Scalable Hospital at Home With Virtual Physician Visits: Pilot Study

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ABSTRACT

Objectives: To evaluate the safety, feasibility, and efficacy of a substitutive Hospital at Home (HaH) model where physician care was provided via 2-way biometrically enhanced tele-video for a 34-day care episode.

Study Design: Prospective, nonrandomized, quasi-experiment.

Methods: Using medical record and patient survey data, we compared patients cared for in HaH (n = 50) versus the traditional acute care hospital (n = 52).

Results: Patients in HaH had substantial contact with the HaH physician, as well as in-person visits with nurse practitioners and other care providers. HaH patients were more satisfied with their care in multiple domains and met illness-specific quality standards at similar rates to hospital comparison patients. Functional outcomes were notable for a trend toward improvements in activities of daily living among HaH patients. Compared with hospital patients at 90 days after discharge, HaH patients were less likely to experience a hospital readmission (adjusted odds ratio, 0.39; 95% CI, 0.21-0.72).

Conclusions: This pilot study suggests that a scalable substitutive model of HaH using biometrically enhanced 2-way tele-video, virtual physician visits, and caring for patients over a 34-day episode is safe, feasible, highly satisfactory, and may be associated with substantial reductions in hospital readmissions.

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Hospital care is not only expensive, but can be unsafe for patients with iatrogenic complications, with adverse events being common.[1-5] Previous literature has found that the Hospital at Home (HaH) model provides hospital-level care in the home as a substitute for acute hospital admission (substitutive HaH), and when compared with usual hospital care, is associated with better outcomes in multiple domains.[6-13] Further, a meta-analysis of randomized, controlled trials of substitutive HaH use demonstrates a 38% reduction in mortality compared with usual hospital care.[14]

Scaling and implementing HaH on a widespread basis is a challenge.[15] HaH was implemented widely in Victoria State, Australia, where it provides a volume of services equivalent to a 500-bed hospital.[16] In the United States, the Johns Hopkins Hospital at Home has been implemented in several Veterans Affairs hospitals and an integrated delivery system[17-19]; however, widespread implementation has been limited by payment, attitudinal, and scalability issues. Widely adopted, HaH could make a significant contribution toward achieving the Triple Aim for healthcare: better patient outcomes, a better system of service delivery, and lower costs.

Models of substitutive HaH that provide substantial physician care do so in the form of in-home physician visits. Methods to deliver the physician component of HaH care in a scalable manner could improve the ability to widely implement HaH. High-quality, 2-way, real-time, biometrically enhanced tele-video capabilities now allow for in-home evaluation of patients via a virtual physician. The goal of this paper is to evaluate the safety, feasibility, and efficacy of a scalable, substitutive HaH model that followed patients for 34 days and used virtual physician visits, and remote biometric monitoring.

METHODS

Patients

The target sample was English-speaking, community-dwelling adults 18 years and older, living in a specific geographic

Take-Away Points

- Hospital at Home (HaH) provides acute, hospital-level care at home as a substitute for hospital admission.
- Despite a robust underlying evidence base, widespread implementation of HaH has been limited by scalability issues.
- This study tested the safety, feasibility, and efficacy of a scalable HaH that provided physician care via 2-way biometrically enhanced tele-video and cared for patients for a 34-day episode.
- This scalable model was safe and efficacious. Compared with hospitalized patients, HaH patients had better satisfaction and lower readmission rates at 90 days.

catchment area, who required acute hospital admission for 1 of the target conditions and who met clinical and social stability criteria, which were based on previously validated Hospital at Home medical eligibility criteria.[20] The target conditions were exacerbation of chronic obstructive pulmonary disease (COPD) or congestive heart failure (CHF), deep vein thrombosis (DVT), asthma, or community-acquired pneumonia. The most common reasons for medical ineligibility were severe hypoxemia, active cardiac ischemia, uncontrolled arrhythmia, end-stage cancer, or other conditions that required intubation or extreme interventions. The most common social stability ineligibility criteria were impaired cognitive and ambulatory status and inadequate support care at home.

Study Site

The study was conducted at Advocate Christ Medical Center, a 695-bed community-based tertiary hospital in Oak Lawn, Illinois. It is part of the Advocate Health Care system, which is Illinois' largest healthcare provider and includes 12 acute care hospitals and over 250 sites of care.

Study Design

The study was a prospective, quasi-experiment. Treatment group patients were recruited between February and October of 2010. Patients meeting HaH admission criteria were identified in the emergency department (ED) or observation unit Monday through Friday. An independent physician, who was blind to group assignment, assessed all patients to validate that they would have required acute hospital admission in the absence of HaH.

