






ORIGINAL RESEARCH

Effectiveness of Telemedicine Visits in Reducing 30-Day Readmissions Among Patients With Heart Failure During the COVID-19 Pandemic

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BACKGROUND: The COVID-19 pandemic resulted in a rapid implementation of telemedicine into clinical practice. This study examined whether early outpatient follow-up via telemedicine is as effective as in-person visits for reducing 30-day readmissions in patients with heart failure.

METHODS AND RESULTS: Using electronic health records from a large health system, we included patients with heart failure living in North Carolina (N=6918) who were hospitalized between March 16, 2020 and March 14, 2021. All-cause readmission within 30 days after discharge was examined using weighted logistic regression models. Overall, 7.6% (N=526) of patients received early telemedicine follow-up, 38.8% (N=2681) received early in-person follow-up, and 53.6% (N=3711) did not receive follow-up within 14 days of discharge. Compared with patients without early follow-up, those who received early follow-up were younger, were more likely to be Medicare beneficiaries, had more comorbidities, and were less likely to live in a disadvantaged neighborhood. Relative to in-person visits, those with telemedicine follow-up were of similar age, sex, and race but with generally fewer comorbidities. Overall, the 30-day readmission rate (19.0%) varied among patients who received telemedicine visits (15.0%), in-person visits (14.0%), or no follow-up (23.1%). After covariate adjustment, patients who received either telemedicine (odds ratio [OR], 0.55; 95% CI, 0.44–0.72) or in-person (OR, 0.52; 95% CI, 0.45–0.60) visits were similarly less likely to be readmitted within 30 days compared with patients with no follow-up.

CONCLUSIONS: During the COVID-19 pandemic, the use of telemedicine visits for early follow-up increased rapidly. Patients with heart failure who received outpatient follow-up either via telemedicine or in-person had better outcomes than those who received no follow-up.

Key Words: electronic health records ■ heart failure ■ hospitalization ■ telemedicine

The COVID-19 pandemic has had a major impact on the delivery of health care in the United States over the past two years.^{1,2} During the early stages of the pandemic, many US health care systems struggled to address the rapid surge in COVID-19 cases and were forced to reallocate resources to treat the most critically ill patients.^{3,4} Many patients with chronic

conditions were also reluctant to seek care in person owing to fears of contracting COVID-19 and/or concerns of inadequate health care resources.^{1,5,6} In response to these challenges, the Centers for Medicare & Medicaid Services and others updated their reimbursement policies to allow health care systems to implement telemedicine visits for patients requiring

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CLINICAL PERSPECTIVE

What Is New?

- Patients with heart failure who received either an in-person or telemedicine follow-up visit after a hospitalization had lower risks of 30-day readmission compared with those who did not receive a follow-up visit.
- There were no significant differences in patients' age, sex, race, and/or socioeconomic status between those who were followed up in person and via telemedicine.

What Are the Clinical Implications?

- Telemedicine may provide a sustainable, cost-effective, and patient-centered approach for helping to reduce rehospitalization in patients with heart failure.

Nonstandard Abbreviations and Acronyms

ADI	Area Deprivation Index
DUHS	Duke University Health System

essential health care services and to help reduce transmission of the virus.^{2,7-9} As a result, many patients have been using telemedicine services to manage their disease as part of their routine medical care or during transitions of care.^{8,10-12}

Heart failure (HF) is one of the most common chronic conditions in the United States and is the leading cause of 30-day readmissions in older adults.¹³ Prior studies have shown that early outpatient follow-up with a health care provider reduces 30-day readmissions and improves quality of life in patients with HF.¹⁴⁻¹⁷ Current clinical guidelines by the American Heart Association recommend outpatient follow-up within 7 to 14 days after discharge as a strategy to prevent 30-day readmissions.^{18,19} Results from a recent randomized control trial have suggested the feasibility of substituting in-person visits with telemedicine visits post discharge in patients with HF.²⁰ Another recent publication demonstrated similar rates of mortality, hospital encounters, and the need for intensive care unit care between patients who received telemedicine visits and those with in-person visits.¹² To date, however, there is a lack of information on whether telemedicine services can also be as effective as in-person visits in reducing the risks of readmission in real-world settings.¹⁷ Furthermore, there is concern that access to telemedicine may be limited among some vulnerable populations—including those of lower socioeconomic status as well as older generations who may face a “digital divide.”^{8,21,22}

To address these critical questions, our study examined the use of telemedicine visits in patients with HF at a large academic health system during the COVID-19 pandemic. We specifically addressed (1) whether the early follow-up rates differed between the pre-COVID period versus during the COVID-19 pandemic; (2) how the COVID-19 pandemic affected early follow-up visits overall, in person, and via telemedicine; (3) whether use of telemedicine visits varied by patient demographic and clinical characteristics; and (4) whether telemedicine visits were as effective as in-person visits in reducing 30-day readmissions. Results are discussed in the context of whether health care systems should continue incorporating telemedicine into current practice as an effective, long-term strategy to provide routine outpatient follow-up and improve outcomes in patients with HF.

METHODS

This is a cohort, correlational study that used data from electronic health records (EHRs). Because of the sensitive nature of the data collected for this study, qualified researchers trained in human subject confidentiality protocols may send requests to the corresponding author to access the data that support the findings of this study.

Participants

Data for this study come from patients hospitalized in the Duke University Health System (DUHS) with a discharge diagnosis of HF based on *International Classification of Diseases, Ninth Revision (ICD-9)* and *Tenth Revision (ICD-10)* codes. On March 10, 2020, North Carolina announced a state of emergency to mitigate the spread of COVID-19 and on March 16 the DUHS announced additional restrictions within the health system.²³ Thus, we included patients with HF who were 18 years of age or older who were hospitalized from March 16, 2020 through March 14, 2021. We excluded patients who died during their index admission and those who were discharged to another acute hospital, a skilled nursing facility or other types of long-term care facility, rehabilitation or other intermediate care facility, or hospice.^{14,16} We also excluded patients who left against medical advice. To ensure that we captured patients' outpatient follow-up visits, rehospitalizations, and neighborhood characteristics, we further limited our study participants to those who resided in North Carolina with a valid home address and 9-digit ZIP code. A pre-COVID group was selected (from March 17, 2019 to March 15, 2020) based on the same inclusion and exclusion criteria (Figure 1). Data from patients' EHRs were extracted using Duke Enterprise Data Unified Content Explorer, a data

