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PII: S2352-9148(21)00188-X
DOI: https://doi.org/10.1016/j.imu.2021.100705
Reference: IMU 100705

To appear in: Informatics in Medicine Unlocked

Received Date: 28 May 2021
Revised Date: 14 August 2021
Accepted Date: 14 August 2021

Please cite this article as: Rimal Y, Gochhait S, Bisht A, Data interpretation and visualization of COVID-19 cases using R programming, Informatics in Medicine Unlocked (2021), doi: https://doi.org/10.1016/j.imu.2021.100705.

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Data Interpretation and Visualization of COVID-19 Cases using R Programming

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Abstract:

Background: Data analysis and visualization are essential for exploring and communicating medical research findings, especially when working with COVID records.

Results: Data on COVID-19 diagnosed cases and deaths from December 2019 is collected automatically from www.statista.com, datahub.io, and the Multidisciplinary Digital Publishing Institute (MDPI). We have developed an application for data visualization and analysis of several indicators to follow the SARS-CoV-2 epidemic using Statista, Data Hub, and MDPI data from densely populated countries like the United States, Japan, and India using R programming.

Conclusions: The COVID19-World online web application systematically produces daily updated country-specific data visualization and analysis of the SARS-CoV-2 epidemic worldwide. The application will help with a better understanding of the SARS-CoV-2 epidemic worldwide.

Keywords: Covid-19, Coronavirus, open data map, data visualization, machine learning

1. Introduction:

The first case of COVID originated in China on Dec 29 and Jan 3, 2020, when fifty people developed pneumonia-like symptoms [1] [2]. Before the Chinese New Year, Wuhan was a significant transport hub [3] [4]. Several new cases of COVID infections were reported daily after that, resulting in the World Health Organization declaring COVID 19 an epidemic [5]. Although 43% of hospitalized patients showed fever symptoms, more than 80% of COVID patients showed fever in hospital and quarantine facilities. Sometimes, these diseases may not get detected based on symptoms alone [6] [7]. COVID 19 disease primarily manifests as
diarrhea, cough, and shortness of breath [9]. We cannot, therefore, assume that patients without fever will not find COVID infection. Early symptoms of diarrhea may occur in 3% to 5% of patients [8]. Those suffering from mild symptoms must isolate themselves for 14 days from the first infection. In this situation, patients who experience difficulty breathing and have chest infections should see a doctor right away [10]. During this time, doctors encourage patients to rest and rebuild their immune system by taking them into quarantine [11].

Only 5% of patients suffer from ARDS (Acute Respiratory Distress Syndrome), a condition in which a virus extends into the air sack with water, making breathing and purifying red blood cells more complex [12]. In cases of severe lung damage, the oxygenation process, which removes blood from the patient and filters it before returning it to the patient, may be necessary [13]. Heart patients, kidney patients, diabetes patients, long-term pharmaceutical users experience more severe symptoms than those younger [14]. Despite this, we are concerned about halting the spread at the community level. Everyone speaks about flattening the curve, which is slowing its spread so that the hospital system can deal with it more quickly rather than having to manually pick it out in a fixed period to prevent the entire hospital system from becoming like a country without toilet paper [15] [16].

**Table 1**: India state data statistics

| States       | India | Gujarat | Uttar Pradesh | Maharashtra | Delhi | Tamil Nadu |
|--------------|-------|---------|---------------|-------------|-------|------------|
| Status       | 22,500| 735     | 929           | 5,368       | 1,379 | 3,827      |
| Confirmed    | 7,20,346| 36858   | 28636         | 2,11,987    | 1,00,823 | 1,14,978 |
| Active       | 2,59,926| 8574    | 8718          | 87682       | 25620 | 46836      |
| Status       | 15,256| 423     | 348           | 3,522       | 749   | 3,793      |
| Recovery     | 4,40,150| 26323   | 19109         | 1,15,262    | 72088 | 66571      |
| Status       | 473   | 17      | 24            | 204         | 48    | 61         |
| Death        | 473   | 17      | 24            | 204         | 48    | 61         |
| Status       | 10M   | 6.3K    | 25.9K         | 22.6K       | 13.9K | 34.8K      |
| Total        | 138019747 | 418.5K | 890K          | 1.1M        | 657.4K | 1.4M      |

Table 1 shows that the total number of COVID cases in India has reached 720346, with 22510 new cases discovered every day in 0607/202 records. Overall, there have been 1704 COVID-related deaths in India. The number represents 4% of all active cases in India. A total of 613 deaths per day out of 8944 patients out of 260022 active cases. In the same way, a country like India has tested 9969662 people out of 13 million people living there.

