Deriving Analytic Insights During a Novel Pandemic

Michael E. DeWitt Jr, Christopher Scheib, Morgan Jones, Pamela Cowin

This paper summarizes the impact health care analytics has had on the COVID-19 pandemic from the combined perspectives of three North Carolina health systems: Vidant Health in Greenville, Duke Health in Durham, and Cone Health in Greensboro. Although these systems serve a diverse set of communities throughout the state, each analytics department shared similar arcs through the pandemic.

Introduction

The SARS-CoV-2 (COVID-19) pandemic has affected many facets of health care operations, including health care analytics. Given the context of a novel pandemic without recent precedent, analytics teams across North Carolina rose to the challenge, providing health system leaders with insights into secure timely care for their communities. Health care analytics departments leveraged internal expertise, utilized novel data sources, and implemented creative approaches to ensure that systems had capacity, staffing, and protective equipment to face a surge of patients. Hotspot identification guided mobile testing and vaccination operations, reaching areas of high transmission and vulnerability. It informed targeted communications and outreach to communities where transmission was high.

A Novel Threat: What is it, Where is it, What are we Seeing?

March 13 was the last date that strategic planning analysts at Duke University Health System were in the office in 2020. Along with other health care analysts across the state, they had been watching the reports of SARS-CoV-2 cases expand across the globe. As the first cases of COVID-19 were reported in the United States, health systems across North Carolina turned to their analytics teams to answer critical questions. Where will *we* first see cases? *How many* cases will we see, how quickly, and *what level of care* will they need? Do we have the *capacity* to care for a surge of patients?

Answering those questions led Duke and Cone Health's analytics teams to record and analyze the patterns of COVID-19 cases as they spread around the country and the world. With initial models projecting hundreds of imminent hospitalizations, Duke's strategic planning team realized that pure epidemiological models needed to be constrained by real-world countermeasures, so they analyzed epidemic spread in other countries and modeled scenarios based on similar impacts in North Carolina. Duke analysts utilized time studies and analyzed the rates of spread from states and countries with earlier index cases to understand the likely rate of spread for North Carolina's regional populations. At Cone, analysts collaborated with researchers in the United Kingdom to deploy a mix of semi-mechanistic and distributional Bayesian models for anticipating case counts and related hospitalizations. These models used classical epidemiological frameworks as their backbones, complemented with statistical models to better approximate how the reproductive rate of COVID-19 cases oscillate over time and are affected by changes in people's behaviors. These statistical models included estimating the underreporting of cases given the initial dearth of available tests and high degree of asymptomatic spread.

Given the range of projections and differing approaches to modeling the pandemic, a need emerged for enhanced communication and collaboration between health systems across the state. Duke helped gather health systems in the region to co-plan, bringing perspectives from the best analysts and data scientists to serve the North Carolina patient population and communities collectively. Weekly phone calls with health systems anonymized models contributed by each system, effectively crowdsourcing projections. This collaborative approach enabled each system to access the best set of information that incorporated the broadest set of potential factors. By anonymizing the models, there was no focus on whose model was best. The collaborative provided feedback to leaders in the North Carolina Department of Health and Human Services (NCDHHS) regarding which data would be needed to better inform analytics and operations for all state health systems. Duke took a leadership role in communicating insights to the office of the governor as well.

During these weekly calls, Vidant analysts shared their

Electronically published July 6, 2021.

Address correspondence to Christopher Scheib, Cone Health, 1200 North Elm St, Greensboro, NC 27401 (christopher.scheib@conehealth.com).

N C Med J. 2021;82(4):284-286.
0029-2559/2021/82415

proactive and innovative approach, called SWARM. Vidant Health could not afford to wait for confirmed positive tests to appear in its service area before taking action. Instead, Vidant analyzed calls to its COVID-19 call center to anticipate where future cases might appear, geocoding where the most calls were coming from and identifying hotspots of activity. Through the SWARM process, Vidant found that this analytic approach could anticipate the appearance of cases a week or two in advance [1]. During the spring of 2020, when robust testing was still scarce, Vidant deployed mobile billboards to pinpoint messaging to residents in neighborhoods where COVID-19 was especially active. Further, Vidant analysts identified skilled nursing facilities (SNFs) located in high-risk areas. Vidant knew that residents of SNFs embedded in hotspot communities faced higher risk of infection. By proactively identifying the risk, Vidant could engage with SNFs in the most affected areas, solidifying infection prevention practices and personal protective equipment (PPE) support. This early engagement with these facilities helped ensure SNF teams had training and materials support when the waves of infection hit.