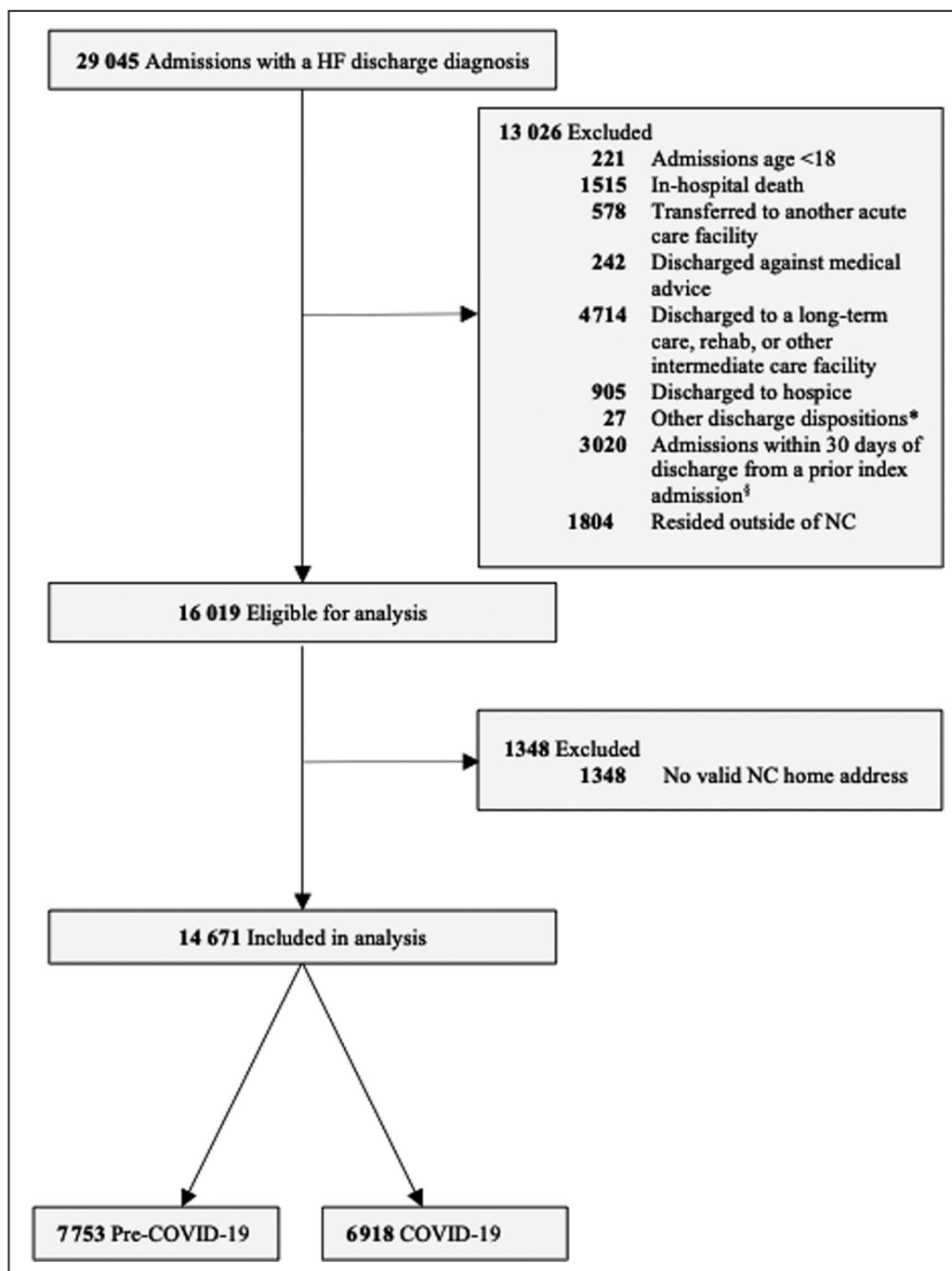


Figure 1. Inclusion and exclusion criteria.

Pre-COVID 19 period: March 17, 2009 to March 15, 2020. COVID-19 period: March 16, 2020 to March 14, 2021. *Other discharge dispositions included discharge disposition unknown or discharged to court/law enforcement. §Based on the Centers for Medicare & Medicaid Services 30-Day Readmission Algorithm, these 3020 hospitalizations were considered readmissions from a prior admission rather than index admissions in this study. HF indicates heart failure; and NC, North Carolina.

extraction system that provides access to clinical data stored in an organizational data warehouse.²⁴ The EHR data were geocoded and linked to census data. The final analytical sample included 6918

patients who were discharged during the COVID-19 pandemic. The study was approved by the institutional review board at DUHS and no informed consent was required.

Measures

Outpatient Follow-up Visits

We defined a follow-up visit within the first 30 days post discharge as an outpatient office visit, clinic visit, or telemedicine visit with a provider from family medicine, internal medicine, geriatrics, or cardiology. From this, we excluded urgent care and emergency department visits as these clinical encounters are unlikely to be planned post discharge follow-up.^{14,16} Following current guidelines, early outpatient follow-up included visits that occurred within the first 14 days of discharge and were categorized into the following categories: (1) in person, (2) telemedicine (eg, audio-only visits, synchronous audio-video visits, etc), or (3) no early follow-up. For patients with multiple outpatient follow-up visits within 30 days of discharge, we included only the first visit in the analysis. Sensitivity analyses were also conducted for follow-up visits within the first 7 days after discharge.

Thirty-Day Readmission

The primary outcome was all-cause readmission within 30 days of discharge from an index hospitalization. As in prior literature, we identified all-cause 30-day readmission (yes/no) based on the number of days after discharge from the index admission to a subsequent inpatient admission using EHRs.²⁵ We further assessed 30-day mortality among study participants. Patient mortality was adjudicated by integrating data from the Duke EHR system, the Death Master Files from National Technical Information Services, and the North Carolina death index from the Social Security Administration.²⁴ A total of 338 patients died within 30 days post discharge (4.9%), and among them, 168 patients had a readmission before death. The 30-day mortality rate in this study was similar to the rates reported in prior research (2.6%–9.7% in other studies).^{25–27} In sensitivity analyses, we used a composite outcome of 30-day readmission or mortality to account for excess mortality following hospital discharge.

Covariates

We extracted sociodemographic characteristics, diagnoses and procedures, laboratory values, medications, and health care use measures from the patients' EHRs. Sociodemographic information included age at index admission, sex, race or ethnicity, marital status, and insurance status. Baseline diagnoses and procedures were identified at the index admission using *ICD-9/ICD-10* codes for acute myocardial infarction, unstable angina, stroke, atrial fibrillation or flutter, mitral or aortic valvular disease, peripheral vascular disease, hypertension, diabetes, hyperlipidemia, chronic obstructive pulmonary disease (COPD), renal disease,

dementia, depression, coronary artery bypass graft surgery, percutaneous coronary intervention, implantable cardioverterdefibrillator placement, and permanent pacemaker implantation. Laboratory values during the admission included estimated glomerular filtration rate, serum potassium, and hemoglobin. Baseline medications included beta blockers, angiotensin-converting enzyme inhibitors/angiotensin II receptor blockers/angiotensin receptor neprilysin inhibitors, hydralazine, loop diuretics, aldosterone antagonists, statins, and aspirin. Health care use measures included length of stay, admission through emergency department versus other (transfer from other hospitals, admission from clinics, etc), discharge destination (home with versus without home health), any hospitalizations in the past year, and having a primary care provider (PCP) on file.

For patients in the COVID-19 group, a categorical variable was created to indicate critical periods during the pandemic (early outbreak, March 16–30, 2020; stay at home, March 31–May 4, 2020; reopening, May 5, 2020–March 14, 2021). These periods were defined based on the dates when COVID-19 related restrictions and executive orders were in place in North Carolina.²⁸

Patient neighborhood characteristics were measured using the Area Deprivation Index (ADI), a composite measure of neighborhood socioeconomic conditions such as education, income, standard of living, neighborhood quality, and housing quality based on the American Community Survey Five Year Estimates.^{29,30} Prior research has demonstrated the validity of using ADI in health outcome research.^{29,31} Details of ADI were documented extensively elsewhere.^{29,32} We obtained the 2018 ADI from the Neighborhood Atlas and used the 9-digit ZIP codes from patients' home address to link the ADI with their EHR data.^{29,30} As in prior research, we used a dichotomized variable to classify neighborhoods as more disadvantaged if the ADI values ranked in the bottom 15% of the national level.^{29,31} Preliminary analyses also assessed whether rurality—as defined by the federal rural–urban commuting area codes³³—played a role in the associations. The results indicated no significant associations and were dropped in the final analyses.

Statistical Analysis

Patient characteristics and outcomes were compared among in-person, telemedicine, and no early follow-up groups using Kruskal-Wallis and Pearson chi-square tests for continuous and categorical variables, respectively. Patient characteristics, early follow-up status, and outcomes were also compared between patients who were admitted during the pre-COVID-19 period and those in the COVID-19 period using Mann-Whitney *U* and Pearson chi-square tests for continuous and categorical variables, respectively. Multivariable logistic

regression models were used to assess factors associated with early telemedicine versus early in-person follow-up. An inverse probability of treatment approach was used to account for potential selection bias related to patients who had more complex health care needs and greater disease severity who were more likely to receive an early outpatient follow-up after discharge.^{34,35} We first considered confounders of the treatment outcome relationship and calculated propensity scores (ie. the probability of receiving an early follow-up) using logistic regression models that included patient age, sex, race or ethnicity, neighborhood characteristics, atrial fibrillation or flutter, mitral or aortic valvular disease, hyperlipidemia, coronary artery bypass graft, percutaneous coronary intervention, estimated glomerular filtration rate, loop diuretics, aldosterone antagonist, principal HF hospitalizations, admission through emergency department, and PCP status (Table S1). We then plotted standardized differences to compare patient characteristics before and after weighting and used a standardized difference of 10 as the marker of balance^{12,36} (Figure S1). We also used the density curves to show the distributions of the propensity scores in patients who received an early follow-up and those who did not, before and after weighting. Figure S2 shows adequate overlap between the 2 treatment groups. We used propensity score weighted logistic regression models to evaluate the associations of early outpatient follow-up and 30-day readmission. Most variables had no missing data; and variables with missing values (<1%) were imputed to “unknown.” All analyses were performed using Stata 16.0 (StataCorp LP, College Station, TX). *P* values are reported as 2 sided, with <0.05 used as the threshold for statistical significance.

RESULTS

The number of in-person, telemedicine, and no early follow-up by week from March 16, 2020 to March 14, 2021 are presented in Figure 2. The early outpatient follow-up rates were stable throughout the COVID-19 pandemic. Compared with the pre-COVID-19 period, the proportion of patients receiving early telemedicine follow-up was significantly higher (0.27% versus 7.60%) during the COVID-19 period (Table S2). The volume of telemedicine visits during the COVID-19 period remained high over the course of the early outbreak and stay-at-home periods, accounting for nearly 50% of all early outpatient follow-up visits during that period. However, the number of in-person follow-ups began to resume whereas the number of telemedicine follow-ups declined as North Carolina entered the reopening phase on May 5, 2020. The number of telemedicine follow-ups remained at a low and stable level throughout the reopening phase.

