Effect of Chronic Disease Home Telehealth Monitoring in the Veterans Health Administration on Healthcare Utilization and Mortality

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ABSTRACT

BACKGROUND: The high prevalence of chronic diseases, including congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and diabetes mellitus (DM), accounts for a large burden of cost and poor health outcomes in US hospitals, and home telehealth (HT) monitoring has been proposed to improve outcomes.
OBJECTIVE: To measure the association between HT initiation and 12-month inpatient hospitalizations, emergency department (ED) visits, and mortality in veterans with CHF, COPD, or DM.
DESIGN: Comparative effectiveness matched cohort study.
PATIENTS: Veterans aged 65 years and older treated for CHF, COPD, or DM.
MAIN MEASURES: We matched veterans initiating HT with veterans with similar demographics who did not use HT (1:3). Our outcome measures included a 12-month risk of inpatient hospitalization, ED visits, and all-cause mortality.
KEY RESULTS: A total of 139,790 veterans with CHF, 65,966 with COPD, and 192,633 with DM were included in this study. In the year after HT initiation, the risk of hospitalization was not different in those with CHF (adjusted odds ratio [aOR] 1.01, 95% confidence interval [95%CI] 0.98–1.05) or DM (aOR 1.00, 95%CI 0.97–1.03), but it was higher in those with COPD (aOR 1.15, 95%CI 1.09–1.21). The risk of ED visits was higher among HT users with CHF (aOR 1.09, 95%CI 1.05–1.13), COPD (1.24, 95%CI 1.18–1.31), and DM (aOR 1.03, 95%CI 1.00–1.06). All-cause 12-month mortality was lower in those initiating HT monitoring with CHF (aOR 0.70, 95%CI 0.67–0.73) and DM (aOR 0.79, 95%CI 0.75–0.83), but higher in COPD (aOR 1.08, 95%CI 1.00–1.16).
CONCLUSIONS: The initiation of HT was associated with increased ED visits, no change in hospitalizations, and lower all-cause mortality in patients with CHF or DM, while those with COPD had both higher healthcare utilization and all-cause mortality.

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INTRODUCTION

More than 60% of adults have been diagnosed with at least one chronic medical condition, and those with chronic conditions comprise approximately 90% of total US healthcare spending.[1] Congestive heart failure (CHF), chronic obstructive pulmonary disease (COPD), and diabetes mellitus (DM) rank in the top 10 principal diagnoses for inpatient stays in the USA, accounting for over 2.3 million hospitalizations each year.[2] Thirty-day hospital readmissions are estimated at 18% for CHF, 22% for COPD, and 14–22% for DM.[3–5] Care coordination, patient education, and rapid post-admission follow-up all reduce hospital readmissions, but these services are not uniformly available.[6,7] In one study of newly diagnosed CHF patients, those who lived in rural areas had 11% fewer emergency department (ED) visits, 22% fewer hospitalizations, and 18% higher all-cause mortality than those who lived in urban areas, suggesting that unmet healthcare needs contribute to higher mortality..[8]

Telehealth has been proposed as one low-cost strategy to improve access to care in both acute and chronic conditions.[9–11] Telehealth enables patients to access healthcare from home with minimal effort and allows for chronic disease management to occur more frequently. In chronic CHF management, for instance, home telehealth (HT) can enable daily weight and vitals monitoring, timely medication changes, provider consultation, and early recognition of decompensation with appropriate intervention.[12] Similar programs have been developed for symptom and spirometry monitoring in COPD and blood sugar monitoring in CHF.

The Veterans Health Administration (VHA) has had a HT program for the past 20 years.[13] The program involves the use of a set of Disease Management Protocols by a nurse care coordinator in conjunction with daily HT monitoring and regular symptom questionnaires.[14] In previous single-center implementation studies, HT monitoring was associated with reduced hospital admissions and decreased costs.[15–18] Telehealth programs function differently at scale, however, so the effect of a HT program on overall population health remains unclear. The objective of this study was to measure the effect of HT use on clinical outcomes and healthcare utilization in a cohort of veterans with chronic disease in a mature telehealth system.

