A Call to Action: Modeling Hospital Capacity in a Pandemic

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OBJECTIVE

Employ a predictive hospital capacity model to facilitate operational planning and response to the unprecedented demand for beds brought on by the COVID-19 pandemic. Specifically, to:

- facilitate proactive bed capacity management to ensure patients can continue to be cared for in the right place at the right time
- plan for a responsible return to pre-pandemic surgical scheduling volumes
- enable operations at record peak capacity rates reaching above 95 percent

PLANNING/RESEARCH METHODS

A prediction model was requested by hospital leaders to assist in decision making in anticipation of COVID-19 hospitalizations. Historical demand trends for beds, largely driven by surgical and procedural practices, were no longer sufficient. Hospital leaders wanted to incorporate community COVID-19 trends and develop additional precision from other sources of bed demand, which had also been altered by the pandemic. The anticipated surge did not materialize, however the need for a predictive model was amplified by subsequent COVID-19 surges and staffing constraints.

Critical Resources:

- Ethan Heinzen – Senior Data Scientist
- Curt Storlie Ph.D. – Consultant, Research
- Data & Analytics Product Team
- Hospital Operations Command Center

IMPLEMENTATION

A COVID-19 model, which included national and community spread information, was produced to assist in a ramp up plan to bring elective surgeries and procedures back up while also accommodating the prediction of COVID-19 cases through end of year. The COVID-19 predictions subsequently led to a hospital – wide bed census model which utilized the COVID-19 outputs along with other hospital inputs (Emergency Department arrivals and admits, surgical and procedural schedules, appointment conversion and hospital to hospital transfer rates) to assist in predicting capacity needs.

Utilizing a multidisciplinary teamwork approach, the two models were developed in partnership between highly technical teams and the operational consumers of the models. The technical teams managed the model build and evolution under an Agile framework. Technical team members included a data scientist, data engineers, and business intelligence experts to visualize the outputs of the model.

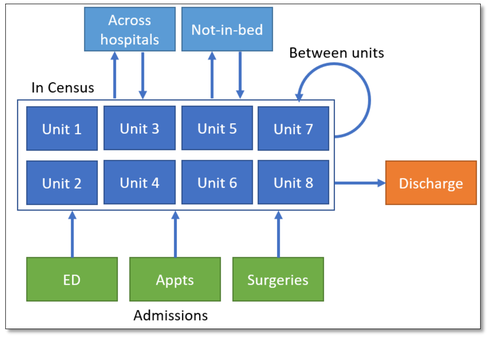
Implementation of the model into daily huddles and its use in hospital bed capacity decision making was managed by operational leaders through an iterative process. Short PDSA cycles were utilized to evaluate success, provide awareness and ensure safe patient care during higher occupancy rates.

These two models initially assisted in managing 1,053 adult acute beds within a two-hospital service area. Later iterations of the models expanded to include 94 pediatric beds, 73 behavioral health beds and integration of 19 other locations within the hospital system.

RESULTS

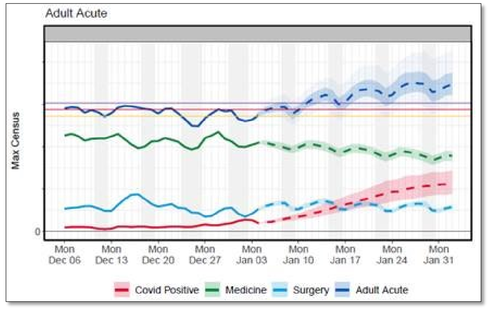
The model served as a call to action, highlighting the need to intervene and avoid the predicted bed capacity constraints. Proactive decisions were made for bed capacity management utilizing prospective data allowing for appropriate capacity to be made available (right type of bed at the right time). This included both the volatility of COVID-19 cases as well as the planned increase in elective surgical scheduling. As a result, hospital leaders were able to effectively manage the re-establishment of elective surgical practices to a level near pre-pandemic case volumes while facilitating care for the fluctuating COVID-19 population. COVID-19 census varied between 0.11% and 14.09% in 2020 and between 0.27% and 10.37% in 2021.

FIGURE 1: Model component diagram



Hospital – wide bed census model utilized the COVID-19 model output along with other hospital inputs (Emergency Department arrivals and admits, surgical and procedural schedules, appointment conversion and hospital to hospital transfer rates) to assist in predicting capacity needs.

FIGURE 2: Model output example



Visuals such as the one above were produced to review with leaders and in operational huddles to determine appropriate action items.

FIGURE 3: Rochester Hospital Operations Command Center

LESSONS LEARNED

Modeling is an iterative process and facilitating successful iteration is key. Regular touchpoints that allow for review by team members with diverse perspectives adds tremendous value. Robust performance evaluation is one way to increase stakeholder buy-in, particularly for those relying on but not helping to manage the model. Mean Absolute Deviation was chosen as the key performance metric for its explainability and meaningfulness to the practice. Its interpretation can be stated as "on average how many beds is the model projection away from actual." Adaptability is a must in a new modeling effort to improve upon the inevitable inaccuracies that arise from unexpected changes in a system.

FUTURE DEVELOPMENT

Further development of the model is actively under way in the following three domains:

- The model's framework is being evaluated for use in automating the calculation of hospital diversion criteria
- A short – term planning version of the model is being built that incorporates parameterized levers where users can make planning decisions in real time to see their expected effects on future capacity
- A longer – term planning version of the model is slotted for development to evaluate the expected impact of growth plans within the practice at large

Multiple iterations of model enhancement to refine model inputs, improve workflows to drive consistency of inputs, and expand outputs to better identify action items

Spring 2020
Pandemic hits and COVID-19 model is developed

Fall 2020
First bed census modeling completed and shared

Fall 2021
Model utilized more for decision making in second large COVID-19 surge

December 2021
Model progress evaluated and future development plans set