Table 1 displays the patient characteristics and outcomes, stratified by early follow-up status. The median age (interquartile range) was 67 [19] years, with 45.4% and 51.5% of the patients being female and non-Hispanic White, respectively. Overall, the early outpatient follow-up rate was 46.3% during the COVID-19 period. Among patients who received an early outpatient follow-up (N=3207), about 1 in 6 had their follow-up visits via telemedicine (N=526). There was no significant difference in sex and race among patients with in-person, telemedicine, or no early follow-up visit. Compared with patients with no early follow-up, patients with an early follow-up either in-person or telemedicine visits were slightly older, were more likely to be

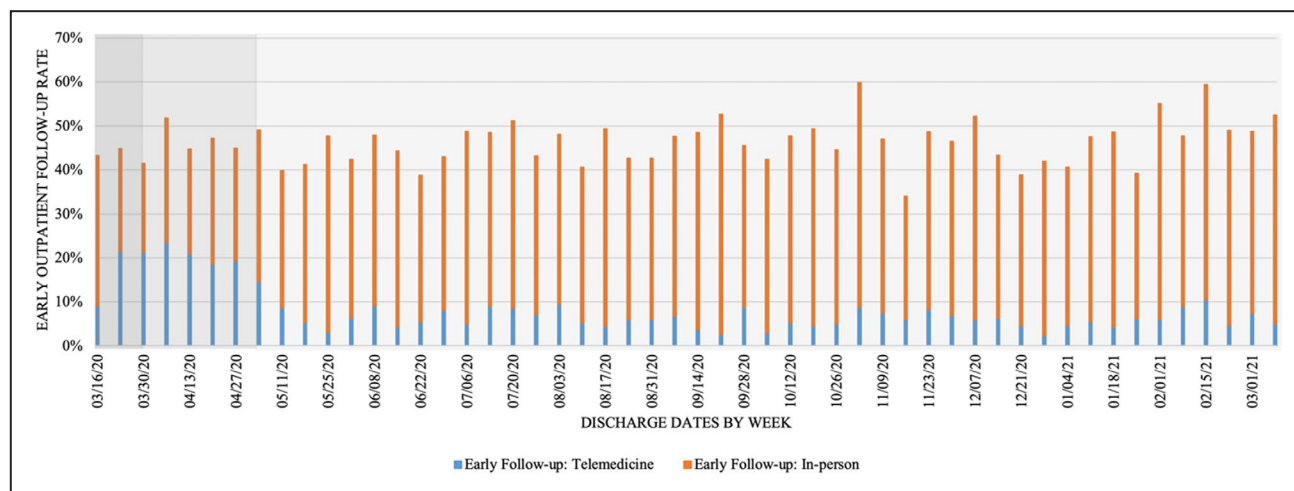


Figure 2. Early outpatient follow-up status during the COVID-19 pandemic.

Early outpatient follow-up was defined as having an outpatient follow up within 14-days after discharge. The gradient background represents different phases during the COVID-19 period: Early outbreak period: March 16 to March 31, 2020; Stay-at-home period: April 1, 2020 to May 5, 2020; Reopening period: May 6, 2020 to March 14, 2021.

Table 1. Baseline Characteristics of Study Participants by Outpatient Follow-up Status During the COVID-19 Pandemic

	No follow-up (N=3711)	Early follow-up (N=3207)			P value Early vs no follow-up
		Overall (N=3207)	In person (N=2681)	Telemedicine (N=526)	
Sociodemographic characteristics					
Age, y, median (IQR)	67 (19)	69 (19)	69 (19)	70 (19)	<0.001
Female sex	1685 (45.4)	1477 (46.1)	1219 (45.5)	258 (49.1)	0.588
Race					0.051
Non-Hispanic White	1912 (51.5)	1738 (54.2)	1471 (54.9)	267 (50.8)	
Non-Hispanic Black	1510 (40.7)	1252 (39.0)	1031 (38.5)	221 (42.0)	
Other	289 (7.8)	217 (6.8)	179 (6.7)	38 (7.2)	
Currently married [†]	1694 (45.7)	1495 (46.6)	1282 (47.8)	213 (40.5)	0.420
Insurance [‡]					<0.001
Medicare fee-for-service	1504 (40.5)	1412 (44.0)	1157 (43.2)	255 (48.5)	
Medicare Advantage	1112 (30.0)	967 (30.2)	805 (30.0)	162 (30.8)	
Medicaid	366 (9.9)	238 (7.4)	190 (7.1)	48 (9.1)	
Other [§]	729 (19.6)	590 (18.4)	529 (19.7)	61 (11.6)	
Disadvantaged neighborhood	594 (16.0)	376 (11.7)	307 (11.5)	69 (13.1)	<0.001
Diagnosis and procedures					
Acute myocardial infarction [†]	263 (7.1)	252 (7.9)	227 (8.5)	25 (4.8)	0.223
Angina	1944 (52.4)	1796 (56.0)	1512 (56.4)	284 (54.0)	0.003
Stroke or transient ischemic attack	114 (3.1)	105 (3.3)	92 (3.4)	13 (2.5)	0.632
Atrial fibrillation or flutter	1337 (36.0)	1524 (47.5)	1274 (47.5)	250 (47.5)	<0.001
Mitral or aortic valvular disease [‡]	739 (19.9)	766 (23.9)	675 (25.2)	91 (17.3)	<0.001
Peripheral vascular disease	509 (13.7)	465 (14.5)	381 (14.2)	84 (16.0)	0.350
Hypertension	3370 (90.8)	2979 (92.9)	2484 (92.7)	495 (94.1)	0.002
Diabetes	1916 (51.6)	1636 (51.0)	1358 (50.7)	278 (52.9)	0.609
Hyperlipidemia	2215 (59.7)	2154 (67.2)	1785 (66.6)	369 (70.2)	<0.001
Chronic obstructive pulmonary disease [†]	948 (25.6)	832 (25.9)	661 (24.7)	171 (32.5)	0.706
Renal disease	1893 (51.0)	1632 (50.9)	1367 (51.0)	265 (50.4)	0.919
Depression	800 (21.6)	702 (21.9)	586 (21.9)	116 (22.1)	0.738
Dementia	309 (8.3)	222 (6.9)	176 (6.6)	46 (8.8)	0.029
Coronary artery bypass graft surgery [*]	88 (2.4)	112 (3.5)	103 (3.8)	9 (1.7)	0.006
Percutaneous coronary intervention [†]	98 (2.6)	113 (3.5)	106 (4.0)	7 (1.3)	0.033
Permanent pacemaker	17 (0.5)	32 (1.0)	29 (1.1)	3 (0.6)	0.008
Implantable cardioverter-defibrillator	37 (1.0)	54 (1.7)	47 (1.8)	7 (1.3)	0.012
Laboratory values					
Estimated glomerular filtration rate, mL/min per 1.73 m ²					<0.001
≥60	1637 (44.1)	1378 (43.0)	1136 (42.4)	242 (46.0)	
45–60	587 (15.8)	622 (19.4)	518 (19.3)	104 (19.8)	
30–45 [*]	539 (14.5)	544 (17.0)	471 (17.6)	73 (13.9)	
<30	896 (24.1)	650 (20.3)	546 (20.4)	104 (19.8)	
Unknown	52 (1.4)	13 (0.4)	10 (0.4)	3 (0.6)	
Potassium, mEq/L					<0.001
<4.0	1632 (44.0)	1431 (44.6)	1182 (44.1)	249 (47.3)	
4.0–4.9	1789 (48.2)	1574 (49.1)	1329 (49.6)	245 (46.6)	
≥5.0	255 (6.9)	196 (6.1)	165 (6.2)	31 (5.9)	
Unknown	35 (0.9)	6 (0.2)	5 (0.2)	1 (0.2)	

(Continued)