METHODS

Study Design, Population, and Data Sources

This analysis was a multicenter retrospective matched cohort study of veterans ≥ 65 years with CHF, COPD, or DM between 2013 and 2018. The Veterans Health Administration operated a comprehensive national health system including inpatient and outpatient care for veterans throughout the USA. Participants were included if they had vested VHA health coverage (i.e., fully qualified for VA services), at least one primary care visit within the VHA between 2013 and 2018 and an inpatient or outpatient and diagnosis code consistent with CHF, COPD, or DM (Supplemental Table 1).[19] We excluded patients with visits in multiple Veterans Integrated Service Networks (VISNs) during the study period, a first HT monitoring code listed after a death date (indicating an administrative error), or missing gender, home location, or Care Assessment Need (CAN) risk adjustment score. The CAN score is a validated risk score that incorporates predictors from sociodemographic variables, medical conditions, vital signs, prior healthcare use, medications, and laboratory tests to estimate the probability of hospital admission or death within 1 year.[20,21].

We used VHA administrative records stored in the inpatient and outpatient tables of the VA Informatics and Computing Infrastructure Corporate Data Warehouse for the period 2012–2019 (to allow for a 12-month lookback period and 12-month outcome period), and we defined VA health coverage from the VA Enrollment File. We used records linked with Medicare Part A and B fee-for-service claims in the VA Medicare Analysis Center to identify healthcare utilization outside the VA health system, and we verified vital statistics with the National Death Index.[22] The local institutional review board determined that this activity constituted quality improvement, and this manuscript is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[23] Detailed statistical methods and analytic approaches are described in Supplemental Appendix A.

Exposure

The primary exposure for this analysis was new HT use, defined using VHA-specific codes indicating telehealth (Supplemental Table 2). HT is a system of chronic disease management that incorporates the use of telehealth-enabled monitoring devices (e.g., scales, blood pressure monitoring, digital symptom inventories) that transmit personal health data to a care coordinator.[24–26] Data are reviewed by a care coordinator or patient's healthcare provider to recommend changes in home management. These processes are part of a mature chronic disease management system available to veterans with complex chronic health problems and for whom frequent travel for treatment or appointments might be inconvenient.[27,28] Supplemental Appendix B (CHF), Supplemental Appendix C (COPD), and Supplemental Appendix D (DM) detail the Disease Management Protocols that are used, and these protocols are available for use in all VA facilities and VISNs nationally. We only included our HT cohort within the first year that patients participated in the program.

Outcomes

The primary outcome of this study was an all-cause inpatient admission in the 12 months after telehealth initiation for exposed veterans and the proxy date for matched unexposed veterans. Secondary outcomes included (1) ED visits and (2) mortality within 12 months. Mortality was defined as all-cause mortality, derived from the VA/Department of Defense Mortality Data Repository.[29] Inpatient admissions and ED visits were separately identified in VHA and non-VHA (using Medicare claims) facilities. In the primary analyses, inpatient admission and ED visit outcomes included combined utilization measures across both VHA and non-VHA facilities.

Data Availability

The datasets analyzed during the current study are not publicly available due to data use provisions related to confidentiality within the Veterans Health Administration, but are available from the corresponding author to appropriately credentialed Veterans Administration researchers on reasonable request.

Statistical Analysis

Main Analysis. HT-exposed veterans were matched in a 1:3 ratio with non-HT controls using an exact matching algorithm on age, sex, race/ethnicity, and rurality. To measure the association between HT utilization and each outcome, we used conditional logistic regression for the matched units to assess the unadjusted odds ratio and 95% confidence intervals (CI). We then constructed multivariable models to adjust for demographic and clinical characteristics beyond the matched design variables that might confound the relationship (further explained in Supplemental Appendix A: including service-connected disability percentage, VISN, duration since diagnosis of chronic disease, zip code mean household income, marital status, weighted Elixhauser score for previous 12 months, number of inpatient admissions in previous 12 months [0, 1, > 1], emergency department visit in previous 12 months, CAN score). Hospitalization CAN scores were included for inpatient admission and ED utilization models, while mortality CAN scores were included in the mortality model. Continuous variables including income, CAN scores, weighted Elixhauser comorbidity index, and duration of illness were dichotomized at the median for final model inclusion.

