# Visualizing Impacts of COVID-19

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**Abstract.** This dashboard presents the worldwide impacts of COVID-19 from multiple dimensions, and it mainly visualizes the answers to the following questions: 1. *How has the pandemic negatively impacted the public health system in different countries as time goes on?* 2. *How did the global education system change during COVID-19?* 3. *How did COVID-19 affect the global economy and financial markets?*

**Keywords:** COVID-19 · Visualization · Public Health· Education· Econ

## 1 Introduction

In 2019, a new coronavirus was identified and had changed humanity's society tremendously. How should we face the "After-COVID-19" era becomes the top issue among almost all people. To respond to the issue, we design a dashboard presenting the trend and degree of the impacts of COVID-19 in three main aspects: public health, education, and economy. Instead of showing the impacts on a single perspective as what has been done by others on the same topic, we made our dashboard original by combining the impact of the COVID-19 crisis on various aspects as a whole. This project is useful for audiences from various countries who would like to know how the pandemic influences their life, and our work enables them to simultaneously compare the burden of COVID-19 in different countries on multiple dimensions.

For the rest of the sections, we elaborate on the details and rationale for this project. In section2, we present existing and related work. In section 3, we present the dataset utilized in this project and the technique we use in the data wrangling/preprocessing part. In section 4, we explain the design considerations in building up the system. In section 5, we showcase the dashboard we have developed. And we conclude in section 6.

## 2 Related Work

For analyzing the impacts of COVID-19, most people/groups have done data visualization mainly focusing on public health, like tracing and reporting the cumulative positive cases and deaths by episode date in different countries. And some others did some studies about the impacts of COVID-19 on economy or

education just focusing on one aspect, they did not analyze and do visualization in multiple dimensions to trace and perform the impacts of COVID-19.

Compared with the prior work, we combined the impact of the COVID-19 crisis on various aspects as a whole to enable users to simultaneously compare the status and degree of COVID-19 in different countries on the dimensions of health, education, and economy.

## 3    Data

Data for this project was collected from multiple sources in four dimensions: **Health:** The related COVID-19's data is collected from Johns Hopkins University(JHU) CSSE COVID-19 dataset [1] and Our World in Data(owid) [2]. For the global COVID-19 confirmed cases and deaths, the data is collected from 2020 to 2021. and the global vaccinated number of persons is collected from 2021 year. In terms of the data preprocessing, we used Python coding to filter blank objects and remove irrelevant items from each dataset. **Education:** There are two education-related datasets. Both of them were made available through the United Nations Educational, Scientific, and Cultural Organization[3, 4]. For the school closure status, the raw dataset contains the status of the global schooling system after the COVID-19 outbreak. We have redesigned the comprehensive data into a more actionable form by summarizing the closure period and grouping it by school status, and we only keep the primary features on the Date, CountryID, Region, and Status. The dataset of the number of enrollments contains the data by different education levels in 2020. To visualize the number of learners affected by the pandemic in a rational method, this data was filtered to only include those countries or regions where schools have been fully closed due to COVID-19. **Economic:** we mainly focus on three parts, GDP, unemployment rate, and international trade business.The data source for GDP and Unemployment Rate comes from the World Bank [5]. Since the complete data for the unemployment rate in 2021 is not yet available, we use the latest available monthly data in 2021.The data for International trade data comes from the International Monetary Fund (IMF) [6]. We first loop through the GDP dataset to search for the top 5 economics. Then we combine those and years as the key to locating the trade volumes between the top 5 economics in the dataset. **World Map:** The geographical information uses the spatial data of World Atlas Topo-JSON. And we also adjusted the country names from the map location data to match with the name from each COVID-19 data.

## 4    Approach

Before developing into the graphic construction on Vue.js, we asked ourselves three questions: What information would users care about the most? How to help users quickly locate the information? What would be the most appropriate graph forms to deliver the message that we want to share with users? Therefore, we start the project from prototype design in Figma. To answer the first question,

we think the most valuable part of our project is the integration from three distinct dimensions. We want users to understand the correlations between them throughout the pandemic. And this most important part should be placed on the home page to catch the user's eyeballs. The layout of the website is the essential key to the second question. Making all graphs into a single page would increase the difficulty for users to query the information and impair the website performance with high latency loading. Therefore, we split the website into four pages. The home page provides basic information about all dimensions. If users want to know more about other dimensions, the page can be redirected to the respective dimension through navigation buttons at the top of each page. To answer the last question, we would like to share our graphic forms' consideration into four pieces: the Home page, the Health page, the Education page, and the Economic page. In the design process, we try to realize the data visualization by balancing the objectivity, functionality, precision, and beauty. The following visualization wheel is used to evaluate our design (see Fig.1). And we follow the principle indicated by Cairo, the form of the dashboard we choose is according to how to let our audiences get what they would like to know from designed d3 graphics as much as possible [8].
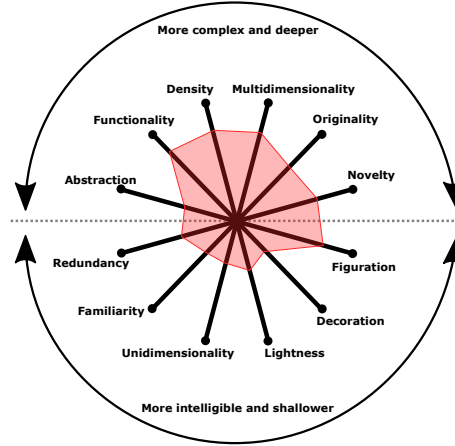