The interactive map of Table 1 is available for free at [https://www.statista.com/statistics/1103458/india-novel-coronavirus-covid-19-cases-by-state/](https://www.statista.com/statistics/1103458/india-novel-coronavirus-covid-19-cases-by-state/), describes the most interactive rather than tabular records when compared to both the given table and the chart presented here. The graph shows states having the highest or lowest number of new COVID cases. Likewise, trend and pattern line graphs and charts provide more information than tabular statistics, as shown in the preceding table.
Compared to the fact table and figure comparisons above, map visualization is one of the most effective tools for presenting data. Despite this, the theory behind flattening the curve ensures that the balance between hospital ventilators, quarantine medicine systems, and human control in every country is maintained. The hospital system can accommodate everyone if the spread is gradual [4]. As a result of 1918's influenza and pneumonia outbreaks in Philadelphia, the mortality rate rose sharply during October [17], enabling a flat curve. As of now, the primary control of COVID-19 is considered social distance [18].

Consequently, flattening the curve consists of 20 seconds of handwashing, 6 feet of social distancing, and wearing a mask unless necessary. However, health workers and those who suffer from symptoms should also wear the mask. Vaccines and antiviral medicines have developed. However, several clinical trials on appropriate vaccines are currently underway. The best way to stop the spread of the disease is to disengage socially to flatten the curve and manage our health care system globally [19]. Twenty-eight vaccines are currently under the testing phase by the WHO [20]. Since healthy individuals are vaccinated, vaccination must be more precise. It should also be very safe to use and require a considerable amount of time to produce. As part of the development process, 20 to 80 people will be evaluated for the medications in the first phase, followed by 100 to 300 healthy participants in the second phase [21]. If there are no harmful substances detected, a license should grant for production, with appropriate precautions for refrigeration. This process requires time. The production is scheduled accordingly for vaccinating the people [22]. For example, the production of the Ebola vaccine took four years. Tests conducted on mice, rabbits, monkeys, and even people in the future. The substance does not cause harm and generates messenger ribonucleic acid (mRNA). In addition, if all of the trials prove to be successful, the World Health Organization (WHO) hopes to shorten the process. The viral infection of COVID-19 is the result of SARS-Cov-2 (Severe Acute Respiratory Syndrome). Coronavirus 2 is similar to the SARS coronavirus, which caused an outbreak in 2002 [23].

According to reports, bat in Wuhan, China, was the primary source of human infection. Later, it spread to other parts of the world. There were 903826 cases worldwide and 45335 deaths in April 2020. Around 5% of the total cases were fatal [9]. In addition, many cases were asymptomatic carriers of the Coronavirus, which resulted in an exact death rate of 0.7% for the total number of cases, according to the study [24]. Reports from CDC expect the number of people affected by these diseases to grow, with up to 25% of the population showing symptoms. With a proper health care system and protective equipment, a curve plot on the y-axis represents the full potential of the health care system to combat COVID-19. Because of this, the data presented in various official sources only show the records that need some visualization plot for better future action.

2. **Methodology and Data Analysis Using R Programming**

Records of COVID-19 updated within 24 hours after the pandemic is declared. This study focuses on the interactive presentation of these figures and data. The data sources for this research include [https://datahub.io/core/covid-19](https://datahub.io/core/covid-19) # resources-covid-19_zip [25] and
Generating graphical outputs from raw open-source records and manage and organize the raw data to create data presentations. After loading various libraries (leaflet), (tidyverse), (ggmap), (htmltools), (leaflet.extras), (maps), (ggplot2), (mapproj), (mapdata), (spData) on the R console, the world city data with 15493 records on 11 variables is stored in the data. The tidier data format changed by using the tbl_df function.

However, the most modern R package readr provides several functions (read_delim(), read_tsv() and read_csv()), which are faster than R base functions and import data into R as a tbl_df (pronounced as “tibble diff”).

