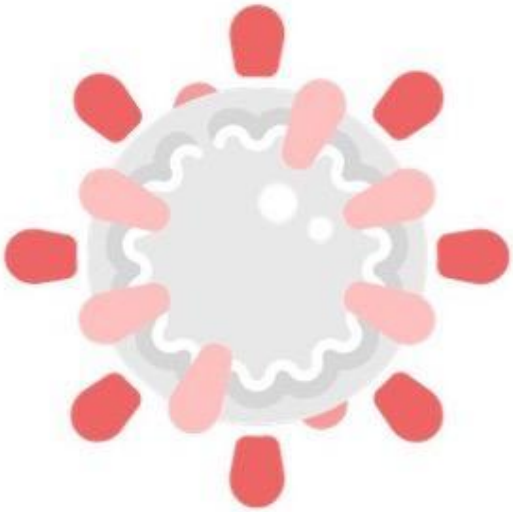
BMI 706 Process Book



COVID-19 & Healthcare Utilization

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Visualization Project Dataset & Tasks

1. Identification of dataset

The COVID-19 pandemic has had a significant impact on healthcare utilization. While some patients have continued to seek emergency care for urgent medical needs, others have been hesitant to go to the healthcare settings due to fears of contracting COVID-19. This has resulted in a change in the overall volumes in healthcare healthcare. The pandemic has also led to changes in the way emergency care is delivered, including increased use of telemedicine and a greater focus on infection prevention and control measures. As the COVID-19 pandemic continues to evolve and in preparation for future public health crises, an analysis of healthcare utilization is prudent.

We will utilize two primary data sources to investigate the impact of the coronavirus pandemic on healthcare healthcare and inpatient admission outcomes in the US. Data on coronavirus cases and deaths will be obtained from the Centers for Disease Control and Prevention (CDC), which maintains geographic and temporal incidence data. Data on healthcare utilization and inpatient admissions will be derived from the Healthcare Cost and Utilization Project (HCUPnet): https://datatools.ahrq.gov/hcupnet. HCUP is a collection of healthcare databases developed through a public/private partnership and sponsored by the Agency for Healthcare Research and Quality (AHRQ). Data is collected by individual states and aggregated by AHRQ. Details regarding HCUP are available: https://www.hcup-us.ahrq.gov/

2. Variables

CDC Data:

1. Weekly US COVID-19 cases and deaths (https://data.cdc.gov/Case-Surveillance/Weekly-United-States-COVID-19-Cases-and-Deaths-by-/pwn4-m3yp/data)
    a. Number of new cases and total cases per week in each US state
    a. Number of new deaths and total deaths per week in each US state
2. COVID-19 (Pfizer) vaccine distribution / allocation https://data.cdc.gov/Vaccinations/COVID-19-Vaccine-Distribution-Allocations-by-Juris/saz5-9hgg/data
    a. Number of 1st dose and 2nd dose allocations by week in each US state

HCUPnet Data: https://datatools.ahrq.gov/hcupnet

1. Healthcare Healthcare
    a. Primary outcomes: number of ED visits; rate of ED visits per 100,000
    a. Secondary outcomes: disposition status (admission / home), cost per visit
    a. Modifying characteristics: age group, race, sex, rural/urban, expected payer, patient-community level income, hospital trauma level, hospital owner
2. Inpatient Hospital Admissions

a. Primary outcomes: average length of stay, number of discharges
a. Secondary outcomes: disposition status (admission / home), cost per admission
a. Modifying characteristics: admission source, age group, race, sex, rural/urban, expected payer, patient-community level income, hospital trauma level

3. Exploratory analysis goals

The pandemic drastically altered healthcare utilization and resource allocation. In particular, there was fluctuating healthcare demand related to treatment of coronavirus itself, as well as changing demands in the care of other conditions secondary to pandemic disturbances. Through exploratory analysis, we aim to evaluate the impact of the population level incidences and coronavirus-related deaths on healthcare utilization (volume, likelihood of admission to hospital) and admission characteristics (volume, length of stay, cost per visit). Temporal and spatial analysis will be performed. We will assess outcomes in the 2-3 year period prior to March 2019 to provide a baseline, and will then evaluate outcomes until 12/31/2022. Data on vaccine availability and allocation may also be used to provide additional context.

4. Target audience

Our analysis is intended for public health officials and healthcare professionals. We intend our visualizations to help provide insight regarding the changing trends and health demands related to the coronavirus pandemic, with a specific emphasis on geographic variation in utilization.

5. Visualization tasks

The main visualization tasks for this exploratory analysis are:
-Plotting number of new COVID cases and deaths by week and/or geography (i.e., county/state)
-Linking COVID cases/deaths to hospital discharge utilization data
-Linking COVID cases/deaths to inpatient outcomes (length of stay)

References

Healthcare Cost and Utilization Project (HCUPnet): https://datatools.ahrq.gov/hcupnet.

Barten, D.G., Latten, G.H. and Van Osch, F.H., 2022. Reduced emergency department utilization during the early phase of the COVID-19 pandemic: viral fear or lockdown effect?. Disaster medicine and public health preparedness, 16(1), pp.36-39.

