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Journal

Telemedicine Journal and e-Health, 27(9)

ISSN

1530-5627

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Publication Date

2021-09-01

DOI

10.1089/tmj.2020.0312

Peer reviewed

Published in final edited form as:
Telemed J E Health. 2021 September ; 27(9): 1003–1010. doi:10.1089/tmj.2020.0312.

Adherence to the use of home telehealth technologies and emergency room visits in Veterans with heart failure

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Abstract

Background: Prior studies have posited that poor patient adherence to remote patient monitoring as the reason for observed lack of benefits.

Introduction: The purpose of this study is to examine the relationship between average adherence to the daily use of home telehealth (HT) and emergency room (ER) visits in Veterans with heart failure.

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Contributing Statement

JG drafted the initial manuscript. JG, MF, BW, and TH contributed to the conception of this study, and along with ML contributed to the design. MY and BV contributed to the data collection and analysis. All participated in the interpretation/discussion and/or review of this manuscript prior to submission.

Conflicts of Interests

No competing financial interests exist.

Materials and Methods: This is a retrospective study using administrative data of Veterans with heart failure enrolled in VA HT Program in the first half of 2014. Zero-inflated negative binomial regression was used to determine which predictors affect the probability of having an ER visit and the number of ER visits.

Results: The final sample size was 3,449 with most being white and male. There were fewer ER visits after HT enrollment (mean ± standard deviation of 1.85 ± 2.8) compared to the year before (2.2 ± 3.4). Patient adherence was not significantly associated with ER visits. Age and being from a racial minority group (not White or Black) and belonging to a large HT program were associated with having an ER visit. Being in poorer health was associated with higher expected count of ER visits.

Discussion: Subgroups of patients (e.g., with depression, sicker, or from a racial minority group) may benefit from added interventions to decrease ER use.

Conclusion: This study found that adherence was not associated with ER visits. Reasons other than adherence should be considered when looking at ER use in patients with heart failure enrolled in remote patient monitoring programs.

INTRODUCTION

Prospective, multicenter, randomized controlled trials (RCT) evaluating effectiveness of remote patient monitoring in patients with heart failure have not resulted in consistent findings.[1] One potential reason for this could be poor adherence to the use of the telemonitoring technologies over time.[2–3] Patient adherence is a key component of effective chronic disease management.[4] In prior studies, adherence to home telemonitoring ranged between 75–98.5%; variation in adherence rates differed based on duration of study, data being monitored (e.g., weight versus blood pressure), how adherence was defined (e.g., 70% compliant or more), and frequency of expected input (e.g., at least 3x/week versus daily).[1] Unfortunately, adherence to the use of home telemonitoring technologies were reported in less than half of the articles included in an overview of systematic reviews on the use of home telemonitoring in patients with heart failure.[5] In addition, there is a lack of discussion regarding the relationship between outcomes of program success and adherence to the use of telemonitoring technologies.[6]

In American men over 65 years of age with heart failure and a recent hospital admission, Veterans have higher readmission rates for heart failure compared to non-Veterans.[7] Heart failure in Veterans has a high mortality rate and total costs,[8] as well as high readmission rates compared to other chronic diseases.[9] In addition, heart failure is one of the chronic conditions strongly associated with emergency room (ER) use in in Veterans.[10] Frequency of ER visits is often used as a measure of remote patient monitoring program success with the goal of decreasing inappropriate ER visits by early identification of signs and symptoms of heart failure and improving access to care through the use of remote patient monitoring technologies.[11] An initial study examining the use of remote patient monitoring in improving heart failure management in older Veterans found a statistically significant fewer ER visits 6 months after enrollment (mean 0.5 (standard deviation or SD 0.9)) compared to before (mean 1.5 ER visits (SD 1.9).[12] However, in a recent single center study in

Veterans with heart failure enrolled in the Department of Veterans Affairs (VA) Home Telehealth (HT) Program, VA's remote patient monitoring program, who completed a year of home telehealth, there was no significant difference in mean urgent care/ER visits one year before (mean 2.5 ± 2.5) compared to one year after HT enrollment (2.3 ± 2.5) when controlling for age, presence of chronic disease, and income.[13] Adherence to the daily use of HT telemonitoring technologies may explain these differing results in Veterans with heart failure. The purpose of this study was to examine the relationship between adherence to the use of HT technologies and health services use, namely ER visits.

