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Meeting the Data Challenges of the COVID-19 Pandemic: A Multi-level Monitoring Solution

Consulting Technology Innovation

Abstract

During the COVID-19 pandemic, Initiate Government Solutions (IGS) leveraged its significant data management expertise to provide support to various government and non-government customers in the form of a single point of reference for COVID-19 (COVID) reporting and metrics. From one underlying data architecture comprised of data from disparate sources, IGS provided resources for a large-scale healthcare entity and developed a multi-level monitoring solution comprised of three reports for organizational leadership, local medical centers, and external communications. These reports provide public-facing deidentified information, leadership deidentified information, and medical center detailed information, including patient and staff care.

The staging area harmonizes data from many sources to provide near-real time analysis of patient-level and system-level data. The COVID reports provide data in four key areas: patient monitoring, staffing resources, supply inventory, and bed capacity. Patient monitoring data encompass COVID screening, vaccination, and case studies (also known as patient stories). Staffing resources data include treatment records for staff captured within the patient data, along with occupation health data and staffing resource counts. Supply inventory data are comprised of counts and availability for key supplies including COVID testing kits, ventilators, gowns, gloves, face shields, masks, and other Personal Protective Equipment (PPE). Bed capacity data provide patient census to identify counts of COVID-positive admitted patients and overall bed use and vacancy. While developing this solution, IGS faced and overcame many challenges and produced a data resource that has positively impacted the healthcare entity and the clients it serves.

Problem Statement

In addition to the enormous toll it has taken on healthcare delivery and human life, the COVID pandemic has highlighted the need for effective disease tracking, resource monitoring and communication among healthcare and government entities. Shortly after COVID was detected in the United States, many entities began to feel the effects of the pandemic in terms of the challenges of tracking resources and communicating between departments. Most organizations had to quickly evaluate and expand existing dashboards or create new data models to monitor resources, employees, and supply chains. Supply chains were disrupted, workers were affected, and healthcare entities became strained. Entities spanning over large geographic areas required visibility into local, regional, and widescale monitoring without the confusion that stems from conflicting data and information.

Initially organizational leadership relied on manually-compiled typed reports from medical center leadership and regional officers. Report content and presentation style was not well defined, which resulted in varied reporting approaches and formats (loose emails, Microsoft Word documents, screen shots, PDF files, and so on). The addition of more and more reporting areas (such as bed capacity and equipment inventory), coupled with significant increases in COVID-positive cases, rendered manual reporting unrealistic and overly burdensome. The initial human-driven effort to capture and report data elements caused variations in interpreting COVID-positive cases, and the complexity of defining COVID patient lists and lack of guidance on how to identify a COVID patient began to take its toll on the field staff attempting to pull the data manually.



Solution Development

IGS staff, working in collaboration with physician champions, created a centralized COVID monitoring platform and communication strategy. To accomplish this task, IGS coordinated frequent meetings between project managers, technical leads, organizational senior leadership staff, and physician champions. During the design phase, meetings occurred frequently, and physician champions invited subject matter experts in the healthcare organization to ensure IT and IGS staff were interpreting requirements correctly and developing accurately curated data. The challenge for IGS was to bring many data sources together into one platform. These data sources included self-reported inventory data, self-reported bed counts, staff exposure, staff screening, and staff vaccination data. IGS staff documented requirements in Git and created a list of sources needed to report on the requested measures.

Different departments in the organization had specific expertise; however, department directors had difficulty seeing the big picture and how their data affected other departments' process flows. The key to success and to addressing this challenge was to make a solution that consolidated the data into a centralized environment. IGS assessed data sources and created several COVID-monitoring databases for staging, development, testing, and production. Database administrators (DBAs) modified existing extraction processes to send data to the staging area and created new extractions to integrate additional sources, the majority of which were related to inventory and equipment data. Using patient care data provided from medical centers in near real time, the DBAs then created curated data sets from the staging database in a data mart.

As with other phases, the development phase was collaborative. Early in the design process, IGS consulted lab managers to build a list of test names with results that might be linked to COVID. In addition, the lab managers integrated newly released COVID screening tests performed at the medical centers with the expected values (positive/negative) from the lab test results. IGS data scientists used natural language (NLP) processing tools to construct new classifiers to identify potential COVID cases and artificial intelligence (AI) tools to search structured patient data and text notes for outside testing and symptoms related to COVID.

Using algorithms comprised of triggers and rules, the data scientists were able to classify patient records into COVID ruled out, probable COVID, and positive COVID cases. Medical center staff reviewed cases to increase confidence in the reported measures, ensure data quality, and recommend any necessary adjustments to the algorithms. Infectious disease staff used the data to determine the definition of a COVID positive patient and adjusted the criteria over time as additional symptoms, testing, and CDC guidance were provided. IGS also worked with the infectious disease staff to identify elements needed for patient stories and case reporting development.

