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Home Telehealth Reduces Healthcare Costs

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ABSTRACT

The aim of this study was to determine whether home telehealth, when integrated with the health facility's electronic medical record system, reduces healthcare costs and improves quality-of-life outcomes relative to usual home healthcare services for elderly high resource users with complex co-morbidities. Study patients were identified through the medical center's database. Intervention patients received home telehealth units that used standard phone lines to communicate with the hospital. FDA-approved peripheral devices monitored vital signs and valid questionnaires were used to evaluate quality-of-life outcomes. Out-of-range data triggered electronic alerts to nurse case managers. (No live video or audio was incorporated in either direction.) Templated progress notes facilitated seamless data entry into the patient's electronic medical record. Participants ($n = 104$) with complex heart failure, chronic lung disease, and/or diabetes mellitus were randomly assigned to an intervention or control group for 6–12 months. Parametric and nonparametric analyses were performed to compare outcomes for (1) subjective and objective quality-of-life measures, (2) health resource use, and (3) costs. In contrast to the control group, scores for home telehealth subjects showed a statistically significant decrease at 6 months for bed-days-of-care ($p < 0.0001$), urgent clinic/emergency room visits ($p = 0.023$), and A1C levels ($p < 0.0001$); at 12 months for cognitive status ($p < 0.028$); and at 3 months for patient satisfaction ($p < 0.001$). Functional levels and patient-rated health status did not show a significant difference for either group. Integrating home telehealth with the healthcare institution's electronic database significantly reduces resource use and improves cognitive status, treatment compliance, and stability of chronic disease for homebound elderly with common complex co-morbidities.

INTRODUCTION

THE ELDERLY WITH COMPLEX CO-MORBIDITIES who receive traditional healthcare services fail to show long-term compliance with prescribed regimens, medications, and dietary restrictions.[1] It has been shown, however, that strategies that include extrinsic motivators promote long-term compliance and reduce recidivism.[2] This study examines the effect on a high-resource-use veteran population of implementing these strategies by means of telemedicine. In 2001, the three most active sources for veteran home care were general hospitals (70% of all such referrals), community sources (19.5%), and nursing homes (5.5%). Of the 23 listed major diagnoses, those with the highest percentage were diabetes mellitus (DM) (12%),

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heart disease and circulatory system disease (24%), stroke (>9%), and chronic obstructive pulmonary disease (COPD) (<9%). Regarding dependency in activities-of-daily-living (ADLs), diabetes (6%), heart and circulatory system diseases (12%), and COPD (4%) accounted for 22% out of a total of 41% not independent in ADLs. Stroke is associated with dependency in six ADLs (3.2%), whereas diabetes, heart and circulatory system diseases, and COPD are associated with dependency in one ADL (>1.5%), two ADLs (<1.4%), and six ADLs (<1%), respectively. Of the 5449 veterans transferred from HBPC, three major destinations accounted for 89% of the total: general hospital (43%), other community-based service (25%), and nursing home (20%).[3]

Home telemedicine (telehealth) transports data rather than people. Telemedicine is a globally expanding technology,[4–7] poised particularly to benefit homebound elderly with chronic complex co-morbidities. Elderly usually require high levels of monitoring and are more likely than younger people to have barriers in ambulation, geographic distance, and transportation to their healthcare providers.[8]

Innovative telecommunication strategies show improved health outcomes for complex-ill elderly.[9,10] Telehealth is achieving integration with home-based primary care services using a patient-centered approach. Innovative strategies for patient education focus on long-term patient compliance and disease-specific education and alert systems for rapid detection and treatment of early signs and symptoms of instability.[2,11] Decreasing the cost of healthcare is a product of preventing unnecessary clinic visits, hospitalizations, and trips to the emergency room.[12]

A positive perception of provider supportiveness (patient centeredness) is the key to achieving improved, sustained, and effective coping mechanisms, motivation, self-determination, self-management of chronic diseases, and enhanced sense of well-being.[1] A positive perception of provider supportiveness enhances objective health outcomes for hypertension, DM, COPD, and congestive heart failure (CHF). In addition, positive patient perceptions and positive objective outcomes correlate with decreased bed-days-of-care (BDOC) and decreased clinic and emergency room visits. Long-term disease-specific patient education is incrementally effective in sustaining long-term compliance for patients with chronic disease.[1,11–15]

