Home Telehealth in the Veterans Health Administration: Trends and Correlates of Length of Enrollment from 2010 to 2017

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BACKGROUND: Home telehealth (HT) programs enable communication and remote monitoring of patient health data between clinician visits, with the goal of improving chronic disease self-management and outcomes. The Veterans Health Administration (VHA) established one of the earliest HT programs in the country in 2003; however, little is known about how these services have been utilized and expanded over the last decade.

OBJECTIVE: To describe trends in use of VHA's HT program from 2010 through 2017 and correlates of length of enrollment in HT services.

DESIGN: Retrospective observational cohort study.

PARTICIPANTS: Patients enrolled in HT between January 1, 2010 and December 31, 2017.

MAIN MEASURES: We described the number and characteristics of patients enrolled in HT, including the chronic conditions managed. We also identified length of HT enrollment and examined patient and facility characteristics associated with longer enrollment.

KEY RESULTS: The total number of patients enrolled in HT was 402,263. At time of enrollment, half were >65 years old, 91% were male, and 59.3% lived in urban residences. The most common conditions addressed by HT were hypertension (28.8%), obesity (23.9%), and diabetes (17.0%). The median time to disenrollment in HT was 261 days (8.6 months) but varied by chronic condition. In a multivariable Cox proportional hazards model, covariates associated with higher likelihood of staying enrolled were older age, male gender, non-Hispanic Black race/ethnicity, lower neighborhood socioeconomic status, living in a more rural setting, and a greater burden of comorbidities per the Gagne index.

CONCLUSIONS: Across 8 years, over 400,000 veterans engaged in HT services for chronic disease management and over half remained in the program for longer than 8 months. Our work provides a real-world evaluation of HT service expansion in the VHA. Additional studies are necessary to identify optimal enrollment duration and patients most likely to benefit from HT services.

KEY WORDS: telehealth; remote patient monitoring; chronic disease self-management.

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INTRODUCTION

Patients living with a chronic illness spend a few hours a year in a primary care clinic, in contrast to the more than 5000 waking hours during which they manage their illness at home.[1] Home telehealth (HT) services—combining patient-provider communication between in-person visits with remote monitoring technology—can bridge the gap between office and home management of chronic disease and improve patient outcomes.[2–4] HT is poised to meet the demands of a rapidly growing aging population with increasing chronic disease prevalence.[5] Moreover, HT services are likely to increase considering payment and delivery changes in response to COVID-19.[6,7]

The Veterans Health Administration (VHA), which serves more than 9 million veterans, was an early adopter of HT services.[8] Since 2003, VHA's HT program has enabled patients to transmit their health data for review by a care coordinator who supports disease self-management and coordinates medical care. Early assessments of VHA's HT program, which were often disease- and duration-specific, showed promise in reducing costs and healthcare utilization and improving mortality and quality of life.[9–18] Based on these early results, the VHA rapidly expanded HT services across

the country. However, little is known about the real-world utilization of VHA's HT program over the last decade, including which veterans are receiving these services, for what conditions, and how long they remain enrolled.

Length of enrollment is a key driver of resources needed for HT programs, including provider staffing, remote monitoring devices, and information technology infrastructure and personnel. Understanding length of enrollment in real-world HT programs, such as within the VHA, can help other organizations anticipate resources required to implement or expand HT programs, which may accelerate in the COVID-19 era and beyond. Furthermore, length of enrollment is likely a driver of behavior change, a fundamental goal of HT programs. Evidence suggests that greater participation (e.g., more sessions or longer duration) in health behavior change programs, such as the VHA's MOVE! Weight Management Program, may lead to better outcomes.[19]

The goal of this study is to describe trends in VHA HT program enrollment from 2010 through 2017; identify the number and characteristics of HT enrollees, number of HT enrollments, chronic conditions managed, and length of enrollment; and examine correlates of length of enrollment in HT. A better understanding of real-world HT utilization patterns of veterans can lay the groundwork to understanding the impact of HT on health outcomes and provide information for HT program resource planning.

