

An Information System for COVID-19 Hospitalization Tracking and Analysis

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In March 2020, public health officials in every US states were scrambling for data to help predict and prepare for “the surge” of hospitalizations due to COVID-19. While there were credible websites reporting on the daily number of cases and deaths in each state (e.g., Johns Hopkins), these data were insufficient for predicting the real-time stress on the hospital systems: cases were under-reported due to lack of testing capability and deaths are a lagging indicator. This information gap drove the team at the University of Minnesota’s Carlson School of Management to launch the [COVID-19 Hospitalization Tracking Project](https://carlsonschool.umn.edu/mili-misrc-covid19-tracking-project) (<https://carlsonschool.umn.edu/mili-misrc-covid19-tracking-project>) – a daily state-by-state view on the number of hospitalizations.

In mid-March, Prof. Pinar Karaca-Mandic, who leads the Medical Industry Leadership Institute (MILI) at the Carlson School of Management, Dr. Archelle Georgiou, Chief Health Officer – Starkey Technologies & Executive-in-Residence at MILI, and Prof. Soumya Sen, who leads the Management Information Systems Research Center (MISRC) at the Carlson School, launched this project to develop systems and processes to collect, track and trend daily COVID-19 hospitalization data from each states’ Department of Health. The team leaders brought complementary strengths to the project. Prof. Pinar Karaca-Mandic is a health economist and a research associate at the National Bureau of Economic Research (NBER). Dr. Archelle Georgiou is a physician, author, medical executive, and a journalist. Prof. Soumya Sen is an expert in designing management information systems and data analytics. Together they provide the shared vision, knowledge, and expertise for identifying data gaps, engineering an end-to-end system for continuous tracking, analyzing the data, and reporting the impact on healthcare systems through research publication and journalism.

The project was launched on March 26, 2020 by contacting the communications director of each state’s health department team. This email described the project, its purpose and requested that they publicly report information on hospitalizations and ICU utilization. The research team identified a set of key metrics and issued a call to the states in *Health Affairs* [1] to report these data consistently. Early on, only 23 states made hospitalization data publicly available; the Carlson team captured these daily data in the project database and has made them freely and publicly available since April 6, 2020. Today, all 50 states and the District of Columbia make data available and are tracked daily on the dashboard.

Research associates access each state’s Department of Health website daily and enter the hospitalization data into an online database. Data collected are: cumulative COVID-19 hospitalizations and ICU admissions; current COVID-19 patients hospitalizations and ICU admissions; ventilator use and any other relevant data state reports. That may include a breakdown of hospitalizations by age, race and ethnicity, capacity of state hospitals, or data by counties or regions within a state. All data are adjusted for states’ population using estimates from the 2018 American Community Survey published by the U.S. Census

Bureau. Additionally, each state’s total hospital bed capacity is calculated based on data from the American Hospital Association Survey, 2018, provided by the Harvard Global Health Institute. Quality control procedures are in place to confirm the accuracy of the data. Data is exported to a publicly accessible visual dashboard that the team built to present the data in several configurations ranging from interactive charts to maps. The project website also provides downloadable historical data, analysis, trend reports and more. We designed a system workflow to collect the hospitalization data from official sources of all states to create a central database. Using iterative design-build-validate-evaluate activities, we developed a dashboard that displays the data by state and sub-state in numeric and graphic formats, along with historical trends.

The COVID-19 hospitalization data quantifies the current impact on hospital systems, supports modeling and forecasting of future utilization, and tracks the rate of change in disease severity. Presenting this data in an accessible manner for individuals, media outlets, and other organizations is key to keeping the public informed about the spread of the pandemic. The project team is collaborating with public health experts across the country and proactively sharing insights to help mitigate the impact of the next wave of the pandemic. We conducted extensive interviews to gather feedback on the dashboard and updated the design continuously to visualize new information and related data analysis. As a result of our collaboration with HHS, they have made important modifications in the data they release to public. For example, they now separately report rates of suspected and confirmed hospitalizations. In addition, they added new data fields to report measures of the completeness for each data element. On December 2, HHS invited our team to vet the new hospital facility-level data prior to its public release on December 7. We collaborated with HHS as well as other health data analysts and made critical suggestions on data elements to improve transparency of the information. We created a FAQ document to support public understanding of data. (https://github.com/CareSet/COVID_Hospital_PUF). On December 7, the Department of Health and Human Services (HHS) released the hospital-facility data publicly and our site was the first in the nation to publish a visualization of COVID-19 hospital occupancy at the county-level across the US [11]. Front-page coverage in the Wall Street Journal and New York Times directly referenced our project resulting in over 70,000 visits to our website in a single day. Till date over 590k unique visitors have accessed the website. With each weekly HHS data update, we refresh our analysis and publish “Key Insights” on the project website.

