

Diagnosis Related Groups of Patients Admitted from an Urban Academic Medical Center to a Virtual Hybrid Hospital-at-Home Program

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Background: The diagnosis related group (DRG) is used as an economic patient classification system based on clinical characteristics, hospital stay, and treatment costs. Mayo Clinic's virtual hybrid hospital-at-home program, advanced care at home (ACH), offers high-acuity home inpatient care for a variety of diagnosis. This study aimed to determine the DRGs admitted to the ACH program at an urban academic center.

Methods: A retrospective study was performed on all patients discharged from the ACH program at Mayo Clinic Florida from July 6, 2020, to February 1, 2022. DRG data were extracted from the Electronic Health Record (EHR). Categorization of DRG was done by systems.

Results: The ACH program discharged 451 patients with DRGs. Categorization of the DRG demonstrated that the most frequent code assigned corresponded to respiratory infections (20.2%), followed by septicemia (12.9%), heart failure (8.9%), renal failure (4.9%), and cellulitis (4.0%).

Conclusion: The ACH program covers a wide range of high-acuity diagnosis across multiple medical specialties at its urban academic medical campus, including respiratory infections, severe sepsis, congestive heart failure, and renal failure, all with major complications or comorbidities. The ACH model of care may be useful in taking care of patients with similar diagnosis at other urban academic medical institutions.

Keywords: hospital at home, home care, home acute care, diagnosis related group, inpatient prospective payment system

Introduction

In 2020, the United States spent approximately \$4.1 trillion on healthcare, equating to \$12,530 per person. It represented an increase of 9.7% above 2019.¹ The most significant percentage of these expenses corresponded to hospital services. To control hospital costs, Medicare and Medicaid Services created the Inpatient Prospective Payment System (IPPS) which linked a predetermined rate for each discharged patient based on the diagnosis related group (DRG).² The DRG is a patient classification system based on clinical characteristics and hospital resource consumption.³ The DRG system is comprised of 20 body areas sorted into ~700 groups that are further sub-grouped according to the presence or absence of complications or comorbidities (CC) or major complications or comorbidities (MCC).⁴ Therefore, DRG is used as an economic patient classification system based on their clinical characteristics, hospital stay, and treatment costs.⁵ The positive impact of DRG on the cost and quality of health care has been reported since 1988.⁴ Classifying patients considering their clinical characteristics and the hospital resources used has proved valuable for managing hospital data, controlling health-care expenditures, and promoting high-quality care.⁴ The worldwide acceptance of this model has been well documented.⁵⁻⁸

As a contribution to decreasing hospital expenses, telemedicine has become a feasible option.^{9,10} Leading this forefront are hospital-at-home (HaH) programs. Traditional HaH models that place physicians and bedside registered nurses (RNs) in the home for direct care have been shown to be both safe and effective in taking care of several core medical diagnosis.^{11,12} Recently, a novel version of HaH introducing digital technology and virtual providers has been created. This virtual hybrid model has mostly been focused on the COVID-19 pandemic of 2020–2022.¹³ The question remains if a wide range of medical diagnosis classified by DRG can be seen in this newer model of care. Accordingly, in 2020 Mayo Clinic initiated a virtual hybrid HaH care model called Advanced Care at Home (ACH). This program offers inpatient-level care to high-acuity patients by combining virtual physicians and bedside RNs located in a central command center (CC) with a vendor-mediated rapid response system and supply chain that delivers the in-home services.¹⁴ A key question that has arisen as multiple HaH programs are implemented throughout the US is how to grow patients volumes rapidly in order to make the programs viable to institutions.¹⁵ Patient acquisition is important for driving patient volumes, so knowing which diagnosis to focus resources on for in-home care delivery is vital aspect of home hospital. Patients admitted to ACH are categorized using the DRG for reimbursement purposes. The purpose of the study is to define and categorize all DRGs admitted into the ACH program at the urban academic center located in Jacksonville, Florida, in order to see which diagnoses are most commonly seen.