Sensitivity Analyses. We conducted several sensitivity analyses to account for effect modification due to sample and temporal measures. For inpatient admissions and ED utilization, we conducted sensitivity analyses on VA-only healthcare utilization and Medicare-only healthcare utilization to assess the impact of VHA services on the location of care. We measured the association between HT and each outcome separately for rural and urban patients. To measure temporal changes in HT delivery, we measured the association between HT use and each outcome in the 2013–2014 and 2017–2018 cohorts. Finally, to limit survival bias, we conducted a sub-analysis of healthcare utilization outcomes for those who were alive at the end of the 12-month follow-up for each condition.

RESULTS

Participant Characteristics

A total of 1,054,630 veterans with CHF, 1,887,915 veterans with COPD, and 2,506,110 veterans with DM were treated between 2013 and 2018, of which 644,019 (61%), 1,422,812 (75%), and 1,662,860 (66%) were eligible for inclusion, respectively. In the final matched sample, there were 34,854 HT users among CHF patients (Supplemental Figure 1), 16,841 HT users among COPD patients (Supplemental Figure 2), and 48,002 HT users among DM patients (Supplemental Figure 3). For each condition, the number of new HT patients declined over the study period (Supplemental Figure 4).

Over 98% of the sample for all three conditions were male, and the majority for each condition were 65–74 years of age (Table 1). In the CHF cohort, those who used HT were more likely to have had ≥ 2 hospital admissions (36% vs. 13%; Cohen's *d* effect size 0.57) and an ED visit (51% vs. 29%; effect size 0.44) in the prior year compared to the non-HT cohort, but other demographic and clinical characteristics were similar (Table 2). Similarly for COPD, those who used HT were also more likely to have had ≥ 2 hospital admissions (30% vs. 8%; effect size 0.60) and an ED visit (46% vs. 25%; effect size 0.45) in the prior year compared to the non-HT cohort.

Inpatient Admissions

CHF. In the year after HT initiation, a greater proportion of veterans who used HT had an inpatient admission compared

Table 1 Matched Demographic Distributions of HT and non-HT Cohorts by Chronic Health Condition

Matched demographic characteristic	CHF		COPD		DM	
	HT +	HT-	HT +	HT-	HT +	HT-
Total	34,854	104,936	16,841	49,125	48,002	144,631
Sex						
Male	98.4	98.4	98.1	98.1	98.2	98.2
Female	1.6	1.6	1.9	1.9	1.8	1.8
Age						
65–74	53.9	53.8	58.4	58.6	70.0	69.9
75–84	29.7	29.7	29.7	29.7	23.1	23.1
≥ 85	16.5	16.5	11.9	11.7	6.9	6.9
Race						
White, non-Hispanic Latino	74.2	74.2	81.7	81.6	71.9	71.9
White, Hispanic Latino	3.8	3.8	1.9	1.9	4.9	4.9
Black	14.7	14.6	10.5	10.6	16.8	16.7
Asian	0.4	0.4	0.3	0.2	0.4	0.4
Native American	0.7	0.7	0.8	0.8	0.8	0.8
Hispanic Latino	0.5	0.5	0.3	0.3	0.6	0.6
Pacific Islander	0.7	0.7	0.7	0.7	1.0	1.0
Non-Hispanic Latino	3.1	3.1	2.2	2.2	2.1	2.1
Missing both	2.0	2.0	1.7	1.7	1.7	1.7
Urban/rural designation						
Urban	61.0	61.0	55.4	55.5	63.0	63.0
Rural	37.3	37.4	42.5	42.4	35.7	35.7
Highly Rural	1.6	1.6	2.1	2.1	1.3	1.3