A data structure containing city name, asci name, longitude-latitude name, and population of the capital city is available open-source on https://datahub.io/core/world-cities. As shown below, the data frame looks like to access one variable in a dataset, use the dollar sign “$”.

To create a new table from combining multiple vectors, use the function data_frame():

```r
#str(data) output shows variables, data type, and few records of the data

$ city: chr “Tokyo” ”New York” ”Mexico City” ”Mumbai”
$ city_ascii: chr “Tokyo” ”New York” ”Mexico City” ”Mumbai”
$ lat: num 35.7 40.7 19.4 19 -23.6
$ long: num 139.8 -73.9 72.9 -96.6
$ country: char “Japan” ”United States” ”Mexico” ”India”
$ iso2: char ”JP” ”US” ”MX” ”IND”
$ iso3: char ”JPN” ”USA” ”MEX” ”IND”
$ admin_name: chr ”Tokyo” ”New York” ”City of Mexico” ”Mumbai”
$ capital: chr ”primary” ”primary” ”admin”
$ population: int 35676000 19354922 18978000 18845000 15926000 14987000 14787000 12815475 12797394
$ id: int 1392685764 1840034016 1484247881 1356226629 1076532519 1356872604 1156073548 1356060520 1840020491 1050529279
```

Variables are categorized using the structure command, which describes their properties. In the tidyverse command, data is filtered via shift-ctrl-m, using the United States data only depending on the information required for the selected country, as described below.

#Using Dplyr library, the Filter function used to filter the data of the country United States
In the same way, the world map records with longitude, latitude group, and region stored in the `w` variable as `w=map data ('world')`. Based on the pattern below, the structure appears like the one below.

# Structure of Map Data

| long    | lat    | group | order | region | sub region |
|---------|--------|-------|-------|--------|------------|
| -69.89912 | 12.45200 | 1     | 1     | Aruba  | <NA>       |
| ……………… | ………… | ……… | ……… | ………  | ……………  |
| -70.05088 | 12.59707 | 1     | 6     | Aruba  | <NA>       |

Data represent the world by country and its subregions. Then use the settings `ink=map data ('world', region=c ('Nepal', 'China'))` to plot the map of that country. Inbuilt `ggplot2` functions typically plot three-country maps, as in the selection below. This `Rmarkdown` file use to test Choropleth's plot on the Japan map from the map data package. Maps include regions only, not subregions.

Fig 1: Country Maps of China, India, and Nepal

The `ggplot` command uses longitude and latitude groups with filled-in region names, and the polygon supports the black border of each county. Like the U.S., each state's data is taken from the world data of each state and matched and grouped with a geographical map. The `ggplot2`, one of the core members of the `tidyverse`, accesses the datasets by running the below code:

```r
> uss=data%>%filter(country=='United States')
```
# Plot the data

```r
> usa = map_data('state')
```

```r
ggplot(usa, aes(x=long, y=lat, group=group, fill=region)) geom_polygon(color='black')
guides(fill=F) are plotted as base map for covid data prediction.
```

![Fig 2: U.S. State maps](image)

The system provides a user-friendly web-based interface for viewing COVID-19 data and metrics. World, country and regional maps are color-coded to represent various selectable infection attributes at those locations. Clicking on any given location brings up a set of pages that provide details about that location—from raw statistics to charts to advanced metrics and commentary. The user interface provides several ways to navigate, such as Map View, Trend View, Stats View, Hotspots View. Below is a detailed introduction to each view.

Application libraries like a library (ggfortify), library (mapdata), library (maps), and library (ggplot2) fig 3. depicts the map of Japan from the world2 data set plotted with jpg *.ggplot2: map_data('world2', 'japan'). It contains 1097 observations with six variable geographic points.

# Structure of Map Data

```r
# Code
$ long: num 124 124 124 124 124 ...
$ lat: num 24.3 24.3 24.3 24.3 24.3 ...
$ region: chr "Japan" "Japan" "Japan" "Japan" ...
$ sub region: chr "Iriomote Jima" "Iriomote Jima" "Iriomote Jima" "Iriomote Jima" ...
```
Fig 3: Japan Country Map

#Japan Map plotted using ggplot library

> ggplot (jp, aes (x = long, y = lat, group = group)) geom_polygon ()

The above maps illustrate the COVID data of country and city records. In addition to the open-source COVID-19 data, a zip file [25] with data projections for country-wise and state-wise records was also available. The COVID data is read into a file whose structure resembles data. As shown below, data frame 528282 records 13 variables from 58 states in the U.S.