Methods

Patient Selection and Setting

This study was approved by the Mayo Clinic Institutional Review Board as a retrospective chart review under protocol number 20–010753 and de-identified patient data was analyzed under protocol number 21–004666. This manuscript was conducted in accordance with the Declaration of Helsinki. The study was conducted between July 6, 2020, and February 1, 2022, at Mayo Clinic Hospital in Florida, a 304-bed community academic hospital in Jacksonville, Florida. The inclusion criteria for this study were the following: 1) all patients discharged from the ACH program in Florida with no age restrictions and 2) all patient who has a DRG assigned at the time of discharge. Patients were excluded from the study if they were discharged from any other ACH location or if they did not have a DRG assigned for analysis. Admission to the ACH program is completely voluntary. Patients provide both oral and written informed consent to participate in the ACH program.

Program Description

The ACH program was developed to deliver continuous care to acutely ill patients at home using different telemedicine modalities. A hybrid care model with virtual and in-person assistance for synchronous and asynchronous evaluation is performed daily by a combination of medical providers overseeing care from a central command center working in conjunction with a medical supply chain consisting of advanced practice providers, community paramedics, registered nurses, home health aides, physical and rehabilitative services, infusion therapists, and phlebotomists who deliver any in-home care needed.¹⁴ The patient selection process begins with an extensive review of the patients' social, demographic, and clinical features. Patients who have a diagnosis that requires an inpatient hospital stay (greater than 28 hours) and who are clinically stable (do not require Critical Care services or emergent surgery/procedures) are considered for transfer into ACH. Common diagnoses considered for ACH care are listed in [Figure 1](#). If the ACH team deems the patient clinically appropriate for ACH care, then a social and demographic screening is conducted to ensure the patients falls within the ACH home care delivery geography, their insurance provider will cover ACH care, and their home environment is safe for both the patient and the in-home providers. Patients with uncontrolled mental illness, intravenous pain medication needs, requiring two-person assistance with activities of daily living, and unstable arrhythmias/requiring continuous telemetry monitoring are excluded from participation in the program. Patients can be transferred to the program directly from the emergency department (hospital substitution) or the hospital wards (reduced length of stay). During the admission process, an exhaustive clinical evaluation, document review, and associated procedures allow patients categorization in one of the DRG. As soon as the patient is transferred home, the acute phase of ACH is activated. Throughout this phase, patients receive care at home like what they would in the in-patient hospital setting

Common Diagnoses Considered for ACH Admission

- Congestive Heart Failure Exacerbation
- Asthma / Chronic Obstructive Pulmonary Disease Exacerbation
- Acute Renal Failure
- Cellulitis
- Gastroenteritis
- Electrolyte Disorders
- Pancreatitis
- Respiratory Failure
- Migraines / Headaches
- Pulmonary Embolism
- Pneumonia
- Deep Venous Thromboembolism
- Urinary Tract Infection
- Recovering Septicemia

Figure 1 Common Diagnoses Considered for ACH Admission.

until their condition stabilizes. Continuous monitoring using a technological kit and audio/video communication is kept during all the patients' stay in the program. Lastly, when all admission reasons have been resolved, the patient is discharged from the program and follow-up is set with their primary care provider. Further detailed information on the ACH program, clinical and social screening criteria, and the delivery on in-home services/rapid response program has been previously published.¹⁶

Data Collection

Data on patients' demographics (age, sex, race) and DRG were extracted from the electronic health record (EHR). Afterward, categorization of the DRG by system was completed. Patient coding required the use of the International Classification of Diseases 10th revision (ICD-10) to determine the patient's principal diagnosis, current data of the IPPS, and software.¹⁷ Deidentified data was transferred to a Microsoft Excel spreadsheet where frequency, percentages, and standard deviation (SD) measurements were performed.

Results

Between July 6, 2020, and February 1, 2022, 451 patients were discharged from the ACH program with a DRG assigned. 54.3% were male and 85.8% of white race, with a mean age of 70.3 years (SD = 14.88) (Table 1).