Radhakrishnan, L., 2022. Pediatric emergency department utiliizations before and during the COVID-19 pandemic—United States, January 2019–January 2022. MMWR. Morbidity and Mortality Weekly Report, 71.
Wai, A.K., Wong, C.K., Wong, J.Y., Xiong, X., Chu, O.C., Wong, M.S., Tsui, M.S. and Rainer, T.H., 2022. Changes in emergency department visits, diagnostic groups, and 28-day mortality associated with the COVID-19 pandemic: a territory-wide, retrospective, cohort study. Annals of Emergency Medicine, 79(2), pp.148-157.

Venkatesh, A.K., Janke, A.T., Shu-Xia, L., Rothenberg, C., Goyal, P., Terry, A. and Lin, M., 2021. Emergency department utilization for emergency conditions during COVID-19. Annals of emergency medicine, 78(1), pp.84-91.

The Design Space & Sketches

Our Design Space.

Representing time series data with geospatial data allows for exploring a variety of design choices. At our disposal are mappings as well as the ability to include interactive features that shift the time horizon. In our sketches, we experiment with designs that incorporate known spatial representations (e.g., a stencil of the United States), as well as figures that incorporate different types of data representation (e.g., bar graph with area chart inset below). We also explore relatively uncommon data representations such as visual 'binning.'

Anticipated Challenges.

Succinctly representing multiple variable types and their relationships is challenging. Our main concern is to provide insightful visualizations that incorporate different data types whilst not confusing or distracting the reader. We have considered both effective and ineffective visualization examples.

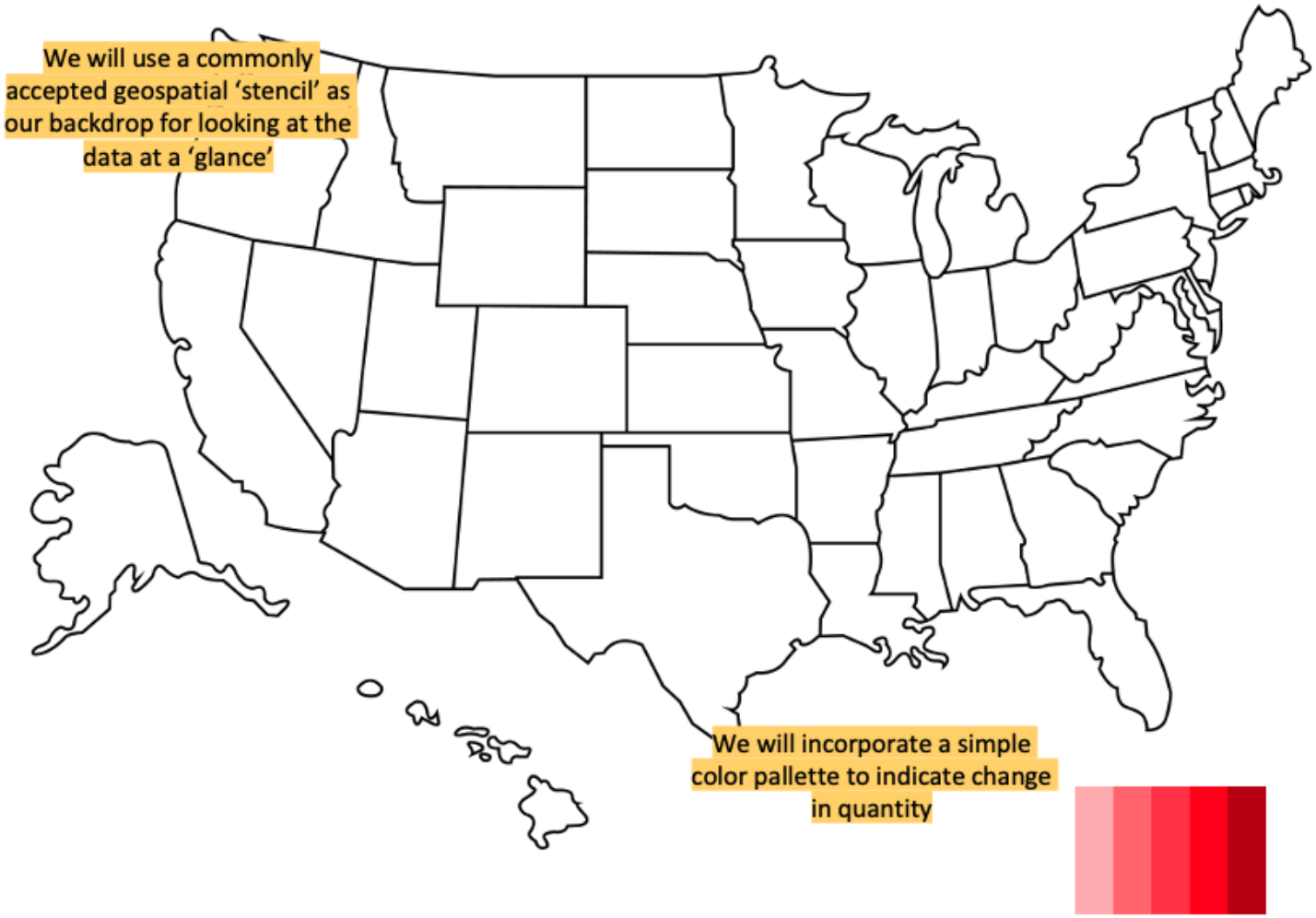
Deployment Approach.