MATERIALS AND METHODS

Research Design and Data Sources

This was a retrospective cohort study using data from the national VA HT Program Office, along with data from the VA Corporate Data Warehouse (CDW).[14] This is part of a larger study that looked at predictors and outcomes of adherence to HT technologies in Veterans with heart failure. [15] Data from the VA HT Program Office are clinical data obtained during usual care and is managed by HT technology contracted vendors behind the VA firewall. Specific to this study, data obtained include Veterans who met the inclusion criteria, reason for enrollment, type of technology assigned, and weekly response or adherence rates for up to a year after first HT technology use.[16] These same patients are then identified in CDW which is a relational database of VA data straight from clinical and administrative encounters. It is updated nightly and contains original patient level data (e.g., demographics, health services use, etc.).[17] The Andersen Behavioral Model was used as a framework to study the relationship between environment, patient characteristics and health behavior (adherence to the use of HT technologies over time), with health services use (ER visits). [18–19] The study was approved by the local VA Institutional Review Boards.

VA Home Telehealth Program

The VA has been at the forefront of remote patient monitoring for patients with chronic diseases. VA's HT Program began in the early 2000's and has grown to an enrollment of over 150,000 Veterans in 2016, serving Veterans with a variety of chronic conditions. The program is associated with a 59% reduction in hospital length of stay and 31% decrease in hospital admissions overall.[20]

Veterans enrolled in the HT Program are assigned a care coordinator, often nurses, who monitor their chronic conditions using health technologies.[16] Inclusion criteria for enrollment in HT include multiple admissions in the past year, frequent emergency room visits, being at risk for institutionalization, or having frequent clinic visits for chronic disease management.[21] Exclusion criteria include living in a nursing home, lack of interest in participation, and residing outside the program service area.[21] HT patients are expected to participate in daily monitoring using their HT technology by answering a series of disease-specific questions and submitting their vital signs (e.g., blood pressure, weight) through peripheral attachments.[16] Abnormal responses then drive care coordination interventions and education provided by HT staff.[16] Educational information specific to the disease and self-management tips can also be included in the messages participants

receive through their HT device. The types of HT technologies vary and include in-home messaging devices with or without peripheral devices for vital signs monitoring, a web browser, or interactive voice response technology.[16, 21] The type of technology given to the Veteran depends on their needs and abilities. Once enrolled, participants are assigned a reason for enrollment, i.e., need for non-institutional care; acute care; chronic care management; or health promotion/disease prevention. Patients assigned to non-institutional care are those who usually require a higher level of care if they are not enrolled in programs to support continued safe community dwelling.[22]

Subject Selection

Veterans included in this study were newly enrolled in the VA HT Program between January 1, 2014 and June 30, 2014 for heart failure and used a messaging device, web browser, or interactive voice response system.