Production

After developing the initial design strategy, creating the centralized environment, adding external data sources, and developing the data mart, IGS staged specific data from the data mart a second time to generate the visual aspects of three COVID monitoring reports: public facing, organizational and regional leadership, and medical center leadership.

The public facing report contains an overarching view of select statistics such as patient testing counts, inpatient counts, and deaths for the overall healthcare system. This report communicates the COVID response to the media and the public and to government and external organizations. The organization and regional leadership report is used daily by the healthcare organization's Chief Executive Officer, Chief Clinical Officer, Chief Operations Officer, and other leadership staff to provide a common COVID operating picture for the organization's Chief Operating Officer, Chief Clinical Officer, and regional officers. In addition to the information provided in the public-facing report, this report provides additional information such as patient infection and deceased count and state of the local medical centers, including staffing, bed capacity, and ventilator and PPE supply levels. The medical center leadership report provides the same information contained in the organization and leadership report, but it also includes protected health information (PHI) for both patients and staff. The patient and staff PHI is restricted to the facility with which the records are associated and access is limited to designated staff within the facility. The medical center Chief Clinical Officer and other designees use the information for case validation, patient care, contact tracing, and resource monitoring. Both the organizational and regional leadership and the medical center leadership reports provide customizable view options to enable staff to see all elements necessary to run their respective areas in the healthcare system from a strategic, operational, or tactical perspective.

During and after development, medical center and regional leadership provided feedback to IGS staff on the usability of the reports and recommended enhancements to the data visualizations. IGS incorporated these recommendations and compared patient lists generated by medical center staff to the reports and inventory counts to ensure accuracy.

The reports came to fruition in just a few weeks and were released in mid-April 2020. Having the support of physician champions was key to making the solution a success. The healthcare system leadership determined that there needed to be one source of truth to inform both the COVID response communications and the COVID numbers reported outside of the organization to public and government entities. Senior leadership recognized that the medical center leadership required a tool to help them manage their resources and minimize the burden of field-level reporting. By generating all three reports from a single data mart, IGS provided a multi-level monitoring solution that assures all this data coincides

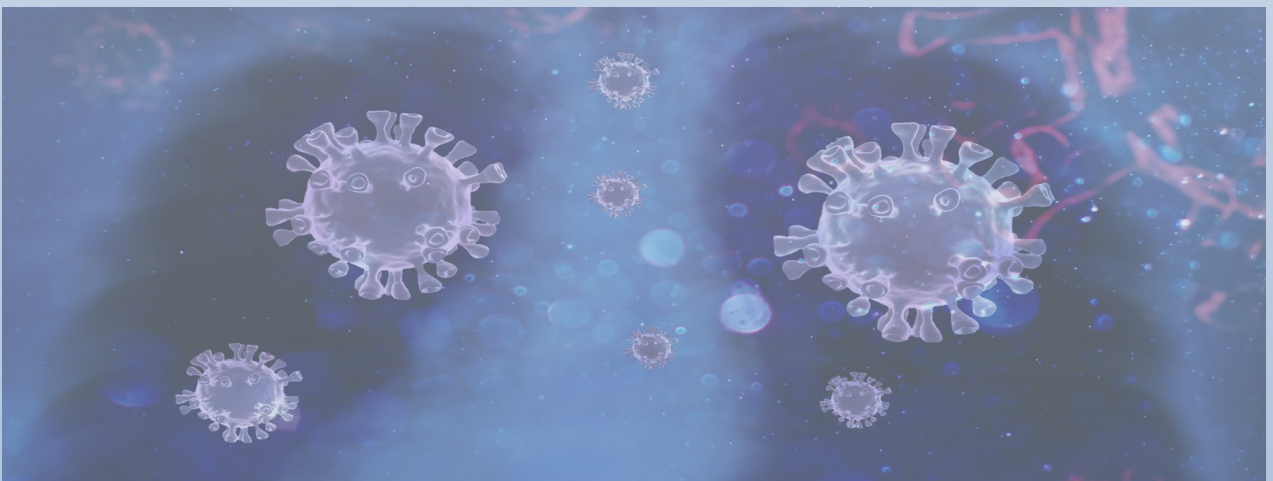


Challenges

During the process of designing, developing, and deploying the multi-level COVID monitoring system, IGS faced and overcame several challenges. For example, escalation of the COVID outbreak necessitated shifting more resources to creating the COVID monitoring platform and visualization tools. The effort required to implement new functionality in the electronic health record (EHR) left certain IT support areas shorthanded, and not all personnel were familiar with the new data structures. As the scope of the COVID reports widened to include measures and calculations, IGS staff were also required to create custom functionality in the visualization tools from version to version.