Categorization of the DRG by systems demonstrated that the most frequent code assigned corresponded to the respiratory system, with 134 patients (29.7%), followed by cardiovascular (13.5%), renal (11.8%), and gastrointestinal (8.4%). Septicemia represented third most frequent with 58 patients (12.9%). However, it was kept as the original category due to the complexity of separating patients into a specific system. These results are displayed in Table 2.

Table 1 Patient Demographics

| | Total n = 451 |
|--------------------------------------|--------------------------|
| Sex | |
| Male | 245 (54.3%) |
| Female | 206 (45.7%) |
| Race | |
| American born African | 1 (0.2%) |
| American Indian/Alaskan Native | 2 (0.4%) |
| Asian Filipino | 16 (3.5%) |
| Black or African American | 29 (6.4%) |
| Choose to disclose | 7 (1.6%) |
| Other | 9 (2.0%) |
| White | 387 (85.8%) |
| Ethnicity | |
| Choose not to Disclose | 11 (2.4%) |
| Hispanic or Latino | 11 (2.4%) |
| Not Hispanic or Latino | 422 (93.6%) |
| Other Spanish Culture (except Spain) | 3 (0.7%) |
| Puerto Rican | 4 (0.9%) |

Table 2 Diagnosis-Related Group Categorized by Systems Assigned to Patients Discharged from the Advanced Care at Home Program at Mayo Clinic Florida Campus

| DRG-Systems | Sex | | Total No. (%) |
|--------------------|-------------------------|---------------------------|--------------------------|
| | Male No. (%) | Female No. (%) | |
| Respiratory | 73 (16.2) | 61 (13.5) | 134 (29.7) |
| Cardiovascular | 40 (8.9) | 21 (4.7) | 61 (13.5) |
| Septicemia | 28 (6.2) | 30 (6.7) | 58 (12.9) |
| Renal | 26 (5.8) | 27 (6.0) | 53 (11.8) |
| GI | 14 (3.1) | 24 (5.3) | 38 (8.4) |
| Others | 19 (4.2) | 13 (2.9) | 32 (7.1) |
| Integumentary | 17 (3.8) | 8 (1.8) | 25 (5.5) |
| Hepato-portal | 9 (2.0) | 7 (1.6) | 16 (3.5) |
| Hematological | 8 (1.8) | 4 (0.9) | 12 (2.7) |
| Musculoskeletal | 4 (0.9) | 6 (1.3) | 10 (2.2) |
| Endocrine | 2 (0.4) | 3 (0.7) | 5 (1.1) |
| Genitourinary | 3 (0.7) | - | 3 (0.7) |
| Reproductive | - | 3 (0.7) | 3 (0.7) |
| Neurological | 1 (0.2) | - | 1 (0.2) |
| Total | 244 (54.1) | 207 (45.9) | 451 (100) |

Abbreviation: DRG, Diagnosis Related Group.

The DRGs with more than 80% of patients are represented in Figure 2. This Pareto diagram showed that most patients were categorized under codes related to respiratory, cardiovascular, renal, and gastrointestinal systems and sepsis.

On the other hand, categories with few patients were classified as “other”, which included codes designated to fever and inflammatory conditions, post-operative and post-traumatic infection, ear-nose-throat (ENT), miscellaneous nutrition and metabolism, other infections and parasitic diseases, extensive and non-extensive operating room procedures no related to the principal diagnosis, viral illness, complications of treatment, alcohol and drug abuse or dependence without rehabilitation therapy without MCC. The number of patients assigned to these codes was less than 3 per code, with infectious and parasitic diseases with operating room procedures with CC with three patients (9.37%). Figure 3 is a graphic representation of this population of patients.

Out of DRG assigned most frequently, with more than ten patients each, respiratory, cardiovascular, integumentary, and renal systems and septicemia were the most used (Table 3). Therefore, respiratory infections and inflammation with MCC (91 patients) for the respiratory system, septicemia or severe sepsis without MV >96 hours with MCC (42 patients) and without MCC (16 patients) for septicemia, heart failure, and shock with MCC (40 patients) for the cardiovascular system, cellulitis without MCC for the integumentary system, and renal failure with MCC and CC (11 patients each code) for renal system. The rest of the groups were less assigned, with less than ten patients per group.