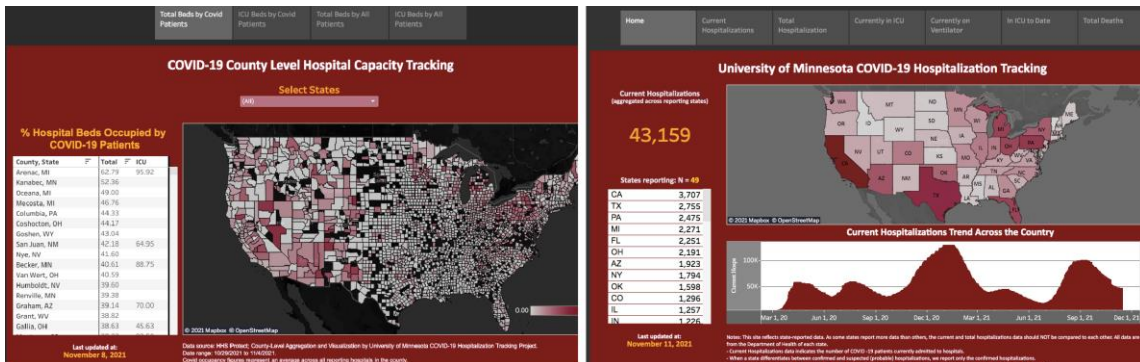


Exhibit 1: Dashboard for COVID general and ICU hospitalization across US states and counties

Prof. Karaca-Mandic and Prof. Sen have served on the U.S. Department of Health and Human Services Working Group for COVID-19 Hospital Actuals and Estimates. Dr. Archelle Georgiou has appeared in many media interviews and television programs to create awareness about the hospitalization trends that are being reported by the project. We also share customized data sets with journalists and provide a regular data feed to National Public Radio (NPR) who uses it to create their dynamic look-up tool called “Where Hospitals Are Filling up” [12]. More than 120 additional media outlets including CNN, U.S. News & World Report, Vox, Bloomberg, MSNBC, NBC Universal, and Star Tribune have cited the project’s data and findings.

The three project co-leads have interviewed with various media organizations, spoke at various public events (e.g., Bill & Melinda Gates Foundation Wisdom Council: Data Solutions for Global Health Challenges and the Minnesota CLE: 2021 Health Law Institute), and published several high-impact research works. Findings by the project team were published in the *Journal of the American Medical Association (JAMA)*, *JAMA Internal Medicine*, *JAMA Pediatrics*, *JAMA Health Forum*, *Journal of General Internal Medicine*, *Health Affairs*, and *Health Management Policy & Innovation*. Coverage of the *JAMA Internal Medicine* paper titled, “Assessment of COVID-19 Hospitalizations by Race/Ethnicity in 12 States” [8] resulted in much needed public awareness of the considerable disparities in the prevalence of COVID-19 across racial and ethnic subgroups. Coverage of “Association of Stay-at-Home Orders With COVID-19 Hospitalizations in 4 States” [3] in *JAMA* offered objective data on the impact of stay-at-home on the number of COVID-19 hospitalizations. “Trends in Pediatric Hospitalizations for Coronavirus Disease” [10] in *JAMA Pediatrics* provided early warning and data about the growing hospitalization rates among younger population in several states. “Association of COVID-19-Related Hospital Use and Overall COVID-19 Mortality in the USA” [9] in *Journal of General Internal Medicine* provided evidence that the actual mortality rate was higher than the initial estimates of CDC. The project data continues to be analyzed and interpreted to offer objective insight to the nation’s management of this public health crisis.

The project has been recognized by various academic and non-profit organizations. AACSB International – the world’s largest business education network and accreditation body – recognized the project as one of its 2021 Innovations That Inspire. The research project also earned two Silver Stevie awards at the 19th annual American Business Awards for the "Most Valuable Non-Profit Response" and "Most Valuable Service" of 2021, and was a finalist at the NIHCM Digital Media Awards.

The project showcases how the IS design science community – with its strengths in developing IT artifacts and data analytics – is uniquely positioned to play an important role in providing data-driven insights for responding to the pandemic and preparing for future adversarial events.