#Structure of data of Covid confirmed cases

```{r}
$ UID: int 16 16 16 16 16 16 16 16 16 16 ...
$ iso2: Factor w/ 6 levels "AS","GU","MP", 1 1 1 1 1 1 1 1 1 1 ...
$ iso3: Factor w/ 6 levels "ASM","GUM","MNP", 1 1 1 1 1 1 1 1 1 1 ...
$ code3: in 16 16 16 16 16 16 16 16 16 16 ...
$ FIPS: in 60 60 60 60 60 60 60 60 60 60 ...
$ Admin2: Factor w/ 1902 levels "","Abbeville", 1 1 1 1 1 1 1 1 1 1 ...
$ Let: num -14.3 -14.3 -14.3 -14.3 -14.3 ...
$ Combined Key: Factor w/ 3261 levels "Abbeville, South Carolina, US", 57 57 57 57 57 57 ...
$ Date: Factor w/ 162 levels "1/22/2020","1/23/2020", 1 2 3 4 5 6 7 8 9 10
$ Case: int 0 0 0 0 0 0 0 0 0 0 ...
$ Long: num -170 -170 -170 -170 -170 ...
$ Country. Region and Province. State: Factor of 58 states of US which structure as UID iso2 iso3 code3 FIPS Admin2 Lat Combined_Key Date Case Long Country. Region
```

1 16 AS ASM 16 60 "" -14.3 American Sa~ 1/22~ 0 -170. US
2 16 AS ASM 16 60 "" -14.3 American Sa~ 1/23~ 0 -170. US
6 16 AS ASM 16 60 "" -14.3 American Sa~ 1/27~ 0 -170. US
Prepare a map data set, a summary, and an arranger used after filtering the records of a single country, such as the United States (U.S.). Therefore the COVID records of the United States (U.S.) can be viewed using the filter with the group with the help of command on 06/07/2020, which includes the counts of 56 states from the United States (U.S.) and the corresponding COVID cases in decreasing order, as shown below.

#Check Province. State summarised records. Convert Province. State Names to Lower Case

```r
> us=ct %>% filter (Country.Region == 'US')
> cc=us %>% group_by (Province.State) %>% summarise (count=n ()) %>%
  arrange(desc(count))
```

| Province. State | Count |
|-----------------|-------|
| Texas           | 41472 |
| Georgia         | 26082 |
| Virginia        | 21870 |
| Kentucky        | 19764 |
| Kansas          | 17334 |

However, another table has street information listed in lower cases, so the lower function changed to the lower cases below.

#Sample records after converting to lower case

```r
> cy$Province.State=tolower (cy$Province.State)
```

| State               | Count |
|---------------------|-------|
| diamond princess    | 162   |
| grand princesses    | 162   |
| Virgin Islands      | 162   |

As shown below, the state information provides the state for the state, providing longitude, latitude, grouping order, region long lat grouping order, and subregion long lat grouping order.
In order to complete the merge operation, map information and COVID cases combine and merge into a standard index as the name of the state and region, while the lower case finishes for the map data organization. The `data1 = merge (ss, cc, by.x='region', by.y='Province. State')` command groups combine, region, longitude, latitude, group, order, sub-region with COVID counted. In the same way, the tabular information selects only the essential records for the map, eliminating unnecessary data.

#Required fields selected after subsetting the summarised data

```r
Using keeps <- c("region","long","lat","group","count") and data1 = data1[keeps] commands.
region long lat group count
alabama -87.46201 30.38968 1 11178
```

In the case of integer types with the region, longitude, latitude, group, and count, the following records of 15537 observations based on five variables chosen for map plotting: This includes 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 11178 as outlined below:

#Data is plotted on U.S. map using ggplot library

```r
ggplot(data1,aes(x=long,y=lat,group=group,fill=count)) geom_polygon(color='gray')
coord_map('polyconic') scale_fill_gradient2(low='white',high='red') theme_void()
ggtitle('Covid Case in US')
```

![Case in US](image)
Fig 4 Covid Data in the U.S.

