Interactive dashboard to monitor the COVID-19 outbreak and Vaccine Administration

Thiyanga S. Talagala[1]

Department of Statistics, Faculty of Applied Sciences

University of Sri Jayewardenepura, Sri Lanka, CO 10230

Randi Shashikala

Department of Statistics, Faculty of Applied Sciences

University of Sri Jayewardenepura, Sri Lanka, CO 10230

Abstract

As of September 20th, 2021, 221 countries and territories are infected by the COVID-19 worldwide pandemic. Dashboards are the most often used visualization method for visualizing COVID-19 data and informing the public. We explored 15 different dashboards.

Keywords: Visualization, multiple time series, heatmap, COVID-19 vaccine, flexdashboard

1 Introduction

COVID-19 has expanded over the globe, having a significant impact on our daily lives and work. Early responses and timely decisions and actions are critical to saving communities and economy worldwide. Data is essential in order to make effective decisions. Data-driven information guides the decision-making process and also evaluates the effectiveness of strategies taken.

Massive amounts of data are being generated in the response to the COVID-19 pandemic. Given this available data, it is critical to create tools for exploratory analysis for policymakers, health officials, and the general public. Dashboards are one of the greatest visual interpretation methods for tracking the COVID-19 pandemic's spread and vaccine administration. Dashboards allow users to quickly interact with a combination of exploratory visualizations and gain a quick overview of the data. This paper describes the development and implementation of a dashboard for the COVID-19 outbreak and vaccine administration data in Sri Lanka.

There are a plethora of COVID-19 visualization dashboards that have been designed to visualize the pandemic's global and local status. Different software can be used to generate dashboards. We explored 15 dashboards designed to visualize COVID-19 data at the global and country levels. First, dashboards were compared to identify the various features, visualization approaches, and enhancements that should be implemented. Next, we developed an interactive dashboard to visualize the COVID-19 outbreak and vaccination information in Sri Lanka. This dashboard provides front-line health officers a situational awareness of the spread of COVID-19 and status of the vaccination program.

The rest of the paper is organized as follows: Section 2 of dashboards created using data related to the COVID-19 pandemic. Section 3 presents the methodology and basic design concept; Section 4 presents the results; and Section 5 concludes.

[1]Corresponding author, email: ttalagala@gmail.com

2 Literature Review

Dashboards are one of the best visual interpretation methods for tracking the spread and communication of the COVID-19 pandemic. The 15 dashboards we used in the literature survey are listed in Table 1. We compared dashboards to identify data types, plotting techniques, colour themes, and other features such as interactivity on plots and panel numbers.

Table 01: Labeled of the Dashboards

No	Name of the Dashboard	Reference
1	COVID-19 dashboard created by the John Hopkins University Center for Systems Science & Engineering (JHU CSSE)	"COVID-19 Map – Johns Hopkins Coronavirus Resource Center" (2022)
2	WHO COVID-19 Dashboard	"WHO Coronavirus (COVID-19) Dashboard" (2021)
3	COVID-19 surveillance dashboard created by the University of Virginia	"COVID-19 Surveillance Dashboard – NSSAC Research" (2022)
4	Corona cases (COVID-19) per municipality in Belgium dashboard	"COVID 19 Dashboard – Belgium" (2022)
5	COVID-19 dashboard for England created by NHS providers	"COVID 19 Dashboard – NHS providers" (2022)
6	NZ COVID-19 Dashboard	"New Zealand COVID-19 Surveillance Dashboard" (2021)
7	Pakistan's official COVID-19 dashboard	"Pakistan's Official COVID-19 Dashboard – Shifa International Hospitals Ltd" (2021)
8	COVID-19 Canada live dashboard	"Track COVID-19 Across Canada Using Our Interactive Dashboards" (2021)
9	India (COVID-19) Dashboard	"COVID 19 Dashboard India – ZOHO Analytics – ZOHO" (2022)
10	Italy COVID-19 dashboard	"COVID-19 integrated surveillance data in Italy – EpiCentro" (2022)

No	Name of the Dashboard	Reference
11	Jamaica COVID-19 Dashboard	"COVID-19 Jamaica - Ministry of Health and Wellness" (2021)
12	GCI COVID-19 dashboard for Russia	"The Global COVId-19 Index (GCI) – Russia Dashboard – PEMANDU Associates" (2021)
13	COVID-19 live situation analysis dashboard of Sri Lanka	"COVID-19: Live situational Analysis Dashboard of Sri Lanka" (2022)
14	COVID 19 ZA South Africa Dashboard	"COVID-19 ZA Dashboard - Data Studio" (2021)
15	COVID-19 dashboard for Germany	"RKI COVID-19 Germany – ArcGIS Experience" (2021)

Table 02 summarizes the data types that are most frequently shown in dashboards. As shown in Table 02, all dashboards which are considered in this paper represent the data related to COVID-19 confirmed cases, recovered cases, and deaths. There were 8 dashboards out of 15 dashboards that contained vaccination details.

