OBSERVATIONS: BRIEF RESEARCH REPORTS

Factors Associated With Risk for Care Escalation Among Patients With COVID-19 Receiving Home-Based Hospital Care

Background: The COVID-19 pandemic, which has resulted in more than 142 million cases globally, has challenged health care systems to rapidly transform care to address complex and dynamic resource demands (1, 2). Early in the pandemic, our large integrated health system implemented the Atrium Health Hospital at Home (AH-HaH) program to deliver home-based, hospital-level care to patients with COVID-19 and increase the health system's bed capacity (3).

Objective: To determine which AH-HaH patients were at increased risk for care escalation to traditional brick-and-mortar facilities.

Methods and Findings: We conducted a retrospective cohort study to follow up on adults (aged ≥18 years) who received treatment for COVID-19 in the AH-HaH program between 23 March and 29 November 2020. The program and eligibility criteria have been described previously; briefly, patients whom the evaluating provider would otherwise have admitted to the brick-and-mortar facility who had safe living situations and clinical stability at admission (normal mental status, vital signs and oxygen saturation suitable for home monitoring, receiving ≤4 L of supplemental oxygen per minute, and no anticipated imaging or invasive procedures within 48 hours) were eligible (3). AH-HaH care included 24/7 telephonic access to nurses; at least daily in-home visits from paramedics; daily virtual visits with a hospitalist; and therapies that included intravenous fluids and antibiotics, noninvasive oxygen, and respiratory medications as needed. We examined patients admitted from ambulatory care, emergency departments, or community settings to AH-HaH within 14 days of an initial positive result on a COVID-19 test. We collected baseline covariates (for example, sociodemographic characteristics, coexisting conditions, and worst vital signs at AH-HaH admission) and treatment information from electronic health records. The Area Deprivation Index, a composite measure of area-level social determinants of health, was calculated at the census tract level for each patient. The primary outcome was direct transfer to an Atrium Health brick-and-mortar facility (inpatient or observation status) within 14 days of index AH-HaH admission. We conducted logistic regression to test the association between baseline covariates and the primary outcome. In a secondary analysis, we applied descriptive statistics to explore characteristics of patients who had immediate (≤48 hours) and nonimmediate (>48 hours) care escalation.

There were 391 eligible patients, 53% of whom were female and 46% of whom were White, with a median age of 56 years (Table). The median length of AH-HaH stay was 3 days (interquartile range, 1 to 5 days). Eighty-four patients (21%) were transferred to a brick-and-mortar facility within 14 days (median time to transfer, 2.2 days [interquartile range, 0.8 to 3.3 days]). Among hospital admissions, 33 required intensive care, 11 required mechanical ventilation, and there were 11 in-hospital deaths (causes included organ failure and shock). In multivariable analysis (Figure), higher oxygen saturation was associated with decreased odds of transfer (odds ratio, 0.87 [95% CI, 0.81 to 0.93]), whereas higher comorbidity burden was associated with increased odds of transfer (odds ratio, 1.12 [CI, 0.99 to 1.26]). In the secondary analysis, respiratory aberrations (such as low oxygen

saturation, supplemental oxygen ≥3 L/min, and high respiratory rate) and tachycardia at enrollment were frequently observed among patients who required immediate care escalation, whereas high-risk chronic conditions (such as hypertension and diabetes) were common among patients who required nonimmediate care escalation.

Discussion: Home-based hospital care is an attractive innovation that may extend critical hospital resources during the COVID-19 pandemic. We found that most patients did not require care escalation, with approximately 1 in 5 admitted within 14 days. We observed more severe respiratory involvement among transferred patients, particularly those requiring immediate care escalation. In addition, overall comorbidity burden was associated with transfer, similar to previous studies describing underlying conditions as important risk factors for severe COVID-19 illness (4). Conversely, we did not observe independent associations between older age or obesity and transfer. This unexpected finding may be due to providers being more cautious about enrolling older or obese persons with additional high-risk characteristics into AH-HaH. Although not statistically significant, race/ethnicity and area-level deprivation warrant additional research given established COVID-19 health disparities and possible bias due to home-based AH-HaH eligibility criteria (5).