As covid-19 was a prominent diagnosis during the study period, a subanalysis was done to look year-by-year at the number of COVID-19 pneumonia patients were admitted to ACH compared to all other pneumonia types. During the study period, 134 patients with a pneumonia diagnosis were admitted to ACH. Of these, 73 (54.5%) were due to

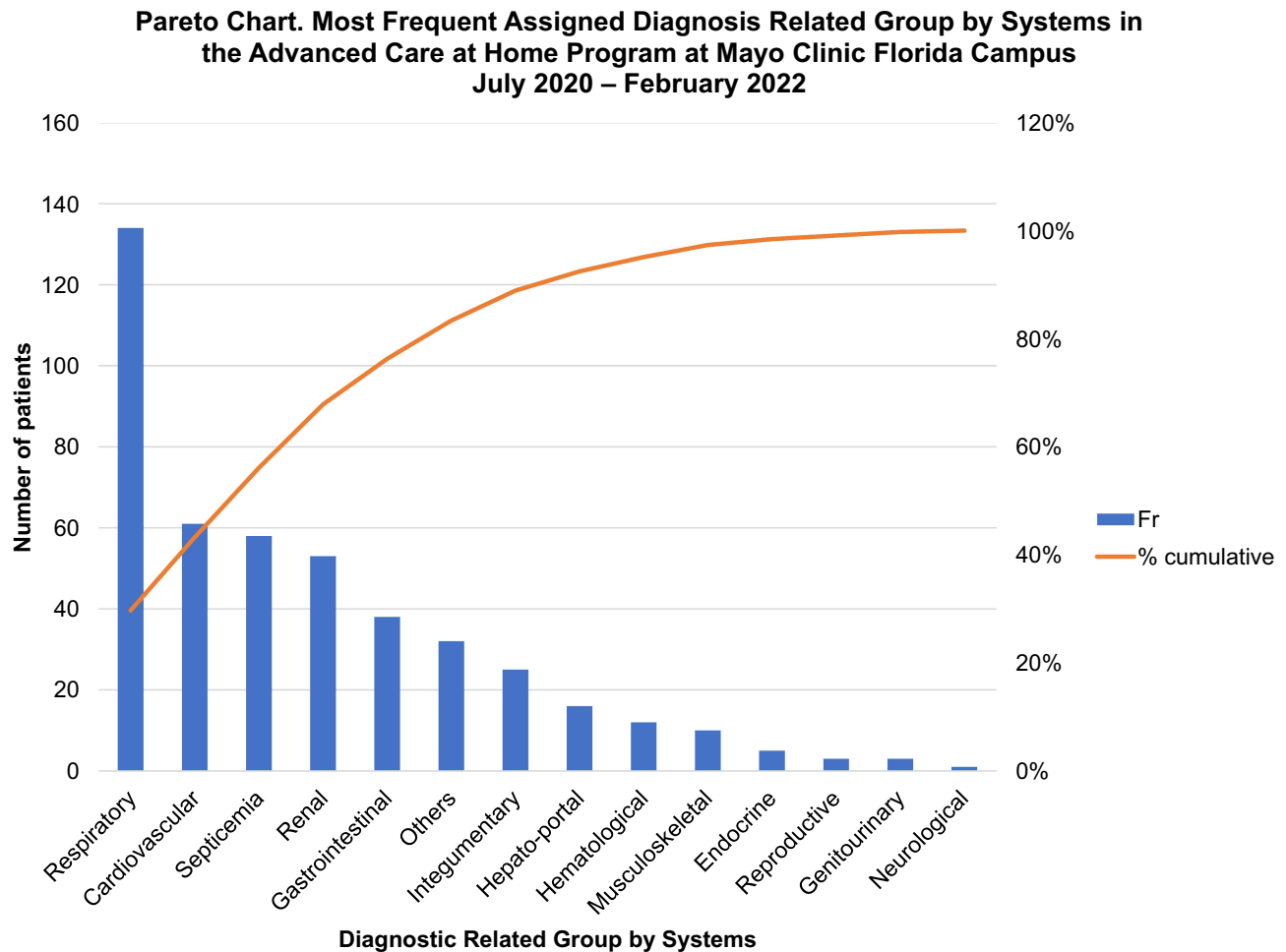


Figure 2 Pareto Chart. Most Frequent Assigned Diagnosis Related Group by systems in the Advanced Care at Home Program at Mayo Clinic Florida campus.

Less Frequently Assigned Diagnosis Related Group Categorized as Other in the Advanced Care at Home at Mayo Clinic Florida Campus July 2020 – February 2022