Table 02: Summary of data represent in the dashboards

Name of the Dashboard	Location (Represented)	Confirmed Cases	Recovered Cases	Deaths	Vaccination Details	Tests	Global Comparison
1	Global	✓	✓	✓	✓		✓
2	Global	✓	✓	✓	✓		✓
3	Global	✓	✓	✓		✓	
4	Belgium	✓	✓	✓			
5	England	✓	✓	✓	✓		
6	New Zealand	✓	✓	✓			✓
7	Pakistan	✓	✓	✓		✓	
8	Canada	✓	✓	✓			
9	India	✓	✓	✓	✓		✓
10	Italy	✓	✓	✓		✓	
11	Jamaica	✓	✓	✓	✓		
12	Russia	✓	✓	✓			
13	Sri Lanka	✓	✓	✓		✓	✓
14	South Africa	✓	✓	✓	✓	✓	
15	German	✓	✓	✓	✓		

Table 03 summarizes the visualization methods used in the dashboards. In almost every dashboard, value boxes have been used to represent these total figures. Bar charts and line charts (trend lines) are most frequently used to visualize this data (confirmed cases, recovered cases, deaths, and vaccination details) with

respect to time. A majority of dashboards presented data either daily or weekly. The mapping is used to track the spatial distribution of COVID-19 cases by country, province, regional etc. When visualizing the data by the map color code system, circles with respect to the size of the cases have been used to visualize the variation in size. The considerable number of dashboards has been used in doughnut-shaped pie charts to represent total COVID-19 confirmed cases, recovered cases, active cases, and deaths as a percentage. Also, region, gender, age group, and ethnicity can be identified as common breakdowns of COVID-19 cases. Data tables for representing case distribution by province/region have been added to some dashboards. Very few dashboards have been visualized in the COVID-19 test details. Only 6 dashboards have been compared to global situations. In addition, the fatality rate, incidence rate, ICU beds, stage of the patients, and hospitalized details have been contained in the several dashboards.

Table 03: Summary of tools which are used for different purpose

Purpose	Bar chart	Line chart	Pie chart	Dot plot	Heat map	Mapping	Data table
COVID-19 confirmed cases	✓	✓		✓		✓	✓
COVID-19 deaths	✓	✓				✓	✓
COVID-19 recovered cases	✓	✓				✓	✓
COVID-19 vaccination		✓				✓	✓
COVID-19 test conducted	✓	✓					
Clinical status	✓						
Cases distribution by age	✓		✓				
Cases distribution by gender	✓						
Cases distribution by area (Province/state/region)	✓	✓			✓	✓	✓
To compare the cases			✓				✓
Global comparison	✓	✓				✓	✓

2.1 2.2 Comparison of Dashboards

Before developing a dashboard, it is necessary to think about which visualization tools & features that should be contained in the dashboards. What are the most suitable plots, how many panels in the dashboard, what data should be included, how to fit dashboard on a screen, colors & is it real time updated or not are the common things that should be considered before develop the dashboards. In table 02 has been compared these visualization tools & features under the following categories.

- Number of panels - How many panels which are included in the dashboard.
- Visualization tools – what are the graphical representations of data which are contained in the dashboards.
- Fitted on a single screen – whether the dashboard fits on a single screen or not (users can see the whole dashboard on a single screen without adjusting through grid overlay or not).
- Color theme – is there a unique color used for one data type in the whole dashboard (i.e.: one color scale for one data type everywhere on the dashboard).
- Dark background – background color of the dashboard is dark or light.
- Data available – whether users can be downloaded/available the data set which has been visualized on the dashboard.
- Real time updated – whether the dashboard is updated daily/ specific time (live dashboard) or not.

Table 04: Comparison of visualization tools & features of dashboard

Name of the Dashboard	Number of panels	Visualization tools	Fitted on a single screen	Color theme	Dark background	Data available	Real time updated
1	1	Bar chart Interactive map	✓	✓	✓	✓	✓
2	4	Line chart Interactive map Data table		✓		✓	✓
3	2	Line chart Bar chart Interactive map Data table	✓	✓	✓	✓	✓
4	1	Line chart Bar chart Pie chart Interactive map	✓		✓	✓	✓
5	1	Line chart Bar chart Data table		✓		✓	✓
6	5	Line chart Bar chart Dot plot Interactive country map				✓	✓
7	1	Line chart Bar chart Country map Data table		✓			✓
8	3	Line chart Bar chart Data table Interactive map			✓		✓

Name of the Dash-board	Number of panels	Visualization tools	Fitted on a single screen	Color theme	Dark back-ground	Data available	Real time updated
9	3	Line chart Bar chart Doughnut shape pie chart Data table Interactive country map		✓		✓	✓
10	2	Bar chart Doughnut shape pie chart Heat map Interactive country map					✓
11	1	Line chart Bar chart Doughnut shape pie chart Data table Interactive country map		✓			✓
12	1	Line chart Bar chart Interactive map		✓	✓		✓
13	1	Line chart Bar chart Doughnut shape pie chart		✓			✓
14	2	Line chart Bar chart Interactive Country map		✓		✓	✓

Name of the Dashboard	Number of panels	Visualization tools	Fitted on a single screen	Color theme	Dark background	Data available	Real time updated
15	1	Line chart Bar chart Data table Interactive map	✓	✓	✓		✓

As shown in Table 4 almost each & every dashboard, line charts & bar charts have been used to visualize the data. Heat map & dot plot has been used only one dashboard. Only four dashboards have been fitted with a single screen. The majority of dashboards have used color theme on the whole dashboard. That is, dashboards have been applied different colors for different type of data (i.e. One specific color for confirmed cases, another color for deaths, etc.) in the whole dashboard. The data set & related links have available on some dashboards & users can download these data sets. There are 6 dashboards with dark background while others have been used light background. Last updated time & date of the latest available data has been reported at the top or bottom of the first panel in the dashboard. Like, half of dashboards included all data in one panel.