Measures

Table 1 shows the specific variables used in this study and its definitions. Based on the Andersen Model, potential predictor variables included environmental factors (e.g., rurality), HT program size, and whether or not the VA facility had an academic affiliation. Based on the Andersen Model patient characteristics included demographic variables (i.e., age, race (White/Black/Other Racial Minority), gender), predisposing factors (e.g., ER use in the prior year,[23] implantable cardiac device,[24] and military service connection,[25]) enabling factors (e.g., type of HT technology, familiarity with use of other health technology (i.e., having signed up for the VA's patient portal)[26]) and need factors (e.g., comorbidity as measured by the Charlson Comorbidity Index using diagnostic administrative data)[27], the probability of admission or death in 90 days as categorized by the Care Assessment Need (CAN) score 95% and above,[28] a diagnosis of depression, cardiac ejection fraction, and reason for enrollment in the HT Program (i.e., non-institutional care versus others). Because of the high number of missing ejection fractions, multiple imputation was used to impute missing ejection fractions using mortality, CAN score, and having a cardiac device. Reason for enrollment (i.e., need for non-institutional care; acute care; chronic care management; or health promotion/disease prevention)[22] was dichotomized into being at risk for institutionalization and all other enrollment criteria. The rationale for this is that patients at risk for institutionalization usually have functional impairment that would require a higher level of care if they were not enrolled in programs to support continued safe community dwelling.[22]

Weekly percent adherence to the use of HT technologies was calculated from weekly response reports obtained from the VA HT Program Office and is defined as the number of days the patient used the technology in a week (0 to 7 days) divided by the number of days in the week (usually 7). Adjustments to the denominator were made if the patient was hospitalized (e.g., if the patient was in the hospital for 3 days out of the week, then the denominator for that week is 4 since that is the number of days the patient could have used their HT technology at home). Average adherences were then calculated for 1 year (52 weeks) after first HT technology use. The number of weekly response reports obtained from the VA HT Program Office was included in the model to adjust for duration of

program involvement that contributed to the outcome being studied (average adherence). For example, a participant who stayed in the program for only a month and used the device daily for 3 weeks out of the 4 weeks in a month would have the same average adherence (75%) as someone who stayed for 6 months and used the device daily for 18 weeks. The main outcome variable, emergency room visits, was obtained using clinic stop codes and were as none (0) or 1 or more for analysis.

Data analysis

Descriptive statistics were used to summarize all variables. Spearman correlation for continuous variables, chi-square test (Fisher's exact test if any expected cell count was less than 5) for categorical variables, and 1-way analysis of variance were used in bivariate analyses to check for multicollinearity and between the covariates and outcome. Variables were kept in the model if they had a statistically significant relationship ($p < 0.05$) with the outcome variable in the bivariate analysis or if they were deemed clinically important (age, race, gender and average adherence at 1 year). Multicollinearity was evaluated using the variance inflation factor in the linear model. The Vuong test was used to determine whether a zero-inflated model was necessary for the count analysis.[29] The zero-inflated negative binomial (ZINB) model was determined to be the best approach for evaluating predictors that affect both the number of ER visits and the probability of having that outcome (ER visit or hospital admission) after HT enrollment. Analyses used the VA Informatics and Computing Infrastructure (VINCI) platform [30] and the R 3.4 statistical package.[31]

RESULTS

A total of 3,449 Veterans met study criteria. The average patient age was 71 years old, and most were white (75%); male (98%); used an in-home messaging device (78%); and had a CAN score of 95% or greater (58%) (Table 2). Close to half were enrolled in the VA patient portal (47%) and almost a third had a diagnosis of depression (30%). Most of the patients received their healthcare in an urban facility (91%); 96% had an academic affiliation (96%). Average ejection fraction was 43% (range 8% – 89%). The mean number of ER visits in the year prior to HT enrollment was 2.2 with 33% of the sample having no ER visits. A year after HT enrollment, the mean number of ER visits was 1.9 with 42% of the sample having no ER visits.

Table 3 shows the results for the probability estimates of the ZINB model. The baseline likelihood (intercept) of having an ER visit is 0.005. With each additional year of age, the odds of having an ER visit after 1 year in the HT Program increased by 3%. Minority Veterans had almost 4 times higher odds of having an ER visit compared to Black Veterans (reference group) holding all the other variables constant. Veterans who belonged to a large HT Program had 2.3 times higher odds of having an ER visit compared to those who belonged to a small HT Program.