Our findings should be interpreted in the context of the retrospective, single-center design utilizing outcomes occurring within Atrium Health, the modest sample size that may limit identification of significant risk factors for care escalation, and the potential for differences between reasons for index admission and care escalation (such as unrelated trauma or illness). Nevertheless, this study provides practical initial evidence to help inform patient selection guidelines as health systems and payers increasingly leverage hospital-at-home as a standard care delivery option.

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Reproducible Research Statement: *Study protocol and statistical code:* Available from Dr. Chou (e-mail, Shih-Hsiung.Chou@atriumhealth.org). *Data set:* Not available.

Table. Characteristics of Patients With COVID-19 Who Received AH-HaH Care*

Characteristic	Overall	Transfer to Hospital Within 14 d	Immediate Care Escalation (≤48 h)	Care Escalation From >48 h to Day 14
Patients, n	391	84	41	43
Event rate (95% CI)†	–	0.21 (0.18–0.25)	0.10 (0.08–0.13)	0.11 (0.08–0.14)
Sociodemographic characteristics				
Median age at admission (IQR), y	56.0 (46.0–67.5)	57.0 (48.0–71.0)	55.0 (46.0–72.0)	58.0 (49.0–69.5)
Gender, n (%)				
Female	205 (52.7)	40 (19.5)	20 (9.8)	20 (9.8)
Male	186 (47.6)	44 (23.7)	21 (11.3)	23 (12.4)
Race/ethnicity, n (%)				
Non-Hispanic White	181 (46.3)	34 (18.8)	18 (9.9)	16 (8.8)
Non-Hispanic Black	144 (36.8)	34 (23.6)	15 (10.4)	19 (13.2)
Hispanic/Latino	51 (13.0)	12 (23.5)	5 (9.8)	7 (13.7)
Other	12 (3.1)	3 (25.0)	2 (16.7)	1 (8.3)
Not specified	3 (0.8)	1 (33.3)	1 (33.3)	0 (0.0)
Median ADI (IQR)	100.6 (88.3–113.8)	102.9 (93.5–119.0)	105.8 (95.1–121.7)	101.1 (87.8–117.1)
Coexisting conditions				
Median CCI score (IQR)	1.0 (0.0–2.0)	1.0 (0.0–3.0)	1.0 (0.0–2.0)	2.0 (0.0–4.0)
CCI score, n (%)				
0	153 (39.1)	26 (17.0)	14 (9.2)	12 (7.8)
1–2	146 (37.3)	30 (20.5)	17 (11.6)	13 (8.9)
3–4	52 (13.3)	15 (28.8)	5 (9.6)	10 (19.2)
≥5	40 (10.2)	13 (32.5)	5 (12.5)	8 (20.0)