Comparison patients were recruited between July 2010 and January 2011. These patients met HaH eligibility requirements, but were admitted to the hospital at times when HaH was not accepting patients (ie, outside of HaH hours or beyond the HaH recruitment period). In order to assure that the groups were as equivalent as possible, an independent physician also assessed all comparison cases to ensure they would have met HaH eligibility, as described by Leff et al,[20] had the program been open for recruitment during their contact with the hospital.

Intervention: The Hospital at Home, Central Station, and Home Monitoring Station

The current HaH model of care was based on the previously described Johns Hopkins Hospital at Home model,[7,21] but introduced 2 innovations. First, it employed a "central station" and home monitoring station that allowed physicians to make virtual, rather than in-person, home visits to patients. This also allowed for remote and continuous monitoring of patients by the care team. Physical in-home visits were made by nurse practitioners and physician assistants. The Central Station was a fully capable call center with 2-way tele-video and voice capability; it also had security, privacy, and patient data redundancy with multiple system backups. The Home Monitoring Station allowed the Central Station to connect fully to patients' homes through a standard telephone land line and for continual monitoring of vital signs, 2-way tele-video conferencing for patient/provider/caregiver interactions, and facilitated responses to situations of clinical concern. Biometric measures were obtained using wireless devices (ie, pulse oximetry, blood pressure, pulse, and weight scales), and when activated, they automatically sent information through a hub to a website (which was linked to the Central Station). Patients received Personal Emergency Response System wristlets that allowed for immediate connection to emergency care. If a scheduled vital sign was not obtained, the system alerted the Central Station prompting a care coordinator call. If there was no response, 911 was called.

The second innovation was for HaH to assume responsibility for a 34-day episode of care, which consisted of an acute and a transition phase. In the acute phase, hospital-level care commensurate with illness acuity was provided. The "greeter," a licensed practical nurse, visited the patient at home immediately after their return from the hospital. Greeters made final assessments of the adequacy of patients' home safety and support, installed and introduced patients and caregivers to the home-based technology, reinforced their training, and activated the Home Monitoring Station. Patients received needed diagnostic studies and therapeutics in the home, including intravenous fluids and medications, oxygen therapy, nebulized bronchodilators and respiratory therapies, and basic radiography and ultrasound. Illness-specific protocols and checklists provided caremaps, which integrated care from multiple providers

(ie, hospital, central station, primary care, and home) and allowed for patient-centered, individualized care. Caremaps provided a clinical infrastructure modeled from the airline industry, with checklists, redundancies around potential failure points, and feedback loops. Virtual physician visits were provided using the central station 2-way tele-video system. Physical home visits were made on the day following admission and on day 3 of the admission, in addition to whenever clinically indicated. Licensed practical nurse care coordinators, in coordination with the HaH physician, followed up on all details of care delivery and care coordination. The timing of discharge from acute phase was analogous to discharge from the traditional acute hospital, and then care shifted into the transition phase.

In the transition phase of HaH, patients had daily contacts alternating between the HaH physician via tele-video monitoring and the care coordinator via telephone until their first visit with their primary care physician (PCP). Nurse practitioners or physician assistants were available to make home visits at the request of HaH physicians, if clinically indicated. When patients saw their PCP, the HaH physician transferred case authority back to patients' PCPs. However, after the visit with the PCP and through day 34 of the admission, at least once a week—and as frequently as every other day, depending on the support required—care coordinators would call patients using scripted protocols to track clinical issues. Positive or concerning findings were communicated to PCPs; such findings would be acted upon by the HaH physician if the PCP could not be reached. For patients who refused follow-up care with their PCP, the approach was modified and they were monitored daily by the Central Station staff until the end of the transition phase. At the conclusion of the transition phase, the patient was fully discharged from HaH care and a final report summarizing the transition phase of care was sent to their PCP.

Medical Record Reviews and Baseline Interview

Medical records were abstracted using a standardized instrument that captured baseline sociodemographic and medical characteristics, as well as treatments received and the patient's hospital course, including complications of care. Study subjects completed a baseline interview that included sociodemographic characteristics, living arrangements, and functional status.