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Table 1. Continued

	No follow-up (N=3711)	Early follow-up (N=3207)			P value Early vs no follow-up
		Overall (N=3207)	In person (N=2681)	Telemedicine (N=526)	
Hemoglobin, g/dL					<0.001
<10.0	1341 (36.1)	1028 (32.1)	867 (32.3)	161 (30.6)	
10.0–11.9	1138 (30.7)	1013 (31.6)	847 (31.6)	166 (31.6)	
≥12.0	1194 (32.2)	1158 (36.1)	962 (35.9)	196 (37.3)	
Unknown	38 (1.0)	8 (0.3)	5 (0.2)	3 (0.6)	
Medications					
Beta blocker [†]	2951 (79.5)	2697 (84.1)	2275 (84.9)	422 (80.2)	<0.001
Angiotensin-converting enzyme inhibitor/angiotensin II receptor blocker/angiotensin receptor neprilysin inhibitor	1038 (28.0)	1028 (32.1)	876 (32.7)	152 (28.9)	<0.001
Hydralazine	929 (25.0)	711 (22.2)	605 (22.6)	106 (20.2)	0.005
Loop diuretics	2623 (70.7)	2545 (79.4)	2136 (79.7)	409 (77.8)	<0.001
Aldosterone antagonist	795 (21.4)	916 (28.6)	771 (28.8)	145 (27.6)	<0.001
Statin	2519 (67.9)	2314 (72.2)	1939 (72.3)	375 (71.3)	0.001
Aspirin [†]	2464 (66.4)	2261 (70.5)	1917 (71.5)	344 (65.4)	<0.001
Health care use					
Principal heart failure hospitalizations	683 (18.4)	929 (29.0)	799 (29.8)	130 (24.7)	<0.001
Admission through emergency department	2447 (66.0)	2313 (72.1)	1905 (71.1)	408 (77.6)	<0.001
Length of stay, median (IQR)	4.17 (5.0)	4.6 (5.2)	4.58 (5.2)	4.7 (5.1)	<0.001
Discharge destination [‡]					0.438
Home without home health	2626 (70.6)	2242 (70.0)	1918 (71.5)	324 (61.6)	
Home with home health	1085 (29.2)	965 (30.1)	763 (28.5)	202 (38.4)	
Hospitalizations in the past year [†]	1779 (48.0)	1604 (50.0)	1305 (48.7)	299 (56.8)	0.085
Has a primary care provider on file	2992 (80.6)	2935 (91.5)	2450 (91.4)	485 (92.2)	<0.001
Discharge date[‡]					
Early-outbreak period	149 (4.0)	112 (3.5)	75 (2.8)	37 (7.0)	0.514
Stay-at-home period	265 (7.1)	362 (11.3)	128 (4.8)	106 (20.2)	
Reopening period	3297 (88.8)	2861 (89.2)	2478 (92.4)	383 (72.8)	
30-d readmission	856 (23.1)	456 (14.2)	377 (14.1)	79 (15.0)	<0.001
30-d readmission or mortality	921 (24.8)	471 (14.7)	386 (14.4)	85 (16.2)	<0.001

P values: comparisons between in person vs telemedicine. IQR indicates interquartile range.

Note. Categorical variables reported as n (%) and continuous variables reported as median (interquartile range).

^{*}P<0.05.

[†]P<0.01.

[‡]P<0.001.

[§]Self-pay N=4.

^{||}Other includes Hispanic/Latino, Asian, American Indian/Alaskan Native, Native Hawaiian or Other Pacific Islander, 2 or More Races, Not Reported, or Other.

Medicare fee-for-service (FFS) beneficiaries, and had more comorbidities such as angina, atrial fibrillation or flutter, mitral or aortic valvular disease, hypertension, and hyperlipidemia. Patients who received an early follow-up were more likely to have a principal index admission for HF, were more likely to be admitted through the emergency department, had slightly longer lengths of stay, and were more likely to have a PCP on file compared with patients with no early follow-up. In addition, patients who lived in a disadvantaged neighborhood were less likely to receive an early follow-up. Overall,

patient characteristics, follow-up rate, and readmission rate during the COVID-19 pandemic were largely the same as those in the pre-COVID-19 period (Table S2).

Among patients who received an early follow-up (N=3207), the factors associated with the modality of follow-up (in person versus telemedicine) are presented in Tables 1 and 2. Results from bivariate and multivariable analyses showed that those who had other insurance coverage, had mitral or aortic valvular disease, received percutaneous coronary intervention, had estimated glomerular filtration rate between 30

Table 2. Potential Factors Associated With Early Telemedicine Versus Early In-Person Follow-up (N=3207)

Variables	Unadjusted		P value	Adjusted		P value
	OR	(95% CI)		OR	(95% CI)	
Age	1.01	(1.00–1.01)	0.143	1.00	(0.99–1.01)	0.915
Female sex	1.15	(0.95–1.41)	0.155	1.15	(0.92–1.43)	0.227
Race (Ref: Non-Hispanic White)						
Non-Hispanic Black	1.18	(0.96–1.45)	0.116	1.13	(0.87–1.45)	0.355
Other*	1.17	(0.78–1.74)	0.442	1.21	(0.79–1.84)	0.376
Currently married	0.74	(0.61–0.91)	0.004	0.88	(0.71–1.11)	0.278
Insurance (Ref: Medicare fee-for-service)						
Medicare Advantage	0.91	(0.73–1.14)	0.431	0.85	(0.67–1.08)	0.192
Medicaid/self-pay	1.15	(0.78–1.69)	0.489	0.99	(0.62–1.59)	0.963
Other	0.52	(0.39–0.71)	<0.001	0.60	(0.41–0.88)	0.008
Disadvantaged neighborhood	0.86	(0.64–1.15)	0.310	0.96	(0.69–1.33)	0.787
Acute myocardial infarction	0.54	(0.35–0.82)	0.004	0.76	(0.46–1.24)	0.268
Angina	0.91	(0.75–1.10)	0.333	1.01	(0.80–1.28)	0.909
Stroke or transient ischemic attack	0.71	(0.40–1.29)	0.261	0.62	(0.34–1.13)	0.120
Atrial fibrillation or flutter	1.00	(0.82–1.22)	0.997	1.03	(0.82–1.30)	0.775
Mitral or aortic valvular disease	0.62	(0.48–0.81)	<0.001	0.67	(0.51–0.89)	0.005
Peripheral vascular disease	1.15	(0.88–1.49)	0.306	1.18	(0.88–1.58)	0.259
Hypertension	1.27	(0.85–1.90)	0.251	1.00	(0.64–1.55)	0.983
Diabetes	1.09	(0.90–1.33)	0.382	1.08	(0.86–1.35)	0.523
Hyperlipidemia	1.18	(0.95–1.46)	0.126	1.36	(1.04–1.77)	0.024
Chronic obstructive pulmonary disease	1.47	(1.19–1.82)	<0.001	1.32	(1.05–1.66)	0.016
Renal disease	0.98	(0.80–1.19)	0.809	1.15	(0.86–1.53)	0.335
Depression	1.01	(0.80–1.28)	0.924	0.86	(0.67–1.11)	0.262
Dementia	1.36	(0.97–1.92)	0.073	1.20	(0.82–1.74)	0.348
Coronary artery bypass graft surgery	0.44	(0.22–0.87)	0.018	0.61	(0.29–1.27)	0.186
Percutaneous coronary intervention	0.33	(0.15–0.71)	0.005	0.40	(0.18–0.92)	0.030
Permanent pacemaker	0.52	(0.16–1.73)	0.289	0.73	(0.21–2.62)	0.633
Implantable cardioverter-defibrillator	0.76	(0.34–1.68)	0.493	0.92	(0.39–2.16)	0.852
Estimated glomerular filtration rate (Ref: ≥60)						
45–60	0.94	(0.73–1.22)	0.650	0.82	(0.60–1.12)	0.220
30–45	0.73	(0.54–0.98)	0.036	0.60	(0.41–0.87)	0.007
<30	0.89	(0.69–1.16)	0.405	0.72	(0.49–1.05)	0.085
Unknown	1.41	(0.37–5.31)	0.613	1.81	(0.27–12.2)	0.543
Potassium (Ref: 4.0–4.9)						
<4.0	1.14	(0.94–1.39)	0.189	1.10	(0.89–1.37)	0.385
≥5.0	1.02	(0.68–1.54)	0.928	0.96	(0.60–1.52)	0.852
Unknown	1.08	(0.13–9.33)	0.941	0.07	(0.002–2.37)	0.141
Hemoglobin (Ref: ≥12.0)						
<10.0	0.91	(0.72–1.15)	0.431	0.83	(0.63–1.10)	0.201
10.0–11.9	0.96	(0.76–1.21)	0.741	0.93	(0.72–1.19)	0.561
Unknown	2.94	(0.70–12.4)	0.141	7.23	(0.61–85.2)	0.116
Beta blocker	0.72	(0.56–0.94)	0.014	0.80	(0.60–1.07)	0.130

(Continued)

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Table 2. (Continued)

Variables	Unadjusted		P value	Adjusted		P value
	OR	(95% CI)		OR	(95% CI)	
Angiotensin-converting enzyme inhibitor/angiotensin II receptor blocker/angiotensin receptor neprilysin inhibitor	0.84	(0.67–1.04)	0.108	0.91	(0.72–1.15)	0.422
Hydralazine	0.87	(0.68–1.10)	0.245	0.86	(0.65–1.13)	0.270
Loop diuretics	0.89	(0.71–1.13)	0.338	1.00	(0.77–1.30)	0.980
Aldosterone antagonist	0.94	(0.76–1.17)	0.599	0.99	(0.78–1.26)	0.959
Statin	0.95	(0.76–1.18)	0.646	0.91	(0.69–1.19)	0.488
Aspirin	0.75	(0.61–0.93)	0.007	0.78	(0.61–0.99)	0.042
Principal heart failure hospitalizations	0.77	(0.62–0.96)	0.021	0.71	(0.56–0.90)	0.005
Admission through emergency department	1.41	(1.12–1.77)	0.003	1.05	(0.80–1.39)	0.712
Length of stay	1.00	(0.99–1.01)	0.965	1.00	(0.99–1.01)	0.509
Discharge to home with home health	1.57	(1.29–1.90)	<0.001	1.29	(1.04–1.61)	0.023
Hospitalizations in the past year	1.39	(1.14–1.69)	0.001	1.28	(1.03–1.58)	0.025
Has a primary care provider on file	1.12	(0.77–1.61)	0.561	1.08	(0.72–1.62)	0.715
Discharge date (Ref: Reopening)						
Early outbreak	3.19	(2.11–4.81)	<0.001	3.34	(2.16–5.19)	<0.001
Stay at home	5.36	(4.04–7.10)	<0.001	5.37	(3.96–7.29)	<0.001

Regression models compare outcomes for patients who received early outpatient follow-up via telemedicine vs those who received early outpatient follow-up in person (reference group).