METHODS

Overview

We conducted a retrospective observational cohort study to describe number of HT enrollments over time, chronic conditions addressed by HT services, length of enrollment, and characteristics associated with length of enrollment. We identified all patients assigned to VHA primary care who enrolled in HT between January 1, 2010, and December 31, 2017, using VHA Support Service Center Capital Assets Databases (VSSC). We captured length of enrollment through December 31, 2019. We obtained patient and facility characteristics from the VHA Corporate Data Warehouse (CDW). Because some enrollment correlates of interest were not available prior to 2010, we excluded enrollments before this year. These analyses were considered quality improvement and, per VHA policy, did not require institutional review board approval or waiver. We obtained a non-research determination (per VHA Handbook 1058.05) from the VHA Office of Primary Care.

VHA Home Telehealth Program

Veterans who enroll in HT receive daily home monitoring and case management for one or more chronic conditions by a care coordinator. Each care coordinator—a registered nurse, social worker, or dietitian—manages 80–100 patients and multiple medical conditions.

Based on the veteran's chronic conditions, the care coordinator assigns disease management protocols, which specify daily symptom evaluation, educational information, and—if relevant to the condition—biometric data submission. A veteran with multiple chronic conditions may be assigned more than one disease management protocol (no primary condition is required) and managed by one coordinator. VHA provides all enrollees with technology that can be used with a standard telephone line, internet connection, or smartphone to enable data transmission, as well as biometric devices (e.g., blood pressure cuff or glucose meter) if relevant. Care coordinators review daily data and take follow-up actions, such as calls to patients for support and education, medication management, appointment scheduling, and communication with medical providers for treatment plan adjustments. Veterans may also call the care coordinator to request assistance.[11,20,21]

Conditions Managed with Home Telehealth

Data from VSSC identified 181 conditions addressed by the HT program. We grouped conditions into 11 categories used by the Agency for Healthcare Research and Quality (AHRQ) in their review of evidence for telehealth[3]: hypertension, obesity, diabetes, cardiovascular disease, mixed chronic physical conditions, behavioral health (e.g., depression, post-traumatic stress disorder), respiratory disease, physical rehabilitation, mixed (behavioral health and another chronic physical condition), other, and missing. The "other" group included conditions that could not be mapped to an AHRQ category, such as hepatitis C, dementia, and multiple sclerosis. The "missing" group included HT enrollments for which a condition was not specified, and we excluded them from all analyses.

Length of Enrollment in Home Telehealth Program

Length of enrollment reflected the difference between the enrollment date and disenrollment date. Length of enrollment was censored at December 31, 2019. Patients can electively disenroll, or a care coordinator can disenroll a patient due to non-adherence (e.g., failure to submit remote monitoring data) or if the patient has achieved stable chronic disease control no longer requiring intensive monitoring and case management. For patients with multiple enrollment periods, we included only the longest period in analyses. If patients had more than one enrollment period of the same length, we used the first enrollment period. Patients who died prior to disenrolling were censored at their date of death.

Covariates

We a priori identified patient- and facility-level characteristics that may influence length of enrollment in HT, based on potential drivers of disparities in access to care.[22] Patient variables at the time of enrollment included age (18–34, 35–44, 45–54, 55–64, 65–74, and 75+ years), sex (male, female),

race/ethnicity (Hispanic, non-Hispanic Black, non-Hispanic White, Other), drive time in minutes to the nearest VHA facility, Gagne comorbidity index,[23,24] rurality of residence, and neighborhood socioeconomic status (SES) index. Drive time (0–30 min, >30 to 60 min, and >60 min), rurality (rural/urban), and neighborhood SES were based on geocoded addresses linked to US Census Bureau information. The neighborhood SES index was previously validated and consists of components related to neighborhood levels of education, employment, use of public assistance, household income, and female heads of household. The index is categorized into deciles, with higher deciles reflecting higher neighborhood SES.[25] The Gagne index is a composite comorbidity score based on ICD-9th and 10th revision codes, with higher scores representing higher 1-year all-cause mortality risk.[23,24] We categorized the Gagne index into quartiles, combining the middle two quartiles as the reference. VHA facility type—where the patient receives primary care—was categorized into larger Medical Centers (VAMCs) and smaller Community-Based Outpatient Clinics (CBOCs) that provide common outpatient services.