3 Methodology

3.1 Data

We obtained data from COVID-19 situation reports published by Epidemiology Unit, Ministry of Health Sri Lanka. We obtained data corresponds to number of death cases, number of hospitalized cases, number of recovered cases and COVID-19 vaccinated counts in Sri Lanka. The data are made available through an open-source R package covid19srilanka (Talagala 2021).

3.2 Design and development

R software was used for data cleaning and analysis. The flexdashboard (Iannone, Allaire, and Borges 2020) package was used to build the data visualization dashboard. The initial layout for the dashboard was prepared based on Krispin (2021). Data visualizations are generated using ggplot2 (**ggplot2?**) and plotly (Sievert 2020) packages in R. we used color-blind friendly colour palettes for the graphics. To represent qualitative data, a diverging colour palette was used, and to represent numeric variables, a sequential colour theme was used. Table 5 provides an overview of methods that have been used to visualize data.

Table 5: Data visualization approaches used to visualize data

Data	**Type of graphics**
Daily COVID-19 confirmed	Time series plots
Daily COVID-19 recovered cases by time	Time series plots
Daily COVID-19 death cases by time	Time series plots
Total COVID-19 confirmed cases by time and wave	Time series plots annotated with vertical lines to denote significant milestones

Data	Type of graphics
Total COVID-19 death cases by time and wave	Histogram
Distribution of COVID-19 patients by districts	Tree map, Choropleth maps, Dorling Cartogram, heatmaps
Total vaccination by first dose and second dose	Time series plot
Total administrated does by vaccine name	Stacked bar chart
Total administrated does by vaccine name	Stacked bar chart
Total administrated does by vaccine name	Stacked bar chart
Comparison of cases with in Sri Lanka with Top 10 countries	Cummulative cases by time, Log of cummulative cases by time, stacked bar chart
Spread of COVID-19 around the world	Choropleth maps

We now describe the novel visualization approaches we included in out dashboard. To effectively distribute the vaccine and to support situational awareness and inform policy makers decision making it is important to know the district-wise spread of COVID-19 cases. We have daily COVID-19 data related to confirmed cases in all 25 districts in Sri Lanka. This structure generates a multiple time series collection. Visualizing these time series data is useful to identify similarities and dissimilarities between districts and their general trends. There are two approaches to visualizing these time series: (i) drawing individual time series plots for each district (as shown in Figure 2), and (ii) simultaneously plots all time series on a single panel (as shown in Figure 3). Plotting all time series simultaneously is also not possible due to overlapping time series and scale differences. Plotting separate panels for each district is not effective. The reason is that it is hard to compare across 25 different panels at once. In order to overcome these problems in multiple time series visualization, we use heat maps ((Peng (2008))) to visualize global and local similarities and dissimilarities across districts. The associated results are shown in Figure 3. Here two heatmaps are used to show the global variations (Figure 3: A) and local variation (Figure 3: B) in the time series collection. Figure 3-A cell colours represent the actual counts of the COVID-19 confirmed cases. This is useful to get an idea about the differences in absolute values. Figure 3-B cell colours represent the normalized values created applying the min-max transformation. Min-max transformation is applied to each district time series by using the corresponding district minimum and maximum value of the time series. This helps us to get an idea about patterns within districts. For example, according to Figure 3A we can see Colombo, Gampaha and Kalutara districs COVID-19 cases are significantly higher than other districts. According to Figure 3B all districts show an increasing trend pattern as the right-hand side of the cells are lighter than the left-hand side cells in the heat map. Furthermore according to Figure 3B all districts reported high number of cases on 19, 24, 29 August, 2021. Figure 3B is useful for identifying these local outlying behaviours. As shown in Figure 4, we also use Choropleth map and Dorling cartogram to visualize spatial distribution of COVID-19 cases. The vaccination information are visualize through interactive time series plots and bar charts. A screenshot of associated panels are shown in Figure 5 and Figure 6.

The source code to reprouduce the results are available in a public GitHub repository and can be access online via https://github.com/thiyangt/covid19srilanka

