

# Potential Impact of Hospital at Home on Postoperative Readmissions

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**H**ospital at home (HAH) is a health care delivery model in which a patient receives care in their home similar to an inpatient hospitalization.<sup>1</sup> These programs offer services including daily physician visits, nursing visits up to 3 times per day, laboratory tests, x-ray imaging, intravenous fluids and medications, continuous vital sign monitoring, and integrated data entry into electronic health records from the home, with a system for timely transfer to an inpatient facility in the case of worsening clinical status. The first HAH programs in the United States were developed at Johns Hopkins Hospital in the late 1990s and were initially targeted toward geriatric patients with chronic medical problems.<sup>2</sup> Follow-up studies focused on medical patients have been performed in multiple patient populations and health systems.<sup>3-9</sup> These studies have demonstrated that for medically ill patients, admission to HAH offers significant benefits compared with inpatient admission, including fewer iatrogenic complications such as delirium, improved patient and caregiver satisfaction, decreased readmission rates, and, in some studies, decreased mortality. HAH has been shown to be 19% to 40% less costly compared with inpatient admission.<sup>2,4-8</sup> Meta-analyses of available data have reinforced these findings.<sup>10-12</sup>

HAH programs may also hold promise in surgical patient populations. One successful pilot program in Spain enrolled 50 patients after laparoscopic colectomy and moved part of their postoperative care to HAH, with good safety results and cost savings.<sup>13</sup> An area of particular interest is postoperative readmissions, which are often studied as a quality metric and may incur additional cost to the hospital when perioperative care is reimbursed as a bundle. Common readmission diagnoses for postoperative patients, including surgical site infection, high-volume ileostomy output, and nausea/dehydration, are issues well suited to HAH care.<sup>1</sup> Offering HAH services to postoperative readmissions may afford these patients the same benefits of receiving care at home as a substitute for the hospital that have already been identified in medically ill patients. In addition, diverting postoperative readmissions to at-home care has the unique benefit of freeing surgical beds, which can increase procedural capacity and therefore surgical access and hospital

## ABSTRACT

**OBJECTIVES:** Hospital at home (HAH) is a health care delivery model that substitutes hospital-level services in the home for inpatient hospitalizations. HAH has been shown to be safe and effective for medical patients but has not been investigated in surgical readmissions. We estimated the potential impact of an HAH program for patients readmitted within 60 days postoperatively and described the characteristics of eligible patients to aid in the design of future programs.

**STUDY DESIGN:** This was a cross-sectional study of 60-day postoperative readmissions at a tertiary care center in 2018.

**METHODS:** We identified the number of readmissions that may have been eligible for HAH, collected descriptive information, and estimated the financial margin that could have been generated had eligible readmissions been diverted to HAH.

**RESULTS:** There were 2366 readmissions within 60 days of surgery in 2018. A total of 731 readmissions met inclusion criteria for HAH (30.1%), accounting for 4152 bed days. Of these readmissions, the most common diagnoses were infection, gastrointestinal complications, and cardiac complications. Patients' home addresses were within 16 miles of the hospital in 447 cases (61.1%). Avoidance of these readmissions and use of the beds for new admissions represented a potential backfill margin of \$8.8 million, not incorporating the cost of HAH.

**CONCLUSIONS:** Many 60-day postoperative readmissions may be amenable to HAH enrollment, representing a significant opportunity to improve patient experience and generate hospital revenue. This is of particular interest in the post-COVID-19 era. To maximize their impact, HAH programs should tailor clinical and operational services to this population.