P values are based on logistic regression models for both unadjusted and adjusted ORs. OR indicates odds ratio.

*Other includes Hispanic/Latino, Asian, American Indian/Alaskan Native, Native Hawaiian or Other Pacific Islander, 2 or More Races, Not Reported, or Other.

and 45, had prescriptions for aspirin, and had a principal HF hospitalization were less likely to receive an early telemedicine follow-up. Patients who had COPD, were discharged to home health, and were discharged during the early outbreak and stay-at-home periods were more likely to receive a telemedicine follow-up. No significant differences were found with regard to age, sex, race, or neighborhood characteristics between patients with in-person or telemedicine follow-up.

The overall 30-day readmission rate during the COVID-19 period was 19.0%. Patients who had an in-person follow-up had significantly lower rates of 30-day readmission than those who had no early follow-up (14.1% versus 23.1%, odds ratio [OR, unadjusted], 0.53; 95% CI, 0.46–0.61). Similar differences were found when comparing telemedicine follow-ups to no early follow-up (15.0% versus 23.1%, OR [unadjusted], 0.58; 95% CI, 0.44–0.76) (Table 3). These differences were robust and remained largely unchanged in the fully adjusted model (in person versus no follow-up, OR, 0.52; 95% CI, 0.45–0.60; telemedicine versus no follow-up, OR, 0.55; 95% CI, 0.44–0.72). Predicted probabilities of 30-day readmission from the fully adjusted models showed that ≈13% of patients who received an in-person follow-up and 14% of patients who received a telemedicine follow-up were readmitted within 30 days

after discharge (Figure 3). Conversely, the 30-day readmission rate was 22% among patients received no early follow-up. The associations were essentially the same between early outpatient follow-up and 30-day readmission or mortality. Findings from sensitivity analyses suggested similar associations between outpatient follow-ups within 7 days and 30-day readmission and the composite outcome as presented previously (Table S3).

DISCUSSION

To our knowledge, this is among the first studies to assess the use and outcomes of telemedicine follow-up visits among patients with HF during the COVID-19 pandemic. In an analysis of nearly 7000 patients with HF from a large academic medical center, we found that the overall rate of early follow-up remained largely unchanged during the pandemic—with a rapid increase in the use of telemedicine visits early in the pandemic. We also found no significant differences in patients’ age, sex, race, and/or socioeconomic status between those who received early follow-up via telemedicine versus in person. Furthermore, patients with HF who received either an in-person or telemedicine

Table 3. Unadjusted and Adjusted Odds Ratios for the Association between Early Outpatient Follow-up Within 14 Days and 30-Day Readmission and Mortality in Patients With Heart Failure (N=6918)

	Unadjusted			Adjusted		
	OR	(95% CI)	P value	OR	(95% CI)	P value
30-d readmission						
No early follow-up	1.00	(reference)		1.00	(reference)	
In-person	0.53	(0.46–0.61)	<0.001	0.52	(0.45–0.60)	<0.001
Telemedicine	0.58	(0.44–0.76)	<0.001	0.55	(0.44–0.72)	<0.001
30-d readmission or mortality						
No early follow-up	1.00	(reference)		1.00	(reference)	
In-person	0.49	(0.43–0.57)	<0.001	0.49	(0.42–0.56)	<0.001
Telemedicine	0.57	(0.44–0.74)	<0.001	0.53	(0.42–0.70)	<0.001

Adjusted logistic regression models included patient sociodemographic characteristics, diagnoses and procedures, laboratory values, medications, health care use measures, and neighborhood disadvantage. OR indicates odds ratio.

follow-up visit after a hospitalization had lower risks of 30-day readmission compared with those who did not receive a follow-up visit.

In this study, the overall rates of early follow-up have remained stable throughout the COVID-19 pandemic. We found that the use of telemedicine visits for early follow-up increased rapidly in the early stages of the pandemic and subsequently decreased as North Carolina entered its reopening phase. These findings are consistent with prior research showing that the volume of telemedicine visits decreased while in-person visits started to resume in May 2020.⁸ These fluctuations of telemedicine visit volume may be due to a range of factors related to implementation, patient and provider preferences, organizational behavior, and policy adoption at the state and national level.^{37–39} For example, it is possible that hospitals were no longer making telemedicine visits a priority and schedulers were less likely to offer telemedicine options to patients. Or patients and/or providers preferred in-person follow-up over telemedicine. We also found that more than half of the patients did not receive an outpatient follow-up within 2 weeks after discharge. Although the DUHS system has implemented a dedicated care transition team at the Heart Center and offers patients with HF access to the Same-Day HF Clinic,⁴⁰ our prior study has found that about 1 in 3 patients experience difficulties accessing their routine medical care.⁴¹ Other research has also indicated that implementing timely outpatient follow-ups has been a challenge.^{14,42} Taken together, more research is needed to examine factors associated with the use of telemedicine visits and to assess whether the use of telemedicine can improve patients’ access to care.

Unlike prior research, the results from this study did not find a “digital divide” between patients who used in-person versus telemedicine follow-up visits.^{8,21,22,43} The reasons are potentially twofold. First, most previous studies assessed the uptake of telemedicine for

general outpatient care—rather than during a critical period of transitional care or among a specific patient population (HF) that was recently hospitalized. Second, only around 14% of study participants lived in the most disadvantaged neighborhood and our exploratory analyses suggested that close to 80% of the patients lived in an urban area. Therefore, the nonsignificant finding may be due in part to the small number of patients in this group.

Nevertheless, we found that patients who lived in a disadvantaged neighborhood were less likely to receive any early outpatient follow-up; and there were no differences in neighborhood characteristics between those who received in-person versus telemedicine follow-ups. It might be that with programmatic efforts to promote telemedicine visits, telemedicine can be a viable way to increase access to care among patients from disadvantaged areas. We also found that patients with dementia were less likely to receive an early follow-up than those without dementia. With prior research demonstrating the high health care use among patients with dementia,⁴⁴ additional efforts are needed to further identify and implement practical strategies to improve access to care in this vulnerable population. In the current study, we found a higher proportion of patients with dementia had followed up via telemedicine rather than in person, suggesting the potential for using telemedicine to address the care needs of these high-risk patients. Our results also showed that patients without a PCP on file and living in a more disadvantaged neighborhood were less likely to receive an outpatient follow-up. Again, these findings underscore the need for targeted interventions to improve access to care. A key benefit of telemedicine is its flexibility; thus, future research is needed to assess whether the use of telemedicine can help health care practices to expand their connections with patients and to facilitate the establishment of care with a PCP.