Abbreviations: *CHF* congestive heart failure, *COPD* chronic obstructive pulmonary disease, *DM* diabetes mellitus, type 2, *HT+* had telehealth, *HT-* no telehealth

Table 2 Baseline Characteristics of Veterans Treated in the VHA by Chronic Health Condition and Home Telehealth Status, 2013–2018

Characteristic	CHF			COPD			DM		
	HT+	HT-	Effect size	HT+	HT-	Effect size	HT+	HT-	Effect size
Demographic characteristics									
Mean income	$71,494	$72,133	0.01	$70,394	$71,743	0.02	$70,966	$72,000	0.01
Marital status %									
Married	56.9	59.6	0.05	55.6	60.6	0.10	62.2	66.4	0.09
Divorced/separated	24.2	23.0	0.03	26.6	24.0	0.06	23.2	20.3	0.07
Widowed	13.6	11.5	0.06	12.9	9.9	0.09	9.3	7.7	0.06
Never married	5.0	5.5	0.02	4.5	5.2	0.03	4.9	5.2	0.01
Unknown	0.4	0.4	0.00	0.3	0.4	0.02	0.4	0.5	0.01
Any service-connected disability %	51.7	48.1	0.07	51.7	50.1	0.03	58.7	56.2	0.05
Clinical characteristics									
Mortality CAN score mean percentile†	18.9	9.8	0.03	18.1	7.4	0.05	8.8	4.9	0.01
Hospitalization CAN score mean percentile†	42.4	18.3	0.07	38.8	13.9	0.11	24.4	10.6	0.04
Duration of illness in month mean	47.5	71.8	0.07	89.9	85.4	0.02	97.3	88.2	0.02
Weighted Elixhauser mean	20.6	17.9	0.01	20.8	18.7	0.01	17.0	15.6	<0.01
Prior healthcare utilization %‡									
Any emergency department visit	50.9	29.4	0.44	46.2	25.0	0.45	26.1	20.1	0.14
Hospital admission									
None	37.6	73.2	0.73	45.2	81.5	0.78	69.6	85.8	0.40
1 admission	26.0	14.2	0.30	24.4	10.6	0.37	15.4	8.9	0.20
≥2 admissions	36.4	12.6	0.57	30.4	7.9	0.60	15.0	5.3	0.33

Abbreviations: *CHF* congestive heart failure, *COPD* chronic obstructive pulmonary disease, *DM* diabetes mellitus, type 2, *HT+* had telehealth, *HT-* no telehealth, *CAN* care assessment need

*All differences were calculated as Cohen's *d* or *h* statistics to assess meaningful differences and represent a standardized mean difference in proportions for categorical variables and means for continuous variables

†The CAN score is a predictor of hospitalization and mortality in veteran populations and is generated from VA electronic health record data that includes information on medical conditions, number of diagnoses, vital signs, medications, laboratory tests, use of care coordination resources, and overall VA healthcare utilization

‡Includes healthcare utilization both within the VHA and outside the VHA captured through Medicare

to those without HT [(50% vs. 31%, respectively), unadjusted odds ratio (uOR): 1.45; 95%CI: 1.40–1.50)] (Fig. 1), but this association disappeared in the adjusted model (adjusted odds ratio [aOR] 1.01; 95%CI 0.98–1.05). Those admissions were more likely to occur in a VHA hospital (aOR 1.23; 95%CI 1.18–1.28) (Supplemental Figure 5).

COPD. HT was associated with increased admissions in COPD patients (47% vs. 23%, respectively; uOR: 2.98; 95%CI: 2.86–3.09) (Fig. 1). In the adjusted model, this translated to a 15% increase in the odds of inpatient admissions in HT patients (aOR: 1.15; 95%CI: 1.09–1.21). These findings were similar across most sensitivity analyses (Supplemental Figure 6).