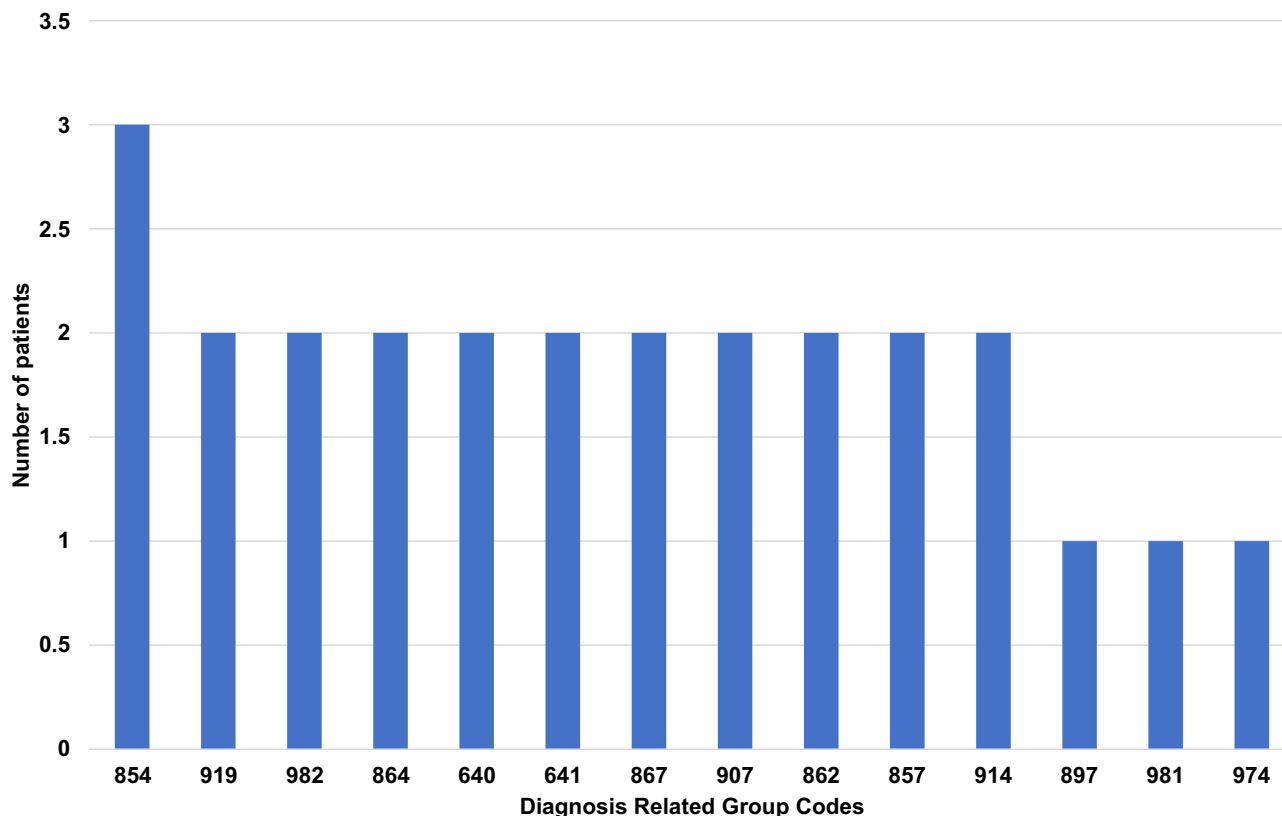


Figure 3 Less Frequently Assigned Diagnosis Related Group Categorized as Other in The Advance Care at Home Program at Mayo Clinic Florida campus, 22. Diagnosis related groups: 854, extensive O.R. procedures unrelated to principal diagnosis with CC; 919, extensive O.R procedures unrelated to principal diagnosis with CC; 982, extensive O.R procedures unrelated to principal diagnosis with CC; 864, fever and inflammatory conditions; 640, miscellaneous disorders of nutrition, metabolism, fluids and electrolytes with MCC; 641, miscellaneous disorders of nutrition, metabolism, fluids and electrolytes without MCC; 867, other infectious and parasitic diseases diagnoses with MCC; 907, other O.R procedures for injuries with MCC; 862, postoperative and post-traumatic infections with MCC; 857, postoperative or post-traumatic infections with O.R procedures with CC; 914, traumatic injury without MCC; 897, non-extensive O.R procedures unrelated to principal diagnosis with MCC; 981, extensive O.R procedures unrelated to principal diagnosis with MCC; 974, HIV with major related condition with MCC.

COVID-19 and 61 (45.5%) were due to other bacterial/viral pneumonia infections. **Figure 4** demonstrates that COVID-19 accounted for 73.7% of pneumonia admissions in 2020, 47.9% of pneumonia admissions in 2021, and 68.4% of pneumonia admissions in 2022.

Table 3 Most Frequently Assigned Diagnosis-Related Group in the Advanced Care at Home Program at Mayo Clinic Florida Campus

| Diagnosis Related Groups | DRG | Sex | | Total No. | |