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revenue. In an effort to address safety concerns and meet bed demands during the COVID-19 pandemic, in March 2020 CMS announced the Hospital Without Walls program, which provides regulatory support and reimbursement for HAH care to hospitals with a qualifying program.<sup>14</sup> The post-COVID-19 era is a unique time to investigate new opportunities for HAH given the dramatic increase in patient, provider, and system-level interest in home-based care.<sup>15</sup>

To better understand the potential impact of an HAH program for surgical patients, we primarily aimed to estimate the population of surgical readmissions at a tertiary care medical center that may be eligible for HAH care. Secondly, we sought to describe the characteristics of the HAH-eligible population and the details of their readmissions to help guide how future HAH programs can be optimally designed to meet surgical patients' needs. Finally, we estimated the margin from new inpatient capacity that could be generated if the hospital avoided HAH-eligible readmissions and backfilled these beds with new medical-surgical admissions.

## METHODS

### Study Setting and Data

This study took place at a 1034-bed tertiary care teaching hospital in New England. This was a cross-sectional study of surgical readmissions occurring within 60 days of index surgery from January 1 through December 31, 2018. We included patients 18 years or older who had surgeries of the following types: burn, cardiac, general/gastrointestinal, gynecology, plastics/reconstructive, oncology, orthopedics, thoracic, trauma, and vascular. Patients from the departments of urology and neurosurgery were not included because of missing data. Information about patient index surgeries and readmission hospitalizations was obtained from an institutional clinical and administrative database linked with the hospital's electronic health record. This project was undertaken as a quality improvement initiative and as such was not formally supervised by the institutional review board per our institution's policy.

### Outcomes and Analysis

Our primary outcome of interest was the estimated number of 60-day readmissions that would have been eligible for HAH in 2018 and the number of bed days associated with these admissions. We chose to focus on postoperative readmissions within 60 days of surgery to ensure availability of adequate data surrounding the index surgery and because readmission within 60 days represents an important quality metric for hospitals and insurance companies. Readmissions were counted separately for patients who had multiple readmissions within 60 days. We applied the following absolute/nonmodifiable exclusion criteria to readmissions adapted from prior HAH studies: home address out of state, transfer from an

## TAKEAWAY POINTS

Hospital at home (HAH) programs have been shown to offer a safe alternative to inpatient admission for select medical patients. This study is the first to estimate the potential impact of HAH as an alternative to postoperative readmissions.

- ▶ Of 2366 readmissions within 60 days of surgery at our institution, 731 readmissions met inclusion criteria for HAH (30.1%), representing 4152 bed days and a potential margin of \$8.8 million.
- ▶ We believe our results will contribute to the expansion of HAH programs to include surgical patients, and we describe clinical/operational characteristics of our postoperative readmissions to aid in program development.

outside hospital or facility, need for reoperation, intensive care unit stay, death during readmission, or planned readmission for chemotherapy.<sup>7,16</sup>

Our secondary aim was to describe the patient and hospitalization characteristics of the cases meeting absolute eligibility criteria for HAH. We focused on characteristics that could give insight into the optimal design of an HAH program, with the goal of identifying criteria that, if followed, would maximize inclusion. Data captured about patients' hospitalizations included geographic location of the patient's home address from our hospital, which we categorized as less than 8 miles, 8 to 16 miles, or more than 16 miles based on the previously established catchment boundary of 8 miles in the medical HAH program at our institution; readmission day of week, which we categorized as weekday or weekend; readmission hour of day (when "admit" order placed), which we categorized into 8 AM to 5 PM, 5 PM to midnight, and midnight to 8 AM, based on typical shift hours for clinician staff; readmission diagnosis; readmission source, defined as the mode of referral of the patient to the hospital; and length of stay.