Recruitment

All adult patients presenting to the ED of Advocate Christ Medical Center during the hours of 8 AM to 6 PM Monday through Friday were screened for participation in the study if they had a chief complaint that was suggestive of one of the target diagnoses. The decision that a patient required hospital admission for a target condition was made by nonstudy ED personnel. Patients determined to require admission were then assessed for eligibility for HaH by a study-associated practitioner; for eligible patients, HaH Central Station physicians performed final assessments of patients' eligibility for HaH care. After confirming study eligibility, the Central Station physician spoke by phone with the patient's PCP to confirm that but for the existence of the HaH the patient would otherwise have been admitted to the acute care hospital and to obtain their assent to admit the patient to HaH. Patients were transferred home after informed written consent was obtained (usually by family members).

Outcomes

Process-of-care outcome measures included time spent in the ED prior to going home or to a hospital bed, the number and duration of contacts with HaH providers for each program phase, the number of visits by other provider types during the acute phase, and whether illness-specific standards of care were met.

Clinical outcome measures included length of stay (LOS) in the acute phase of care, the percent of patients who received various medical services, initial disposition upon discharge from acute care, and mortality. Patients' functional status was measured by using a summary score of Katz' activities of daily living ([ADL] range 0 to 6),[22] and Lawton-Brody's instrumental activities of daily living ([IADL] range 0 to 8).[23] Data regarding patient's functional status were collected from the patient at the time of enrollment and via phone interviews at 7, 30, and 90 days. Patient satisfaction with care was measured by using a modified version of the Client Satisfaction Questionnaire (CSQ-8)[24,25] augmented with 7 questions targeting the unique aspects of HaH at 7 days after enrollment using a 1 to 5 Likert scale (1 = strongly disagree, 5 = strongly agree). A summary score was derived as a mean score for all questions on the instrument.

Health service utilization at 30 and 90 days after discharge from the acute phase of HaH or after discharge from the acute hospital was assessed using a modified version of the Services Assessment for Children and Adolescents[26,27] and Advocate Health System administrative data.

Statistical Analysis

Descriptive statistics presented as sums, means, standard deviations, or percentages were used for demographic and health status measures. An unpaired *t* test was used to compare patient's satisfaction with care, and a 2-way

Table 1. Baseline Characteristics of the Study Participants

Characteristics	Hospital at Home Group N = 50	Hospital Comparison Group N = 52	*P*
Age, mean (SD) [range]	63.9 (16.3) [27-90]	63.1 (12.7) [35-87]	.777
Female, n (%)	27 (54%)	31 (60%)	.567
Race			
African American, n (%)	15 (30%)	21 (40%)	
Caucasian, n (%)	31 (62%)	30 (58%)	
Hispanic, n (%)	4 (8%)	1 (2%)	.249
Any impairment in ADLs, n (%)	4 (8%)	5 (10%)	1.000
Any impairment in IADLs, n (%)	28 (56%)	19 (37%)	.049
Number of medications taken on chronic basis, mean (SD)	6.04 (4.9)	5.98 (4.9)	.952
Number of chronic conditions, mean (SD)	5.7 (2.1)	4.8 (2.0)	.082
Charlson comorbidity index, mean (SD)	1.6 (1.5)	1.6 (1.2)	.986
Lives alone, n (%)	9 (18%)	11 (21%)	.688
Primary admission diagnosis			
COPD, n (%)	15 (30%)	20 (38%)	
Congestive heart failure, n (%)	8 (16%)	9 (17%)	
Deep vein thrombosis, n (%)	10 (20%)	3 (6%)	
Asthma, n (%)	4 (8%)	5 (10%)	
Community-acquired pneumonia, n (%)	13 (26%)	15 (29%)	.313
Recruitment source			
Emergency department, n (%)	21 (42%)	44 (85%)	
Observation unit, n (%)	29 (58%)	8 (15%)	<.001

ADL indicates activities of daily living; COPD, chronic obstructive pulmonary disease; IADL, instrumental activities of daily living.

repeated measures ANOVA was used to assess patients' functional status (ADLs and IADLs) at baseline, 7 days, 30 days, and 90 days. Baseline characteristics and illness quality measures were analyzed using Student's *t* test for continuous data and χ^2 or Fisher's Exact test for the categorical data. The odds of experiencing readmission to the hospital at 30 and 90 days by study group were modeled using logistic regression analysis adjusted for age, gender, and comorbidity index. All analyses were conducted using SPSS version 19.0 (SPSS Inc, Chicago, Illinois).

Approval and Safety Monitoring

The Advocate Health Care Institutional Review Board approved the study. Written informed consent was obtained from all study subjects. A Data Safety Monitoring Board met twice during the study to review patient experiences, data, and safety.