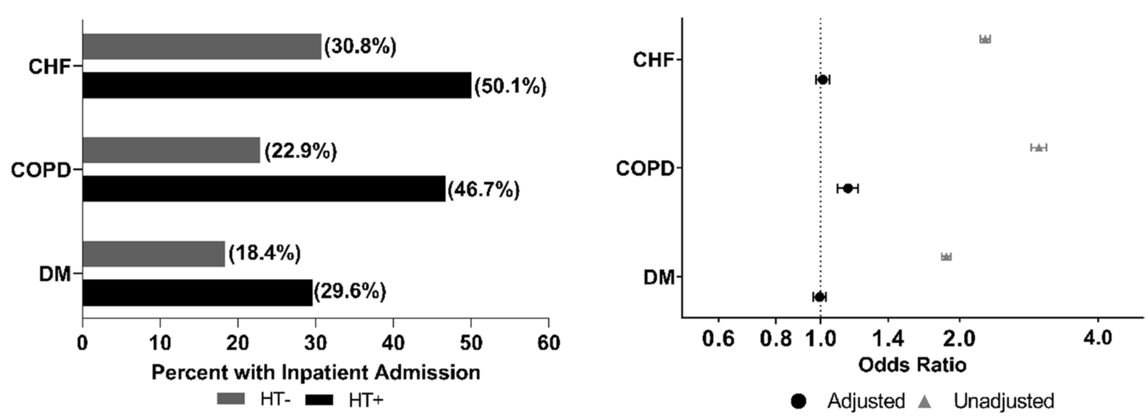

Figure 1 Inpatient admissions of matched cohort by chronic health condition and telehealth status. Each bar shows the proportion of veterans with each chronic condition that had an inpatient admission (left panel). Gray bars show the proportion of veterans that did not use any home telehealth (HT) monitoring that had an inpatient admission during the year, and black bars show the proportion of veterans who had HT monitoring that had an inpatient admission visit during the year. Veterans using both clinical video telehealth and home telemonitoring in any given year were excluded from the sample. In the second panel (right), the unadjusted (gray) and adjusted (black) odds ratios are presented to show the relationship between HT monitoring and inpatient admissions.

DM. Veterans using HT had more admissions compared to those without HT (30% vs. 18%, respectively; uOR: 1.87; 95%CI: 1.83, 1.92) (Fig. 1), but this effect disappeared in multivariable modeling (aOR: 1.00; 95%CI: 0.97–1.03). Similar to CHF, those admissions were more likely to occur in VHA hospitals (aOR: 1.21; 95%CI: 1.16–1.26) (Supplemental Figure 7).

ED Visits

CHF. Veterans who used HT had a greater probability of ED visits compared to those who did not (40% vs. 31%, respectively; uOR: 1.55; 95%CI: 1.51–1.59) (Fig. 2), and this effect persisted in the adjusted model (aOR: 1.09; 95%CI: 1.05–1.13). These increased visits were most pronounced in VHA EDs (aOR: 2.79; 95%CI: 2.62–2.98) (Supplemental Figure 8).

COPD. Veterans using HT had a greater proportion of ED visits compared to those who did not (41% vs. 27%, respectively; uOR: 1.90; 95%CI: 1.83–1.97) (Fig. 2). In the adjusted model, the odds of an ED visit were greater in the HT cohort compared to the non-HT cohort (aOR: 1.24; 95%CI: 1.18–1.31). Sensitivity analyses demonstrated overall similar results in most sub-groups (Supplemental Figure 9).

DM. Veterans who used HT had a greater proportion of ED visits compared to those who did not (26 vs. 22%, respectively; uOR: 1.24; 95%CI: 1.21–1.27) (Fig. 2). In the adjusted model, this relationship was attenuated (aOR: 1.03; 95%CI: 1.00–1.06). Visits were more likely to be in VHA EDs (aOR: 1.59; 95%CI: 1.47–1.71) (Supplemental Figure 10).

All-Cause Mortality

CHF. Veterans who used HT had a higher unadjusted 1-year all-cause mortality compared to those who did not (16% vs. 12%, respectively; uOR: 1.45, 95%CI: 1.40–1.50) (Fig. 3), but in the adjusted model, HT was associated with lower all-cause mortality (aOR 0.70; 95%CI: 0.67–0.73). Sensitivity analyses were similar (Supplemental Figure 11).