While many COVID-19 figures have been generated and distributed through the lay-press and scholarly publications, we aim to add to these visualizations in a novel way by incorporating healthcare system utilization data. Specifically, we plan to produce dynamic visual representations of how COVID-19 impacted utilization of Emergency Departments, nation-wide, covering the Pre- and Post-COVID period of 2019-2021.

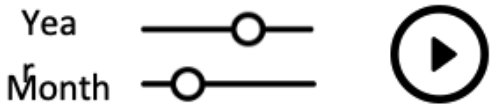
Ultimately, we want the reader to walk away with insights on how COVID-19 impacted healthcare utilization across several utilization metrics. We also want to take advantage of the detail of our datasets that range from national to state-level data. We plan to incorporate selectors that allow the reader to change the active window with both geographic (e.g., state) and temporal variables (e.g. month of the year). We will also incorporate a selector that changes the metric of interest. From a technical perspective, we feel we can accomplish this functionality using the Altair visualization library.

Sketches to follow:
Viz 1 - Interactive Weekly COVID Case Counts
Viz 2 - Sankey Flow Diagram Showing Admissions Types
Viz 3 - Sankey Flow Diagram Showing Admissions Types Change Pre- to Post-COVID |
Viz 4 – Monthly Sedimentation Flow
Viz 5 – Cases & Outcome Metrics

Viz 1 – Interactive Weekly COVID Case Counts



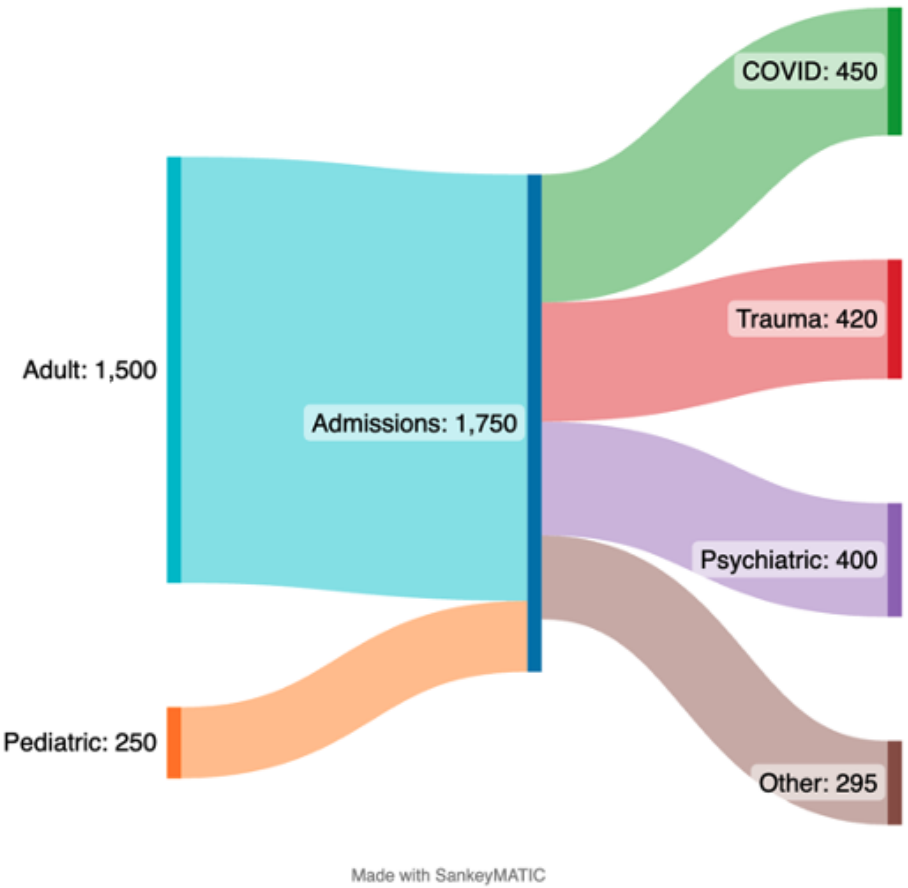
We want to be able to capture the temporal changes in the data and allow the reader to customize their view according to desired year and month inputs



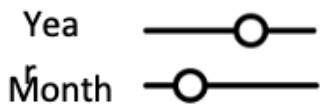
Having an animation feature would enrich the visualization to allow the reader to examine a progressive represenation of the temporal data

Viz 2 – Sankey Flow Diagram Showing Admissions Types

Sankey flow diagrams provide a visually intuitive means for examining 'flows' of data that can be either static or incorporate a temporal element. For this first Sankey diagram we thought provide granular data on one of the metrics (admission types) with a selectable temporal element (month, year) would be effective.