Statistical Analysis

We first examined the distribution of patient- and facility-level characteristics of HT program enrollees using means and standard deviations (SD) for continuous variables and numbers and percentages for categorical variables. For descriptive statistics on length of enrollment overall and by the conditions managed, we reported the median values and interquartile range (IQR) due to skewness. To explore trends in enrollment over time, we plotted the number of new and concurrent enrollments aggregated at the year-level. Although excluded from the main analyses, we also descriptively characterized patients with multiple enrollments, including the number and distribution of enrollments, time between enrollments, and proportion with enrollments for the same (vs. different) condition.

We employed a Cox proportional hazards model to estimate hazard ratios (HR) and 95% confidence intervals (CIs) to explore patient- and facility-level correlates of length of enrollment. We entered all covariates in the model simultaneously and used disenrollment or censoring as the time to event outcome. We examined whether the assumption of proportional hazards (i.e., constant hazard ratios over time) was violated using Schoenfeld residuals.[26] Attributable to the large sample size, there was evidence of violation of this assumption. Accordingly, we used inverse probability weighting and bootstrapped the model with 1000 repetitions to obtain 95% confidence intervals (CIs) and p values. We interpreted all HRs as a weighted average of the values over the entire follow-up period.[27] To determine whether correlates varied by condition, we also repeated the Cox proportional hazards models restricted to enrollments for each of the top three most common conditions addressed in the HT program: hypertension, diabetes, and obesity.

All statistical analyses were conducted in R version 4.1.0. All reported p values are two-sided using an alpha=0.05.

RESULTS

Patient and Facility Characteristics of HT Enrollees

We identified 427,687 distinct patients with 549,194 HT enrollment periods. After exclusions for date of death prior to enrollment (N=184 patients), 427,503 patients were remaining with 485,466 HT enrollment periods. After excluding multiple enrollment periods (N=57,819 enrollment periods) and two or more longest enrollment periods of the same length (N=144 enrollment periods), there were 427,503 patients and enrollment periods. Lastly, we removed 25,240 patients for whom the medical condition for enrollment was missing, for a final analytic cohort of 402,263 patients and enrollment periods. Half of HT participants were 65 and older at the time of enrollment and 91% were male (Table 1). Nearly two-thirds of enrollees were non-Hispanic White, 20.4% non-Hispanic Black, 6.7% Hispanic, and 4.5% "other." These demographics on age, gender, and race/ethnicity are similar to VHA total population.[28,29] HT enrollees had an average Gagne score of 1.35 (SD=2.36) and a drive time of 22 min (SD=23.6) to the nearest VHA facility. The average neighborhood SES index decile was 4.18 (SD=2.86) and 59.3% of patients lived in urban locations. Slightly more than half of patients enrolled

Table 1 Demographic and Clinical Characteristics of Patients Enrolled in the Veterans Health Administration Home Telehealth Program, 2010–2017 (N=402,263)

	*N, %**
Patient-level characteristics	
Age categories	
18–34	10,449 (2.6)
35–44	21,086 (5.2)
45–54	49,792 (12.4)
55–64	110,392 (27.4)
65–74	129,065 (32.1)
75+	71,061 (17.7)
Sex	
Male	366,139 (91.0)
Female	36,124 (9.0)
Race/Ethnicity	
Hispanic	26,858 (6.7)
Non-Hispanic Black	82,246 (20.4)
Non-Hispanic White	256,642 (63.8)
Other	18,009 (4.5)
Neighborhood socioeconomic status index decile	4.18 (2.86)**
Rurality	
Urban residence	238,659 (59.3)
Rural residence	151,736 (37.7)
Gagne score	1.35 (2.36)**
Drive time to nearest VHA facility (min)	22.28 (23.63)**
Facility-level characteristics (primary care site)	
VHA Medical Center (VAMC)	210,890 (52.4)
Community-Based Outpatient Clinic (CBOC)	164,969 (41.0)

*Numbers may not add to totals and percentages to 100% due to missing data
**Mean (SD)

Table 2 Distribution of Conditions Addressed Through the Veterans Health Administration Home Telehealth Program and Duration of Enrollment