COPD. Veterans who used HT had higher 1-year all-cause mortality compared to those who did not (17% vs. 8%, respectively; uOR: 2.50, 95%CI: 2.37–2.63) (Fig. 3), though this effect was attenuated in the multivariable model (aOR: 1.08; 95%CI: 1.08–1.16). Sensitivity analyses demonstrated similar results in all sub-groups (Supplemental Figure 12).

DM. Veterans who used HT had a higher unadjusted 1-year all-cause mortality compared to those who did not (7% vs. 5%, respectively; uOR: 1.49, 95%CI: 1.43–1.55) (Fig. 3), but similar to our CHF cohort, the adjusted model showed lower all-cause mortality in the HT group (aOR: 0.79; 95%CI: 0.75–0.83). Sensitivity analyses demonstrated similar results (Supplemental Figure 13).

DISCUSSION

In this study, we assessed the association between the use of the HT program within the VHA for patients with CHF, COPD, or DM and 1-year healthcare utilization and mortality. As an early adopter of telehealth modalities, the VHA presents a unique opportunity to evaluate the effect of a HT program on a national scale across medical conditions. Additionally, we examined sub-groups for potential

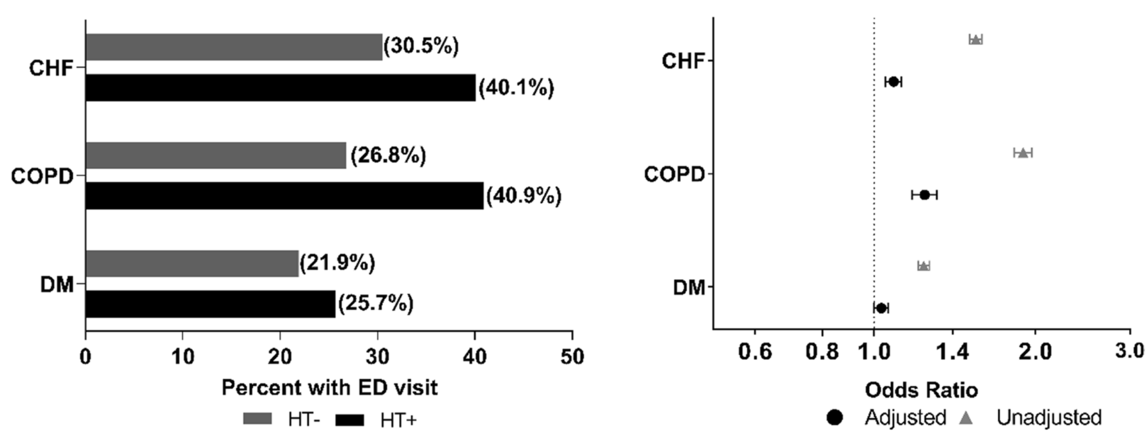

Figure 2 Emergency department visits of matched cohort by chronic health condition and telehealth status. Each bar shows the proportion of veterans with each chronic condition that had an emergency department (ED) visit (left panel). Gray bars show the proportion of veterans that did not use any home telehealth (HT) monitoring that had an ED visit during the year, and black bars show the proportion of veterans who had HT monitoring that had an ED visit during the year. Veterans using both clinical video telehealth and home telemonitoring in any given year were excluded from the sample. In the second panel (right), the unadjusted (gray) and adjusted (black) odds ratios are presented to show the relationship between HT monitoring and ED visits.