|--|------------|------|------------|-----------|------------|
| | | Code | Female No. | | Male No. |
| Respiratory System | | | 61 | 73 | 134 |
| Respiratory infections and inflammations with MCC | 177 | | 36 | 55 | 91 |
| Septicemia | | | 28 | 30 | 58 |
| Septicemia or severe sepsis without MV >96 hours with MCC | 871 | | 18 | 24 | 42 |
| Septicemia or severe sepsis without MV >96 hours without MCC | 872 | | 10 | 6 | 16 |

(Continued)

Table 3 (Continued).

| Diagnosis Related Groups | DRG | Sex | | Total No. |
|----------------------------------|------------|------------|-----------|-----------|
| Systems | Code | Female No. | Male No. | |
| Cardiovascular System | | 21 | 40 | 61 |
| Heart failure and shock with MCC | 291 | 13 | 27 | 40 |
| Integumentary System | | 8 | 17 | 25 |
| Cellulitis without MCC | 603 | 8 | 10 | 18 |
| Renal System | | 27 | 26 | 53 |
| Renal failure with CC | 683 | 6 | 5 | 11 |
| Renal failure with MCC | 682 | 3 | 8 | 11 |

Abbreviations: DRG, diagnosis Related Group; MCC, major complications or comorbidities; MV, mechanical ventilation; CC, complications, or comorbidities.

Discussion

In this descriptive analysis, we are able to review all the DRGs seen in our ACH program at our urban campus. We found that seven core DRGs accounted for the majority (50.8%) of all patients. These DRGs were respiratory infection with MCC, septicemia with and without MCC, heart failure with MCC, cellulitis without MCC, and renal failure with and

Admissions due to Respiratory Causes to the Advanced Care at Home Program at Mayo Clinic Florida Campus July 2020 - February 2022