Infrastructure challenges also arose. The centralized platform was developed using existing resources in the organization and on-premises servers. Maintenance and data outages on the servers affected the COVID reports and thus impacted the communication between organizational leadership and medical centers. The organization also acquired new hardware, and installation and configuration of the new servers and migration from the old hardware to the new hardware required downtime. Expanding database sizes could have potentially caused serious issues and significant downtime; however, IGS staff acted proactively to avoid such problems. They noticed that the core databases used for staging the raw data and the curated data sets on the data mart were coming close to exceeding their configured sizes and quickly adjusted the database sizes to accommodate the additional data elements and volumes.

Conflicting communication also posed challenges. Medical centers and organization leadership initially sent out separate policies, memorandums, and directives that had conflicting information related to COVID, primarily in the areas of inpatient care, outpatient care, informatics, virtual health, and education. In April 2020, the organization provided guidance for inpatient bed management, surge planning, and PPE self-reporting to solidify processes. Initially the organization used a bed management application to track bed availability; however, hospitals had to have the flexibility to quickly designate isolation areas for COVID cases and to allocate ICU and medical beds for surge capacity. The bed data incorporated for the COVID reporting became a combination of facility self-reported data, including surge ward/bed counts, and data sent from the bed management application.



Another challenge arose when IGS staff attempted to merge equipment and inventory data for the COVID reports. Although they were able to expediently add additional equipment, inventory and purchasing data from the medical centers to the centralized platform, the lack of standardization in local medical center logistics policies greatly affected the data mining efforts for PPE, ventilators, and other crucial equipment. Acquisition and item naming conventions also varied, which resulted not only in unstandardized naming but also in different purchasing pathways and data flows for every medical center. For example, there were over 17,000 different names for N95 respirator masks, making it challenging to accurately determine how many masks a medical center, a regional area, or the organization as a whole had available. Methods for counting also varied, and it was often unclear if the counts were for number of boxes, number of pallets, or actual supply in the containers. The PPE represented in the COVID reports came from extracted data and facility self-reported data, which IGS staged in the centralized database and incorporated into the data mart.

Initial lack of standardization among medical centers for COVID lab tests posed an additional challenge. To overcome this challenge, organizational leadership implemented laboratory oversight and provided guidance for naming COVID screening and lab tests as well as monitoring the naming conventions from individual medical centers for non-compliance. When vaccinations were being distributed, a more coordinated effort from healthcare system leaders ensured better standardization of the manufacturer nomenclature and administration in the underlying data. The centralized platform provided the majority of the vaccination data for patients, including flags to indicate when a patient had obtained a vaccination from an entity outside of the organization. Another challenge with vaccination data was tracking staff inoculation, given that some medical centers recorded the data in the patient record and others in occupational health tools.

Along with many issued policies came modifications not only to staff workflows but also to the EHR. The organization implemented changes in documentation templates, clinical reminders, screening, triage, testing, intubation, and virtual care. In October 2020, the World Health Organization (WHO) approved International Classification of Disease (ICD) diagnosis codes for COVID, but initially they were not widely used in the medical centers. Many of these changes affected the NLP and AI algorithms used to identify COVID positive cases and patient story data associated with patient care, making it challenging to adapt and phase in changes through version control.

The development of the COVID reports required extraction of new data sources that were not yet covered by the existing data governance in the healthcare system. The intricacies of the multi-level monitoring system were unknown at first, and data dictionary information was not readily available or entirely reliable. IGS engaged with department directors overseeing the data flows to make improvements and clarify ownership of the data by department directors.

