



# Evaluating Racial/Ethnic Differences in Care Escalation Among COVID-19 Patients in a Home-Based Hospital

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## Abstract

The novel coronavirus disease 2019 (COVID-19) has infected over 414 million people worldwide with 5.8 million deaths, as of February 2022. Telemedicine-based interventions to expand healthcare systems' capacity and reduce infection risk have rapidly increased during the pandemic, despite concerns regarding equitable access. Atrium Health Hospital at Home (AH-HaH) is a home-based program that provides advanced, hospital-level medical care and monitoring for patients who would otherwise be hospitalized in a traditional setting. Our retrospective cohort study of positive COVID-19 patients who were admitted to AH-HaH aims to investigate whether the rate of care escalation from AH-HaH to traditional hospitalization differed based on patients' racial/ethnic backgrounds. Logistic regression was used to examine the association between care escalation within 14 days from index AH-HaH admission and race/ethnicity. We found approximately one in five patients receiving care for COVID-19 in AH-HaH required care escalation within 14 days. Odds of care escalation were not significantly different for Hispanic or non-Hispanic Blacks compared to non-Hispanic Whites. However, secondary analyses showed that both Hispanic and non-Hispanic Black patients were younger and with fewer comorbidities than non-Hispanic Whites. The study highlights the need for new care models to vigilantly monitor for disparities, so that timely and tailored adaptations can be implemented for vulnerable populations.

**Keywords** Care escalation · Racial/ethnic · COVID-19 · Home-based hospital

## Introduction

Over 414 million people have been infected with the novel coronavirus disease (COVID-19) globally [1]. Approximately one in five of these reported infections and one in six reported deaths (i.e., over 920,000) have occurred in the USA, as of February 2022 [2]. Throughout the COVID-19 pandemic, racial and ethnic disparities have been widely observed in COVID-19 testing, hospitalizations, and health outcomes [3–9]. Specifically, literature shows non-Hispanic Blacks and Hispanics had a higher incidence of COVID-19,

and higher rates of hospitalization and in-hospital mortality compared to non-Hispanic Whites [10–13]. In addition, racial/ethnic disparities in access to telemedicine services have been reported among patients with chronic diseases, which may have far-reaching consequences given the prominent role telemedicine has played during this pandemic [14]. Outside of the hospital setting, telemedicine-based interventions like hospital at home have been leveraged to rapidly increase health system capacity and access to services, while reducing infection risk. However, experts have diverging opinions regarding the effects of such care models on health disparities [15, 16]. Thus, the question of whether telemedicine effectively reached populations at risk for health disparities, especially in acute care, remains unanswered.

Atrium Health is one of the 85 healthcare systems approved for providing Acute Hospital Care at Home through the Centers for Medicare & Medicaid Services Acute Hospital Care at Home Program [17]. The program aims to help hospitals expand access in the face of capacity

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issues related to COVID-19. Atrium Health Hospital at Home (AH-HaH) provides advanced, hospital-level medical care and monitoring for patients, who would otherwise be hospitalized in a traditional setting, through 24/7 virtual nursing, daily virtual provider visits, and twice daily in-home Community Paramedicine visits [18]. Our prior research showed that majority of COVID-19 patients admitted to AH-HaH did not require care escalation to conventional brick-and-mortar hospitals [19]. This study further investigates whether the rate of care escalation differed based on patients' racial/ethnic backgrounds.