RESULTS

In the HaH group, 3402 patients with qualifying presenting complaints were screened. Of these, 2678 were immediately excluded because they came from a nursing home, lived outside the HaH geographic catchment area, or were admitted at times when HaH did not accept admissions. Another 651 patients (86%) were ineligible for HaH for either medical or social indications. Additionally, 53 (51%) refused HaH care. This resulted in a final HaH group comprised of 50 patients (49%) that provided research consent and were treated in HaH. In the hospital comparison group, similar proportions of patients were ineligible for HaH (79%) and refused data collection (53%), leaving 52 patients in the hospital comparison group. The eAppendix Figure (available at **www.ajmc.com**) depicts patient flow and data availability by study group.

Table 1 describes the baseline characteristics of participants. Overall, patients were Caucasian, with low acuity levels, a moderate burden of comorbid illness, and a modest level of functional impairment. There were no significant differences in sociodemographic characteristics between groups. Exacerbation of COPD and episodes of community-acquired pneumonia were the most common admission diagnoses. Groups were comparable on ADLs but the HaH group reported more impairment on IADLs.

Table 2. Contacts and Provider Use for Hospital at Home Patients by Phase of Care

	Acute Phase	Transition Phase
Mean days in phase, (SD) [range]	3.7 (1.45) [1-8]	28.5 (7.32) [0-32]
Mean number of contacts with physician via Central Station, (SD) [range]	4.56 (1.80) [1-10]	4.32 (3.15) [0-13]
Mean duration of each contact with physician via Central Station, minutes, (SD) [range]	44.22 (19.74) [15-120]	35.09 (14.35) [13-60]
Mean number of in-person contacts with a nurse practitioner or a physician assistant, (SD) [range]	1.76 (0.95) [0-5]	1.0 (1.48) [0-8]
Mean duration of each in-person contact with nurse practitioner or physician assistant, minutes, (SD) [range]	63.23 (20.05) [27-135]	NA
Mean number of registered nurse visits, (SD) [range]	1.54 (1.62) [0-5]	2.24 (3.09) [0-11]
Patients with in-person registered nurse visits, n (%)	27 (54%)	24 (48%)
Mean number of telephonic contacts with care coordinators, (SD) [range]	2.4 (1.56) [0-9]	7.62 (4.99) [0-22]
Patients with nurse aide visits, n (%)	2 (4%)	1 (2%)
Mean number of nurse aide visits, (SD) [range]	0.1 (0.58) [0-4]	0.18 (1.27) [0-9]
Patients with physical/occupational therapy visits, n (%)	2 (4%)	3 (6%)
Mean number of physical/occupational therapy visits, (SD) [range]	0.06 (0.31) [0-2]	0.44 (2.03) [0-12)
Patients with social worker visits, n (%)	0	5 (10%)
Mean number of social worker visits, (SD) [range]	0	0.10 (0.30) [0-1]
Number of 911 calls, n (%)	2 (4%)	5 (10%)

The ED observation unit provided 58% of admissions to HaH, while 85% of comparison patients were admitted to the hospital directly from the ED (P <.001). Time spent in the ED prior to admission was similar for the 2 groups and had a mean of 405 minutes.

Table 2 provides details on the types, quantity, and duration of HaH provider contact sessions with patients during the acute and transition phases of an HaH admission. Patients received substantial provider input during their experience in HaH, and only 5 patients—2 in the acute phase and 3 in the transition phase—required physical/occupational therapy. There was a statistically nonsignificant trend toward a shorter mean LOS during the acute phase of HaH and traditional hospital care (3.64 vs 4.31 days, respectively; P = .088). Due to the availability and frequent contact of the Central Station staff and physicians, 911 was called only 7 times: 2 in the acute phase and 5 in the transition phase. Illness-specific standards of care reported by the hospital and system for acute hospital admission were met with similar frequency in both groups and are described in Table 3.

Table 4 compares patient satisfaction experienced by patients in each of the study groups. Participants in the HaH group had better satisfaction in multiple domains, as well as a higher overall satisfaction score (4.40 vs 4.01; P = .001). In particular, there was statistically significant better satisfaction with staff, convenience for caregivers, and comfort, convenience, and safety for patients.

Table 5 compares the functional, clinical, and health service utilization outcomes. There were no statistically significant differences in functional outcomes with regard to ADL or IADL status between study groups, but there was a statistically nonsignificant trend toward better ADL outcomes at 90 days in HaH (P = .064). Rates of clinical complications were equivalent between groups. HaH patients were less likely to receive specialty consultations or difficult procedures than patients treated in the hospital. Two patients were transferred from HaH to complete their acute admission in the hospital and did well clinically. HaH patients were less likely to be discharged from acute care to a skilled nursing facility or inpatient rehabilitation facility (0% vs 12%; P = .027)

Health service utilization following acute care discharge was notable for lower use of a skilled nursing facility or inpatient rehabilitation among HaH patients at 30 days (2 % vs 13 %; P = .026) and 90 days (4% vs 19%; P = .013). The odds of readmission occurring among HaH-treated patients compared with hospital patients adjusted for age, gender, and Charlson comorbidity index at 30 and 90 days, respectively, was 0.45 (95% CI, 0.19-1.08) and 0.39 (95% CI, 0.21-0.72).