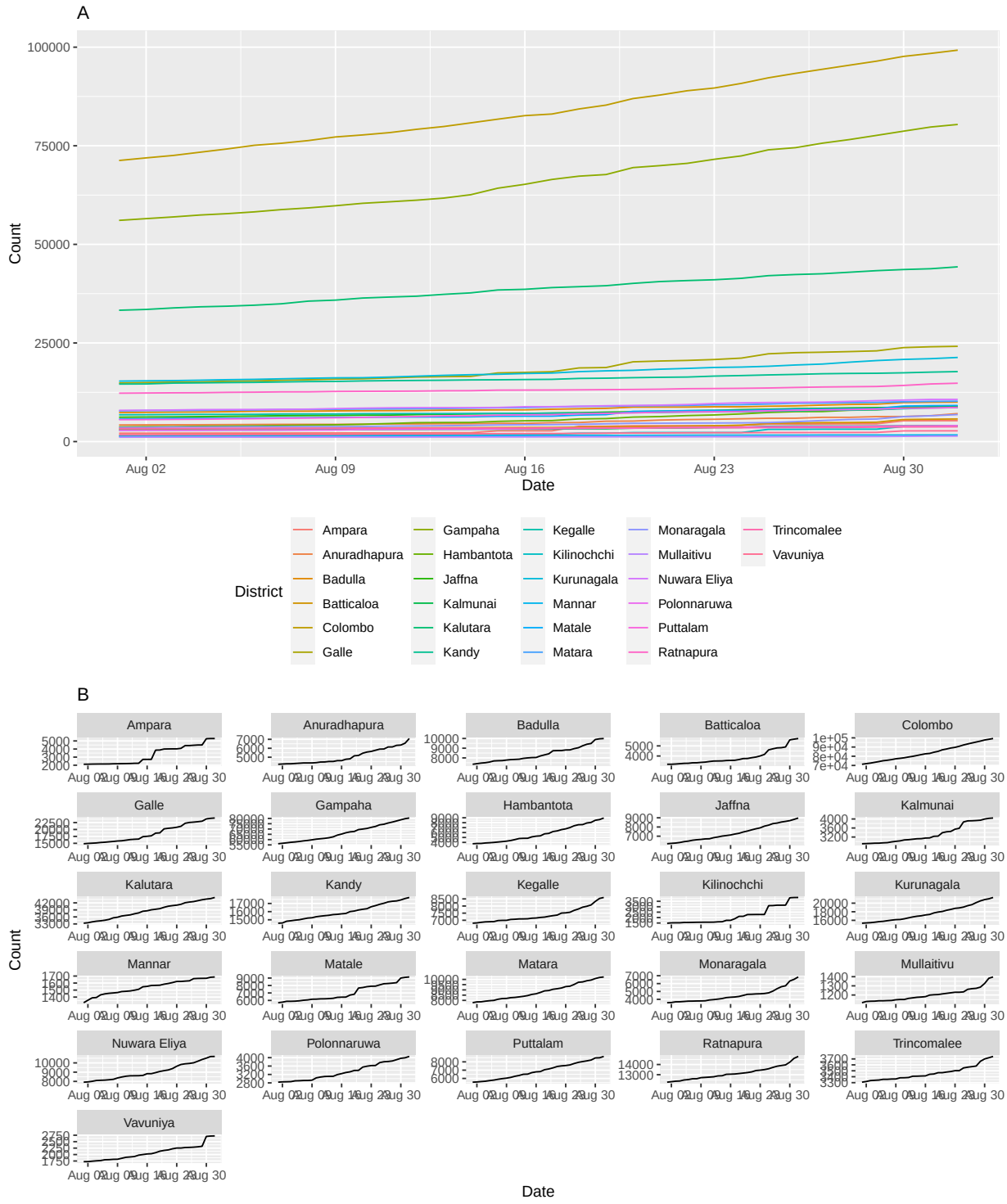

Figure 1: Distribution of COVID19 Cases by Districts: (A) Plotted on a Single Panel, (B) Plotted on Separate Panels.