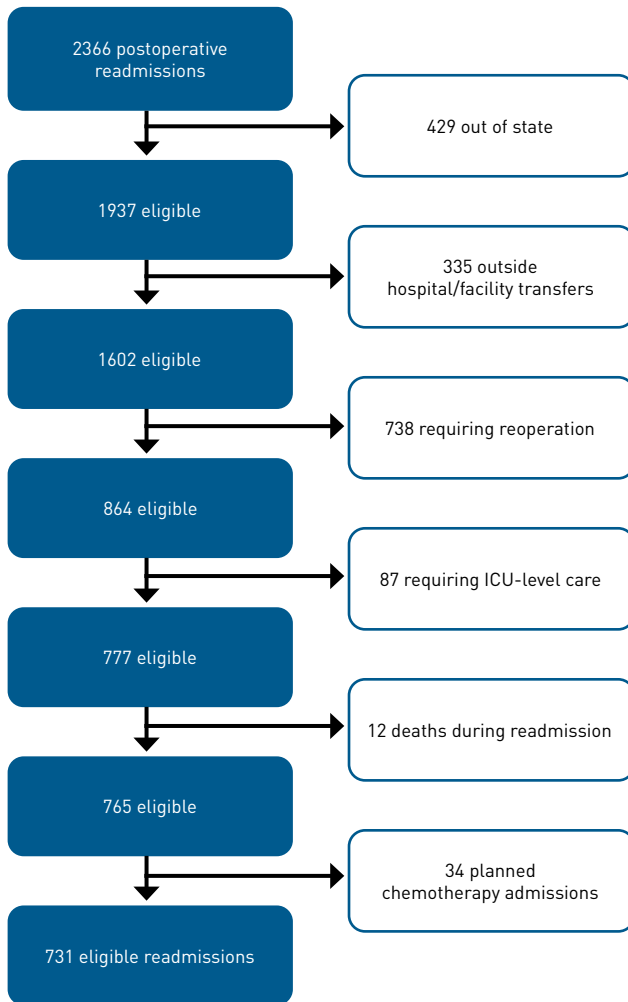
Finally, we estimated the potential financial impact on hospital margin of diverting surgical readmissions to an HAH program. Our estimate presumed that the avoided bed days would be backfilled by new patient hospitalizations. Data regarding number of bed days for readmissions in 2018 were collected from the institutional database. To estimate the additional hospital margin captured from these new hospitalizations, we used the mean revenue and cost of medical-surgical bed days at our institution in 2018 US\$.

## RESULTS

In 2018, there were 22,422 surgical encounters and 2366 readmissions (10.6%) within 60 days of index surgery. These readmissions represented an estimated 19,449 hospital bed days. The **Figure** demonstrates that 731 (30.1%) patients who were readmitted within 60 days would have been eligible for HAH based on our absolute exclusion criteria, representing 4152 hospital bed days. Need for reoperation was the most common absolute exclusion criterion (738 patients).

**Table 1** describes the characteristics of the patients admitted within 60 days of surgery, comparing those eligible for HAH and

**FIGURE.** Sixty-Day Readmissions in Departments of Gynecology, General Surgery, and Orthopedics With Hospital at Home Exclusion Criteria Applied



ICU, intensive care unit.

those ineligible after applying absolute exclusion criteria. The division of these patients among departments was similar in the 2 groups, with 534 (73.1%) from the Department of Surgery, 143 (19.6%) from the Department of Orthopedics, and 54 (7.4%) from the Department of Gynecology in the HAH-eligible cohort. In the HAH-eligible population, 275 (37.6%) patients lived within 8 miles of the hospital and an additional 172 (23.5%) lived between 8 and 16 miles away. The most common reasons for readmission were wound or deep space infection, gastrointestinal complication (including nausea/vomiting with dehydration and/or obstruction), and cardiac problems (including volume overload, atrial fibrillation, and pericarditis). The mean (interquartile range) length of stay was 6 (4) days, with 514 (70.3%) admissions lasting less than a week. A total of 574 (78.5%) HAH-eligible readmissions occurred

