Using Data and Artificial Intelligence to Enable Successful Hospital at Home Programs

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***Abstract*—During the COVID-19 pandemic, health systems and payers had to take novel and extraordinary approaches to create hospital capacity and avoid hospital infections. Hospital at home programs have existed for years, but the pandemic environment led to additional interest, funding and reimbursement approvals for these programs. The hospital at home program is simply the monitoring and treatment of an acute inpatient patient at their residence. Research shows that outcomes and patient experience can be better with a hospital at home stay, while costs are much less. Nonetheless, these programs are relatively new and there are not well-researched standards for choosing patient cohorts or monitoring patient progress. Most hospitals either have a very restricted definition of eligible patients or leave the recommendation to the attending physician. While there are many case studies around the success of individual patients in hospital at home programs, there has been little research into choosing patient cohorts. In this study, we propose to use existing research around clinical trial enrollment and clinical data mining to better identify patient cohorts. We propose to use existing predictive analytics solutions to predict outcomes, adverse events and resource needs for individual patients. By combining all of these approaches, we can identify patients who are likely to succeed with hospital at home treatment, and we can monitor these patients and intervene to avoid risk of complications or adverse events.**

Keywords-hospital at home; care pathways; quality; artificial intelligence; predictive analytics; supervised learning; data mining; cardiology.

I. INTRODUCTION

The Hospital at Home (HaH) model is an innovative approach to healthcare delivery that provides acute, hospital-level care to patients in their homes. First conceptualized in the 1990s by researchers at Johns Hopkins University, HaH was developed to address rising healthcare costs, hospital overcrowding, and the desire to improve patient-centered care [1]. The model includes comprehensive medical services such as intravenous medications, oxygen therapy, diagnostic imaging, and frequent clinical monitoring, traditionally available only in inpatient settings. Evidence has demonstrated that HaH can be safe and effective for managing conditions, such as heart failure, Chronic Obstructive Pulmonary Disease (COPD), and community-acquired pneumonia, with outcomes that are equivalent or superior to traditional hospitalization in terms of mortality, readmission rates, and patient satisfaction [2] [3].

The COVID-19 pandemic significantly accelerated the adoption of HaH programs globally. In the United States, the Centers for Medicare & Medicaid Services (CMS) introduced the Acute Hospital Care at Home waiver in 2020, allowing eligible hospitals to receive full Medicare reimbursement for delivering inpatient-level services at home [4]. Since then, hundreds of health systems have implemented or expanded HaH initiatives, citing benefits such as reduced exposure to hospital-acquired infections, shorter lengths of stay, and improved patient experience [3]. Despite these advances, challenges persist, including regulatory uncertainty, reimbursement limitations in non-pandemic contexts, provider hesitancy, and the need for reliable home infrastructure and caregiver support [5]. As healthcare systems aim to modernize care delivery, understanding the sustainability and scalability of HaH models remain a critical area for ongoing research.

The rest of this paper is organized as follows. Section II describes the challenges and proposed solutions. The proposal is divided into a series of subproblems that are individually described and evaluated. Section III draws conclusions.

II. THE CHALLENGES AND PROPOSED SOLUTIONS

The goal of our hospital at home program is to produce the best outcomes at the lowest cost. Restated, the goal is to identify patients who are likely to succeed in the program without incurring significant resources, and to monitor those patients carefully and take action before any complications and negative outcomes. We have divided the hospital at home program into three distinct data problems. The first challenge is identifying and choosing the patients for the program. The second challenge is to predict the resources and cost needed to treat those patients and to predict the outcomes. This both helps us choose the best patients and provides information vital for resource planning and budgets. The third challenge is monitoring those patients during the program and intervening when necessary.

A. Choosing the Patient Cohort

For the purposes of our experiment, we have chosen to limit the program to patients who are primarily being treated by the cardiology specialty. Vast research has shown success in treating cardiology patients with hospital at home programs [6][7]. Furthermore, the technology to remotely monitor these patients is widely available and well researched [8][9]. To identify patients for the program, we leverage approaches from past research, and we follow the standards set by clinical trials for identifying and enrolling patients [10][11][12].

B. *Predicting the Outcomes and the Cost*

We set up a discrete event model for the hospital at home program. In such a model, the resources and constraints are identified. There is significantly less variation in available resources compared to creating a virtual digital twin of an entire hospital, but it is still a complex problem. Then, historical patient records are used to determine the resources needed to treat a patient. Finally, new patients are matched to similar past patient records using pattern matching and biostatistics. We propose to leverage the approach described in [13]. This will allow us to both predict outcomes (length of stay and readmissions primarily) and to estimate cost of treatment. Through modeling clinic needs of similar previous, we are able to show the expected length of stay, required therapies, medications and treatments, cost of treatment, and likelihood of adverse events or readmissions.

Finally, we leverage data from patients treated at home to create a supervised learning feedback loop. This will allow us to better refine the patient cohort selection program. To achieve this supervised learning, we propose to follow the approach of [14]. This allows us to data mining past information to best predict who will need intervention.

C. *Monitoring the Patients*

As already mentioned, there are significant resources and technology to monitor cardiac patients remotely. There are also many documented care paths tailed to cardiac patients [15][16]. We propose to leverage process mining tools to implement our care pathways and detect patient care variations [17][18].

Our remaining challenge becomes how to realize from all these data points when a patient is at risk and needs intervention. In [19], machine learning is used to predict adverse events in an ambulatory patient cohort. We propose that we retrain this specifically off of hospital-at-home patients and predict when a patient will need to return to acute hospital care. As the patient is more tightly monitored, and the number of adverse events is reduced, we believe that this approach has an opportunity for significant success.

III. CONCLUSION

Past results and research have demonstrated that hospital-at-home programs have the potential to improve outcomes and reduce costs. For this project, we look at how data and technology can help a health system develop a hospital at home program. We break this problem domain into several smaller and more controlled opportunities. We then propose to repurpose successful past research to approach each of the identified opportunities. We propose that these solutions can be applied to hospital-at-home programs and that there is significant opportunity to develop more successful programs using data and technology.

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