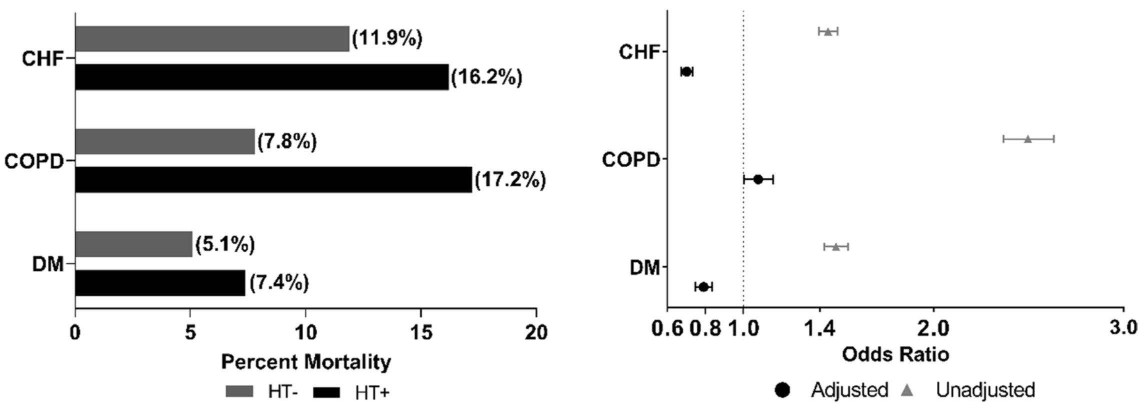

Figure 3 One-year all-cause mortality of matched cohort by chronic health condition and telehealth status. Each bar shows the proportion of veterans with each chronic condition that died during the 1-year follow-up (left panel). Gray bars show the proportion of veterans that did not use any home telehealth (HT) monitoring that died during the year, and black bars show the proportion of veterans who had HT monitoring that died during the year. Veterans using both clinical video telehealth and home telemonitoring in any given year were excluded from the sample. In the second panel (right), the unadjusted (gray) and adjusted (black) odds ratios are presented to show the relationship between HT monitoring and all-cause mortality.

variability that could be useful to target the intervention to patients most likely to benefit. In aggregate, we observed that HT patients with CHF and DM had increased ED visits, no change in hospitalizations, and lower all-cause mortality, while those with COPD had both higher healthcare utilization and all-cause mortality. We also showed that increased utilization in the HT group was mainly within VHA facilities, which has important economic implications for the VHA. These findings are relevant, because they suggest that HT for chronic disease management may function primarily as an effective early warning system, which might not reduce healthcare utilization, but is associated with a significant reduction in reduced mortality for 2 of the 3 chronic conditions assessed.

Our findings were consistent with anticipated outcomes of an HT program, which are to improve access to care and clinical outcomes.[30] Our findings contradict some HT studies both within the VHA and non-VHA settings. In a recent meta-analysis of post-discharge virtual care across chronic diseases, virtual visits as part of a transitional care program were shown to reduce both mortality and hospital admissions after admission for CHF but not COPD, but no significant effect was observed in ED visits.[31] The post-discharge interventions included in this systematic review were different from chronic disease HT, but similarly, used virtual care to supplement home-based chronic disease management. The meta-analysis included randomized trials and small cohort studies. Our study of a large, national cohort may better represent the effects of a mature intervention in an integrated network.

One significant difference between our work and prior telehealth studies is that we measured the effect of a mature VA HT intervention at scale. Health interventions that achieve maturity may achieve different results than pilot programs because they may lose fidelity to the original intervention, enroll different types of patients, function differently in a different context, or have different incentives outside the context of a clinical study. A 2006 study of an early application of HT for DM in the VHA showed decreased hospital admissions, but their cohort ($n = 391$) had a baseline admission risk almost twice our sample—suggesting that there may be heterogeneous treatment effects.[32] A 2012 study of VHA HT for COPD also showed reduced healthcare utilization, but the study was limited only to those with the most frequent baseline annual COPD exacerbations—only 33% of the total number of COPD patients enrolled in the HT program in the participating center.[33] Our study included the entire range of baseline severity of illness, and our results were more modest than those observed in studies of more severe baseline illness.