**TABLE 1.** Characteristics of 60-Day Postoperative Readmissions in 2018, Eligible and Ineligible for HAH

Characteristic	Admissions eligible for HAH, n (%)	Admissions ineligible for HAH, n (%)
Department/division of surgery		
Ob-gyn	54 (7.4)	58 (3.5)
Orthopedics	143 (19.6)	362 (22.1)
General/GI surgery	130 (17.8)	225 (13.8)
Cardiac	101 (13.8)	173 (10.6)
Thoracic	54 (7.4)	203 (12.4)
Surgical oncology	64 (8.8)	142 (8.7)
Plastics	37 (5.1)	70 (4.3)
Vascular	66 (9.0)	199 (12.2)
Trauma/burn	82 (11.2)	203 (12.4)
Patient age in years		
Median (IQR)	64 (20)	65 (21)
Home distance from hospital		
< 8 miles	275 (37.6)	392 (24.0)
8-16 miles	172 (23.5)	237 (14.5)
In Massachusetts, > 16 miles	284 (38.9)	577 (35.3)
Out of state	0	429 (26.2)
Insurance		
Medicare	300 (41.0)	768 (47.0)
Medicaid	70 (9.6)	87 (5.3)
Private	361 (49.4)	780 (47.7)
Readmission source		
Self-referral	418 (57.2)	252 (15.4)
Physician office	313 (42.8)	832 (50.9)
Acute care hospital	0	330 (20.2)
Nonhospital facility	0	221 (13.5)

(continued)

on a weekday, and 663 (90.1%) readmissions presented between 8 AM and midnight.

If all the readmissions meeting HAH inclusion criteria had been avoided and the associated 4152 bed days had been filled with other medical-surgical patients, the margin from new inpatient capacity would be an estimated \$8,847,300 across all departments (Table 2).

## DISCUSSION

To our knowledge, this is the first study to estimate the potential impact of HAH as an alternative to inpatient care for postoperative readmissions. We found that at a large tertiary care hospital in 2018, 731 readmissions within 60 days of surgery were eligible for enrollment in HAH after applying absolute exclusion criteria.

**TABLE 1.** (Continued) Characteristics of 60-Day Postoperative Readmissions in 2018, Eligible and Ineligible for HAH

Characteristic	Admissions eligible for HAH, n (%)	Admissions ineligible for HAH, n (%)
Readmission day		
Weekday	574 (78.5)	1355 (82.9)
Weekend	157 (21.5)	280 (17.1)
Readmission time of day		
8 AM to 5 PM	418 (57.2)	819 (50.1)
5 PM to midnight	245 (33.5)	416 (25.4)
Midnight to 8 AM	68 (9.3)	400 (24.5)
Length of stay		
0-2 days	153 (20.9)	262 (16.0)
3-4 days	235 (32.1)	340 (20.8)
5-6 days	126 (17.2)	273 (16.7)
≥7 days	217 (29.7)	760 (46.5)
Readmission diagnosis		
Pain	23 (3.1)	17 (1.0)
UTI	18 (2.5)	19 (1.2)
Pneumonia/pneumonitis	36 (4.9)	42 (2.6)
SSI/deep infection/sepsis	177 (24.2)	415 (25.4)
Bleeding	26 (3.6)	100 (6.1)
Dehydration/FTT	12 (1.6)	6 (0.4)
Gastrointestinal	72 (9.8)	119 (7.3)
Wound (noninfectious)	8 (1.1)	129 (7.9)
Drain/tube malfunction	2 (0.3)	11 (0.7)
Cardiac	79 (10.8)	84 (5.1)
Kidney failure	25 (3.4)	19 (1.2)
Chemotherapy	0	61 (3.7)
Unknown	63 (8.6)	257 (15.7)
Other	190 (26.0)	356 (21.8)
Total number of readmissions	731	1635

FTT, failure to thrive; GI, gastrointestinal; HAH, hospital at home; IQR, interquartile range; ob-gyn, obstetrics/gynecology; SSI, surgical site infection; UTI, urinary tract infection.

These readmissions accounted for an estimated 4152 hospital bed days. Further, our analysis identified clinical and operational characteristics of eligible readmissions that could guide the optimal design of future HAH programs so that they address the maximal number of surgical readmissions.