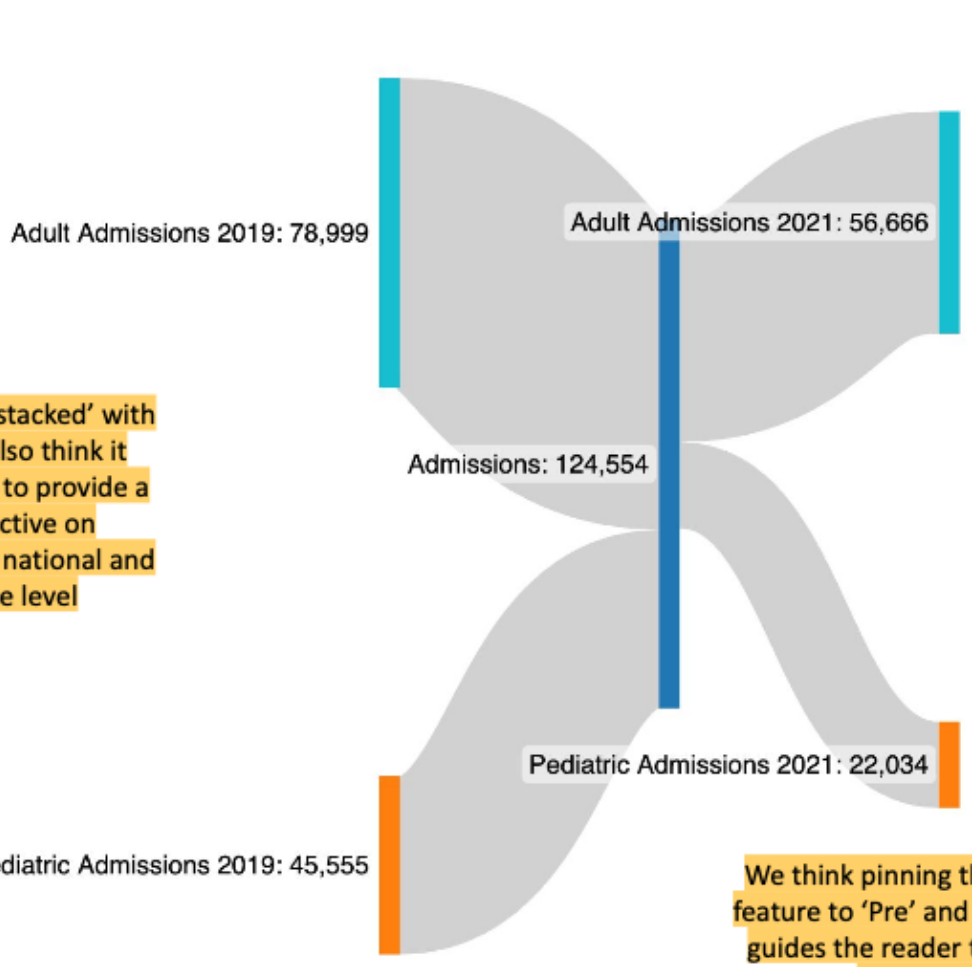


Temporal selector allows the reader to change the year and month



Assigning different and contrasting colors helps the reader quickly see how the 'flows' of patients change by classification

Viz 3 – Sankey Flow Diagram Showing Admissions Types Change Pre- to Post-COVID



This figure could be 'stacked' with our Viz 2, but we also think it could be standalone to provide a different perspective on admissions at both a national and state-selectable level

The state selector allows the reader to examine either national or state-level data

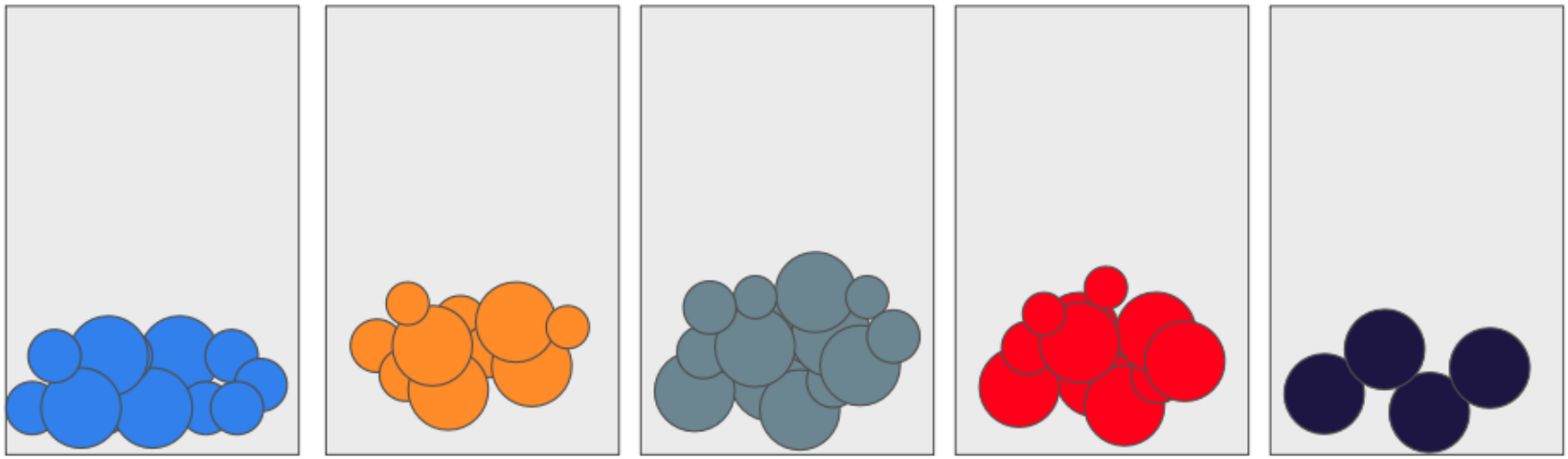
We think pinning the temporal feature to 'Pre' and 'Post' COVID guides the reader towards the main insight