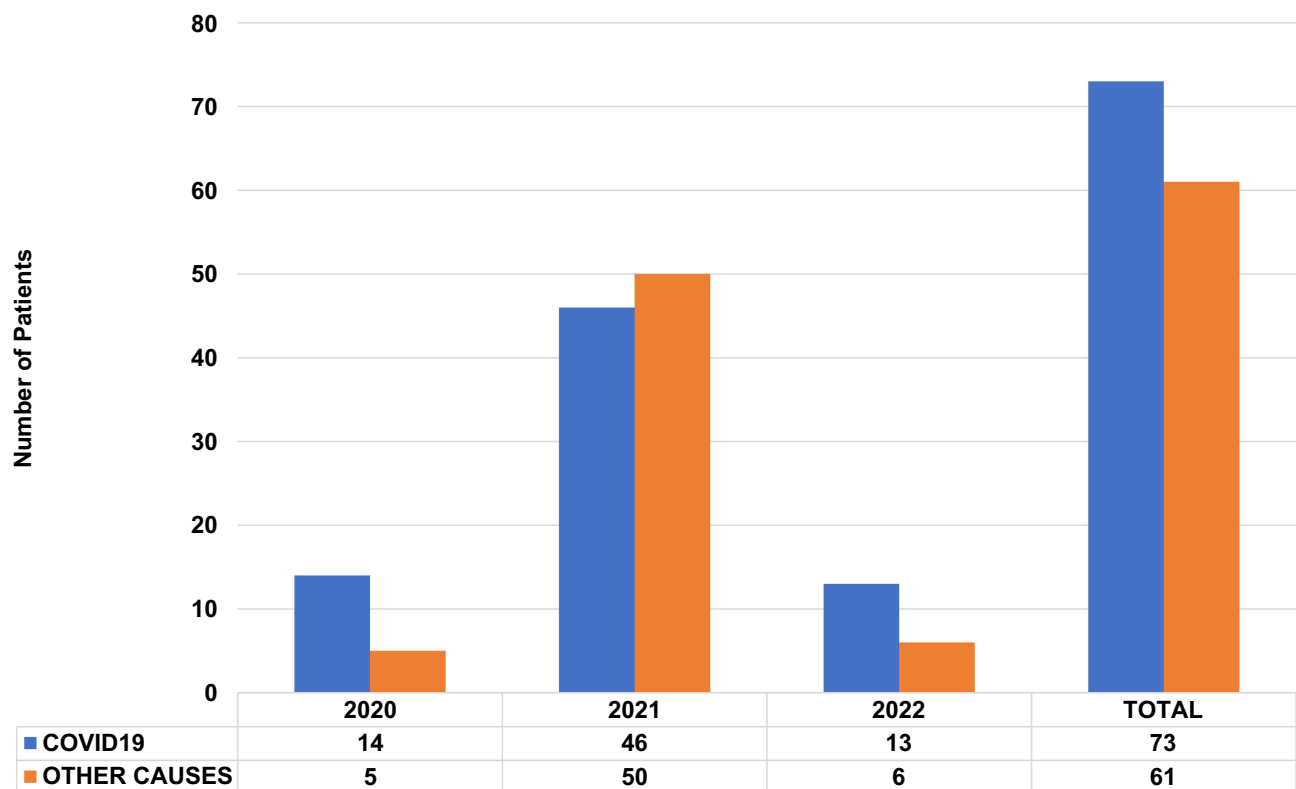


Figure 4 Admissions due to Respiratory Causes to the Advanced Care at Home Program at Mayo Clinic Florida Campus July 2020–February 2022.

without MCC. These findings are important as they give us a specific focus on what high-acuity diagnosis urban hospital systems can target with their HaH programs in order to make the biggest impact to patient acquisition. As the HaH model grows, many urban systems may not have the resources or partnerships to cover a large range of high acuity diagnosis in the home setting. Limits to hospital resources or supply chain workforce may force them to focus their HaH efforts. If they begin with a list concentrating on pneumonia, heart failure, cellulitis, stable septicemia, and renal failure, they can cater their limited resources and supply chain to make the most impact to patient volumes. As these diagnoses are common admissions to traditional hospital inpatient wards,¹⁸ urban hospital systems can drive up their HaH patient acquisition efforts, which is crucial to program sustainability while also actively addressing hospital ED and medical ward overcrowding by moving this patient population into the HaH program.