Cerebrovascular disease, n (%)				
Yes	26 (6.6)	9 (34.6)	4 (15.4)	5 (19.2)
No	365 (93.4)	75 (20.5)	37 (10.1)	38 (10.4)
Congestive heart failure, n (%)				
Yes	40 (10.2)	8 (20.0)	2 (5.0)	6 (15.0)
No	351 (89.8)	76 (21.7)	39 (11.1)	37 (10.5)
Peripheral vascular disease, n (%)				
Yes	21 (5.4)	3 (14.3)	2 (9.5)	1 (4.8)
No	370 (94.6)	81 (21.9)	39 (10.5)	42 (11.4)
Renal disease, n (%)				
Yes	36 (9.2)	12 (33.3)	4 (11.1)	8 (22.2)
No	355 (90.8)	72 (20.3)	37 (10.4)	35 (9.9)
Diabetes, n (%)				
Yes	126 (32.2)	38 (30.2)	14 (11.1)	24 (19.0)
No	265 (67.8)	46 (17.4)	27 (10.2)	19 (7.2)
Chronic obstructive pulmonary disease, n (%)				
Yes	116 (29.7)	28 (24.1)	14 (12.1)	14 (12.1)
No	275 (70.3)	56 (20.4)	27 (9.8)	29 (10.5)
Cancer, n (%)				
Yes	32 (8.2)	8 (25.0)	5 (15.6)	3 (9.3)
No	359 (91.8)	76 (21.2)	36 (10.0)	40 (11.1)
Hypertension, n (%)				
Yes	210 (53.7)	48 (22.9)	21 (10.0)	27 (12.9)
No	181 (46.3)	36 (19.9)	20 (11.0)	16 (8.8)
BMI‡, n (%)				
Not obese	134 (34.3)	39 (29.1)	23 (17.2)	16 (11.9)
Class I obesity	91 (23.3)	18 (19.8)	11 (12.1)	7 (7.7)
Class II obesity	59 (15.1)	12 (20.3)	5 (8.5)	7 (11.9)
Class III obesity	77 (19.7)	15 (19.5)	2 (2.6)	13 (16.9)
Not documented	14 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)
Illness severity at enrollment				
Oxygen flow rate, n (%)				
Room air	243 (62.1)	39 (16.0)	11 (4.5)	28 (11.5)
1–2 L/min	91 (23.3)	19 (20.9)	9 (9.9)	10 (11.0)
≥3 L/min	57 (14.6)	26 (45.6)	21 (36.8)	5 (8.8)
Median oxygen saturation (IQR), %	94.0 (91.0–96.0)	91.0 (88.0–94.2)	89.0 (83.0–92.0)	93.0 (90.0–95.0)
Median respiratory rate (IQR), breaths/min	22.0 (20.0–27.0)	24.0 (20.0–32.5)	25.0 (20.0–34.0)	23.0 (20.0–28.0)
Median systolic blood pressure (IQR), mm Hg	118.0 (106.5–127.0)	112.5 (100.0–121.2)	110.0 (99.0–118.0)	113.0 (102.0–123.5)
Median temperature (IQR), °C	37.7 (37.2–38.4)	37.9 (37.3–38.6)	38.1 (37.3–38.9)	37.8 (37.2–38.4)
Median pulse (IQR), beats/min	99.0 (90.0–110.0)	103.0 (93.0–111.0)	109.0 (98.0–114.0)	97.0 (91.5–105.0)
Chest CT or radiograph, n (%)				