Condition	*N* (%)	Duration of enrollment, days
		Median (25th percentile, 75th percentile)
Full sample	402,263 (100)	261 (113, 666)
Hypertension	115,838 (28.8)	262 (112, 667)
Obesity	96,210 (23.9)	185 (104, 327)
Diabetes	68,452 (17.0)	322 (118, 840)
Mixed chronic conditions	42,674 (10.6)	462 (150, 1097)
Cardiovascular disease	40,096 (10.0)	375 (126, 898)
Behavioral health	20,299 (5.0)	299 (106, 760)
Respiratory disease	10,981 (2.7)	451 (161, 1079)
Mixed (behavioral and physical)	5427 (1.3)	464 (154, 1110)
Other	1954 (0.5)	172 (73, 420)
Physical rehabilitation	332 (0.1)	221 (103, 547)

in HT received care at a VAMC (52.1%) with the remainder receiving care at a CBOC. The most common conditions addressed by HT were hypertension (28.8%), obesity (23.9%), and diabetes (17.0%; Table 2).

Multiple Enrollments

In this sample, 47,740 patients had multiple enrollments. Among these patients, 86.6% had 2 enrollments, 11.3% had 3 enrollments, and 2.0% had 4 or more enrollments with an average time between enrollments of 491.7 days (IQR: 25% 115, 50% 333, 75% 728). Nearly half of these patients had multiple enrollments for the same condition (data not shown).

Trends in HT Enrollment Over Time

The number of new enrollments per year increased from 2010 through 2013 with a peak of 61,504 new enrollments in 2013, after which the number of new enrollments decreased slightly (Fig. 1). Concurrent enrollments (i.e., number of new plus ongoing enrollees) increased up to 2015 with a gradual decrease thereafter.

Length of HT Enrollment

Among all HT enrollees, the median time to disenrollment was 261 days (8.6 months; IQR 113–666; Table 2). The probability of disenrollment at 30 days was 6.5% (95% CI 6.4%, 6.5%), at 60 days was 13.5% (95% CI 13.4%, 13.6%), and at 1 year was 58.5% (95% CI 58.3%, 58.6%). Excluding the "other" category, median time to disenrollment was shortest for obesity, physical rehabilitation, and hypertension (185, 221, and 262 days, respectively) and longest for mixed physical and behavioral health, mixed chronic physical conditions, and respiratory disease (464, 462, and 451 days, respectively; Table 2).

Correlates of Length of Enrollment in HT

In the multivariable Cox proportional hazards model, compared to enrollees 18–34 years of age, all older age groups had a lower risk of disenrolling over the study period (Fig. 2). Risk of disenrollment was lowest among the oldest age group relative to the 18–34-year age group (75+ years; HR=0.15, 95% CI 0.13, 0.18). Female patients, compared to male patients, were 24% more likely to disenroll (HR=1.24; 95% CI 1.13, 1.37). Non-Hispanic Black patients, compared to non-Hispanic White patients, were 16% less likely to disenroll (HR=0.84; 95% CI 0.80, 0.90) but there were no other differences by race/ethnicity. The lowest decile of neighborhood SES index was associated with a 10% increased risk of disenrolling compared to the highest decile (HR=1.01 per one decile increase; 95% CI 1.00, 1.02). Urban residence, compared to rural residence, was associated with a 7% increased risk of disenrollment (HR=1.07, 95% CI 1.01, 1.13). Compared to patients in the combined middle two quartiles of Gagne scores, patients in the bottom quartile of Gagne scores (e.g., with fewer comorbidities) were 7% more likely to disenroll (HR=1.07; 95% CI 1.02, 1.13), while patients in the top quartile of Gagne scores were 32% less likely to disenroll (HR=0.68; 95% CI 0.66, 0.71). There were no differences in risk of disenrollment by VHA facility type or drive time.

In the three separate Cox proportional hazards models for patients enrolled for hypertension, diabetes, and obesity, the hazard ratios for age and non-Hispanic Black race were consistent with the full model in magnitude and statistical significance (Table 3). Hazard ratios for female sex and SES index were consistent with the full model in magnitude but not statistical significance. Hazard ratios for Hispanic race, "other" race, urban residence, drive time, Gagne index, and facility type were inconsistent in magnitude across all models.