To estimate the number of patients eligible for HAH within the postoperative readmission population, we used absolute exclusion criteria based on available data and aligned with criteria used in previous studies of medical HAH programs. We did not include all criteria that might be important when enrolling a patient into HAH because of limitations on the clinical information available in our database, such as patient delirium, severe laboratory abnormalities, or condition-specific characteristics. We also did not exclude patients for program-modifiable factors, such as catchment area,

**TABLE 2.** Revenue Margin From New Inpatient Capacity Generated by Avoiding 60-Day Readmissions for Surgical Patients, by Department

Department	Number of 60-day readmissions	Total readmission hospital bed days	Revenue margin opportunity <sup>a</sup>
Gynecology	54	108	\$230,132
Surgery	534	3686	\$7,854,323
Orthopedics	143	358	\$762,845
Total	731	4152	\$8,847,300

<sup>a</sup>Revenue opportunity based on mean length of stay for medical-surgical patients, mean revenue, and cost of medical-surgical hospitalization at our institution.

because these patients might be reachable with alterations in a program's design. Because this was a retrospective study, we could not exclude patients who would have refused to be enrolled in HAH or those who could not have been enrolled because of lack of at-home social support (determined by a survey assessing access to a phone, help from a caregiver, adequate food supply, and a few other parameters). In previous HAH trials, 30% to 50% of patients or caregivers declined HAH admission despite meeting eligibility criteria.<sup>5,7,8</sup> There has been an explosion of interest in home-based care secondary to the COVID-19 pandemic, and we suspect that patient/caregiver uptake will increase significantly over time.<sup>15</sup> Nevertheless, application of our limited absolute exclusion criteria selects for an upper bound of the number of patients who would have been candidates for HAH in 2018.

However, we maintain that the impressive number of readmissions and bed days that might have been avoided with an HAH program among this cohort supports investment of hospital resources in HAH programs for a surgical population and in pilot studies to confirm their efficacy. In addition to the potential clinical outcome and financial benefits, the improvement of the patient and family experience with HAH as an alternative to inpatient admission has been well studied,<sup>3,5</sup> and this option should be made available to surgical patients. We expect that patient demand for at-home care and reimbursement options will continue to rise post COVID-19.

The biggest exclusion criterion for eligible admissions in this study was the need for reoperation. Although using retrospective data in this study makes clear which patients required reoperation, this may not be immediately apparent prospectively when triaging a patient for inpatient admission vs HAH. Careful attention must be paid to risk-stratifying patients for the potential need for reoperation. In addition, HAH programs have the capability to retriage patients to the inpatient setting if a disease process were to evolve requiring reoperation or other inpatient-level care. Clear escalation processes and timely transfer are important components of a safe retriage process for patients enrolled in HAH.

The most common readmission diagnoses within 60 days of surgery were superficial skin infection/deep space infection, cardiac complications (volume overload, atrial fibrillation, pericarditis), and gastrointestinal complications (nausea/vomiting with dehydration and/or obstruction). Based on these common

diagnoses, an HAH program designed for postoperative patients should have the capability to dose intravenous (IV) antibiotics (in some cases as frequently as every 6 hours); manage drains and complex wound care; obtain daily laboratory results; provide IV fluids, electrolytes, and antiemetics; manage nasogastric tubes to suction; and utilize continuous wearable vital sign monitors. Many of these services have been included in prior successful HAH programs,<sup>2,4-8</sup> and all these services are feasible in the home with the appropriate infrastructure.

