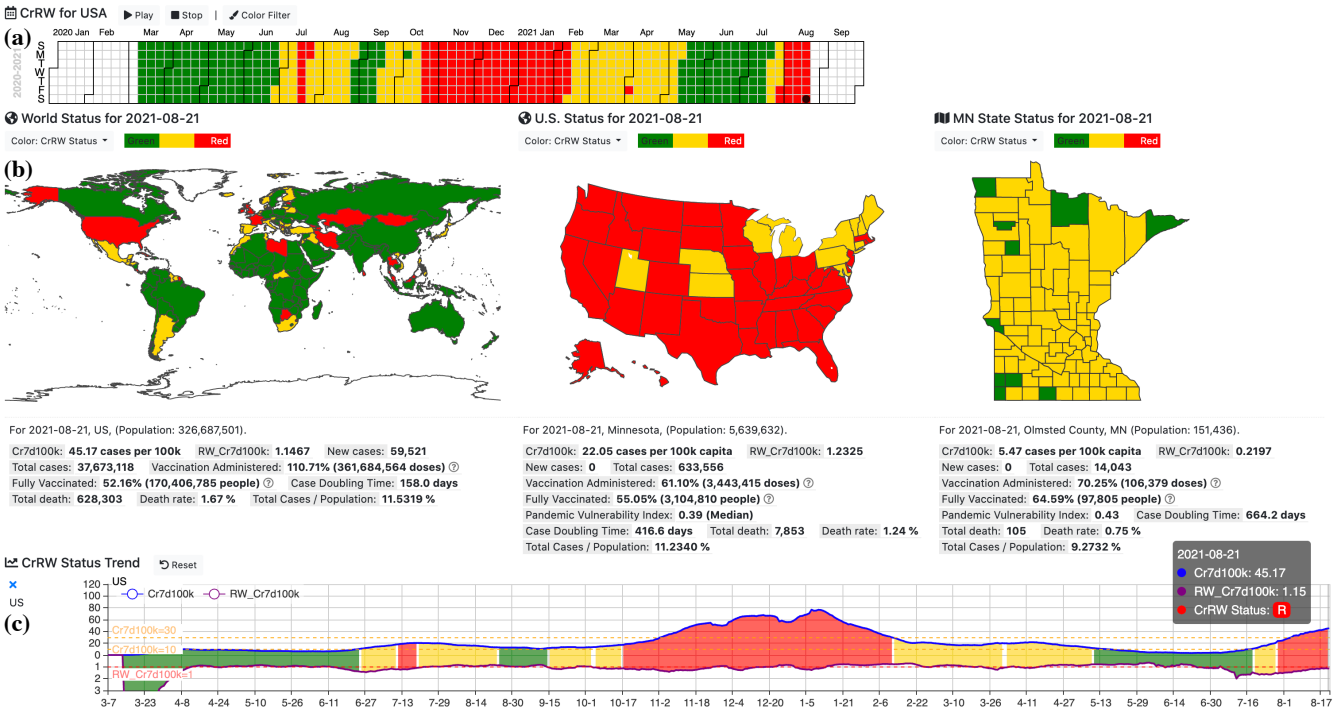

Figure 1: A demonstration of the COVID-19 dashboard showing: (a) the calendar heatmap, (b) the maps showing the multi-scale geographical distribution of the pandemic; and (c) a trend view depicting the overall trend of the pandemic within the selected regions at a county level.

4 Visualization Design

There are two coordinated views for exploring the COVID-19 pandemic situation: the map view and the trend view.

The map view combines a calendar heatmap (Fig. 1(a)) and three choropleth maps (Fig. 1(b)) to visualize temporal and geographical trends. In the calendar heatmap, each date cell is color-coded using the CrRW status. When clicking the date cell, the maps will update according to the date. The three maps are color-coded by the user-selected indicator at varying geographic granularities to simultaneously show the pandemic in different regions. The map is linked with the trend view for interactive exploration. When clicking on a region, the corresponding regional trend chart will be added in the trend view.

The trend view shows the long-term trend of the pandemic for selected regions (Fig. 1(c)). Each trend chart shows the daily values of 3 indicators over a period: Cr7d100k, RW Cr7d100k, and CrRW status. The Cr7d100k is shown as a solid blue line in the upper, while the RW Cr7d100k is the solid purple line in the lower. The area between two lines is color-filled according to the CrRW status on each day. The two lines form a band, whose height represents the general situation and severity of the pandemic. When hovering any trend chart, the details on that date will appear in all trend charts for comparison.

5 Discussion

As the COVID-19 pandemic spreads, we continuously evaluated the visual designs and the effectiveness of our dashboard. Our users check this dashboard daily and use the results in our internal processes for decision making. We collected and summarized their comments as follows.

First, it is important to select appropriate indicators and thresholds to describe the pandemic correctly. The CDT is sensitive to regional changes in the pandemic at an early stage, but as the number of confirmed cases increases, it is not sensitive to the same number of new cases as before. Therefore, when the number of confirmed cases is large, Cr7d100k and RW_Cr7d100k perform better for showing the short-term changes, and the CDT can instead be used as a secondary reference.

Second, as the COVID-19 situation changes, the concerns of users are also changing, and the system need to be adapted to the changes. For example, since Jan 2021, vaccines have gradually been distributed. We found that the coverage of vaccines is of concern to users and combining the coverage of vaccines can be helpful in making policies. Therefore, two indicators related to vaccines were added according to the needs of the analysis.

6 Conclusion and Future Works

In this work, we present a visualization system to track the COVID-19 pandemic from a variety of geographical granularities and perspectives. Although the outbreak has been significantly controlled by the non-pharmacological interventions and large-scale vaccination, it is not yet completely over. New variants appear to spread more easily and might reduce the effectiveness of the antibodies generated by a COVID-19 vaccine or lead to an increased risk of hospitalization and death. Further research is needed, and we will keep our system updated.

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