A second possible impact of our findings is an impact on hospital finances by targeting these core DRGs in their HaH programs. Maximizing the financial impact from a particular DRG requires thorough assessment and documentation of all the patient's conditions impacting the hospital course. The assignment of a specific DRG to patients is based primarily on clinical diagnosis, the severity of the disease, comorbidities, and procedures that need to be performed.¹⁹ Therefore, health-care providers play the crucial role in fully documenting the patient's clinical status and clinical coders consequently translating it into the most appropriate code. Otherwise, a DRG misclassification would lead to the loss of revenue or inaccurate payment of hospital reimbursement.²⁰ Having a program focused on several core diagnoses may maximize documentation and billing efforts. Additionally, these seven major DRGs making the most impact to patient volumes in our study have been associated with an increase in payment revenue over the last 5 years.¹⁸ This is likely due to the number of resources necessary to effectively impact the quality of care in these disease states. Currently, Medicare is reimbursing hospital programs equivalent DRG payments regardless of the site of care, meaning a CHF exacerbation treated in the hospital wards or in a home hospital program receives the same reimbursement for care services. Thus, financial benefit would come from cost savings. Previous studies of cost saving opportunities in the home hospital model have found significant opportunities, including a 32% reduction in overall costs when treating inpatients in the home setting and a 38% reduction in acute care episode costs.^{11,21} This amount of cost reduction makes sense as in the brick-and-mortar setting, hospital overhead and capital costs make up 48% of health-care dollars attributed to hospital care.²² By eliminating the non-healthcare associated costs seen in hospital admissions, such as the cost to build new facilities, the cost of utilities such as water and power, the cost of environmental and laundry services, and the facility depreciation costs, academic medical centers practicing HaH while collecting full DRG payments may be able to spend health-care dollars on patient care instead of overhead services. Additionally, HaH programs continue to work to optimize in-home supply chain care delivery, eliminating the waste of redundant or non-necessary care. It is believed that a proper combination of both adequate patient volumes (to justify a robust supply chain) as well as efficient care delivery is what will make HaH systems economically viable.²³ In order to drive the patient volumes necessary to equal supply chain resources and expenditures, programs scaling their HaH programs will want to focus on the DRGs that give them the greatest opportunity to enroll patients. By focusing on the 7 DRGs we have listed in [Table 3](#), programs may be able to get to an average daily census that makes their HaH program cost effective. Combining optimized HaH documentation for these high acuity diagnoses along with the cost savings seen in HaH could benefit urban health systems, many of which are non-for-profit with very tight operating margins. Future studies looking at HaH cost efficiencies, patient enrollment volumes, and average daily census requirements necessary to be at least cost-equivalent to brick-and-mortar care with respect to these DRGs are necessary.

Limitations

Our study has several limitations. First, the correct coding of the DRGs reviewed in this study relies upon the accurate documentation of both the primary diagnosis and all comorbidities in the medical record. Provider error or brevity in documentation may have led to improper DRG or MCC coding or MCC inclusion. Second, the subjective interpretation of the data also poses a risk of bias in this study.

Conclusion

Advance Care at Home can admit a wide variety of diagnosis to its program. The majority of patients admitted to the urban academic HaH program belonged to seven core DRGs in five disease areas, consisting of pneumonia, sepsis, heart failure exacerbation, cellulitis, and renal failure. Urban academic medical centers can consider focusing their HaH patient acquisition and in-home resources on these diagnoses to make the largest impacts to program growth, hospital capacity, and possibly reimbursement. Considering that DRG influences the average length of stay, cost-effectiveness, and quality of care offered, further research based on these DRGs in the HaH model should be conducted.

Disclosure

Dr Michael J Maniaci reports Mayo Clinic discloses a financial investment in Medically Home LLC, the company that provides the Cesia Continuum™ software platform that enables the virtual care delivery; no authors receive any financial impact from this investment. Dr Sagar B Dugani reports grants from NIH/NIMHD, during the conduct of the study. The authors report no other conflicts of interest in this work.

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