Monthly sedimentation flow

Sedimentation flow will occur for each outcome, with size of circle representing volume

Month / Year

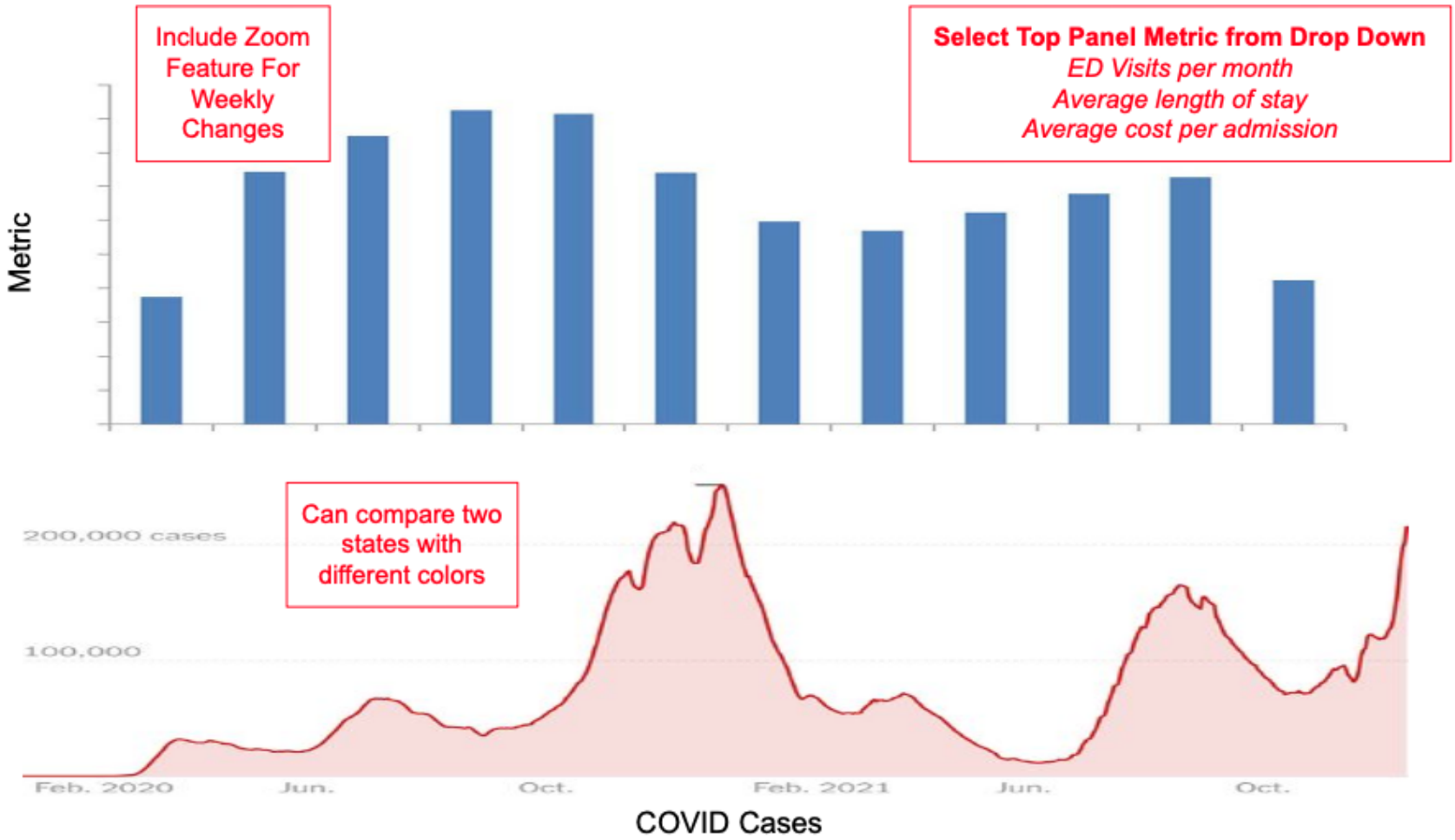
Month and year will update as sedimentation flow proceeds