Table 3. Comparison of Illness-Specific Standards of Care in the Hospital at Home and Hospital Comparison Groups

Quality Indicators	Hospital at Home Group N = 50	Hospital Comparison Group N = 52	*P*
Chronic obstructive pulmonary disease	N = 15	N = 20	
Use of corticosteroids	15 (100%)	20 (100%)	
Use of antibiotics	15 (100%)	19 (95%)	1.000
Use of nebulized bronchodilators	15 (100%)	20 (100%)	
Smoking cessation advise	15 (100%)	20 (100%)	
Influenza vaccination	8 (53%)	5 (25%)	.086
Pneumococcal vaccination	10 (67%)	16 (80%)	.451
Congestive heart failure	N = 8	N = 9	
Use of an ACE inhibitors/ARBs	5 (63%)	7 (78%)	.620
Use of beta-blockers	8 (100%)	9 (100%)	
Assessment of left ventricular function obtained	6 (75%)	9 (100%)	.206
Deep vein thrombosis	N = 10	N = 3	
Major or minor bleeding	0	0	
Asthma	N = 4	N = 5	
Use of long-acting inhaled corticosteroid	4 (100%)	5 (100%)	
Smoking cessation instruction	4 (100%)	5 (100%)	
Pneumococcal vaccination	3 (75%)	4 (80%)	1.000
Community-acquired pneumonia	N = 13	N = 15	
Antibiotics within 6 hours of arrival to ED	12 (92%)	15 (100%)	.464
Blood cultures obtained before administration of antibiotics	4 (31%)	3 (20%)	.670
Antibiotic selection (adherence to guidelines)	13 (100%)	15 (100%)	
Influenza vaccination	4 (31%)	4 (27%)	1.000
Pneumococcal vaccination	9 (69%)	11 (73%)	1.000

ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blocker; ED, emergency department.

DISCUSSION

The goal of this paper is to evaluate the safety, feasibility, and efficacy of a scalable, substitutive HaH model that followed patients for 34 days and used virtual physician visits and remote biometric monitoring. To our knowledge, based on our comprehensive global literature search, this is the first study of its kind. Results of this pilot suggest that this model is feasible, safe, and efficacious for patients with COPD, CHF, DVT, asthma, and community-acquired pneumonia who are deemed to be stable clinically (defined in the **eAppendix Table**). HaH patients experienced comparable clinical outcomes to those admitted to the hospital. Satisfaction with HaH was better in multiple domains compared with acute hospital care, and specific features (ie, less caregiver burden, HaH equipment, greeter) were rated at high levels. Condition-specific quality metrics were achieved at high rates. Notably, the risk of hospital readmission for HaH-treated patients at 90 days was significantly lower than those in the usual care group.

The innovations introduced in this HaH model have important implications for dissemination and implementation of the model. To date, dissemination of HaH in the United States has been limited by attitudinal, payment, and scalability issues. Attitudinal issues usually focus on the assumption that hospital care is safe and that providing acute care in the home setting is inherently inferior, despite data from multiple randomized controlled trials suggesting the opposite.[14] Payment issues have also been a barrier. In the United States, there is no payment for HaH care in fee-for-service models, which makes adoption difficult. The ability of HaH to provide virtual physician visits and continual remote monitoring improves the ability to achieve scale. A virtual physician visit is not limited by geography or time spent traveling from home to home;

Table 4. Comparison of Patient Satisfaction at 7 Days Between Hospital at Home and Hospital Comparison Groups