## Methods

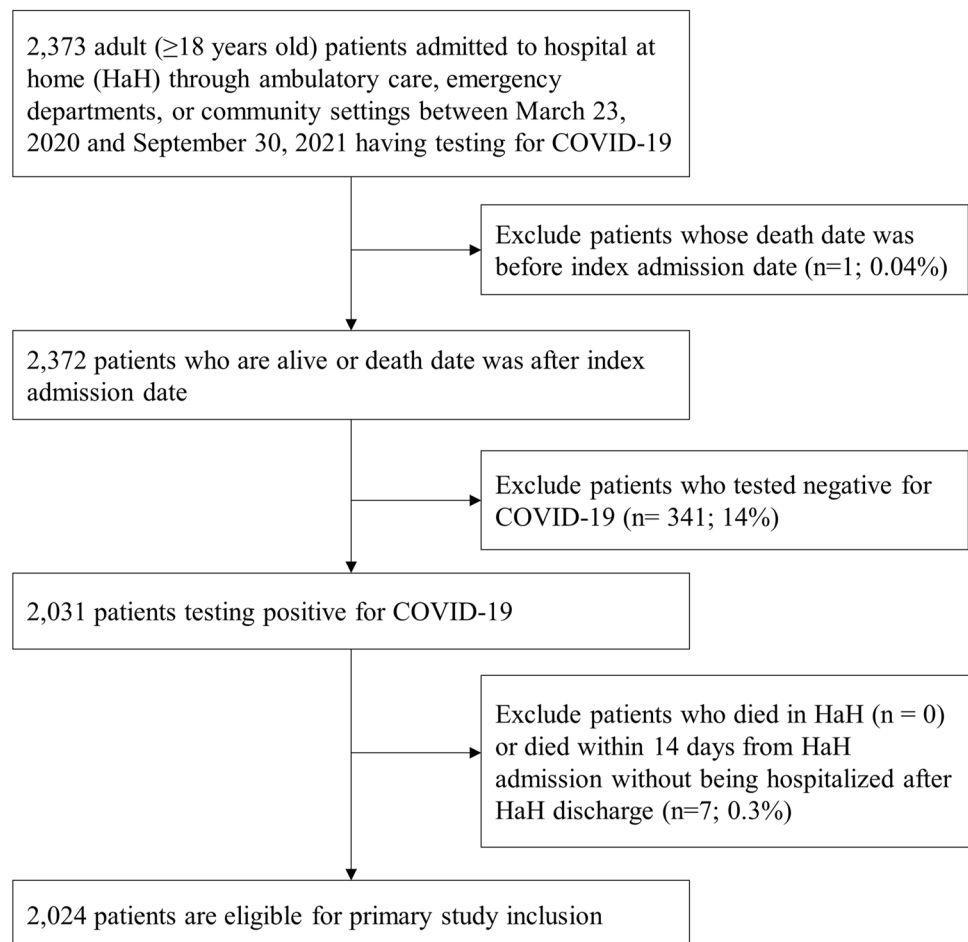
### Setting and Data Source

This retrospective study used electronic medical record (EMR) data at Atrium Health, a large integrated healthcare system based in Charlotte, NC. Atrium Health has more than 1500 care locations across North Carolina, South Carolina, and Georgia. The EMR system contains data for more than 10 million patient visits annually.

### Study Sample

The study cohort consisted of 2031 adults ( $\geq 18$  years) who were admitted to AH-HaH from ambulatory care (note, direct referrals from ambulatory care to AH-HaH were discontinued at the beginning of March 2021), emergency departments, or community settings within 14 days of initial positive COVID-19 test (nasopharyngeal swab via polymerase chain reaction [PCR] testing) between March 23, 2020, and September 30, 2021. The enrollment eligibility criteria included patients who resided in Greater Charlotte area with safe living situations, a working phone, and clinical stability at admission (e.g., vital signs suitable for home monitoring, receiving  $\leq 4$  l/min supplemental oxygen, no anticipated imaging or invasive procedures within 48 h, and at baseline mental status) [18]. Only the first AH-HaH encounter was included if a patient had multiple visits during the study period. Patients who died in AH-HaH ( $n=0$ ) or who died after AH-HaH discharge but within 14 days of AH-HaH admission ( $n=7$ ) were excluded, resulting in a final sample of 2024 patients (Fig. 1).