Operationalizing Insights

As SARS-CoV-2 cases appeared across the state, the health systems operationalized insights from their respective analytics departments. Analysts from all three health systems met with emergency management teams and command center team members regularly, often daily, when iterative model development was critical. Insights from these cross-functional team meetings led to targeted supply chain decisions, actions to expedite low stock items, and rapid allocation of support staff.

For Cone, there were immediate concerns around hospital capacity and the quantity of PPE on hand. Early models showed the potential for a large volume of COVID-19 patients requiring hospitalization. Additionally, there were open questions regarding how much PPE each patient would require. Before the availability of PPE data from verified COVID-19 inpatient cases, Cone's earliest models leveraged learnings from recent epidemics, utilizing the PPE guidance of the Centers for Disease Control and Prevention (CDC) for Ebola as a starting point prior to having known PPE utilization rates for COVID-19 [2]. Projections of inpatient COVID-19 demand helped justify opening the Cone Health Green Valley Campus, previously the site of the recently closed Women's Hospital. This site became the first field hospital in the state solely dedicated to the treatment of COVID-19. The opening of Cone Green Valley presented analysts with an additional challenge since inpatient COVID-19 patients were being transferred to the dedicated facility from a broader service area than Cone typically sees. Cone data scientists adjusted to this challenge and created reproductive number forecasts for each of the 100 counties in North Carolina, which helped inform their models. The reproductive number forecasts estimated the average number of secondary infections caused by a primary infection. A reproductive number above one indicated that the infection was spreading in that given county, while a reproductive number below one indicated it was slowing.

In addition to insights into operational planning, Cone's analytics department engaged with the clinical teams when assessing the treatment of COVID-19 patients. Early in the pandemic, members of the clinical staff at Cone Health hypothesized that tocilizumab, an interleukin (IL)-6 inhibitor, could be used to treat COVID-19 patients. Running this trial, analysts within the Cone enterprise analytics team used matched retrospective cohorts to show evidence suggesting that this inpatient treatment improved mortality risk and decreased length of stay [3]. These results later were confirmed by a much larger randomized study [4]. Similarly, the analytics team identified SARS-CoV-2-positive patients as candidates for monoclonal antibody therapy (mAbs). Using a novel approach to applying the patient selection algorithm while also considering a patient's social vulnerability, analysts identified candidates and the clinical team contacted them to offer mAbs therapy. A retrospective matched analysis showed a statistically significant reduction in the likelihood of inpatient admission for patients receiving the treatment [3]. These treatments' quantified success led to requests from the state for additional allocations of mAbs and provisioning of more staffing and space to offer the infusion.

Duke developed a similar command structure to turn insights into actions. The strategic analytics team fed insights into its Hospital Incident Command System to expedite evidence review. The expedited review resulted in quick action regarding the supply chain, infectious disease protocols, and clinical protocols, letting everyone's expertise shine. With operations and analytics acting hand-in-hand, issue resolution occurred at the root cause level, and analytics-informed root cause analysis facilitated rapid, data-informed decision making by subject matter experts and those experiencing the issues first hand. The support structure in place then provided a way for problems or decision points to be rapidly elevated to leadership when needed.

All Transmission Is Local: Meeting the Virus Where It Is

Health systems across the state developed a much deeper appreciation for the complex demographic characteristics of their service regions. This included taking a more granular approach to all data, approaching disease transmissions, testing, and vaccination at a census tract level. In the early collaborative calls, it became evident that communities across the state, from rural portions of the state to more densely populated ones, experienced facets of the pandemic differently. Targeted testing, vaccination outreach, and messaging needed to be tailored to each community and its population. Vidant noted its increased focus on the ambulatory and public health settings, moving upstream from its core inpatient services.

Utilizing the SWARM approach, Vidant engaged local community leaders and its own employees to get the message out. This communication strategy created targeted messaging and actions instead of broad communications. Once analysts saw areas of activity, they would focus on areas where employees lived and ask them to put up yard signs communicating actions people could take to prevent the spread of the virus, as well as Vidant's COVID-19 hotline number, which could be called for additional resources. Employees became engaged and wanted to see where COVID-19 activity was highest. The relationships built with these communities bridged their mAbs therapy outreach and vaccination communications.

Cone pursued a similar approach by developing a novel outbreak detection and case connection algorithm [5]. Linking connected cases with demographic analysis at granular community levels allowed the mobile clinic teams to target outreach for testing and vaccination deployments. Analytics informed the prioritization of areas with a high number of connected cases, low testing coverage, and a high case incidence rate. Duke, Vidant, and Cone vaccine distribution efforts were all able to leverage processes, workflows, and insights gained first from COVID-19 testing analysis.