	Hospital at Home Group N = 50	Hospital Comparison Group N = 52	*P*
Overall score, mean (SD)	4.40 (0.52)	4.01 (0.53)	.001
General satisfaction			
Overall service quality	4.41 (0.58)	4.22 (0.76)	.169
Received exactly what needed	4.35 (0.64)	4.10 (0.79)	.096
Program/hospital met needs	4.37 (0.65)	4.22 (0.62)	.248
Recommend program/hospital	4.37 (0.71)	4.28 (0.61)	.507
Overall satisfaction	4.33 (0.79)	4.16 (0.77)	.298
Would participate/come again	4.41 (0.75)	4.14 (0.81)	.090
Staff			
Doctors knowledge	4.46 (0.55)	4.18 (0.63)	.024
Doctors availability	4.43 (0.54)	4.02 (0.80)	.004
Staff communication style	4.54 (0.55)	4.26 (0.66)	.025
Contacting staff when needed	4.39 (0.68)	4.14 (0.64)	.066
Primary doctor kept informed	4.22 (0.66)	3.94 (0.79)	.067
Caregivers/family members			
Easier for caregivers/family members	4.39 (0.65)	4.22 (0.55)	.167
Caregivers missed less work	4.26 (0.68)	4.02 (0.69)	.088
Caregivers travel time	4.50 (0.55)	3.90 (0.91)	<.001
Comfort, convenience, and safety			
Comfort with program/hospital	4.48 (0.66)	3.58 (1.25)	<.001
Safety	4.48 (0.55)	3.90 (0.95)	.001
Convenience	4.50 (0.62)	3.02 (1.20)	<.001
Quality of interactions with staff	4.15 (0.84)	4.04 (0.75)	.493
Hospital at Home specific questions			
Less stressful for caregivers having patients treated at home than in the hospital	4.35 (0.67)	N/A	N/A
Equipment was easy to use	4.33 (0.79)	N/A	N/A
Equipment worked very well	4.26 (0.71)	N/A	N/A
Had all necessary equipment	4.39 (0.68)	N/A	N/A
Greeter was polite	4.54 (0.50)	N/A	N/A
Greeter was knowledgeable	4.54 (0.55)	N/A	N/A
Greeter answered all questions	4.57 (0.54)	N/A	N/A

N/A indicates not applicable.

subsequently, these physicians can care for a significantly greater number of patients than an in-person HaH physician. The virtual nature of this model also refutes the idea that HaH patients are not "monitored" or "observed." Both patients and clinicians reported being satisfied with this modality of interaction.

Another innovation in this pilot was managing all HaH admissions for a 34-day episode of care. This is important given the associated reduction in hospital readmissions at 90 days. We hypothesize that a number of factors contributed to this outcome, including providing care over an extended timeframe, having time to address patients' multiple conditions, building trust and paying attention to issues of care transition with the knowledge that comes from having cared for a patient at home, and ensuring timely follow-up with the patient's physician. This study is unique within the HaH models in its use of the virtual physician and the extended episode of care.

Table 5. Comparison of Functional Outcomes, and Clinical Complications, Discharge Disposition, and Health Service Utilization at 30 and 90 Days

	Hospital at Home Group N = 50	Hospital Comparison Group N = 52	*P*
Activities of daily living			
Baseline, mean (SD)	5.93 (0.46)	5.77 (0.96)	
7 days, mean (SD)	5.95 (0.22)	5.50 (1.41)	
30 days, mean (SD)	5.90 (0.37)	5.61 (1.21)	
90 days, mean (SD)	5.81 (0.80)	5.39 (1.43)	.064
Instrumental activities of daily living			
Baseline, mean (SD)	6.74 (1.77)	7.20 (1.55)	
7 days, mean (SD)	6.83 (1.64)	6.52 (2.03)	
30 days, mean (SD)	7.02 (1.72)	6.70 (2.06)	
90 days, mean (SD)	7.19 (1.53)	6.59 (2.33)	.587
Clinical complications			
Falls, n (%)	0	0	
Delirium/confusion, n (%)	0	2 (4%)	.495
Urinary issues, n (%)	1 (2%)	2 (4%)	1.000
Bowel issues, n (%)	4 (8%)	7 (13%)	.374
Use of sleeping medications, n (%)	3 (6%)	4 (8%)	1.000
Transfer to ICU, n (%)	0	2 (4%)	.495
Intubation, n (%)	0	2 (4%)	.495
Emergency situation, n (%)	1 (2%)	2 (4%)	1.000
Transfer from Hospital at Home to acute hospital to complete acute inpatient admission, n (%)	2 (4%)	NA	
Discharge disposition after acute phase			
Home, n (%)	48 (96%)	46 (88%)	
Skilled nursing facility or inpatient rehabilitation facility, n (%)	0	6 (12%)	.027
Service utilization and mortality at 30 days			
Any patient with specialty consultation, n (%)	12 (24%)	41 (79%)	<.001
Number of specialty consultations, mean (SD)	0.34 (0.72)	1.50 (1.15)	<.001
Any patient with difficult procedure,[a] n (%)	18 (36%)	35 (67%)	.002
Number of difficult procedures, mean (SD)	0.52 (0.85)	1.37 (1.23)	<.001
Emergency department visits, n (%)	4 (8%)	2 (4%)	.398
Unique patients with hospital readmission, n (%)	6 (12%)	12 (23%)	.173
Total number of hospital readmissions, n (%)	7 (14%)	17 (33%)	.072
Skilled nursing facility or inpatient rehabilitation facility, n (%)	1 (2%)	7 (13%)	.026
Death, n (%)	1 (2%)	1 (2%)	.860
Cumulative service utilization and mortality at 90 days			
Emergency department visits, n (%)	7 (14%)	6 (12%)	.660
Patients with hospital readmission, n (%)	12 (24%)	22 (42%)	.063
Total number of hospital readmissions, n (%)	14 (28%)	39 (75%)	.002
Skilled nursing facility or inpatient rehabilitation facility, n (%)	2 (4%)	10 (19%)	.013
Death, n (%)	3 (6%)	1 (2%)	.313