Fig. 1 Selection of study cohort



## Measures

The primary outcome was care escalation, defined as direct transfer from AH-HaH to a brick-and-mortar facility (also referred to as “traditional hospitalization”) within 14 days of index AH-HaH admission—similar to our prior research [19]. If care is escalated, the patient was not well-controlled during the hospitalization and requires additional support to maintain their health status. Patient demographics included age, gender, race/ethnicity, and marital status. Race/ethnicity was captured from predefined fields in the EMR that were self-reported by patients. Patients’ body mass index, Charlson Comorbidity Index (CCI), most recent oxygen saturation prior to AH-HaH admission, and baseline healthcare utilization (i.e., number of inpatient, outpatient, and emergency department [ED] visits within 1 year prior to the index date) were included as covariates. Total minutes travel-time to the closest hospital and Area Deprivation Index (ADI) [20] were linked to each patient’s record based on the addresses in the AH enterprise data warehouse. ADI [21] is a factor-based index that incorporates 17 indicators of poverty, educational attainment, and housing quality at the census tract level using the American Community Survey 5-year 2013–2017 estimates [22]. We grouped ADIs into quartiles (Q1–Q4), with Q1 representing affluent communities with the lowest level of exposure to social and health risk factors.

## Statistical Analysis

Sample characteristics were reported as percentages or medians as appropriate. Chi-square tests and *t*-tests were used for bivariate analyses. Logistic regression was used to examine the association between care escalation within 14 days from index AH-HaH admission and race/ethnicity. Models were adjusted for age, gender, marital status, CCI, baseline healthcare utilization, and neighborhood characteristics based on census tract (travel time in minutes to the closest hospital and ADI). Odds ratios (OR) and 95% confidence intervals (95% CIs) were reported. In exploratory analyses, we applied descriptive statistics to examine the distributions of patient characteristics within race/ethnicity and age strata. *P*-values < 0.05 were considered statistically significant. Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

## Results

Among 2024 eligible patients with COVID-19 who were admitted to AH-HaH during the study period, 49.7% were female, with median age of 56 years and median CCI score of 2. More than one-half (52.3%) were non-Hispanic White, 30.6% were non-Hispanic Black, and 11.4% were Hispanic.

There were 369 (18.2%) patients who required care escalation within 14 days. Among those requiring care escalation, 54.1% were non-Hispanic White, 27.5% non-Hispanic Black, and 13.0% Hispanic (Table 1). Additionally, 47.0% were female, 56.2% married, and the median CCI score was 3. In adjusted analyses, the odds of care escalation from AH-HaH were lower among non-Hispanic Blacks (OR 0.84, 95% CI: 0.61–1.00, *p* = 0.052) but higher among Hispanics (OR 1.34, 95% CI: 0.99–1.81, *p* = 0.055) compared to non-Hispanic Whites, though odds of care escalation in both groups were not statistically significant. Additionally, patients who were older, with a higher number of ED visits in the 1 year prior to AH-HaH admission, and whose ADI was in the third quartile (relative to the first quartile) were more likely to have care escalated to a brick-and-mortar hospital within 14 days than others. Conversely, patients with a CCI score of 1–2 (relative to 0) were less likely to have care escalation (Fig. 2).

In exploratory analyses stratified by race/ethnicity, we found non-Hispanic White patients were older and frequently lived in more affluent communities (ADI quartiles 1 and 2); non-Hispanic Black patients were often obese (31% with Obesity Class III) and lived in more socioeconomically disadvantaged communities (ADI quartile 4); Hispanic patients were younger, with fewer comorbidities, but living in more socioeconomically disadvantaged areas (ADI quartile 4) (Table 2). Additionally, we observed associations between older age at admission and care escalation within non-Hispanic White and non-Hispanic Black subgroups, but not in Hispanic patients. Non-Hispanic White patients who required care escalation also more frequently had high comorbidity burden (CCI = 3–4 or ≥ 5) and high area level deprivation (ADI quartile 3 or 4) compared to those who did not require care escalation. Similar associations were not observed to be statistically significant within non-Hispanic Black or Hispanic subgroups. When stratified by age at AH-HaH admission, older patients were mostly non-Hispanic White, female, less obese, but with more comorbidities, compared to patients less than 65 years old (Table 3). Older patients who required care escalation more frequently had high comorbidity burden (CCI = 3–4 or ≥ 5), high area level deprivation (ADI quartile 3 or 4), and baseline ED utilization, compared to those who did not require care escalation. Similar associations were not observed to be statistically significant within patients < 65 years of age at AH-HaH admission.