Some of the effects of HT could represent specific features of the HT intervention. In a recent report from a CHF HT program in France, an intensive educational and monitoring program was associated with fewer hospitalizations and decreased mortality, but a daily educational intervention was an important part of the program and the effect was greatest in those participants who engaged most with the telemonitoring service.[34] In contrast, Hofer et al.[35] reported the results of a HT program for COPD in Germany, which yielded similar results to our findings, increased healthcare utilization and more outpatient care and prescriptions.

We are encouraged by the association between HT and survival in CHF and DM. Importantly, HT was used for patients at high risk of poor short-term outcomes (16% 1-year mortality for CHF, 17% for COPD, and 7% for DM). Not surprisingly, those patients who required the most care were more likely to be enrolled in HT. The fact that HT was associated with increased ED visits with no difference in hospital admissions suggests that it was functioning partly as a surveillance system—identifying patients most likely to benefit from acute intervention. This relationship also increases confidence in our findings because, while residual confounding in our observational cohort could explain increased healthcare utilization, we would not expect residual confounding to explain improved survival. We did not measure the clinical interventions associated with HT, but future work could examine the frequency and timing of medication changes, dietary recommendations, or other clinician-directed care in the HT group. Early warning systems are most effective when decompensation can be reversed by specific interventions, such as those used for CHF and DM.

A finding relevant to any integrated health system is the extent to which HT enrollment was associated with receiving ED and inpatient care within the VHA system. Perhaps because of the early warning surveillance function of the HT intervention, veterans who required ED visits or hospital admissions were more likely to be treated in a VHA facility. This effect could be due to early identification of decompensated disease, when patients could still get to a VHA facility, or it could be because HT staff directly arranged for VHA care. As in many integrated health systems, though, this effect aligns closely with a strategic priority to keep VHA-funded care within the VHA system for improved efficiency and lower cost.[36].

Another key observation was that the effect of HT varied by the chronic disease studied. While increased ED utilization and decreased mortality were consistent with similar effect sizes in CHF and DM, this was not the case for COPD. Conflicting evidence in HT use for COPD was previously identified in a recent review, which found low to very low quality of evidence across all outcomes. A 2019 meta-analysis of 27 studies demonstrated reductions in ED visits and hospitalizations overall with integrated HT, but this impact was significantly attenuated for COPD. These findings may not be unexpected because COPD is often treated with more stable medication regimens than CHF or DM and the need for short-term medication management may not require the technical fidelity of HT. Some elements of the outpatient management of patients with lower respiratory tract disease may be evolving as clinicians are increasingly comfortable with telehealth-enabled home management.[37,38].

Our study has several limitations. First, our observational design using administrative data could be subject to residual confounding and data inconsistencies. We carefully selected parameters from the electronic health record that are likely to be accurately recorded, we verified mortality data with the National Death Index, and we used robust matching and regression adjustment in our analysis, but residual confounding may remain. The second limitation is that we are not able to accurately describe the mechanisms of telehealth interventions. For HT especially, the value of the intervention is knowing how education, medication changes, medication adherence, and other clinical interventions are applied in response to the data collected, but we do not have these interventions described in our data. Third, our data do not contain a measure of HT "dose," which is the frequency of engagement with the HT service. We classified all patients accessing the intervention as an "exposed" patient, so any patients who stopped using the service were classified as being affected by the service. This approach more likely reflects actual behavior in a mature telehealth network, but we are not able to report treatment retention. Finally, our study was conducted in the VHA, and VHA-specific elements of care delivery and health system organization may differ substantially from non-VHA care so that the effect of telehealth may differ.

In conclusion, the initiation of HT is associated with increased ED visits, no reduction in hospital admissions, and decreased mortality in CHF and DM. HT use was also associated with healthcare being provided more in VHA facilities. Future work will focus on the specific interventions implemented using HT, developing care pathways that can reduce hospitalization and ED utilization, and better ways of integrating home care, telehealth, and outpatient management to optimize outcomes of chronic disease.

Supplementary Information *The online version contains supplementary material available at https://doi.org/10.1007/s11606-023-08220-5.*

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Declarations

Conflict of interest *The authors report that they have no conflicts of interest.*

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