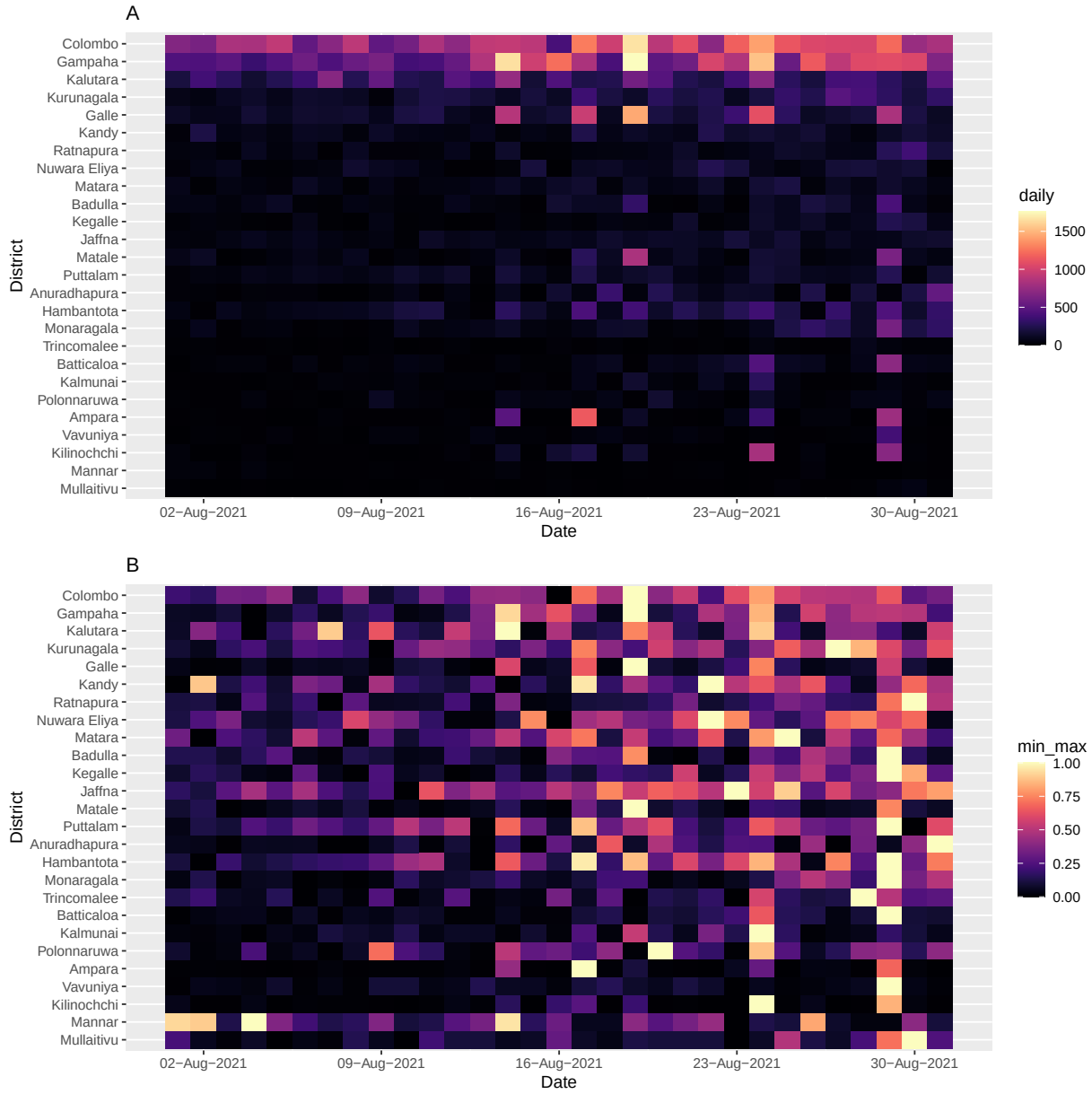

Figure 2: (A) Global View of Distribution of COVID19 Cases by DIstricts, (B) Local View of Distribution of COVID19 Cases by Districts

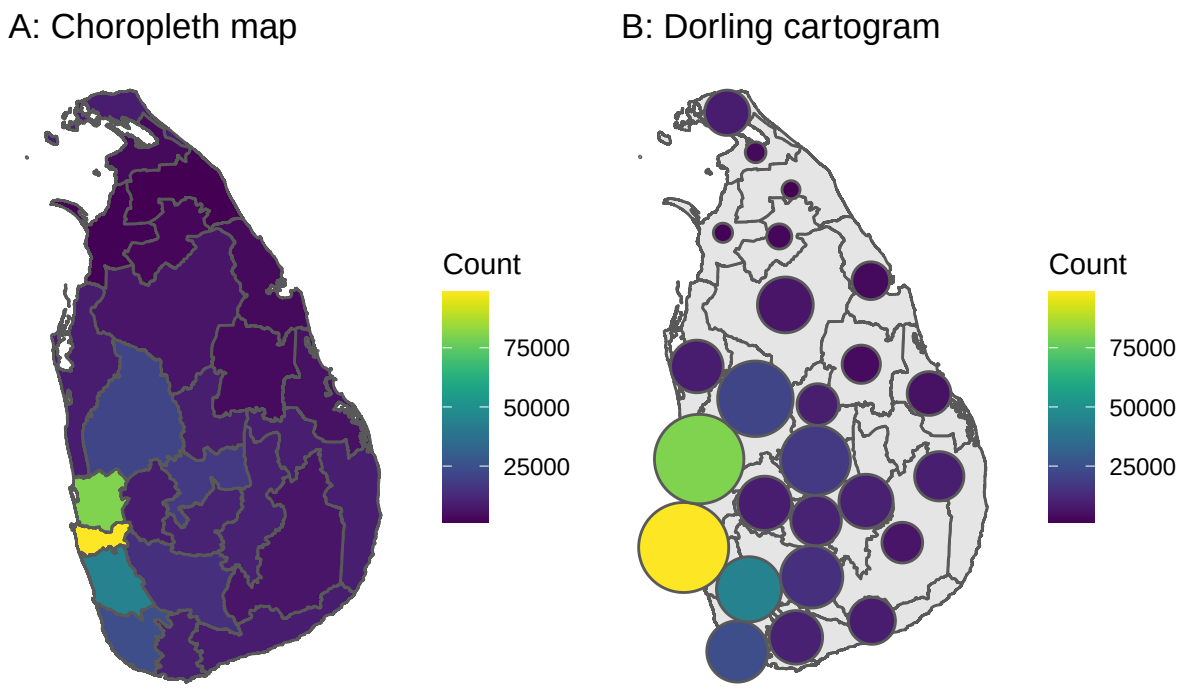

Figure 3: Spatial DIstribution of COVID1-19 Cases by Districts

4 Results

The "Sri Lanka COVID-19 Dashboard" provides an overview of the COVID-19 pandemic and administration of vaacine information in Sri Lanka. This dashboard has eight panels as listed in Table 6.