The command displays the U.S. map mapped with the number of COVID cases ranked higher and lower levels. In a legend scale, the color indicates the highest to the lowest state. As a result, the output is more than adequate to present tabular data using the statistics above, like India's tabular records. According to the legend on the left, there are a total of 79 cases with fading colors. Interactive maps of COVID record data could easily be visualized using clusters. Through using multiple map providers, the leaflet packet connects the online world map. Marker clusters, for example, add tiles that are circular markers with names and colors that add to a map.

#Data plotted using leaflet library on U.S. map

```r
> dataf %>% leaflet() %>% addTiles() %>% addCircleMarkers(radius = 2, label = ~htmlEscape(city), color = 'red', clusterOptions = markerClusterOptions())
```

Fig 5: Covid Maps with Respective Data of the U.S.
Using a *leaflet*, `addTiles` with circle markers, and describing each state's respective locations help plot a map of COVID cases in each state. Viewing the state aggregate features of the country's map in zoomed-in mode.

Fig 6: Interactive Geographic Map of U.S.
By highlighting the boundaries of maps, planners can better judge what measures should consider. Using the zoom in and zoom out feature, the leaflet with added tiles could plot COVID total cases state-wise and city-wise with the border area location of the open street base maps. In the following manner, COVID data from many states and cities shall be share interactively.

3. Discussion

The COVID-19 pandemic is challenging our society and economy in an unprecedented way. Overall, the U.S. response to containing COVID-19 may not have been as effective as other countries, like Japan and India. These studies may have been due to insufficient or delayed testing and a lack of alternative monitoring tools near the pandemic's beginning [27]. Early warning and detection may represent a critical opportunity for India, Japan, and the U.S. to track the rate of respiratory illness and quickly institute policies to prevent or at least mitigate a future outbreak.

The study recommended that the COVID-19 diagnosis and prognosis models adhere to transparent and open-source reporting methods to reduce bias and encourage real-time application. Secondly, with the help of the system, it provides a user-friendly web-based interface for viewing COVID-19 data and metrics. World, country and regional maps are color-coded to represent various selectable attributes of the infection at those locations with latitude and longitude values for the countries like India, Japan, and the U.S.

Real-time epidemiologic data is critical to managing different aspects of a pandemic. For instance, this data can help public health authorities forecast demand/surge models, thereby allowing public or private organizations to reposition resources or reallocate personnel quickly. These are corroborating data that should consider in combination with other indicators, such as the officially reported number of newly positive laboratory tests, disease-related hospitalizations, and disease-related deaths.

4. Conclusion

In this paper, we have studied COVID data interpretation and visualization using open-data sources for larger countries like the USA and India to understand better how COVID is spreading nationwide and internationally. An effective tool for updating country-specific analysis and visualizing epidemiological indicators of the COVID-19 epidemic, COVID19-World aims to fill a gap in the field by presenting a set of valuable tools for the current global COVID-19 epidemic. Through the web application, a better understanding of the epidemiological development in each country can be obtained and help with country-specific surveillance.

Despite promising results, some additional suggestions could enhance the performance of the algorithms and make them more useful, for example, by strengthening the datasets of several health centers throughout the country or by ensuring that all details in the screening are filling with accuracy.
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Acknowledgement

I would congratulate the authors for having a good spirit and providing their valuable time over this research. We would also thank Pokhara University, Nepal, Symbiosis International (Deemed University), constituent of Symbiosis International (Deemed University), Pune, India, Birla Institute of technology, Pilani, India, Chulabhorn College of Medical Science, Chulabhorn Royal Academy, Thailand, Biological Sciences and Sports Health Department, Suez Canal University, Egypt for their motivation and support in editing this manuscript. At last, I would also thank Informatics in Medicine Unlocked for providing us the platform.
Conflict of Interest and Authorship Conformation Form

Please check the following as appropriate:

- All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.

- This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

- The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript.

- The following authors have affiliations with organizations with direct or indirect financial interest in the subject matter discussed in the manuscript:

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Declaration of interests

√☐ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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