## Discussion

Our study adds to the literature on the the impact of telemedicine on racial/ethnic health disparities by examining differences in care escalation among adults with COVID-19

**Table 1** Characteristics of patients with COVID-19 who received AH-HaH care

	Overall	Care escalation within 14 days		<i>p</i> -value
		No	Yes	
<i>N</i> (%)	2024	1655 (81.8)	369 (18.2)	
Age at admission, median [IQR], years	56 [44, 66]	55 [44, 65]	59 [49, 69]	<0.001
Female, <i>n</i> (%)	1006 (49.7)	833 (50.3)	173 (46.9)	0.250
Race/ethnicity, <i>n</i> (%)				0.667
Non-Hispanic White	1059 (52.3)	859 (51.9)	200 (54.2)	
Non-Hispanic Black	620 (30.6)	514 (31.1)	106 (28.7)	
Hispanic	230 (11.4)	185 (11.2)	45 (12.2)	
Other or not report	115 (5.7)	97 (5.9)	18 (4.9)	
Married, <i>n</i> (%)	1161 (57.4)	956 (57.8)	205 (55.6)	0.450
Body mass index, <i>n</i> (%)				0.855
Not obese	751 (37.1)	611 (36.9)	140 (37.9)	
Obesity Class I	585 (28.9)	485 (29.3)	100 (27.1)	
Obesity Class II	315 (15.6)	257 (15.5)	58 (15.7)	
Obesity Class III	373 (18.4)	302 (18.2)	71 (19.2)	
Charlson Comorbidity Index, <i>n</i> (%)				<0.001
0	866 (42.8)	726 (43.9)	140 (37.9)	
1–2	759 (37.5)	635 (38.4)	124 (33.6)	
3–4	230 (11.4)	170 (10.3)	60 (16.3)	
≥5	169 (8.3)	124 (7.5)	45 (12.2)	
Area Deprivation Index, <i>n</i> (%)				0.009
Quartile 1	503 (24.9)	427 (25.8)	76 (20.6)	
Quartile 2	534 (26.4)	450 (27.2)	84 (22.8)	
Quartile 3	465 (23.0)	363 (21.9)	102 (27.6)	
Quartile 4 (highest deprivation)	522 (25.8)	415 (25.1)	107 (29.0)	
Total minutes travel to the closest hospital, median [IQR]	15.5 [11.5, 21.6]	15.5 [11.5, 21.7]	15.4 [11.5, 21.5]	0.634
Most recent O <sub>2</sub> saturation, median [IQR]	96 [94, 97]	96 [94, 97]	96 [94, 97]	0.712
Baseline healthcare utilization*, median [IQR]				
Inpatient visits	0 [0, 0]	0 [0, 0]	0 [0, 0]	0.004
Outpatient visits	0 [0, 2]	0 [0, 2]	0 [0, 3]	0.014
Emergency department visits	0 [0, 1]	0 [0, 1]	1 [0, 1]	0.009

Abbreviation: *IQR*, interquartile range

\*Baseline healthcare utilization includes all visits within 1 year prior to the index date