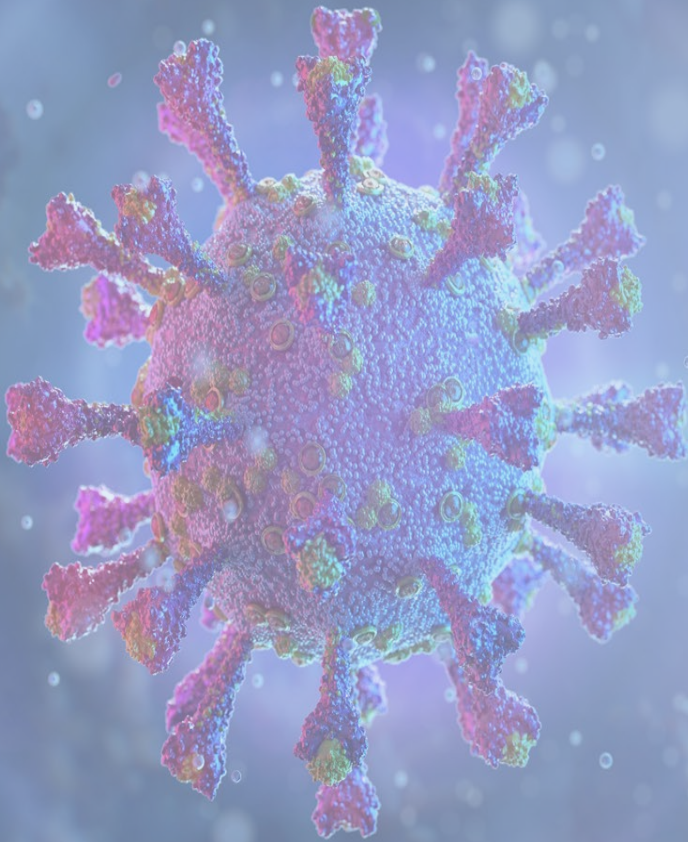
Impact on Decision Making

One critical factor in the success of the COVID report implementation was the direction provided by the healthcare system senior leadership to ensure adoption of the reports as the authoritative source throughout the organization. Memorandums and policies aided in governing the use of the reports and facilitated communication between field, regional and senior leadership. Had there been a lack of senior level guidance, it is likely the healthcare system would still be struggling with using inconsistent methods and manually-collected data.

Having a centralized repository of metrics enables senior leadership to quickly evaluate increases in COVID outbreaks and determine if specific locations are at risk of becoming overwhelmed. For example, the metrics were able to identify Chicago as a “hotspot” and shift resources to support the increase in COVID cases and resupply depleted PPE at that medical center. However, there were locations, such as New Orleans, where cases escalated so quickly that there were not any clear predictive indicators. Although predictive analytics did not recognize the surge of outbreak in New Orleans, the reports were nonetheless helpful in tracking patient movements from hospital to hospital. Many non-COVID patients were transferred from New Orleans to assisted living and nursing home units in Biloxi, MS, Jackson, MS, and Alexandria, LA which increased the capacity at the medical center to admit COVID positive and critical cases. Surge protocol designed to expand medical/surgical and ICU beds at medical centers is visible in the leadership and facility reports. Generating the COVID reports from the same source guarantees that the healthcare system Chief Clinical Officer, Chief Operations Officer, regional officers, and facility CEO are looking at the same figures and is key to communication and decision making at all levels. Metrics from the COVID reports provide guidance on medical center visitation restrictions and identify supply shortages that have helped drive organizational policy for the extended and reuse of PPE. Reporting to public and government entities has been tightly controlled to ensure the same data sets are provided and avoid the creation of different “stories” between the healthcare facilities and the media.

In addition, the healthcare senior leadership and analytics teams have relied on the centralized data for decision making on cancelling in-person appointments and creating policy and goals towards increasing telehealth appointments. Based on metrics gathered from the data mart, medical center staff were able to cancel non-urgent and elective procedures. The centralized data is also being used to identify cancelled appointments, reschedule surgeries, and track the increase of telehealth encounters.

The success of the centralized data mart, with its multi-level monitoring capabilities, has led the organization to consider expanding the solution to include monitoring for other potential outbreaks and predictive modeling. Having access to the data mart’s centralized data has enabled infectious disease and research staff to add calculations and develop various predictive models. Another area being expanded is the patient story, with a focus on patient tracing from admission with COVID diagnosis or symptoms through discharge, including movements in and out of the ICU. The data mart captures all labs, drugs, and treatment to help create an overall picture of patients’ histories of care, also known as patient stories. Patient story data contains insight on treatment and outcomes provided to patients in either an outpatient or inpatient setting. Expanding the patient story may help determine why outcomes of COVID infection vary from patient to patient and provide patterns that will help providers draw conclusions and implement changes to improve poor outcomes. Vaccine adoption factors, including socio-economic data, efficacy and side effect models will also likely be developed from the centralized data.



Conclusion

IGS helped to develop a multi-level, audience-tailored COVID reporting system based on a centralized data mart comprised of data from many sources. Using this solution, the healthcare organization was able to visualize the progression and impact of the pandemic. The reports facilitated communication pathways between multiple layers of organizational leadership, regional officers, and medical center leadership and provided public awareness of the efforts being made by the healthcare organization. The project was a success, and indications are that further development will be added to continue meeting the needs of many departments and to progress toward early identification of other biologic threats to public health

About the Author: Trinity Hall has more than 18 years supporting the U.S. Department of Veterans Affairs as a government employee. As the Chief Data Architect for Initiate Government Solutions, she brings extensive data management and data architecture experience of Veterans Health Administration (VHA) data sets.

Initiate Government Solutions, LLC is a health information technology services company that supports improving public healthcare organizations. Our focus is on big data, data analytics, informatics, interoperability and modernization of federal EHR systems. We support medical research for over 16 million veterans and 10,000 researchers, turning raw clinical data into actionable healthcare for Veterans Affairs. We also support the mission critical EHR systems (RPMS) for over 400 Indian Health Service and tribal clinical facilities

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