With regard to operational characteristics of the readmissions, we focused on readmission source, location of the patient's home address, and date/time of admission. The large proportion of readmissions referred by outpatient providers from their clinics indicates an opportunity to avoid both an emergency department (ED) visit and an inpatient readmission by enrolling patients in HAH directly from clinic. This capability would require a relationship between surgeons and HAH enrollment teams, as well as strategies to minimize impact on regular clinical operations, which has been previously documented as a barrier to successful implementation of HAH programs.<sup>17</sup> Within our institution's HAH program for medical patients, the solution to this has been to employ a nurse practitioner or physician assistant who receives all HAH referrals from providers. This individual partners with outpatient and ED teams to help evaluate, triage, and onboard eligible patients, as well as arrange for the transition home. The development of this role has streamlined workflow, made enrollment easier for providers, and ensured safe transitions of care. The opportunity to enroll patients while avoiding the ED may be further maximized by increasing availability of surgical urgent care, which would increase access to a non-ED location where patients could be evaluated and triaged. HAH personnel could concentrate resources to these locations to enroll eligible patients.

Distance from the hospital is a significant barrier to successfully enrolling patients in HAH.<sup>2,4,8</sup> Patients must be close enough that a team of providers can reach them and should be able to be transferred to a hospital if needed. This is a bigger challenge for surgical patients compared with medical patients because the former tend to come to a tertiary care center from farther geographic locations. We found that to capture half of the patients in this cohort eligible for HAH, the catchment area needed to be extended to a 16-mile radius around our hospital. Further widening the catchment area, and thus HAH enrollment, would require creative solutions that likely need to be individualized based on the specific location, health care system, and available resources. Options include utilizing satellite hospitals/care facilities to reach patients living farther away and increasing the reach of HAH by considering transportation logistics such as traffic patterns and the presence of highway access.

We examined the day of the week and time of day of the 60-day postoperative readmissions to better understand when to prioritize having HAH enrollment services available. Previous HAH studies have documented loss of up to nearly 50% of potential enrollment opportunities if hours are limited to weekdays.<sup>2,4</sup> Because our

readmissions were more likely to occur on weekdays and in the late morning through early evening, enrollment services for postoperative readmissions should include those time periods. Other institutions seeking to implement an HAH program for surgical patients may adjust time frames for HAH enrollment based on their own admission patterns.

We estimated that our hospital could generate nearly \$9 million of margin in new admissions by backfilling beds if all the eligible 60-day readmissions were avoided. Postoperative readmissions within 60 days of surgery are in many cases not reimbursed by insurance companies and come at a higher cost than average to the hospital, making avoidance of admissions for this population particularly financially rewarding. Our calculation does not take into account the cost of the HAH services that would be required, but previous studies have demonstrated that HAH services are significantly less costly than inpatient admission.<sup>2,4-11</sup> These studies have shown that cost savings are derived from avoided lodging, food, laundry, and heating/lighting, as well as decreased utilization of testing (eg, fewer laboratory draws/imaging studies).<sup>7,8</sup>

### Limitations

The findings of this study are limited in that it was performed at a single tertiary care center, and there may be differences in the postoperative readmission populations in other care settings. Our inability to capture several additional clinical and social exclusion criteria, as discussed earlier, is a limitation as well. We were unable to address issues surrounding surgeon trust and patient buy-in at this stage, both of which are important to implementation of an HAH program. Future studies will address enrollment of postoperative patients outside a 60-day window, as well as immediate postoperative patients interested in early discharge from the inpatient ward to HAH. Both of these populations represent additional opportunities for utilizing an HAH program designed for surgical patients. We are beginning to roll out an HAH pilot program for surgical patients at our institution, which will allow for identification of and problem-solving around additional feasibility issues.

## CONCLUSIONS

This work supports the concept that many 60-day postoperative hospital readmissions may be amenable to diversion to HAH. Given the previously identified benefits of HAH programs compared with inpatient admission for medically ill patients, including fewer iatrogenic complications and improved patient and caregiver satisfaction, as well as the opportunities for health care cost savings, expanding these services to include postoperative patients represents an exciting opportunity for patients and health care systems. We anticipate that patient and provider interest in alternatives to inpatient admission will escalate in the post-COVID-19 era, as patients are concerned about spending time inside hospitals. HAH could be an excellent option to address this need going forward. ■



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