Table 4 shows the results for the count portion of the ZINB model. The baseline count of having an ER visit is 0.81 among those who have the possibility of going to the ER. Holding all other variables constant, White Veterans have 14% fewer ER visits compared to Black Veterans. Those with a CAN score of greater than 95% (probability of hospital admission or

death in 90 days) have a 62% greater expected count of ER visits in the year after compared to those with lower CAN scores. Compared to those with no diagnosis of depression, those with depression have a 13% higher expected count of ER visits. Those who have moderately high comorbidities (3rd quartile in number of Charlson Comorbidity Index (CCI) score) have a 31% greater expected count of ER visits after HT enrollment compared to those with low score in the CCI. Those who scored highest in the CCI have a 43% higher expected count of ER visits after HT use compared to those with low CCI scores. Those with a cardiac implant have a 13% higher expected count of ER visits compared to those w/out cardiac implant. Those with an ER visit in the year before are expected to have an 89% higher count of ER visits in the year after than those who did not have an ER visit in the year before.

DISCUSSION

Our findings showed a significant decrease in ER visits in Veterans 1 year after enrollment in the VA HT Program, similar to a study done by the national VA HT Program Office.[32] This is in contrast with the findings of a recent meta-analysis that found that home telemonitoring increased the odds of ER visits after 6 months.[33] This difference may be due to duration as our current study looked at number of ER visits over a year instead of 6 months and comparison group used. Authors of the meta-analysis also posited that differences in outcome at different time point may be due to adherence, however our current study found that adherence to the use of HT technologies in the year following HT enrollment was not significantly associated with ER use.

The current study also found that Veterans who belong to large HT programs have 2.3 times higher odds of having an ER visit compared to those who belong to small HT programs. A prior study in Veterans with heart failure found differences in risk standardized mortality rates by VA facility that were not fully explained by differences in Veteran demographics or comorbidities, highlighting the need to evaluate differences in cardiovascular care among VA facilities, but also the role of organizational factors (e.g., structures, available resources, and processes) in health services use.[34] Further research is needed to identify differences in organizational factors that may affect adherence to the use of HT devices, but also differences in outcomes for this population. Interventions that included team case management to address patient needs and availability of other settings to provide non-urgent care have been used to effectively decrease ER visits in patients deemed as high utilizers of the ER for their care.[35]

Being older was associated with having higher odds of an ER visit after one year of HT use after controlling for other variables. This is not surprising as heart failure is progressive and older age is often associated with other comorbid conditions. Race differences were also noted with those belonging to a minority groups having higher odds of having an ER visit a year after enrollment and those being White having lower expected count of ER visits compared to Blacks among those who have the possibility of going to the ER. Thus, HT programs should consider potential reasons for race discrepancies and target interventions for at-risk Black and minority Veterans to ensure the decrease of potentially inappropriate ER use if other venues of care (e.g., primary care) are available. A prior study in Veterans

with heart failure also noted a statistically significant higher rate of emergency room/urgent care visits and lower outpatient clinic visits in Black Veterans compared to White Veterans. [36]

Heart failure is a progressive disease associated with other comorbidities and high rehospitalization rates [37] Not surprising, our study also found that those who are sicker (i.e., high CAN score, have depression, high number of comorbidities, those with cardiac implants, and prior ER use) have higher odds of going to the ER after HT enrollment holding all variables constant including adherence to the daily use of HT technologies. Depression, for example, has been found in prior studies to be associated with decreased adherence and is most concerning due to the high prevalence of depression in patients with heart failure.[38] HT programs should develop individualized interventions to target sub-groups of patients (e.g., those with depression) to decrease ER visits post HT enrollment. In addition, high CAN scores and prior ER use are often reasons for HT enrollment. Processes should be in place to promote continued engagement by patients in the HT Program. For example, in one study of patients with diabetes, provider interest in the patient use of the program (e.g., reviewing their HT data or results during a clinic visit) was an important reason for continued patient engagement in the HT Program. [39]

This study had some limitations, including use of secondary VA data and a singular focus on Veterans enrolled in the HT Program with heart failure in the first half of 2014. Due to use of secondary data, we do not know how frequently the care coordinators were engaged with enrolled patients or what interventions they were delivering to patients, which may have affected the outcome. ER visits obtained outside the VA system were not included in the analysis. This also study did not determine the appropriateness of ER visits or access to other care services (e.g., access to primary care) which has been found in to be significantly associated with ER use [10]. In addition, follow-up is limited to only 1 year after HT first use.