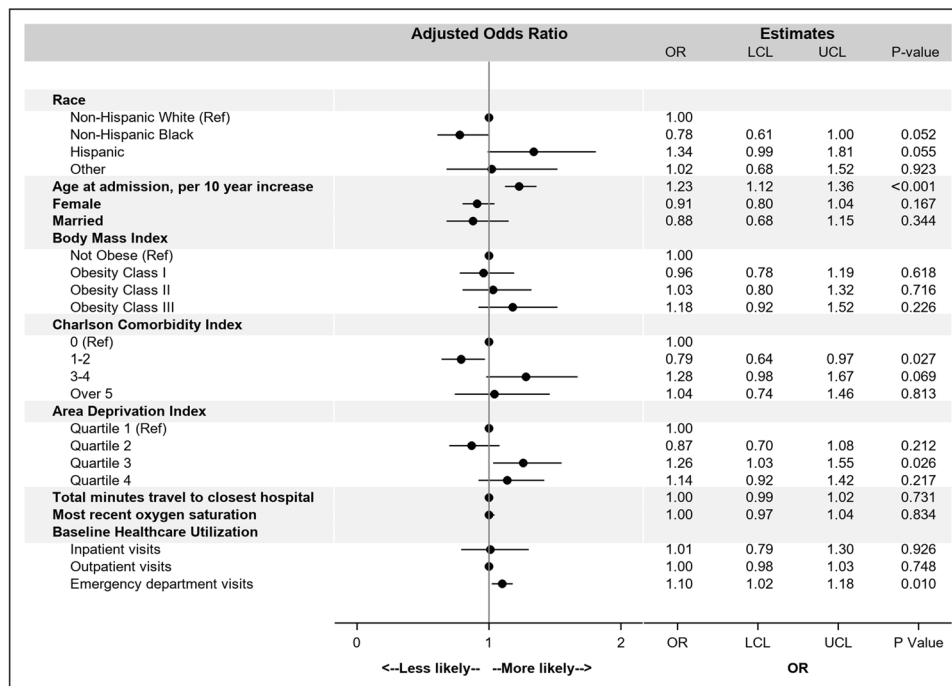
admitted to AH-HaH. Notably, we did not find significant differences in care escalation between Hispanic or non-Hispanic Black patients compared to non-Hispanic White patients. However, we found that AH-HaH patients who were older, who had more baseline ED visits at admission, and who were living in more socioeconomically disadvantaged neighborhoods (ADI quartile 3) had a higher risk of transfer to a traditional hospital. These findings are consistent with other research showing that both clinical and socioeconomic factors contribute to observed disparities in COVID-19 outcomes [11].

Our findings from this large, racially and ethnically diverse cohort of patients who received hospital-level care at home have important implications for future patient selection and delivery of acute care at home. First, although

we did not find statistically significant differences in care escalation from AH-HaH to brick-and-mortar facilities for Hispanic vs. non-Hispanic White patients, other studies of patients hospitalized in traditional care settings indicate that Hispanics have been disproportionately impacted by poor COVID-19 outcomes [9, 10, 23]. Similar studies have shown that Hispanic patients have higher rates of hospitalization, severe disease requiring intensive care, intubation, and mortality [24–27].

The reasons why our study did not show a significant difference in care escalation for Hispanic patients despite documented disparities in outcomes in other settings are unclear, but may be explained in part by their younger age and fewer comorbidities—both of which have been identified as key predictors of less severe COVID-19 outcomes

**Fig. 2** Forest plot of the association between care escalation and race, patients diagnosed with COVID-19 and admitted to Atrium Health Hospital at Home. Legend: Black circle and horizontal line represent the point estimate for each odds ratio and 95% confidence interval, respectively. Abbreviation: OR, odds ratio; LCI, lower confidence interval; UCL, upper confidence interval; Ref, reference group



[28]. Additionally, AH-HaH offers access to care that overcomes many traditional barriers that may contribute to published health disparities. While the odds of care escalation were not significant, the direction towards increased risk despite this being a younger, healthier population highlights the potential for social determinants of health, like disadvantaged living and working conditions, to play an outsized role in affecting outcomes. Supporting this notion, we evaluated area level factors (i.e., ADI) as proxies for individual level social determinants and found higher area level deprivation, specifically quartile 3 and to a lesser degree quartile 4, was associated with increased odds of care escalation. We also found patterns suggesting high rates of care escalation with higher area level deprivation within each race/ethnicity strata, though small subgroup sample sizes limit robust interpretation. Additionally, while census tracts aim to represent small, homogenous population groups, there remains substantial potential for individual variation across census tracts and ADI quartiles. Home environment is key to safe and effective delivery of HaH care. Thus, advancing knowledge of strategies to enhance access to and delivery of HaH care to patients in diverse living conditions and how HaH models can partner with support resources to make diverse living conditions safer are key areas for further research.