References

1. Karaca-Mandic P, Georgiou A, Sen S. “Calling All States To Report Standardized Information On COVID-19 Hospitalizations,” *Health Affairs Blog*, April 7, 2020. DOI: 10.1377/hblog20200406.532030 <https://www.healthaffairs.org/doi/10.1377/hblog20200406.532030/full/>
2. Karaca-Mandic P, Georgiou A, Sen S., Zhu Y, Everhart A. Vu, K “Early Insights from the University of Minnesota’s COVID-19 Hospitalization Tracking Dashboard” *Health Management, Policy, Innovation*, April 13, 2020 <https://hmpi.org/2020/04/13/early-insights-from-the-university-of-minnesotas-covid-19-hospitalization-tracking-dashboard/>
3. Sen S, Karaca-Mandic P, Georgiou A. Association of Stay-at-Home Orders With COVID-19 Hospitalizations in 4 States. *Journal of American Medical Association (JAMA)*. May 2020, 323(24): 2522–2524. <https://jamanetwork.com/journals/jama/fullarticle/2766673>
4. Goldman D, Karaca-Mandic P, Hedt S, “[Should We Open California Beaches? Coronavirus Trends Vary by County](#)”, The Evidence Base, April 29, 2020
5. Hedt S, Karaca-Mandic P “[L.A. County Coronavirus Hospitalizations Trending Down; Other Urban California Counties Show Mixed Progress](#)”, The Evidence Base, June 3, 2020
6. Karaca-Mandic P, Goldman D, Hedt S, “[Orange County COVID-19 Hospitalizations Up 130% Since June 1](#)”, The Evidence Base, July 16, 2020
7. Karaca-Mandic P, Hedt S, “[Counties in the Inland Empire and Central Valley Report High and Rising COVID-19 Hospitalizations](#)”, The Evidence Base, July 17, 2020
8. Karaca-Mandic P, Georgiou A, Sen S. “Assessment of COVID-19 Hospitalizations by Race/Ethnicity in 12 States,” *Journal of American Medical Association (JAMA) Internal Medicine*, August 2020. <https://jamanetwork.com/journals/jamainternalmedicine/fullarticle/2769369>
9. Karaca-Mandic P, Sen S, Georgiou A, Zhu, Y, Basu, A. Association of COVID-19-Related Hospital Use and Overall COVID-19 Mortality in the USA, *Journal of General Internal Medicine*, August 2020. <https://link.springer.com/article/10.1007/s11606-020-06084-7>
10. Levin Z, Choyke K, Georgiou A, Sen S, Karaca-Mandic P “Trends in Pediatric Hospitalizations for Coronavirus Disease”, *JAMA Pediatrics*, January 11, 2021 (originally scheduled for December 28, 2020 but then re-scheduled by the editorial team to January 11, 2021). <https://jamanetwork.com/journals/jamapediatrics/fullarticle/2775008>
11. Karaca-Mandic, P “New Data, Dashboard Provide Information on COVID-19 Hospital Capacity”, *STAT News*, December 10, 2020, <https://www.statnews.com/2020/12/10/new-data-dashboard-provide-information-on-covid-19-hospital-capacity/>
12. Sean McMinn and Pien Huang “COVID-19 Data Release Shows Where Hospitals Around The Country Are Filling Up”, December 7, 2020. <https://www.npr.org/sections/health-shots/2020/12/07/944021201/new-covid-19-data-release-shows-where-hospitals-around-the-country-are-filling-u>

Verification

The project is led and driven by university-based faculty and Ph.D. students for research purposes.

SUPPORTING DOCUMENTATION:

1. Website: [COVID-19 Hospitalization Tracking Project \(https://carlsonschool.umn.edu/mili-misc-covid19-tracking-project\)](https://carlsonschool.umn.edu/mili-misc-covid19-tracking-project)

PEER-REVIEWED PUBLICATIONS:

2. Gupta S, **Georgiou A, Sen S**, Simon K, **Karaca-Mandic P**, “US Trends in COVID-19-Associated Hospitalization and Mortality Rates Before and After Reopening Economies”, *JAMA Health Forum*, 2(6), 2021. <https://jamanetwork.com/journals/jama-health-forum/fullarticle/2781505>
3. Levin Z, Choyke K, **Georgiou A, Sen S, Karaca-Mandic P**, “Trends in Pediatric Hospitalizations for Coronavirus Disease”, *JAMA Pediatrics*, January 11, 2021. <https://jamanetwork.com/journals/jamapediatrics/fullarticle/2775008>

4. **Karaca-Mandic P, Sen S, Georgiou A, Zhu Y, Basu A**, “Association of COVID-19- related Hospital Use and Overall COVID-19 Mortality in the USA, *Journal of General Internal Medicine*, August 19, 2020. <https://link.springer.com/article/10.1007/s11606-020-06084-7>
5. **Karaca-Mandic P, Georgiou A, Sen S**, “Assessment of COVID-19 Hospitalizations by Race/Ethnicity in 12 States”, *JAMA Internal Medicine*, August 17, 2020. <https://jamanetwork.com/journals/jamainternalmedicine/fullarticle/2769369>
6. **Sen S, Karaca-Mandic P, Georgiou A**. “Association of Stay-at-Home Orders With COVID-10 Hospitalizations in 4 States” *JAMA*, May 27, 2020. <https://jamanetwork.com/journals/jama/fullarticle/2766673>
7. **Karaca-Mandic P, Georgiou A, Sen S**, “Early Insights from the University of Minnesota's COVID-19 Hospitalization Tracking Dashboard,” *Health Management Policy & Innovation* (HMPI), April 13, 2020. <https://hmpi.org/2020/04/13/early-insights-from-the-university-of-minnesotas-covid-19-hospitalization-tracking-dashboard/>
8. **Karaca-Mandic P, Georgiou A, Sen S**, “Calling All States to Report Standardized Information on COVID-19 Hospitalizations,” *Health Affairs*, April 7, 2020. <https://www.healthaffairs.org/doi/10.1377/hblog20200406.532030/full/>