In conclusion, with the recent changes to improve reimbursement for remote patient monitoring services [40, 41] and increase in public funding through the Coronavirus Aid, Relief and Economic Security (CARES) Act for health care systems to buy connected devices for use in telehealth services,[42] use of remote patient monitoring is expected to expand. This study increases our understanding of the relationship between patient adherence to daily use of telemonitoring technologies and health service use. Specifically, this is the first study to include adherence to the daily use of HT technologies as a predictor of ER visits in Veterans with heart failure enrolled in remote patient monitoring program in the VA. Finding that adherence was not associated with ER use a year after HT enrollment invites further study into other factors that may explain why HT has not consistently resulted in decreased health service use in heart failure.

ACKNOWLEDGEMENTS

The contents do not represent the views of the U.S. Department of Veterans Affairs or the United States Government.

This paper is part of a larger retrospective research study that looked at predictors and outcomes of adherence to the use of home telehealth technologies in Veterans with heart failure. Predictors of adherence at 1, 3, 6, and 12

months after program enrollment is published in the Journal of Gerontological Nursing, 2020:46(7):26-34. This current paper uses the same cohort but looks at the relationship between adherence and emergency room visits after one year of program enrollment.

Funding and all other required statements.

This work was supported by VA Nursing Research Initiative (IK3 HX001608) from the United States (U.S.) Department of Veterans Affairs Health Services Research and Development Service. Dr. Yefimova was supported by the VA Office of Academic Affiliations through the VA/National Clinician Scholars Program. In addition, resources and/or the use of facilities at the VA Greater Los Angeles Healthcare System, VA Informatics and Computing Infrastructure (VA HSR RES 13-457) in VA Salt Lake City, and Southern Arizona VA Health Care System were used to complete this project.

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Table1.

Variable Definitions

Variables	Definition	Coding
Age	Age at time of home telehealth (HT) enrollment	Age in years
Race	As reported by Veteran in medical records	White Black Other Racial Minorities
Gender	As reported in medical records	Male Female
Enrolled in VA patient portal	Patient enrollment in the My HealtheVet (VA's online patient health portal)	Yes No
Ejection Fraction (%)	Percent ejection fraction in the last echocardiogram prior to HT enrollment or up to 3 months after HT enrollment whichever was closest	Percent ejection fraction
Presence of implantable cardiac device (ICD)	Presence of an ICD, pacemaker or Left Ventricular Assist Device procedure in the year prior to or after HT enrollment	Yes or no
Care Assessment Need (CAN) Score	the probability of admission or death in 90 days	0–94% 95%+
Reason for enrollment	Obtained at initial HT assessment, i.e., need for non-institutional care due to impairment in activities of daily living; acute care; chronic care management; or health promotion/disease prevention.	Non-institutional Care Other
Technology type	Assigned as part of HT enrollment; includes in-home messaging devices, a web browser, or interactive voice response technology	In-home messaging device Other
Has depression	Presence of International Classification of Diseases (ICD) 9/10 codes for depression	Yes No
Charlson Comorbidity Index	Calculated based on diagnosis	1–3 (lower comorbidity) 4–5 6–7 8–22 (high comorbidity)
Service connection	Based on illness or injury obtained during military service; rated from 0 – 100% based on severity and effects on daily living	0–69% 70%+
Rurality	Based on census block population density of the VA facility that the patient utilized	Rural Urban
Home telehealth program size	Based on the number of patients enrolled at the end of June 2014 in the local facility	Small (up to 624 patients) Medium (625 – 849 patients) Large (850 – 1,495 patients)
Goes to a facility with an academic affiliation	Based on VA Office of Academic Affiliation listing of VA facilities with academic affiliations	Yes No
Average adherence at 1 year	Calculated based on weekly percent average adherence	Percent average adherence
Number of weekly adherence reports for the year after HT first use	Sum of weekly reports of adherence per week; available only if the Veteran used their HT technology at any time during the week	Number of weekly reports
Emergency room visits in the prior year first HT use	Emergency room and urgent care clinic stop codes	0 1+
Emergency room visits in the year after first HT use	Emergency room and urgent care clinic stop codes	0 1+