DISCUSSION

From 2010 through 2017, VHA expanded HT services to nearly half a million veterans. Veterans were enrolled for a median of more than 8 months, and 40% stayed enrolled for at least 1 year. Hypertension, obesity, and diabetes accounted for two-thirds of HT enrollment over the study period, consistent with these being highly prevalent conditions among veterans.[30] In multivariable analyses, correlates of longer length of enrollment included older age, male gender, non-Hispanic Black race/ethnicity, greater burden of comorbidities, and rural residence.

VHA's HT program provides an unprecedented opportunity to examine enrollee characteristics and enrollment patterns in a rapidly expanding telehealth program. Historically, poor reimbursement for telehealth services has limited the size of telehealth programs in other health

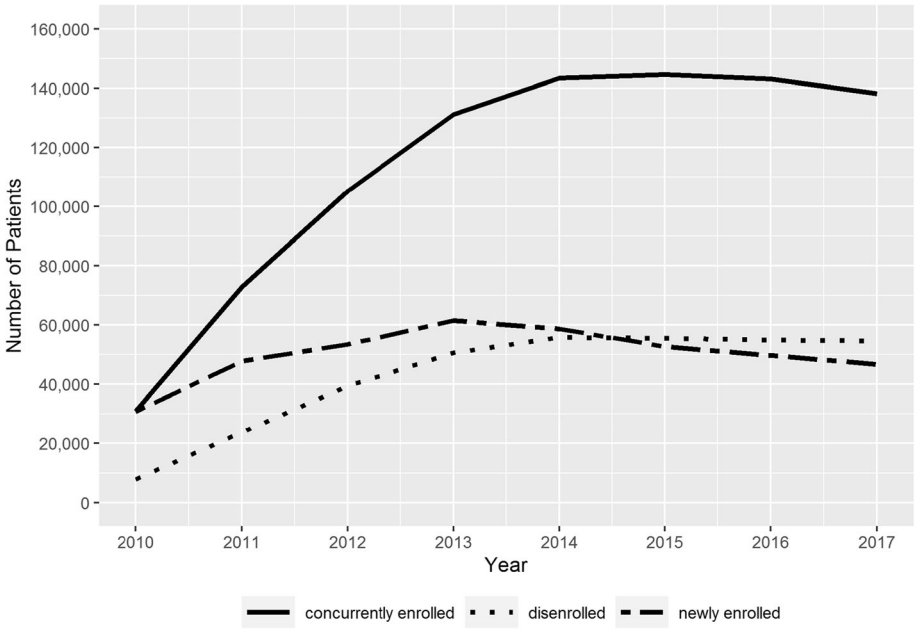

Figure 1 Patient enrollment and disenrollment in the Veterans Health Administration Home Telehealth program, 2010–2017.

systems.[31] Our analysis reflects the largest number of HT enrollees whom we identified over an 8-year period. This longitudinal cohort of HT users provides important information on how long patients may use HT services, which is useful for resource planning in support of HT programs (e.g., number of care coordinators needed).