ICU indicates intensive care unit.
[a]Difficult procedures to accomplish at home were: computed tomography, magnetic resonance imaging, echocardiogram, other ultrasound imaging, cardiac telemetry, exercise stress test, ventilation perfusion scan, endoscopic procedures, and blood product transfusion.

Unlike other HaH studies, it showed a reduction in hospital readmission rate. An Italian-based HaH model for patients with COPD demonstrated a reduction in readmission of approximately 50% at 6 months.[13] Compared with previous HaH studies, however, we did not find reductions in the rates of clinical complications.

Limitations

There are several important limitations to this study. First, this quasi-experimental study inherits the limitations of nonequivalent groups design. Although we took several steps to produce groups that were comparable, because we did not use random assignment, differences in outcomes may be attributable to selection bias. For example, more patients in the comparison group were recruited in the observation unit (85%) than in the HaH group (58%), which could indicate a clinical difference in the groups or a result of the HaH recruitment process. Second, the intervention and comparison groups were not accumulated in precisely the same timeframes, and this may have introduced an additional element of bias. Third, assessment of post acute health service utilization was limited to patient survey and Advocate Health System administrative data. We did not use a full claims data approach, and it is possible that our data did not fully capture complete postacute health service utilization. Fourth, the generalizability of the study's results is limited by the fact that only 5 acute diagnoses were included, and that the majority of patients were clinically stable, did not require physical/occupational therapy visits, and were selected from a single medical center. Future research is needed for assessing the safety, feasibility, and efficacy of the HAH model in patients with other diagnosis, higher levels of severity, and that require physical/occupational therapy.

Lastly, we did not report on the costs of providing HaH care compared with usual care. Previous studies[28] of the Hopkins HaH demonstrated lower total costs of care; however, the focus of this report was on the safety, feasibility, and efficacy of this novel HaH model. Included in this study were patients covered by a variety of payers, including commercial fee-for-service, Medicare fee-for-service, and both Medicare and non-Medicare managed care. The variety of payers and small sample size limited our ability to develop reasonable costing estimates. Nevertheless, as a pilot study of this innovative program that required launching and implementation, we felt a need to keep it small. We feel that in the scalable model, we would expand the clinical indications as well as the geographic catchment area and would achieve a greater number of patients served by the program.

CONCLUSIONS

In conclusion, we found that an HaH model using virtual physician visits, implementing remote biometric monitoring, and taking care of clinically stable patients with COPD, CHF, DVT, asthma, and community-acquired pneumonia over an episode of acute and postacute care was feasible, safe, and efficacious. Patients in this study received successful care at home, avoided unnecessary hospital-related costs, and achieved lowered readmission rates. This model may be the most scalable HaH model described to date; however, it is in need of further field testing.

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Authorship Information: Concept and design (WTS, AR, DC, KC); acquisition of data (WTS, SS, AR, KC); analysis and interpretation of data (WTS, SS, AR, DC); drafting of the manuscript (WTS, SS, AR, DC); critical revision of the manuscript for important intellectual content (WTS, SS); statistical analysis (WTS, SS); provision of patients or study materials (DC, AR, KC); obtaining funding (WTS, DC, KC); administrative, technical, or logistic support (SS, AR, KC); supervision (WTS, SS, AR, DC, KC); and patient care (KC).