Table 2.

Patient characteristics (n=3,449)

	n (%)	mean ± SD
Age	---	70.8 ± 10.4
Race		
White	2,577 (74.7)	---
Black	645 (18.7)	
Other Racial Minorities	227 (6.6)	
Gender		
Male	3,377 (97.9)	---
Enrolled in VA patient portal	1,602 (46.5)	---
Ejection Fraction (%)	---	42.7 ± 15.8
Presence of cardiac device	1,063 (30.8)	---
Care Assessment Need Score		
0 – 94%	1,308 (37.9)	---
95%+	2,008 (58.2)	
Reason for enrollment		
Non-institutional care	2,058 (37.9)	---
Other	1,391 (58.2)	
Technology type		
In-home messaging device	2,678 (77.7)	---
Has depression	1,1016 (29.5)	---
Charlson Comorbidity Index		
1–3 (lower comorbidity)	1,002 (29.1)	6.5 ± 3.2
4–5	793 (23.0)	
6–7	779 (22.6)	
8–22 (high comorbidity)	855 (24.8)	
Service connection		
0 – 69%	2,324 (67.4)	35.7 ± 42.8
70%+	1,125 (32.6)	
Rurality		
Urban	3,151 (91.4)	---
Home telehealth program size		
Small	1,139 (33.0)	---
Medium	1,155 (33.5)	
Large	1,155 (33.5)	
Goes to a facility with an academic affiliation	3,324 (96.0)	---
Average adherence at 1 year	--	57.1 ± 30.6
Number of weekly adherence reports submitted	--	34 ± 19.4
Emergency room visits in the prior year		

	n (%)	mean ± SD
0	1,138 (33)	---
Emergency room visits 1 year after		
0	1,456 (42)	---

Table 3.

ZINB Model estimates

Predictors	Emergency Room Visits	
	Beta[a]	Odds Ratios
Intercept	−5.36 (NS)	0.005
Age	0.03	1.03
Race (reference group: Black)		
White	NS	NS
Other minority (non-Black)	1.38	3.98
Large home telehealth program size	0.83	2.30

[a] $p<0.05$; NS = not significant

Model included (not shown due to NS): gender, Care Assessment Need score, depression, comorbidity index, presence of cardiac implant, having prior emergency room visit before home telehealth enrollment, rurality, percent ejection fraction, average adherence and number of weekly reports submitted.

Table 4.

Count Model Estimates

Predictors	Emergency Room (ER) Visits	
	Beta[a]	Odds Ratio
Intercept	−0.21 (NS)	0.81
Race (reference group: Black)		
White	−0.15	0.86
Other minority (non-Black)	NS	NS
CAN score ≥ 95%	0.48	1.62
Has depression	0.13	1.13
Moderately high CCI	0.27	1.31
High CCI	0.36	1.43
Presence of cardiac implant	0.12	1.13
Had 1+ ER visits in the prior year before home telehealth use	0.63	1.89

[a] $p<0.05$; NS = not significant; CAN = Care Assessment Need; CCI = Charlson Comorbidity Index

Models included (not shown due to NS): age, gender, program size, rurality, percent ejection fraction, average adherence and number of HT reports submitted.