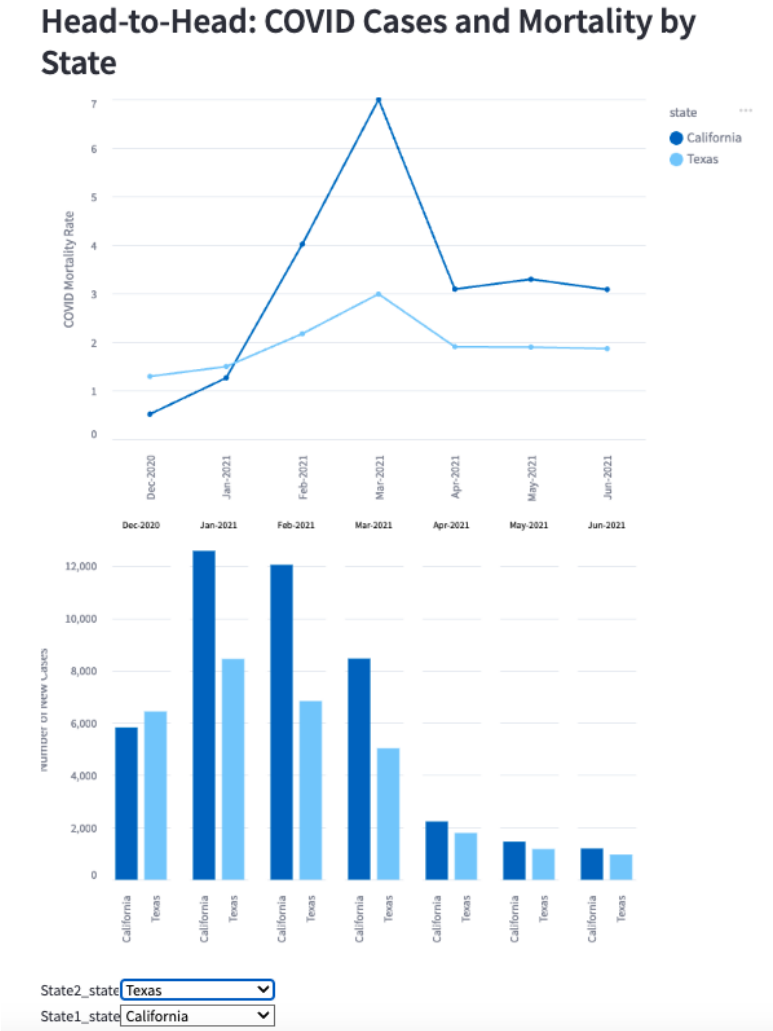
ED Visits | Admissions | COVID cases | COVID deaths | Vaccines

Massachusetts

State can be modified / selected from dropdown menu


Include Zoom Feature For Weekly Changes
Select Top Panel Metric from Drop Down
ED Visits per month
Average length of stay
Average cost per admission
Metric
Can compare two states with different colors
200,000 cases
100,000
Feb. 2020
Jun.
Oct.
Feb. 2021
Jun.
Oct.
COVID Cases

Screenshots from live demo illustrating the key observations

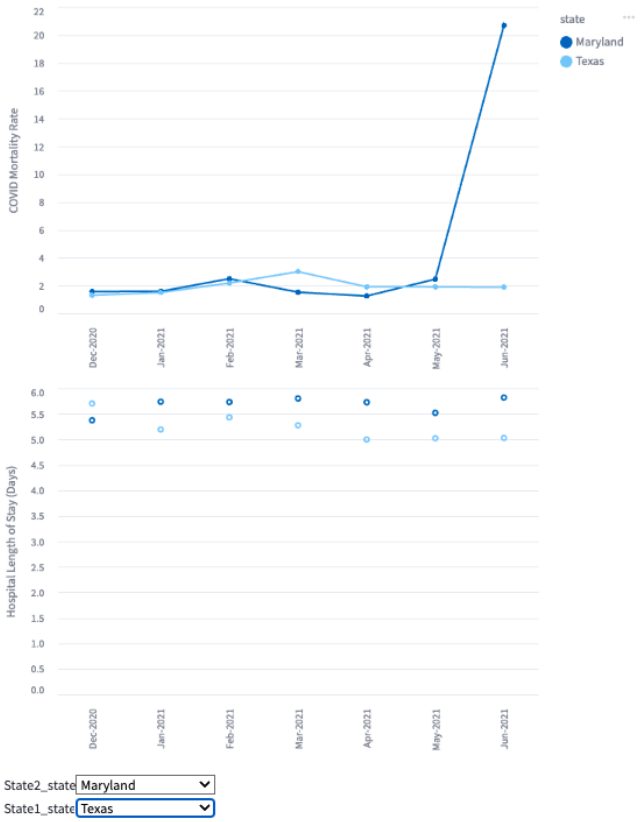


Key Insight:

The volume of COVID-19 cases was higher at different times in different states.

Mortality did not appear to be reproducibly associated with COVID-19 new case volumes.