**Fig. 1.** This visualization wheel is showing an analysis to our designed dashboard in multiple dimensions

**Home Page.** With the answer to the previous questions, an interactive choropleth map with a time slider and a drop-down list can not only help the user quickly locate the information but also catch their attention [7]. Toggling the time slider, the user can quickly see the transition of the world through the change of color. From the options list, the user can quickly compare which dimension is influenced the most on a specific date. For each dimension, we use a separate set of colors to represent the choropleth. In addition, we try to link the

color to our common sense. For instance, red is mostly associated with death. Thereby, we use it to present the daily death data. When a cursor hovers over the area of a country, a tooltip box with all essential data will appear in the top right corner to minimize the pop-out effect for the main map. Considering we only have less than 30 seconds of visual short-term memory, users can click on the country on the map to cache it into the table. Users can also add or delete the information. Moreover, as the time slider change, the information on the table will also get updated. But still, we haven't answered how can a user see the correlation among the three dimensions. A simple scatter plot might be a good solution. A user can customize the dimension for the x-axis, y-axis, and bubble size. Following Miller's Law, we limited the maximum number of data points to 7.[9] Since we are insensitive to the area difference of the circle, users can see the value of the circle in text, as the cursor hovers the data point. When the table is empty, a scatter plot section will be unnecessary and be hidden until a new element is added to the table.

**Health Page.** The health page consists of three visualization techniques. First, for visualizing the collected data of global COVID-19 confirmed cases, we design an interactive d3 proportional symbol map. On the map, users can directly see the bubble size of the confirmed cases is changing with the time when the user drags the time slider. In this way, users can see the growth speed of COVID-19 confirmed cases in each country. The second d3 visualization on this page is an interactive bar chart that helps users compare the total confirmed cases or total deaths in each country by sorting in different dimensions, like sorting by the number of cases or GDP in the 2020 year ascendingly/descendingly. Through this interactive bar chart, users can fast know which country's public health is significantly impacted by the coronavirus. The last part of health data visualization is an interactive and responsive choropleth map. It presents the global status of the cumulative number of people vaccinated. As the fill color darker green indicates more vaccinated people in this area, users can intuitively understand the status of global vaccination. This map allows users to click on each country to check on a pie chart of the vaccination rate and a line chart of the cumulative confirmed COVID-19 cases of the selected country on the right side.

**Education Page.** The education page consists of four visualization techniques. The first horizontal dendrogram shows the regions/countries that are still affected by partial or full school closure based on the most recent data (Oct.31/2021). The second time slider choropleth tracks the overall evolution of school status for 18 months by countries during the COVID-19 pandemic. This d3-map allows users to see that the global schooling system was affected most severely around May 2020, and the negative impacts of COVID-19 on education have been mitigated starting from March 2021. The third interactive bar chart helps users in understanding which countries have the longest/shortest closure period by providing options of different searching criteria. The last animated donut charts provide search form options of region and gender. The charts visualize the answers to the questions such as: In which education level, learners

are most severely affected by COVID-19 in South and West Asia Region? What is the difference between the distribution of affected learners in the Central and Eastern Europe region and the Central Asia region?

**Economic Page.** The economics page consists of three visualization techniques. The first treemap shows how GDP shrinks with the development of COVID-19. We can see that the GDP of most countries decreases as time goes by. The second heatmap shows how the lockdown and other public policies incur more unemployment globally. Finally, the final export and import chord diagram shows that although the world is suffering from the COVID-19. We still need each other, the trade between nations is almost the same with or without the COVID-19. By compacting all three graph forms into a normal window size, users can grasp the information inattentively.

## 5   System

We utilize both Leaflet and D3 to render the world Mapbox with a choropleth map on it. By using d3 to monitor the changes on the Mapbox, the time slider, the table, and the buttons on the scatter plot, we can interact with all components on the home page. In addition, we use Bootstrap-Vue to construct the table and grid system to enforce the web page layout so that the order of the components remain consistent as the size of the window page change. We also add a resize function with D3 to make the scatter plot responsive. To build up the dendrogram, treemap, and chord graph, We use d3 layout to construct all the hierarchies. The animated and interactive donut chart was developed by using d3.pie and form controls. D3-map is also used to construct the choropleth map and proportional symbol map. In addition, we use Core.js to enable the hover effect on the graphic forms and the animation on the year button.

## 6   Conclusion

To summarize, this dashboard brings information on how the globe was impacted by the pandemic as time goes on. As can be seen from the global choropleth map of vaccinations, taking vaccination is a way to protect public health, but relying on vaccines alone still cannot eradicate the negative impacts of COVID-19. The education sections offer users an overview of the affected global education system, and users can tell from the duration of school closures bar chart that Uganda and Nepal were affected most severely by the pandemic with the longest fully closed period. And lastly, we confirmed our assumptions of the negative impact on employment due to COVID-19 lockdown policies. If we have more time, we would first integrate the data into a single data set before designing the graph to develop the project in a more systematic way. And we would add more dimensions like international travel and e-commerce in our project to offer users a more comprehensive view of COVID-19 global impacts.

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