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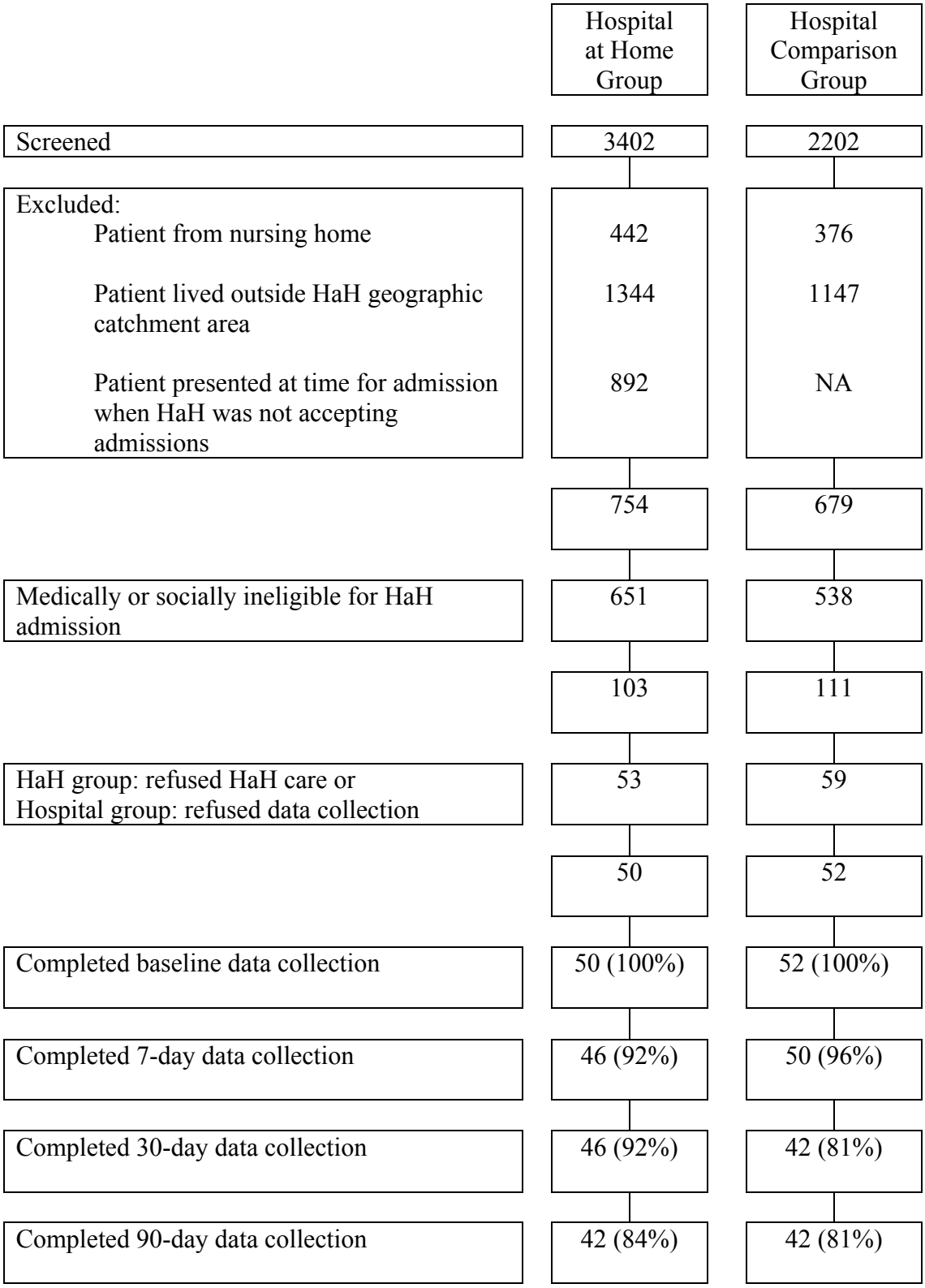
eAppendix

Table. HaH Eligibility Criteria

Blood pressure: >100 systolic (or at baseline), <200
Heart rate: >50 or <105 (or at baseline)
Respiratory rate: <30 (or at baseline)
Acute changes in EKG
Temperature: >97°F or ≤103°F (<101°F **o**r LOS reduction)
Pulse oximetry: >90% (or no more than 3 L NC or 35% mask) 2 supplementation
Pain: able to be controlled
Blood glucose level: >80 or <500 at time of discharge home
Peak flows: asthma only—PF>200 or 75% of baseline
WBC count: <30 k
Hemoglobin: >9 mg (or at baseline)
Creatinine: <2.5 (or at baseline)
Certainty of diagnosis

EKG indicates electrocardiogram; HaH, Hospital at Home; LOS, length of stay; WBC, white blood cell.

Figure. Study Pipeline



HaH indicates Hospital at Home.