Table–Continued

Characteristic	Overall	Transfer to Hospital Within 14 d	Immediate Care Escalation (≤48 h)	Care Escalation From >48 h to Day 14
Yes	137 (35.0)	35 (25.5)	20 (14.6)	15 (10.9)
No	254 (65.0)	49 (19.3)	21 (8.3)	28 (11.0)

ADI = Area Deprivation Index; AH-HaH = Atrium Health Hospital at Home; BMI = body mass index; CCI = Charlson Comorbidity Index; CT = computed tomography; IQR = interquartile range.
* Few patients had history of rheumatic disease (n = 17), myocardial infarction (n = 12), dementia (n = 8), peptic ulcer disease (n = 5), organ or hematologic transplant (n = 4), or AIDS/HIV (n = 3). Percentages presented with categorical variable counts in the right 3 columns represent the row percentage of patients who transferred to the hospital within 14 days or experienced either immediate care escalation (≤48 h) or care escalation from >48 h to day 14, respectively. Data were missing for BMI (n = 14 [3.6%]), oxygen saturation (n = 1 [0.3%]), respiratory rate (n = 3 [0.8%]), systolic blood pressure (n = 7 [1.8%]), temperature (n = 4 [1.0%]), and pulse (n = 5 [1.3%]). All other variables had no missing values. Eleven patients died in the hospital after transfer within 14 days from AH-HaH admission. These patients had medical complications, such as worsening COVID-19 pneumonia, respiratory failure, septic shock, and cardiac arrest. The median time to transfer for these 11 patients was 1.4 days (IQR, 0.7–2.7 days), median length of stay in the brick-and-mortar hospital was 15 days (IQR, 10–23 days), median CCI score was 2 (IQR, 0.5–3.5), the worst oxygen saturation was 88% (IQR, 81.5%–90.5%), and median oxygen flow rate was 2 L/min (IQR, 0–4 L/min) at AH-HaH admission.
† Event rates are presented as binomial proportions with 2-sided 95% CIs.
‡ Not obese: BMI ≤29.9 kg/m^2; class I obesity: 29.9 kg/m^2 < BMI ≤34.9 kg/m^2; class II obesity: 34.9 kg/m^2 < BMI ≤39.9 kg/m^2; class III obesity: BMI >39.9 kg/m^2.
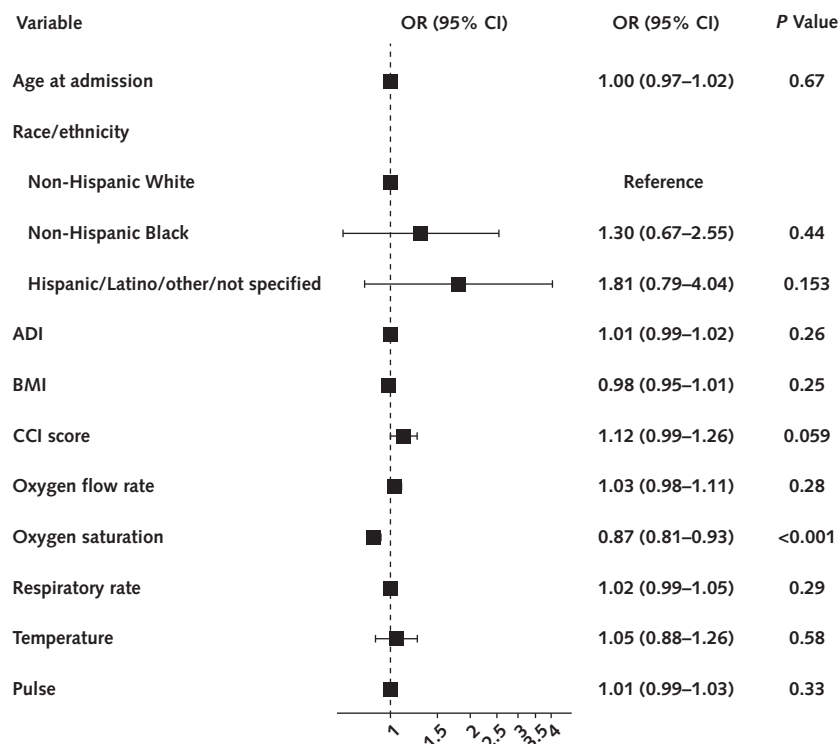
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Figure. Forest plot of the associations between patient characteristics at Hospital at Home admission and transfer to a brick-and-mortar facility within 14 days.

Variable	OR (95% CI)	OR (95% CI)	*P* Value
Age at admission		1.00 (0.97–1.02)	0.67
Race/ethnicity			
Non-Hispanic White		Reference	
Non-Hispanic Black		1.30 (0.67–2.55)	0.44
Hispanic/Latino/other/not specified		1.81 (0.79–4.04)	0.153
ADI		1.01 (0.99–1.02)	0.26
BMI		0.98 (0.95–1.01)	0.25
CCI score		1.12 (0.99–1.26)	0.059
Oxygen flow rate		1.03 (0.98–1.11)	0.28
Oxygen saturation		0.87 (0.81–0.93)	<0.001
Respiratory rate		1.02 (0.99–1.05)	0.29
Temperature		1.05 (0.88–1.26)	0.58
Pulse		1.01 (0.99–1.03)	0.33

The point estimate for each OR is represented by a black square, with the 95% CI represented by a horizontal line. Eighteen observations (4.6%) were excluded from the model because of missingness in ≥1 of the covariates. The Hispanic/Latinx, "other," and "not specified" racial/ethnic groups were combined because of the small numbers of persons in each group. ADI = Area Deprivation Index; BMI = body mass index; CCI = Charlson Comorbidity Index; OR = odds ratio.