Table 6: Description of the panels

Name of the Panel	Description of the Panel
Overview	Total count of COVID-19 confirmed, recovered, deaths, active cases & total vaccine doses administered. Provide an overview of daily COVID-19 confirmed, recovered & deaths by plots.
Cases by Wave	There are three tabs in this panel. * Total COVID-19 confirmed cases - Cumulative count of COVID-19 confirmed cases with specific dates * COVID-19 Cases Distribution by Wave - Daily confirmed cases by wave * COVID-19 Deaths Distribution by Wave - Daily deaths by wave
COVID-19 Patients Distribution	Provide an overview of confirmed cases district wise distribution. There are four tabs in this panel. * Total COVID-19 Patients Distribution in Sri Lanka - Total confirmed counts for each district is represented by tree map * Country Map - Total confirmed cases in each district represented by Sri Lanka country map * Distribution of Daily COVID-19 Patients for Last 30 Days - Visualize the daily confirmed cases distribution by districts in last 30 days * By Applying Min-Max Transformation - Visualize the details in the third tab by applying min-max transformation for each district
Vaccination Details	Provide an overview of COVID-19 vaccination in Sri Lanka. There are two tabs. * Total Vaccine Doses - Visualize the administered vaccine doses as first dose only & fully vaccinated * Total Administered Doses by Vaccine Name - Visualize the vaccination by vaccine names
Top 10 Countries	In this panel, compare the Sri Lanka confirmed & deaths with top 10 countries in the world (top 10 countries - The countries which have been reported highest number of confirmed cases as 31st of August 2021). There are two tabs. * Comparison of Cumulative Cases in Sri Lanka with Top 10 Countries - Compare the confirmed and deaths in Sri Lanka with top 10 countries by cumulative time series plots * Comparison of Log of Cumulative Cases in Sri Lanka with Top 10 Countries - Compare the confirmed and deaths in Sri Lanka with top 10 countries by log cumulative time series plots (The data has been pulled from WHO)
Global Comparison	Compare the total confirmed & deaths in Sri lanka with top 10 countries in Global & Asia. There are two tabs. * Comparison of the sri Lanka with Top 10 Countries Reporting the Most COVID-19 Cases in the World - Compare the total confirmed & deaths in Sri Lanka with top 10 countries in the world & compare the case fatality ratios * Comparison of the sri Lanka with Top 10 Countries Reporting the Most COVID-19 Cases in the Asia - Compare the total confirmed & deaths in Sri Lanka with top 10 countries in the Asia & compare the case fatality ratios

Name of the Panel	Description of the Panel
Global Map	Visualize the distribution of confirmed, recovered & deaths in the world by world map.
About	This panel contains the details about the dashboard.