Furthermore, our study is one of the few studies conducted to investigate racial/ethnicity disparities among patients admitted to a hospital at home program. Prior studies have focused on engagement of minorities in virtual care delivery during the COVID-19 pandemic with mixed results. A study of veterans found that patients who were non-White or of

Hispanic origin tended to be more familiar with virtual care compared to White patients [29]. However, other studies have found that non-Hispanic Blacks tend to use less virtual healthcare compared to Whites, but not Hispanic patients [30, 31]. Discrepancies between previous findings underscore familiar challenges associated with implementing new care innovations and the importance of diversity and inclusion during early design and evaluation phases. Compared to prior studies with low proportions of Hispanic patients (for example, 1.2% in study by Aziz et al.) [31], one primary strength of our study was the inclusion of a Hispanic population that was representative of our geographic region (11.1% vs. 10.7% in North Carolina) [32]—strengthening the applicability of our findings to the overall population from which the study cohort was drawn. As the healthcare services offered via telemedicine are increasing at an exponential rate, continued evaluation will be needed to determine how different patient groups interact with these services and to consider the potential impact of widespread implementation.

Finally, our study also found that patients with higher numbers of ED visits in the year prior to AH-HaH admission were more likely to be transferred to brick-and-mortar hospital within 14 days than others. There are multiple different interpretations that may be relevant to our findings. Patients with higher ED visits prior to AH-HaH admission may be more vulnerable to the effects of COVID-19, as these patients tended to have more comorbidities than patients with lower ED visits. Alternatively, higher ED utilization may reflect structural or financial barriers that limit access to needed healthcare services, such as outpatient primary

**Table 2** Characteristics of patients with COVID-19 who received AH-HaH care, stratified by race/ethnicity

	Non-Hispanic White		<i>p</i> -value	Non-Hispanic Black		<i>p</i> -value	Hispanic		<i>p</i> -value
	Care escalation within 14 days			Care escalation within 14 days			Care escalation within 14 days		
	No	Yes		No	Yes		No	Yes	
All	876 (82.7)	183 (17.3)		527 (85.0)	93 (15.0)		186 (80.9)	44 (19.1)	
Age at admission, median [IQR], years	59 [49, 69]	63 [55, 72]	<0.001	51 [40, 61]	55 [46, 65]	0.014	45.5 [37, 56]	49 [33.5, 59]	0.950
Female, <i>n</i> (%)	405 (46.2)	81 (44.3)	0.684	306 (58.1)	51 (54.8)	0.571	90 (48.4)	21 (47.7)	1.000
Married, <i>n</i> (%)	620 (70.8)	130 (71.0)	1.000	200 (38.0)	32 (34.4)	0.562	89 (47.8)	19 (43.2)	0.617
Body mass index, <i>n</i> (%)			0.531			0.417			0.968
Not obese	364 (41.6)	76 (41.5)		132 (25.0)	27 (29.0)		76 (40.9)	17 (38.6)	
Obesity Class I	258 (29.5)	46 (25.1)		140 (26.6)	25 (26.9)		68 (36.6)	18 (40.9)	
Obesity Class II	130 (14.8)	33 (18.0)		92 (17.5)	10 (10.8)		27 (14.5)	6 (13.6)	
Obesity Class III	124 (14.2)	28 (15.3)		163 (30.9)	31 (33.3)		15 (8.1)	3 (6.8)	
Charlson Comorbidity Index, <i>n</i> (%)			<0.001			0.313			0.235
0	372 (42.5)	65 (35.5)		198 (37.6)	32 (34.4)		114 (61.3)	29 (65.9)	
1–2	333 (38.0)	55 (30.1)		223 (42.3)	37 (39.8)		54 (29.0)	11 (25.0)	
3–4	108 (12.3)	39 (21.3)		56 (10.6)	9 (9.7)		8 (4.3)	4 (9.1)	
≥5	63 (7.2)	24 (13.1)		50 (9.5)	15 (16.1)		10 (5.4)	0 (0.0)	
Area Deprivation Index, <i>n</i> (%)			0.001			0.950			0.847
Quartile 1	303 (34.6)	43 (23.5)		72 (13.7)	13 (14.0)		28 (15.1)	8 (18.2)	
Quartile 2	228 (26.0)	39 (21.3)		151 (28.7)	24 (25.8)		47 (25.3)	9 (20.5)	
Quartile 3	217 (24.8)	64 (35.0)		95 (18.0)	18 (19.4)		43 (23.1)	9 (20.5)	
Quartile 4	128 (14.6)	37 (20.2)		209 (39.7)	38 (40.9)		68 (36.6)	18 (40.9)	
Total minutes travel to the closest hospital, median [IQR]	16.7 [12.8, 23]	17 [12.7, 22]	0.364	13.9 [10.4, 18.9]	13.7 [11, 20]	0.747	13.8 [10.9, 19.1]	13.2 [9.7, 22]	0.451
Most recent O <sub>2</sub> saturation, median [IQR]	95 [94, 97]	95 [94, 96.5]	0.193	96 [94, 98]	96 [95, 98]	0.250	96 [94, 97]	96.5 [94.5, 98]	0.515
Baseline healthcare utilization*, median [IQR]									
Inpatient visits	0 [0, 0]	0 [0, 0]	0.027	0 [0, 0]	0 [0, 0]	0.388	0 [0, 0]	0 [0, 0]	0.361
Outpatient visits	0 [0, 2]	0 [0, 3]	0.091	0 [0, 2]	1 [0, 3]	0.234	0 [0, 1]	0 [0, 1.5]	0.736
Emergency department visits	0 [0, 1]	0 [0, 1]	0.342	1 [0, 1]	1 [0, 2]	0.105	0 [0, 1]	1 [0, 1]	0.102