Head-to-Head: COVID Mortality & Hospital Length of Stay

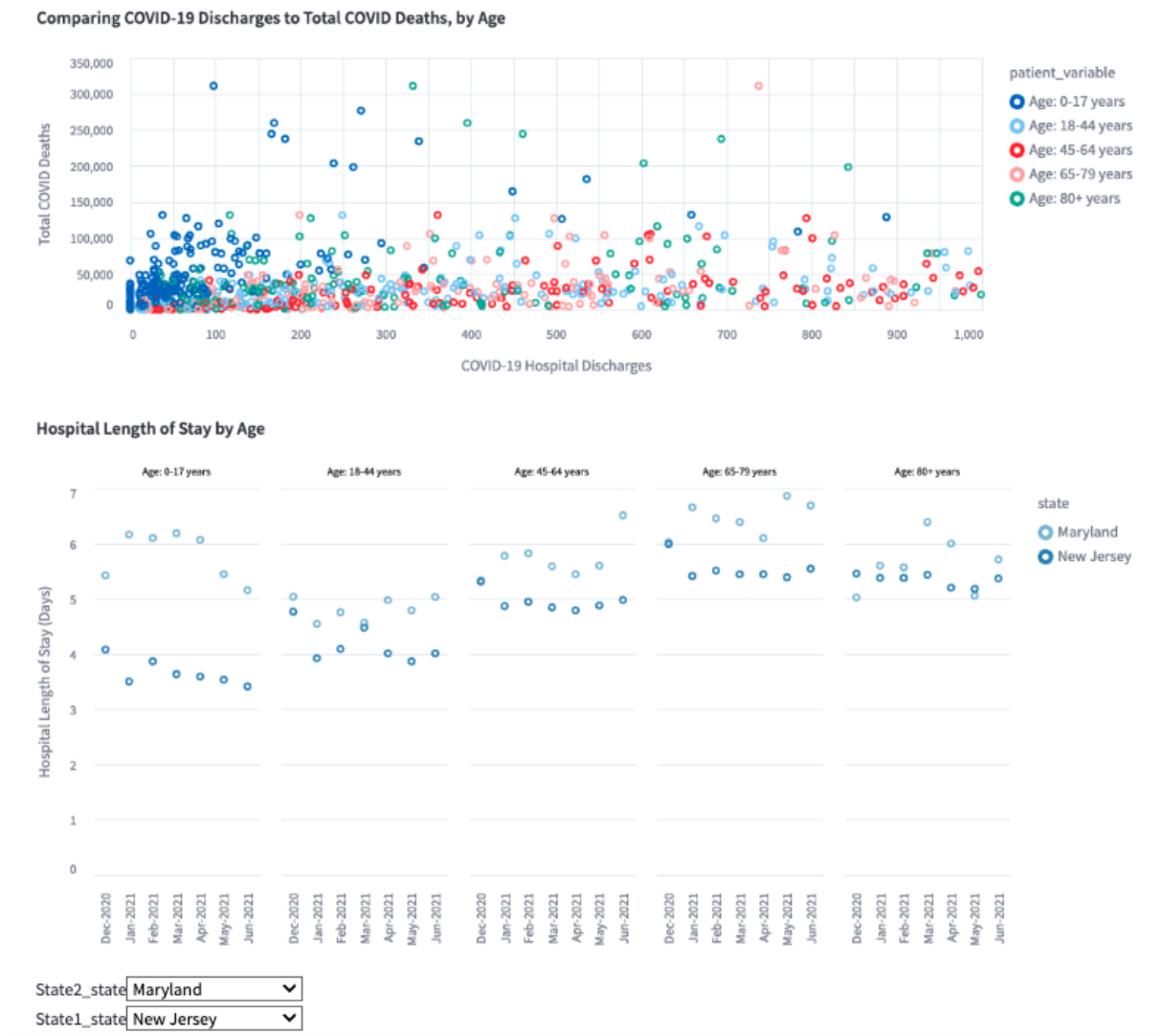


Key Insight:

Length of stay may have been associated with COVID-19 mortality rates.

Not shown in this representation, there was some notable variation in length of stay across states.

Length of stay may be a proxy for severity and volume of COVID-19 cases.



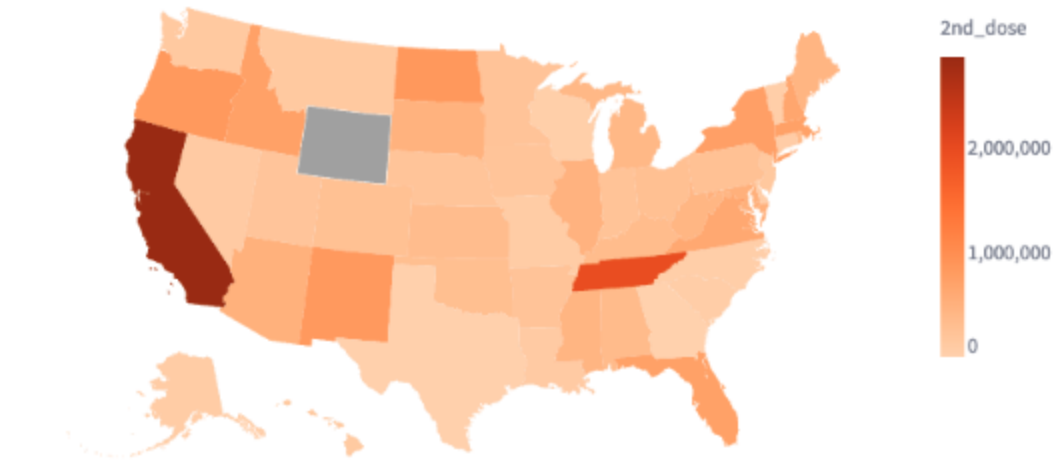
Key Insight:

The number of COVID-19 related hospital discharges did not appear to correlate with total COVID-19 deaths.

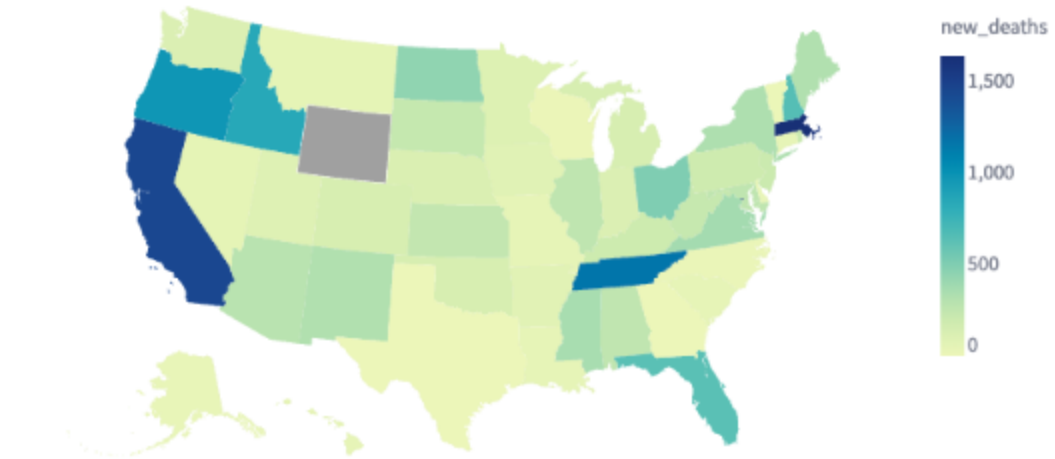
WIth exception for younger (pediatric) patients where there was both lower deaths and discharges.

There was some variability by state in regard to hospital length of stay and age.

Number of Individuals who Received 2 Doses of COVID Vaccine by State in the United States May-2021



Number of New Deaths by State in the United States May-2021



Key Insight:

There appeared to be a trend in COVID-19 dose density and number of deaths.

This may represent local awareness of the impact of COVID-19 and motivation to a vaccination (e.g., higher local-regional death → more motivated to get vaccinated)

Ideas for future work or additional sketches.

There are several ideas for future work or additional sketches that could enhance the project's scope and impact as an analytic tool. One possible direction could be to add more granular data to the visualization, such as hospital-level data. This could provide a more detailed understanding of how COVID-19 impacted healthcare utilization, which could be especially useful for policymakers and healthcare providers. Additionally, incorporating data on the presenting diagnoses and needs of the patients who visited the hospital (e.g., ICD-10 codes for diagnoses, CPT codes for procedures and interventions) could provide valuable insights into how different populations and specific medical conditions were affected by the pandemic.

Another potential area of focus could be to explore the impact of COVID-19 on healthcare utilization beyond inpatient hospital care. For example, the project could incorporate data on urgent care, primary care and subspecialist outpatient visits. This could provide a more comprehensive understanding of how COVID-19 affected the healthcare system. Additionally, incorporating data on healthcare provider staffing levels could shed light on the challenges healthcare systems faced during the pandemic and how they responded to them.

Another idea is to investigate the long-term effects of the pandemic on healthcare utilization, such as delayed or deferred care, and how this may impact public health outcomes in the future.

Further still, the project could benefit from incorporating qualitative data, such as patient experiences and healthcare worker perspectives, to provide a more comprehensive understanding of the impact of COVID-19 on healthcare utilization. This could be achieved through surveys or interviews with healthcare professionals and patients, which could be integrated into the project through interactive features, such as pop-ups or annotations. Finally, the project could consider including visualizations that compare healthcare utilization across different countries or regions, providing a global perspective on the pandemic's impact on healthcare systems.

Overall, there are many potential directions for future work or additional sketches that could further enhance the project's impact and utility. By broadening the project's scope in these ways, it could provide valuable insights into the complex and multifaceted impact of COVID-19 on healthcare utilization.

Contributions of each team member.

Both Brendin Beaulieu-Jones and Matt Crowson participated equally in the design, drafting and finalization of each component of this final project.

Brendin Beaulieu-Jones took the lead on the visualization artistic design and coding
Matt Crowson took the lead on the design and deployment of the streamlit app.