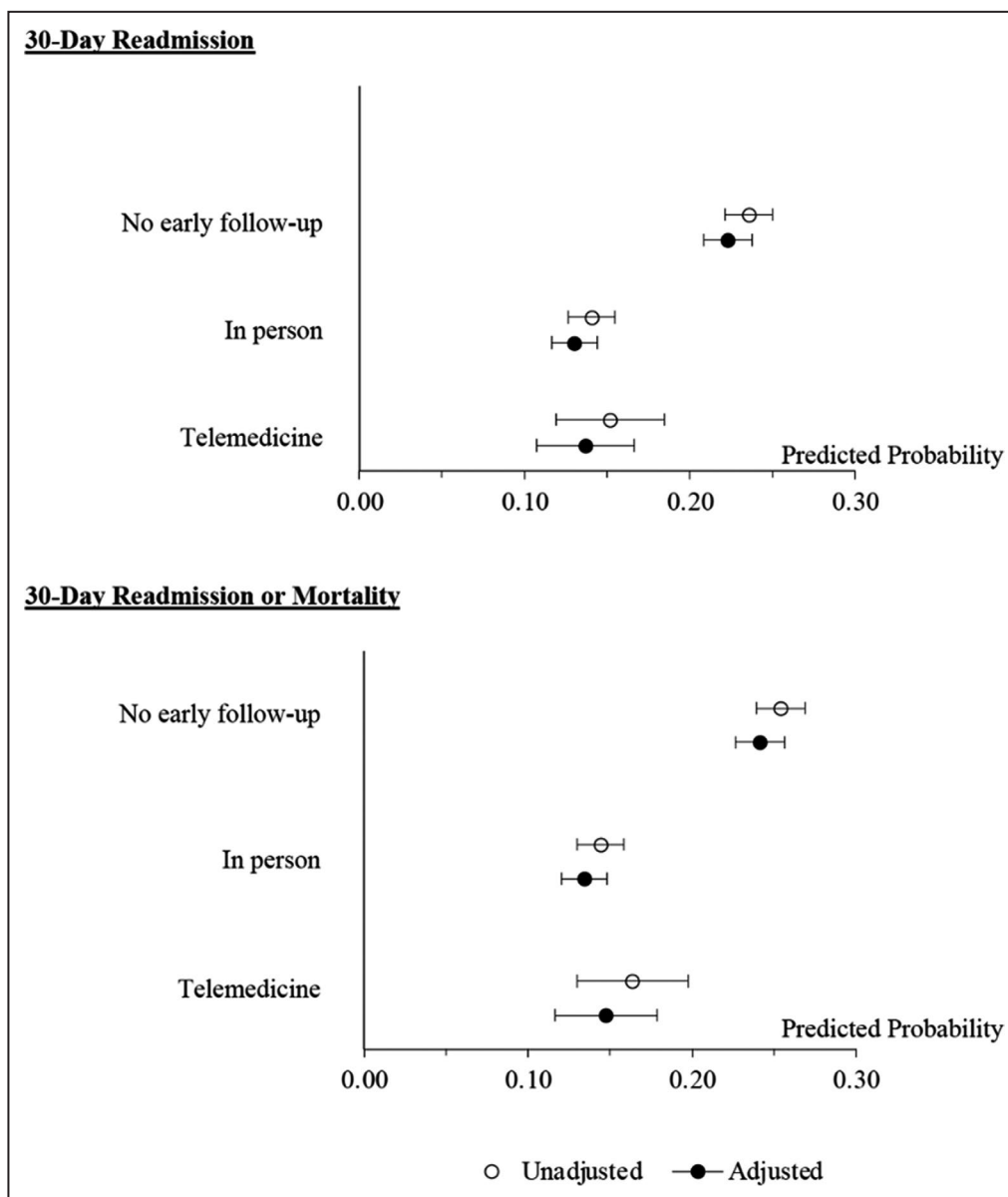


Figure 3. Predicted probability (95% CI) of 30-day readmission and mortality by early outpatient follow-up status among patients with heart failure (N=6918).

Adjusted models included patient sociodemographic characteristics, diagnoses and procedures, laboratory values, medications, health care use measures, and neighborhood disadvantage.

We found several factors that were associated with early telemedicine versus in-person follow-up. Specifically, patients who had mitral or aortic valvular disease, received percutaneous coronary intervention, had reduced kidney function, were prescribed aspirin, or were hospitalized because of HF were less likely to receive follow-up via telemedicine than in person. It may be that these patients had more complex conditions that required physical assessments and/or laboratory testing from an outpatient visit. Although there are concerns that some telemedicine visits such as phone calls may have not been sufficient to adequately monitor patients conditions, emerging evidence has

suggested the feasibility and validity to perform physical assessments remotely.⁴⁵ In addition, the Heart Failure Society of America has issued a statement that promotes the use of telemedicine in a full range of patients with HF.⁴⁶ We also found that patients who were discharged to home health were more likely to receive a telemedicine follow-up. Accordingly, prior research has suggested that the use of telemedicine in patients with HF receiving home services reduces the risks of 30-day readmission.^{10,47} It is possible that a combination of telemedicine and home health services contributes to their success in reducing 30-day readmissions among patients with HF. It might also be

that individuals who had home health visits received additional assistance from the home health team to set up their telemedicine appointments. Therefore, more research is needed to develop guidelines or protocols to inform clinicians with regard to who may benefit the most from telemedicine visits post discharge.

We also found that patients with private, commercial, or other health insurance were less likely to receive telemedicine follow-ups than Medicare fee-for-service beneficiaries. It might be that the Centers for Medicare & Medicaid Services provided reimbursement parity for telemedicine visits throughout the COVID-19 pandemic; whereas for private insurers, the coverage for telemedicine services varied from payer to payer and some of these policies have already expired.⁴⁸ Additionally, in our study, most telemedicine follow-ups occurred during the early phases of the pandemic, and the Centers for Medicare & Medicaid Services were among the first payers that broadened their coverage to reimburse telemedicine visits.⁷ Our results also suggested that patients with COPD were more likely to be followed up via telemedicine. Given that many health care systems have implemented policies such as screening for symptoms upon arrival to prevent the transmission of COVID-19,^{49,50} patients with COPD may not be able to pass the symptom screening test to be seen in person. Relatedly, patients with COPD may also be reluctant to go to the hospital owing to the fear of contracting the virus and choose telemedicine instead. As a result, it is possible that reimbursement policies for telemedicine visits and hospital-level visiting policies have had an impact on the use of telemedicine for outpatient follow-ups.

Results from this study suggest that early telemedicine and in-person follow-up are both associated with lower rates of 30-day readmission among patients with HF. Sensitivity analyses that focused on earlier follow-ups (within 7 days) yielded similar results. These findings were similar to a prior study that reported no differences in the rates of hospital admissions among patients with HF who received telemedicine visits compared with in-person visits.¹² Other small-scale, descriptive studies also showed that 30-day readmission rates were lower in patients who received a telemedicine follow-up post discharge than in those who received usual care.^{10,11,47} Together, these findings suggest that telemedicine has the potential to serve as an effective early outpatient follow-up strategy that can have positive outcomes in patients with HF. In addition, although the readmission rates were essentially the same during the pre-COVID-19 and COVID-19 periods, results from our exploratory analysis suggested that the readmission rates were lower in the earliest phase of the pandemic but quickly returned to the pre-COVID-19 level (14.6% in the early-outbreak period versus 19.2% in the reopening period). These patterns

suggest that hospitals may have experienced a lack of beds and/or shortages of staff at the beginning of the pandemic or that patients' fear of exposure may have played a role.

Currently, despite changes in policy to improve coding for telemedicine visits, North Carolina is one of the few states that does not have a commercial payer telemedicine statute.⁵¹ Given that the COVID-19 pandemic resulted in a rapid implementation of telemedicine into clinical practice, to what extent health care systems and payers should maintain and/or expand the use of telemedicine warrants further evaluation. We found that early telemedicine follow-ups can reduce the risks of 30-day readmission in patients with HF. Still, not all patients with HF can be followed up via telemedicine. To date, there are no guidelines on the clinical consideration of using telemedicine^{46,52}; and prior research has shown variability in the acceptance and use of telemedicine across specialties and patient populations.^{8,21,22,43,53–55} Therefore, future research is needed to inform health care systems and policymakers to establish a sustainable, cost-effective, equitable, patient-centered, and evidence-based adoption plan for telemedicine. In particular, it is critical for health care systems to improve telemedicine access among vulnerable and underserved patient populations. For example, in patients with limited access to technology and/or adequate broadband Internet, the health care team should consider offering a call-in option to the patient or providing them with information on nearby/free hotspot locations. For patients who are older adults, it may be particularly helpful to offer support services to assist older adults with setting up their smart devices before the telemedicine visit. It should also be noted that the implementation of these strategies often require the health care team to work with other sectors such as community organizations and telecommunication carriers.⁵⁶ Therefore, public investment and cross-sector collaboration are key to the expansion of telemedicine services.

Several limitations of this study should be acknowledged. First, the study was conducted in a single academic medical center, which limits the generalizability of the study findings. Relatedly, we lacked information on outpatient follow-ups and/or hospitalizations that occurred outside of DUHS. Second, we acknowledge that patients' physiological indicators such as ejection fraction were not readily available in the current data sources. Nevertheless, prior research has suggested that the outcomes that we examined (ie, 30-day all-cause readmission and mortality) are relevant regardless of the severity of HF.¹⁵ Third, the current data sources did not include detailed information on the modality of telemedicine. Therefore, we were unable to compare across different types of telemedicine services. We also lacked data on patients' satisfaction and comfort level with telemedicine, patients' and

providers' preference for using telemedicine, and the quality of telemedicine follow-ups. Relatedly, there may be additional confounding factors contributing to the associations that were not measured in this study. Lastly, we were not able to obtain information on no-shows and/or refusals. It is possible that some patients with HF were scheduled for a telemedicine or in-person follow-up but were unable or chose not to attend.

CONCLUSIONS

Patients who received either a telemedicine or in-person follow-up within 2 weeks after discharge had a significantly lower rate of 30-day readmission than those who did not. These findings provide strong evidence for the use of telemedicine post discharge to reduce the risks of 30-day readmission. Our study also identifies several factors that are associated with the use of telemedicine versus in-person visits. These findings have important implications for adopting telemedicine into routine medical care to improve outcomes in patients with HF.