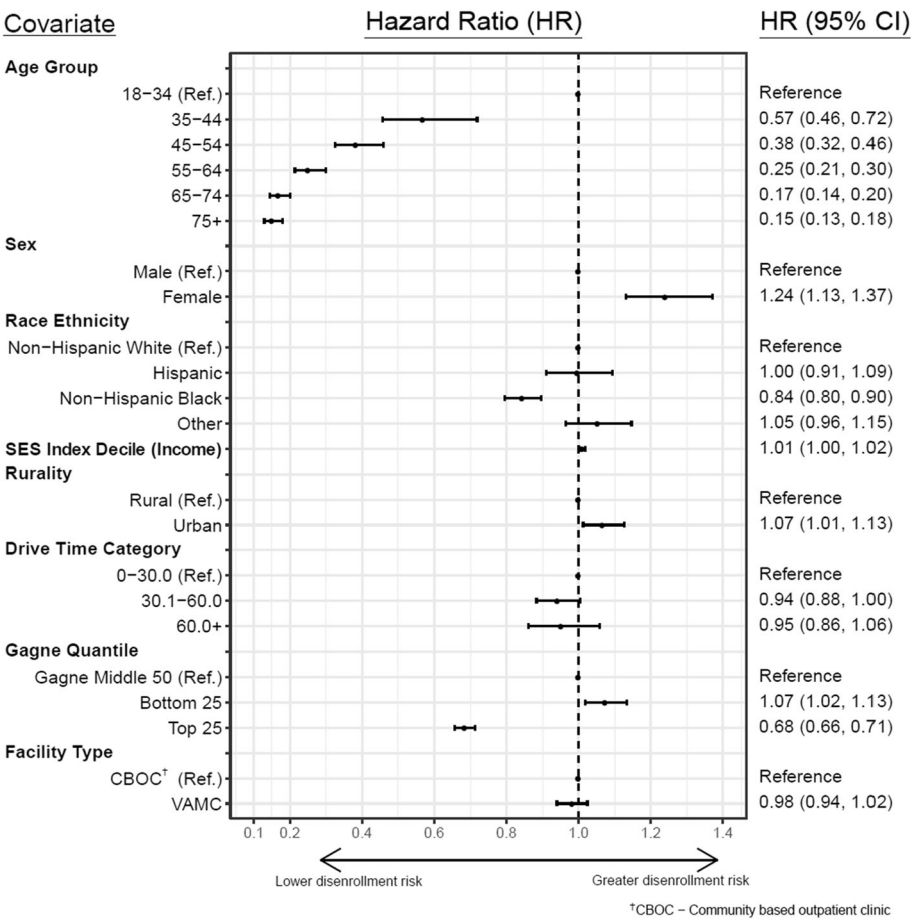

Figure 2 Forest plot of results from the multivariable Cox proportional hazards model for time to disenrollment in the Veterans Health Administration Home Telehealth program, 2010–2017.

Table 3 Results from the multivariable Cox proportional hazards models by condition for time to disenrollment in the Veterans Health Administration Home Telehealth program, 2010–2017

	HTN		Diabetes		Obesity	
	HR (95% CI)	*p* value	HR (95% CI)	*p* value	HR (95% CI)	*p* value
Age group						
18–34 (Ref.)	-	-	-	-	-	-
35–44	0.67 (0.47, 0.98)	0.04	0.46 (0.34, 0.64)	<.01	0.68 (0.46, 1.00)	0.06
45–54	0.43 (0.32, 0.61)	<.01	0.33 (0.26, 0.43)	<.01	0.32 (0.21, 0.47)	<.01
55–64	0.3 (0.22, 0.42)	<.01	0.23 (0.18, 0.29)	<.01	0.26 (0.18, 0.38)	<.01
65–74	0.22 (0.17, 0.31)	<.01	0.17 (0.13, 0.22)	<.01	0.20 (0.14, 0.30)	<.01
75+	0.22 (0.16, 0.31)	<.01	0.17 (0.14, 0.22)	<.01	0.25 (0.14, 0.45)	<.01
Sex						
Male (Ref.)	-	-	-	-	-	-
Female	1.07 (0.94, 1.20)	0.29	1.16 (1.03, 1.31)	0.02	1.03 (0.82, 1.31)	0.79
Race ethnicity						
Non-Hispanic White (Ref.)	-	-	-	-	-	-
Hispanic	0.87 (0.78, 0.97)	0.02	1.17 (1.05, 1.30)	0.01	1.11 (0.82, 1.56)	0.55
Non-Hispanic Black	0.79 (0.74, 0.84)	<.01	0.85 (0.79, 0.91)	<.01	0.68 (0.55, 0.84)	<.01
Other	0.96 (0.85, 1.08)	0.51	1.18 (1.05, 1.32)	0.01	0.96 (0.61, 1.55)	0.89
SES index decile (income)	1.01 (1.00, 1.02)	0.07	1.00 (0.99, 1.01)	0.95	0.98 (0.95, 1.01)	0.16
Rurality						
Rural (Ref.)	-	-	-	-	-	-
Urban	1.14 (1.07, 1.22)	<.01	0.98 (0.92, 1.05)	0.54	1.16 (0.94, 1.41)	0.16
Drive time category						
0–30.0 (Ref.)	-	-	-	-	-	-
30.1–60.0	1.01 (0.94, 1.09)	0.72	0.93 (0.86, 1.01)	0.06	1.11 (0.86, 1.41)	0.40
60.0+	0.98 (0.83, 1.13)	0.78	0.89 (0.75, 1.05)	0.15	0.92 (0.58, 1.56)	0.70
Gagne quantile						
Gagne middle 50 (Ref.)	-	-	-	-	-	-
Bottom 25	1.06 (1.00, 1.12)	0.07	1.00 (0.93, 1.07)	0.97	0.99 (0.82, 1.17)	0.90
Top 25	0.90 (0.85, 0.97)	<.01	0.99 (0.93, 1.06)	0.83	0.90 (0.64, 1.25)	0.54
Facility type						
CBOC (Ref.)	-	-	-	-	-	-
VAMC	0.90 (0.85, 0.95)	<.01	1.05 (1.00, 1.11)	0.06	0.89 (0.75, 1.05)	0.21