What Is Next for Health Care Analytics

The COVID-19 pandemic has had several significant impacts on the current and future role of analytics within health care systems. During the pandemic, the value of analytics as supporting operational decisions became clear to executive leaders, and the pandemic demonstrated the organizational value of analytics as a discipline.

Attempts to manage through the pandemic demonstrated that insights derived from data and subject matter experts need to be democratized and shared broadly. Additionally, these insights should be available to those making decisions on the ground. When insights into the data are shared quickly with operational teammates, actions can be taken in a data-informed way and escalation can occur quickly. Having the best available information and analysis can amplify preexisting expertise relationships by allowing data-informed decision making and conversations to occur. However, models cannot solve all problems. By connecting operational leaders and staff with the analytics team, iteration of analysis and modeling can lead to faster understanding and quantification of a given problem or situation. Transparency regarding insights as a part of the process increases buy-in among leaders and employees [6-8]. These insights can also be shared with other community partners, as was done during the pandemic, including sharing insights with the public, local officials, local health departments, and the state government.

The COVID-19 pandemic surfaced inequities in health that existed before but gained greater visibility. Health care analytics teams across the state leveraged social vulnerability data and analysis at smaller granularities (e.g., census blocks and tracts) to highlight opportunities for improving accessibility and outcomes. These differences in access, opportunities, and lived experiences often necessitate different modes of outreach and action. This lens of and respect for structural and geospatial heterogeneity has spilled over into other work, including quality measures and ambulatory practices. Analytics promises to inform health systems' efforts to identify and address the social and behavioral drivers of health with new and enhanced capabilities operationalized during this COVID-19 crisis. NCMJ

Michael E. DeWitt Jr, MS senior data scientist, Cone Health, Greensboro, North Carolina.
Christopher Scheib executive director, Enterprise Analytics, Cone Health, Greensboro, North Carolina.
Morgan Jones, MSPH, FACHE vice president, Strategic Planning and Business Development, Duke University Health System, Durham, North Carolina.
Pamela Cowin, PhD, RN administrator, Transitional Care Programs, Vidant Health, Greenville, North Carolina.

Acknowledgments
Disclosure of interests. No disclosures were reported.

References
1. Kearney GD, Cowin P, Hickey T, et al. SWARM: A regional health system's intervention approach to COVID-19 outbreaks in nursing and adult care homes in rural eastern North Carolina. J Hosp Adm. 2020;9(4):27-33. doi: https://doi.org/10.5430/jha.v9n4p27
2. Centers for Disease Control and Prevention. Guidance on Personal Protective Equipment (PPE) To Be Used By Healthcare Workers during Management of Patients with Confirmed Ebola or Persons under Investigation (PUIs) for Ebola who are Clinically Unstable or Have Bleeding, Vomiting, or Diarrhea in U.S. Hospitals, Including Procedures for Donning and Doffing PPE. CDC website. https://www.cdc.gov/vhf/ebola/healthcare-us/ppe/guidance.html. Updated August 30, 2018. Accessed March 24, 2021.
3. Ramaswamy M, Mannam P, Comer R, Sinclair E, McQuaid DB, Schmidt ML. Off-label real world experience using Tocilizumab for patients hospitalized with COVID-19 disease in a regional community health system: a case-control study. medRxiv. Preprint. 2020. doi: 10.1101/2020.05.14.20099234
4. RECOVERY Collaborative Group, Horby PW, Pessoa-Amorim G, et al. Tocilizumab in patients admitted to hospital with COVID-19 (RECOVERY): preliminary results of a randomised, controlled, open-label, platform trial. medRxiv. Preprint. 2021. doi: 10.1101/2021.02.11.21249258
5. DeWitt M. Automatic contact tracing for outbreak detection using hospital electronic medical record data. medRxiv. Preprint. 2020. doi: 10.1101/2020.09.08.20190876
6. Yin RK. Case Study Research and Applications: Design and Methods. 6th ed. Thousand Oaks, California: SAGE Publications, Inc.; 2018.
7. Aguinis H, Solarino AM. Transparency and replicability in qualitative research: the case of interviews with elite informants. Strateg Manag J. 2019;40(8):1291-1315. doi: 10.1002/smj.3015
8. Mendes-Da-Silva W. Have we been transparent enough? Challenges in replicability and credibility in business research. Rev Adm Contemp. 2019;23(5):695. doi: 10.1590/1982-7849rac2019190306