ARTICLE INFORMATION

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Disclosures

None.

Supplemental Material

Tables S1–S3
Figures S1–S2

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SUPPLEMENTAL MATERIAL

Table S1. Factors Associated with Early Outpatient Follow-up during COVID-19 that were included in the IPW (N = 6,918).

Variables	Model 1			Model 2		
	OR	(95% CI)	P value	OR	(95% CI)	P value
Age	1.00	(1.00-1.01)	.345	1.00	(1.00-1.01)	.696
Female	1.09	(0.97-1.22)	.149	1.09	(0.98-1.22)	.113
Race (Ref: NH White)						
NH Black	1.08	(0.95-1.23)	.252	1.05	(0.93-1.18)	.464
Other	1.02	(0.83-1.27)	.829	1.02	(0.82-1.26)	.891
Currently married	0.95	(0.85-1.07)	.416			
Insurance (Ref: Medicare FFS)						
Medicare Advantage	0.85	(0.75-0.96)	.009			
Medicaid/Self-pay	0.83	(0.66-1.04)	.104			
Other	0.97	(0.82-1.14)	.689			
Disadvantaged neighborhood	0.75	(0.64-0.89)	.001	0.75	(0.64-0.88)	<.001
Acute MI	0.98	(0.78-1.22)	.850			
Angina	0.91	(0.81-1.03)	.137			
Stroke or TIA	1.09	(0.82-1.46)	.542			
Atrial fibrillation or flutter	1.51	(1.35-1.70)	<.001	1.57	(1.40-1.76)	<.001
Mitral or aortic valvular disease	1.19	(1.05-1.36)	.008	1.21	(1.06-1.37)	.004
Peripheral vascular disease	1.02	(0.87-1.18)	.844			
Hypertension	1.13	(0.92-1.37)	.244			
Diabetes mellitus	0.90	(0.81-1.02)	.089			
Hyperlipidemia	1.20	(1.06-1.35)	.004	1.19	(1.07-1.33)	.002
COPD	0.97	(0.86-1.09)	.606			
Renal disease	0.95	(0.82-1.10)	.485			
Depression	1.05	(0.92-1.19)	.506			
Dementia	0.78	(0.63-0.95)	.014			
Coronary artery bypass graft surgery	1.81	(1.30-2.52)	<.001	1.72	(1.25-2.37)	.001
Percutaneous coronary intervention	1.56	(1.12-2.17)	.008	1.54	(1.14-2.06)	.004
Permanent pacemaker	2.04	(1.08-3.87)	.029			
Implantable cardioverter defibrillator	1.64	(1.03-2.61)	.039			
eGFR (Ref: ≥60)						
45 - 60	1.12	(0.96-1.31)	.164	1.07	(0.93-1.24)	.347
30 - 45	1.06	(0.88-1.27)	.558	0.99	(0.85-1.16)	.913
<30	0.89	(0.73-1.08)	.236	0.79	(0.69-0.91)	.001
Unknown	0.76	(0.35-1.66)	.487	0.46	(0.24-0.85)	.014
Potassium (Ref: 4.0 - 4.9)						
<4.0	0.97	(0.87-1.08)	.610			
≥5.0	1.01	(0.82-1.26)	.897			
Unknown	0.56	(0.18-1.80)	.333			
Hemoglobin (Ref: ≥12.0)						
<10.0	0.84	(0.74-0.97)	.017			
10.0 - 11.9	0.91	(0.80-1.04)	.162			
Unknown	0.61	(0.24-1.55)	.301			
Beta blocker	1.16	(1.01-1.33)	.037			
ACEI/ARB/ARNI	1.11	(0.98-1.24)	.091			
Hydralazine	0.85	(0.74-0.97)	.018			
Loop diuretics	1.22	(1.08-1.39)	.002	1.22	(1.08-1.38)	.001

Aldosterone antagonist	1.26 (1.11-1.43)	<.001	1.30 (1.15-1.48)	<.001
Statin	1.02 (0.90-1.17)	.726		
Aspirin	1.25 (1.11-1.41)	<.001	1.24 (1.10-1.39)	<.001
Principle HF hospitalizations	1.77 (1.56-2.02)	<.001	1.77 (1.56-2.01)	<.001
Admission through ED	1.40 (1.24-1.58)	<.001	1.40 (1.25-1.58)	<.001
Length of stay	1.00 (1.00-1.01)	.245		
Discharge to Home with Home Health	1.01 (0.90-1.14)	.857		
Hospitalizations in the past year	1.09 (0.98-1.21)	.104		
Has a PCP on file	2.60 (2.21-3.07)	<.001	2.58 (2.19-3.04)	<.001
BIC	9371.611		9175.515	

Abbreviations: ACEI: Angiotensin-converting enzyme inhibitors; ARB: Angiotensin II receptor blockers; ARNI: Angiotensin receptor neprilysin inhibitor; COPD: Chronic obstructive pulmonary disease; ED: Emergency department, eGFR: Estimated glomerular filtration rate; FFS: Fee-for-Service; HF: Heart Failure; IPW: Inverse probability weighting; IQR: Interquartile range; MI: Myocardial infarction; PCP: Primary care provider; TIA, Transient ischemic attack.

Note: Regression models compare outcomes for patients who received early outpatient follow-up vs. those who did not receive early outpatient follow-up (reference group).

Model 1 was fully adjusted. Model 2 retained key patient characteristics (age, sex, race, and insurance) and included significant variables based on backward stepwise-selection procedures (.01 threshold).

Table S2. Characteristics of Study Participants in the Pre- and COVID-19 Time Periods.

	Total (N =14,671)	Pre-COVID (N = 7,753)	COVID (N =6,918)	P value
Sociodemographic Characteristics				
Age, median (IQR)	68 (19)	67 (19)	68 (19)	.049
Female	6,807 (46.40)	3,645 (47.0)	3,162 (45.7)	.113
Race				.757
Non-Hispanic White	7,715 (52.6)	4,065 (52.4)	3,650 (52.8)	
Non-Hispanic Black	5,899 (40.2)	3,137 (40.5)	2,762 (39.9)	
Other	1,057 (7.2)	551 (7.1)	506 (7.3)	
Currently married	6,849 (46.7)	3,660 (47.2)	3,189 (46.1)	.178
Insurance				.007
Medicare FFS	6,368 (43.4)	3,452 (44.5)	2,916 (42.2)	
Medicare Advantage	4,226 (28.8)	2,147 (27.7)	2,079 (30.1)	
Medicaid	1,301 (8.9)	697 (9.0)	604 (8.7)	
Other	2,776 (18.9)	1,457 (18.8)	1,319 (19.1)	
Disadvantaged neighborhood	2,081 (14.2)	1,111 (14.3)	970 (14.0)	.593
Diagnosis and Procedures				
Acute MI	1,075 (7.3)	560 (7.2)	515 (7.4)	.608
Angina	6,849 (46.7)	3,660 (47.2)	3,189 (46.1)	.505
Stroke or TIA	1,060 (7.2)	529 (6.8)	531 (7.7)	.047
Atrial fibrillation or flutter	6,003 (40.9)	3,142 (40.5)	2,861 (41.4)	.308
Mitral or aortic valvular disease	3,165 (21.6)	1,660 (21.4)	1,505 (21.8)	.613
Peripheral vascular disease	2,046 (14.0)	1,072 (13.8)	974 (14.1)	.660
Hypertension	13,428 (91.5)	7,079 (91.3)	6,349 (91.8)	.309
Diabetes mellitus	7,442 (50.7)	3,890 (50.2)	3,552 (51.3)	.157
Hyperlipidemia	9,077 (61.9)	4,708 (60.7)	4,369 (63.2)	.002
COPD	3,930 (26.8)	2,150 (27.7)	1,780 (25.7)	.006
Renal disease	7,370 (50.2)	3,845 (49.6)	3,525 (51.0)	.100
Depression	2,976 (20.3)	1,474 (19.0)	1,502 (21.7)	<.001
Dementia	1,060 (7.2)	529 (6.8)	531 (7.7)	.047
Coronary artery bypass graft surgery	419 (2.9)	219 (2.8)	200 (2.9)	.810
Percutaneous coronary intervention	426 (2.9)	215 (2.8)	211 (3.1)	.319
Permanent pacemaker	109 (0.7)	60 (0.8)	49 (0.7)	.644
Implantable cardioverter defibrillator	166 (1.1)	75 (1.0)	91 (1.3)	.047
Lab Values				
eGFR, mL/min/1.73m ²				.002
≥60	6,298 (42.9)	3,283 (42.3)	3,015 (43.6)	
45 - 60	2,764 (18.8)	1,555 (20.1)	1,209 (17.5)	
30 - 45	2,297 (15.7)	1,214 (15.7)	1,083 (15.7)	
<30	3,178 (21.7)	1,632 (21.1)	1,546 (22.4)	
Unknown	134 (0.9)	69 (0.9)	65 (0.9)	
Potassium, mEq/L				.034
<4.0	6,579 (44.8)	3,516 (45.4)	3,063 (44.3)	
4.0 - 4.9	7,118 (48.5)	3,755 (48.4)	3,363 (48.6)	
≥5.0	876 (6.0)	425 (5.5)	451 (6.5)	
Unknown	98 (0.7)	57 (0.7)	41 (0.6)	
Hemoglobin, g/dL				.012
<10.0	4,956 (33.8)	2,587 (33.4)	2,369 (34.2)	
10.0 - 11.9	4,737 (32.3)	2,586 (33.4)	2,151 (31.1)	
≥12.0	4,866 (33.2)	2,514 (32.4)	2,352 (34.0)	
Unknown	112 (0.8)	66 (0.9)	46 (0.7)	
Medications				
Beta blocker	11,473 (78.2)	5,825 (75.1)	5,648 (81.6)	<.001
ACEI/ARB/ARNI	3,900 (26.6)	1,834 (23.7)	2,066 (29.9)	<.001