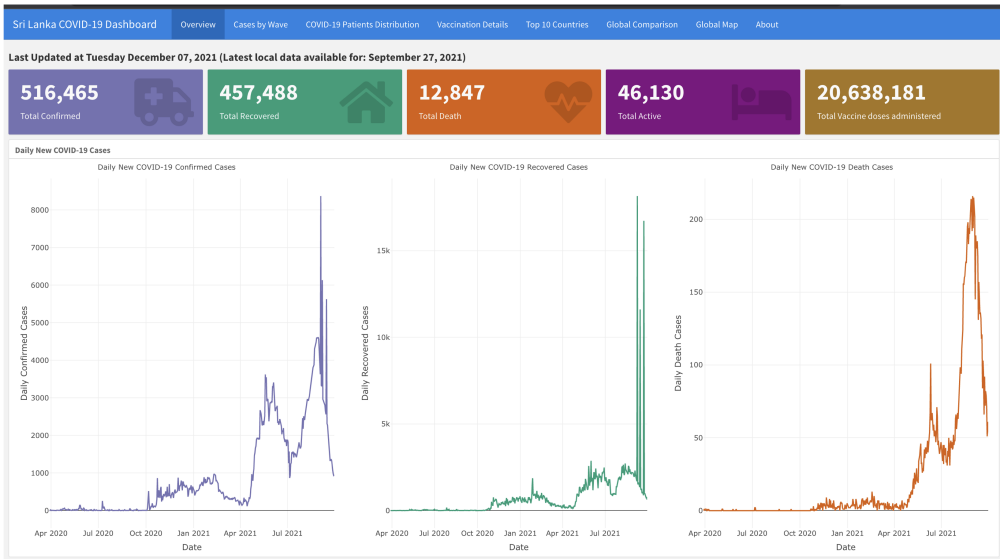

Figure 4: Screeshot of Panel 1

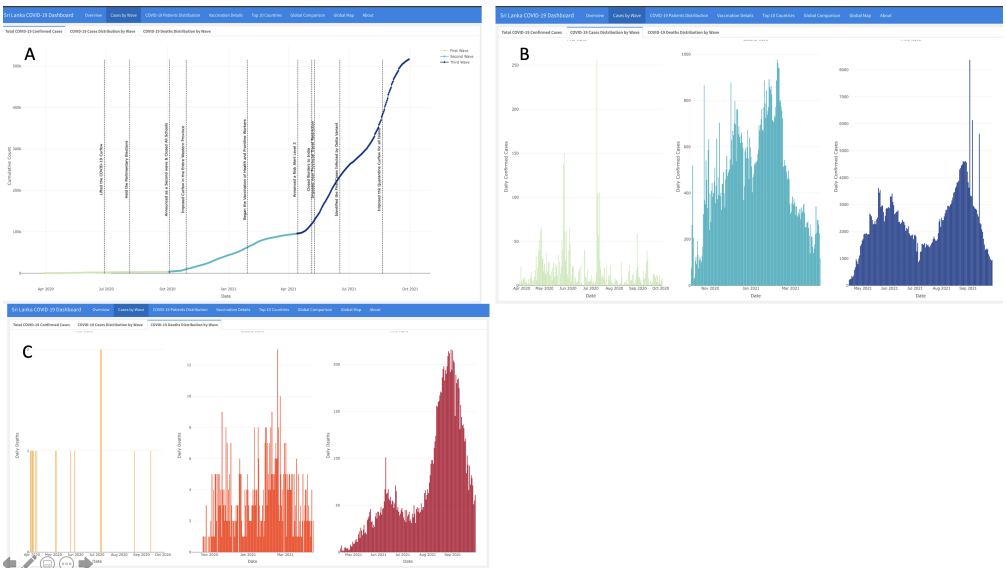

Figure 5: Screeshot of Panel 2

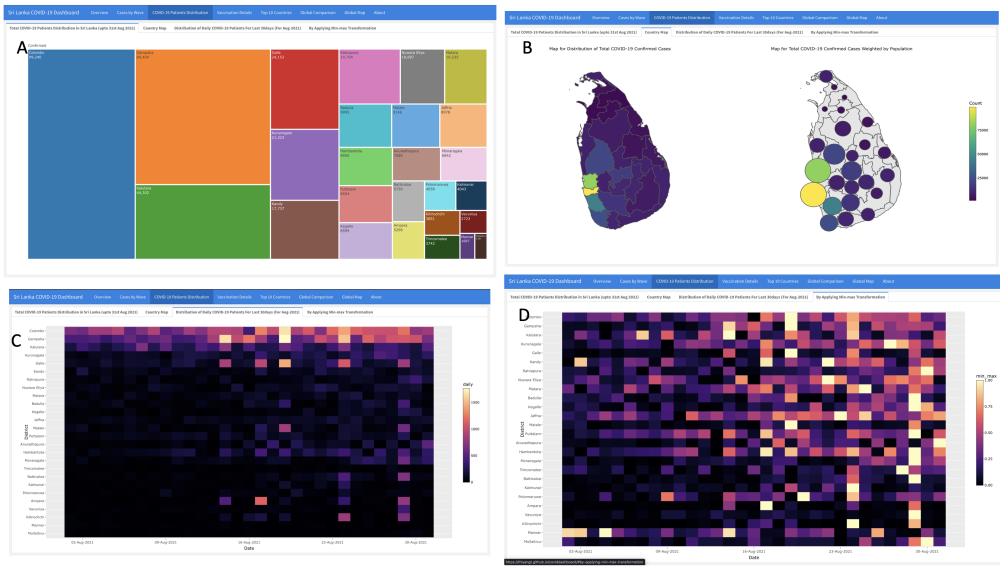

Figure 6: Screeshot of Panel 3

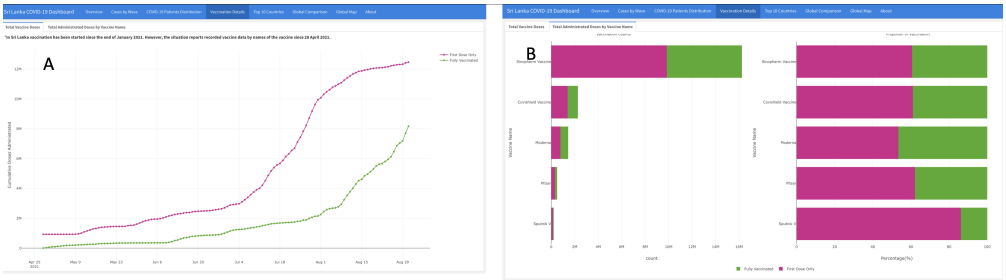

Figure 7: Screeshot of Panel 4

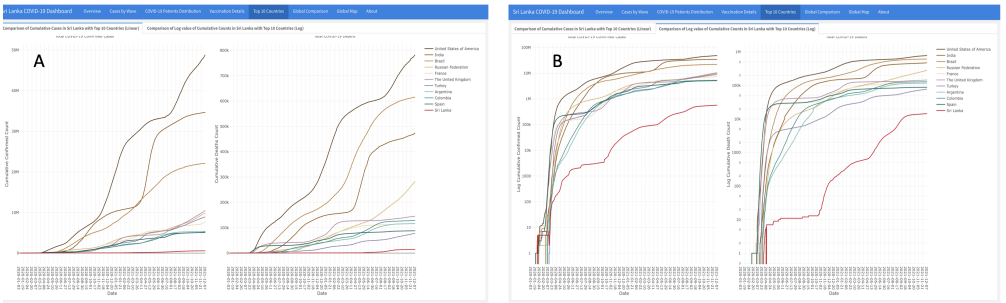

Figure 8: Screeshot of Panel 5

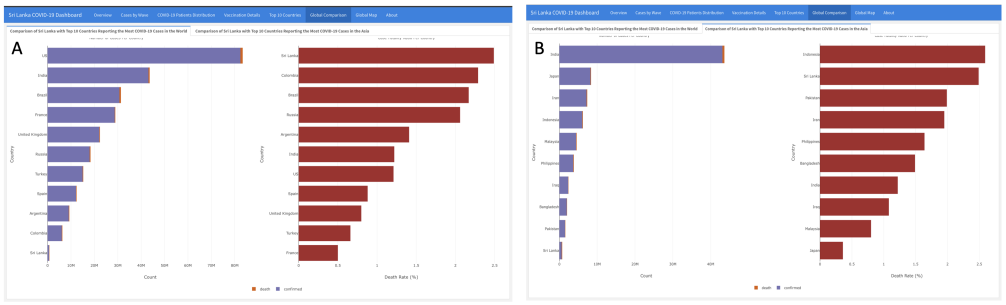

Figure 9: Screeshot of Panel 6

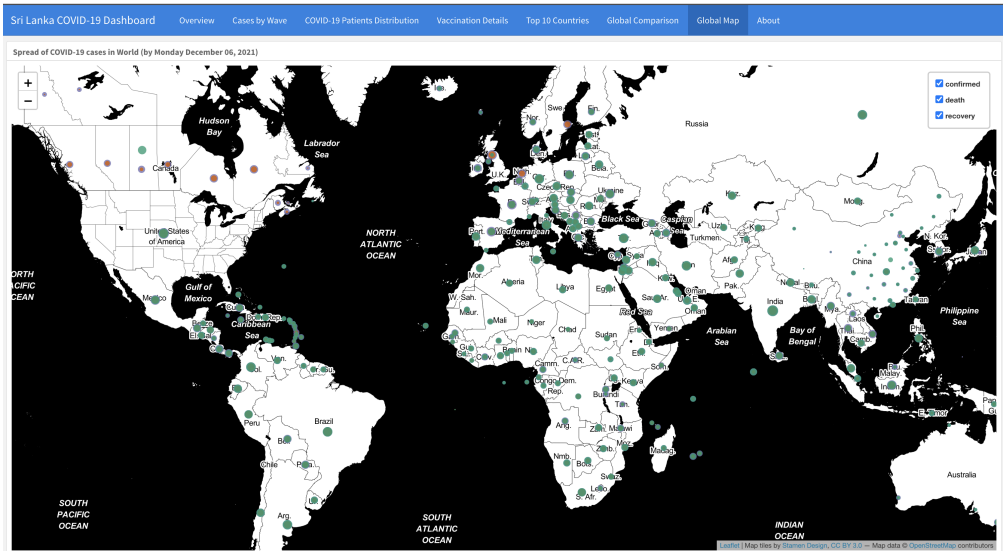

Figure 10: Screeshot of Panel 7

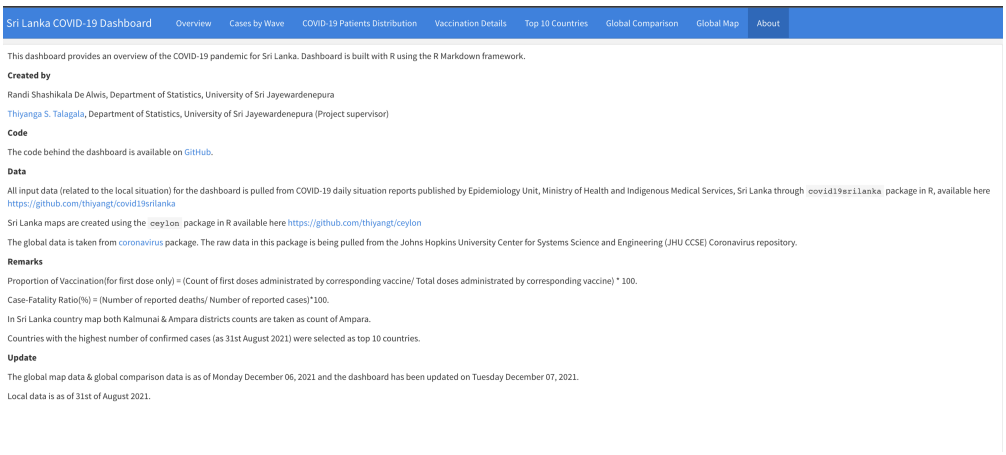

Figure 11: Screeshot of Panel 8

5 Discussion and Further research

Bar charts and line charts are the most frequently used tools for the visualization of total cases, daily cases and comparisons with respect to time. Some dashboards contained doughnut shape pie charts to summarize the total figures. In almost each and every dashboard, value boxes have been used to represent total figures. Some dashboards contained interactive maps & data tables to visualize the distribution of cases by country, province, region or state. All dashboards are daily updating real time dashboards. Gender, age groups and ethnicity can be identified as common breakdowns. The data sets & related links are available on most of the dashboards & can be downloaded. It can be seen that it is very easy, clear and user friendly to identify confirmed, recovered and deceased cases in dashboards which include one color theme for the whole dashboard. Dashboards with the dark background are more comfortable to the eyes than dashboards with light background & light colors. Also, it is better if the dashboard can be fitted on a single screen rather than adjusting through a grid overlay.

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