Abbreviation: *IQR*, interquartile range

\*Baseline healthcare utilization includes all visits within 1 year prior to the index date



**Table 3** Characteristics of patients with COVID-19 who received AH-HaH care, stratified by age group

	Age < 65		<i>p</i> -value	Age ≥ 65		<i>p</i> -value
	Care escalation within 14 days			Care escalation within 14 days		
	No	Yes		No	Yes	
All	1238 (84.9)	220 (15.1)		448 (79.2)	118 (20.8)	
Race/ethnicity, <i>n</i> (%)			0.343			0.642
Non-Hispanic White	563 (45.5)	101 (45.9)		313 (69.9)	82 (69.5)	
Non-Hispanic Black	437 (35.3)	67 (30.5)		90 (20.1)	26 (22.0)	
Hispanic	164 (13.2)	37 (16.8)		22 (4.9)	7 (5.9)	
Other or not report	74 (6.0)	15 (6.8)		23 (5.1)	3 (2.5)	
Female, <i>n</i> (%)	618 (49.9)	99 (45.0)	0.188	229 (51.1)	60 (50.8)	1.000
Married, <i>n</i> (%)	689 (55.7)	118 (53.6)	0.607	282 (62.9)	72 (61.0)	0.749
Body mass index, <i>n</i> (%)			0.758			0.594
Not obese	371 (30.0)	62 (28.2)		253 (56.5)	67 (56.8)	
Obesity Class I	389 (31.4)	66 (30.0)		101 (22.5)	27 (22.9)	
Obesity Class II	208 (16.8)	43 (19.5)		54 (12.1)	10 (8.5)	
Obesity Class III	270 (21.8)	49 (22.3)		40 (8.9)	14 (11.9)	
Charlson Comorbidity Index, <i>n</i> (%)			0.092			0.022
0	606 (48.9)	100 (45.5)		126 (28.1)	34 (28.8)	
1–2	480 (38.8)	81 (36.8)		169 (37.7)	29 (24.6)	
3–4	93 (7.5)	28 (12.7)		83 (18.5)	26 (22.0)	
≥ 5	59 (4.8)	11 (5.0)		70 (15.6)	29 (24.6)	
Area Deprivation Index, <i>n</i> (%)			0.230			0.062
Quartile 1	298 (24.1)	48 (21.8)		134 (29.9)	23 (19.5)	
Quartile 2	344 (27.8)	50 (22.7)		113 (25.2)	27 (22.9)	
Quartile 3	270 (21.8)	57 (25.9)		102 (22.8)	36 (30.5)	
Quartile 4	326 (26.3)	65 (29.5)		99 (22.1)	32 (27.1)	
Total minutes travel to the closest hospital, median [IQR]	15.5 [11.5, 21.6]	15.5 [11.6, 21.8]	0.697	16.2 [12.2, 21.8]	15.5 [11.6, 21.4]	0.322
Most recent O <sub>2</sub> saturation, median [IQR]	96 [94, 98]	96 [94, 97]	0.720	95 [94, 97]	96 [94, 97]	0.792
Baseline healthcare utilization*, median [IQR]						
Inpatient visits	0 [0, 0]	0 [0, 0]	0.302	0 [0, 0]	0 [0, 0]	0.128
Outpatient visits	0 [0, 1]	0 [0, 2]	0.143	1 [0, 3]	1 [0, 4]	0.365
Emergency department visits	0 [0, 1]	1 [0, 1]	0.168	0 [0, 1]	0.5 [0, 1]	0.041