Hydralazine	3,214 (21.9)	1,574 (20.3)	1,640 (23.7)	<.001
Loop diuretics	10,337 (70.5)	5,169 (66.7)	5,168 (74.7)	<.001
Aldosterone antagonist	3,290 (22.4)	1,579 (20.4)	1,711 (24.7)	<.001
Statin	9,602 (65.5)	4,769 (61.5)	4,833 (69.9)	<.001
Aspirin	9,385 (64.0)	4,660 (60.1)	4,725 (68.3)	<.001
Healthcare Utilization				
Principle HF hospitalizations	3,529 (24.1)	1,917 (24.7)	1,612 (23.3)	.044
Admission through ED	9,885 (67.4)	5,125 (66.1)	4,760 (68.8)	<.001
Length of stay, median (IQR)	4.13 (4.9)	4.04 (4.8)	4.3 (5.3)	<.001
Discharge destination				.021
Home without Home Health	10,457 (71.3)	5,589 (72.1)	4,868 (70.4)	
Home with Home Health	4,214 (28.7)	2,164 (27.9)	2,050 (29.6)	
Hospitalizations in the past year*	7,441 (50.7)	4,058 (52.3)	3,383 (48.9)	<.001
Has a PCP on file	12,538 (85.5)	6,611 (85.3)	5,927 (85.7)	.487
30-day readmission	2,782 (19.0)	1,470 (19.0)	1,312 (19.0)	.994
30-day readmission or mortality	2,952 (20.1)	1,560 (20.1)	1,392 (20.1)	1.00
Early outpatient follow-up				<.001
No early follow-up	8,138 (55.5)	4,427 (57.1)	3,711 (53.6)	
Early follow-up – in person	5,986 (40.8)	3,305 (42.6)	2,681 (38.8)	
Early follow-up – telemedicine	547 (3.7)	21 (0.3)	526 (7.6)	

Abbreviations: ACEI: Angiotensin-converting enzyme inhibitors; ARB: Angiotensin II receptor blockers; ARNI: Angiotensin receptor neprilysin inhibitor; COPD: Chronic obstructive pulmonary disease; COVID-19: Coronavirus Disease 2019; ED: Emergency department, eGFR: Estimated glomerular filtration rate; FFS: Fee-for-Service; HF: Heart Failure; IQR: Interquartile range; MI: Myocardial infarction; PCP: Primary care provider; TIA, Transient ischemic attack.

Note: Categorical variables reported as n (%) and continuous variables reported as median (IQR).

Pre-COVID-19 period: 03/17/2019-03/15/2020. COVID-19 period: 03/16/2020-03/14/2021.

Table S3. Unadjusted and Adjusted Odds Ratios for the Association between Early Outpatient Follow-up within 7 Days and 30-Day Readmission and Mortality in Patients with Heart Failure (N = 6,918)

	Unadjusted OR (95% CI)	P value	Adjusted OR (95% CI)	P value
30-Day Readmission				
No early follow-up	1.00 (reference)		1.00 (reference)	
In-person	0.69 (0.59-0.81)	<.001	0.70 (0.60-0.82)	<.001
Telemedicine	0.76 (0.56-1.03)	.078	0.69 (0.51-0.94)	.018
30-Day Readmission or mortality				
No early follow-up	1.00 (reference)		1.00 (reference)	
In-person	0.65 (0.56-0.76)	<.001	0.66 (0.56-0.78)	<.001
Telemedicine	0.74 (0.55-1.00)	.051	0.68 (0.50-0.91)	.011

Abbreviations: CI: Confidence Interval; OR: Odds ratio.

Note: Adjusted logistic regression models included patient sociodemographic characteristics, diagnoses and procedures, lab values, medications, healthcare utilization measures, and neighborhood disadvantage.

Figure S1. Confounding Factors among HF Patients with and without an Early Follow-up Compared Using Standardized Differences.

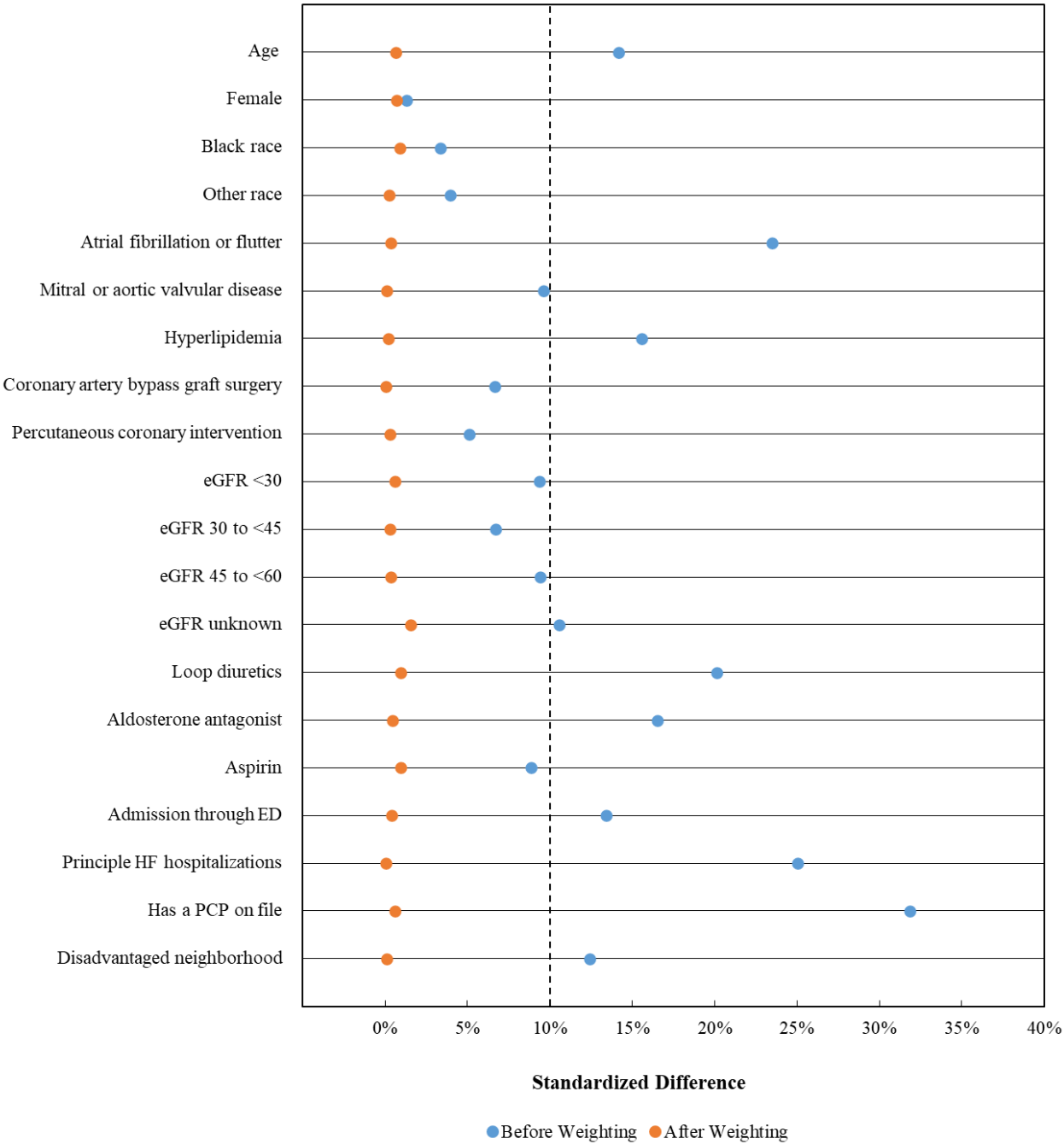


Figure S2. Estimated Density of the Propensity Scores (PS) among HF Patients with and without an Early Follow-up before and after PS Weighting.