Length of enrollment can also be an important indicator that the VHA HT program is improving access for vulnerable patient populations.[22] Several patient factors associated with longer enrollment in our full study population may reflect barriers to receiving in-person care, such as a greater burden of chronic conditions, older age, and lower SES. On the other hand, women veterans were more likely to disenroll from HT, which may be attributable to lower satisfaction with and more rapid attrition from VHA among this population.[32–34] These results are in contrast to the work conducted by Guzman-Clark et al. that also examined predictors of disenrollment from VHA HT within a 1-year timeframe in a population of 3500 patients with heart failure.[35] Patients who were older, sicker, and White were more likely to disenroll, which contrasts with our findings of older and sicker patients being *less* likely to disenroll. When we explored heterogeneity by the top three most common indications for enrollment (hypertension, diabetes, and obesity) within our sample, we observed that older age and non-Hispanic Black race were associated with decreased risk of disenrollment, similar to the results in the full sample. For all other predictors in our analysis, however, associations with length of enrollment were different than the full sample in at least one of the condition-specific models. This work highlights the importance of exploring heterogeneity of HT effects, including the predictors of length of enrollment by different chronic conditions.

Our work to understand length of enrollment in HT services has several limitations. First, we did not have information about why a veteran disenrolled from HT services. Disenrollment may be viewed as a success if due to achieving stable disease control. Alternatively, disenrollment may indicate non-adherence to HT protocols, resulting in elective disenrollment by the patient or disenrollment by care coordinators. Future research should capture both provider and patient reasons for disenrollment. Second, possible contributors of length of enrollment such as digital literacy, caregiver support, baseline degree of disease control, patient engagement (participation in or adherence to remote monitoring), and patient activation (having knowledge, skill, and confidence to self-manage one's own care) are unmeasured in our current work.[36–38] Third, only a single enrollment period per patient was included in the analysis and correlates of length of enrollment may differ among the subgroup of participants with multiple enrollments. Lastly, we were unable to examine associations between length of enrollment and specific health behaviors and outcomes assessed with remote patient monitoring (e.g., blood pressure, weight, blood glucose), as this data is stored external to the VHA electronic health record by a third-party server and was not accessible for this study. Despite these limitations, our study used data from an ongoing, fully implemented program not bounded by predetermined intervention durations or specific chronic conditions. A

resulting strength is our examination of enrollment patterns, durations, and correlates in a real-world context over time.

In conclusion, our study examined trends in a nationally implemented remote patient monitoring program within an integrated healthcare system over 8 years of rapid expansion, providing a greater understanding of the characteristics of enrolled patients and correlates of length of enrollment. As the prevalence of chronic diseases increases in the USA, home telehealth programs like VHA's offer a convenient, patient-centered approach to care for overburdened health systems and providers.[3,39] The COVID-19 pandemic has only strengthened the imperative to offer alternatives to face-to-face encounters to care for chronically ill patients.[40,41] As health systems invest in telehealth, understanding the types of diseases and the characteristics of the population served by VHA's HT program may guide implementation of HT programs outside the VHA. Furthermore, the evidence on telehealth for chronic disease management remains sparse and mixed, likely due to heterogeneity of effect across patient populations, chronic conditions, and type/duration of interventions. This highlights the need for future studies to design real-world evaluations of home telehealth services to better identify the most effective program components and the patients most likely to benefit.

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Declarations:

Conflict of Interest: *The authors declare that they do not have a conflict of interest.*

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