Abbreviation: *IQR*, interquartile range

\*Baseline healthcare utilization includes all visits within 1 year prior to the index date

care, and increase risk of poor health outcomes like disease progression requiring care escalation. Similar underpinning reasons as are likely to be present for patients residing in areas with a high neighborhood deprivation index.

### Limitation

Several limitations should be noted in this study. First, this retrospective study was conducted within a defined region of southeastern U.S., which may limit generalizability to regions with different populations, healthcare infrastructure, or COVID-19 policies. However, we include a large, diverse cohort from urban and rural areas. Of particular note, regarding the generalizability of our findings, there have been

large regional differences observed in COVID-19 disparities [33, 34]. Indeed, our findings that non-Hispanic Blacks did not experience worse care escalation outcomes and may even have had better outcomes, compared to non-Hispanic Whites, may provide further evidence in support of these regional differences. Second, there may be unique aspects of the AH-HaH delivery model compared to other Hospital at Home programs, and generalizability may be further limited to patients meeting the AH-HaH eligibility criteria (e.g., a working telephone, either patient or family members who speak English or Spanish, and ability to comply with monitoring protocols). Third, while we included area-level demographics (i.e., ADI and total minutes travel to the closest hospital) as a proxy estimation of socioeconomic status,

we lacked the additional precision that would be gained from direct measures of patients' socioeconomic status that may affect patient outcomes.

## Conclusion

Our results suggest that AH-HaH effectively leveraged telemedicine to reach a diverse population, reinforcing that such models can play a key role in advancing access to care. However, the higher odds of care escalation for patients living in areas with high area deprivation indexes highlight the need both for novel programs to vigilantly monitor disparities and for further research that explores if tailored support like enhanced social services may ensure that vulnerable populations are able to access novel care strategies.

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The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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**Author Contribution** Drs. Liu and Chou had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Concept and design: Liu, Chou, Kowalkowski. Acquisition, analysis, or interpretation of data: Liu, Chou, Taylor, Kowalkowski, Priem, Sitammagari, McWilliams. Drafting of the manuscript: Liu, Chou, Taylor. Critical revision of the manuscript for important intellectual content: Liu, Chou, Taylor, Murphy, Kowalkowski, Priem, Sitammagari, McWilliams. Statistical analysis: Liu, Chou. Administrative, technical, or material support: Murphy, Hole, McWilliams. Supervision: Taylor, McWilliams.

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## Declarations

**Ethics Approval** This study was approved by the Atrium Health Institutional Review Board.

**Informed Consent** Not applicable.

**Consent to Participate** Not applicable; this was a retrospective cohort study.

**Consent for Publication** Not applicable; this was a retrospective cohort study.

**Conflict of Interest** The authors declare no competing interests.

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