Telemedicine's role as a technological communication tool has evolved beyond early experimental applications into a real-world cost-saving strategy. For example, a 4-year telehealth Medicare- and Medicaid-funded project will examine healthcare and resource use outcomes for elderly diabetics in underserved areas in New York State. End points will include A1C and lipid levels, blood pressure (BP), patient satisfaction, and healthcare resource costs and use.[8] National healthcare systems beyond the United States and Europe are using telemedicine to provide clinical healthcare services in remote regions. In Ankara, Turkey, combining fields of medicine, telecommunication, and informatics enables clinical healthcare to reach rural areas.[4] In Italy, seven 3-year research projects served a dual goal: To improve healthcare, management, and performance and to encourage large-scale implementation for actual reduction in healthcare costs.[6] The goal of Bhutan's Health Telematics Project is to decrease time and distance barriers and optimize use of limited available health services.[7] Telemedicine in Norway enhances the working environment in psychiatry, dermatology, pathology, and otolaryngology by decreasing provider travel, increasing time for other work, and by promoting professional security through integrated support systems.[16] In Ecuador, a telemedicine project achieved significant positive clinical outcomes and economic value for pre-surgical and post-surgical consultations; the project reached people in remote rural regions outside of Cuenca and the Andes Mountain range.[17]

Research comparing teledermatology with traditional in-person clinic visits showed shorter waiting times for scheduling patients, increased efficiency and productivity for clinicians, and less operational costs for the clinic. For patients, time and cost reductions resulted from reduced travel to clinic and fewer unnecessary clinic visits.[9] Teledermatology facilitates transmission of dermatologic images, accurate diagnoses, and provider satisfaction, although one-way video is not patient-centered and reduces patient satisfaction by weakening the patient–provider relationship.[10] A multination European telemedicine project integrated broadband with video-conferencing and eight telehealth services. Positive outcomes included user satisfaction with video and audio communication as well as confidentiality for three levels of participants—medical staff, patients, and supporters. Medical staff trusted some remote assessments, although not assessment or treatment for critical situations.[18] Video-telephone and regular telephone reminders each improve medication compliance in elderly patients with CHF more than usual healthcare services or prepoured pillboxes. Long-term reinforcement methods and patient centeredness instill positive perceptions of provider supportiveness and increase the likelihood of successful telehealth outcomes.[2,15]

A program of home telehealth using FDA-approved peripheral devices and supported by patient education enables transmission of valid and reliable data to healthcare providers and eliminates the need for frequent and costly preventive community nurse visits.[19] Comparing the cost–benefit ratio of traditional healthcare management in a clinic setting to home telehealth healthcare management is vital to shifting telemedicine from an under-utilized healthcare model to a pragmatic operational method of providing healthcare services. Retrospective reviews of telemedicine studies show little attention to sustained real-world viability. Too few studies have focused on (1) cost benefit analysis, (2) long-term outcome data, (3) confidentiality issues, and (4) access to care.[20,21]

Cost-effectiveness analysis of telemedicine for real-world application requires examining healthcare costs and the broad spectrum of factors that influence them. A comprehensive multivariable approach is necessary to identify and measure direct and indirect healthcare costs. Fundamental variables that determine costs of alternate healthcare models include (1) transportation between remote site and clinic, (2) clinic timeframe and support personnel, (3) target population such as elderly with complex chronic co-morbidities, (4) specialist consultation, (5) type of telemedicine device and peripherals, (6) telephone connection costs, and (7) ongoing community nurse visits. Large-sample, long-term studies (rather than small-scale pilot studies) can more accurately simulate real-world healthcare challenges and can more closely determine whether telemedicine strategies influence access to care and reduce healthcare costs.[22–25]

Quality-of-life questionnaires require objective and subjective measures to accurately assess individualized patient-centered healthcare approaches. Elderly patients in declining life-stages with chronic co-morbidities may show divergent responses to subjective and objective questionnaires. Elderly with chronic complex diseases may react differently from young people with reversible conditions to the functional effects of illness and therapy. Satisfaction and happiness each characterize a particular timeframe between present experience and expectations. Among chronically-ill elderly, satisfaction and happiness may change daily depending on perceptions of well-being. The domains affecting perceptions of health and disease are level of physical functioning, psychological state, socioeconomic status, environment, social relationships, and somatic sensations.[26,27]

MATERIALS AND METHODS

Our current telehealth project was preceded by a pilot project. Results of the 90-day pilot study (n = 20), conducted at VA Connecticut Healthcare System (VACT) showed that remote patient monitoring decreases healthcare costs and improves well-being of frail elderly veterans with complex co-morbidities residing at home. Although the pilot study differed from the present study in that it included a costly central station for collecting and transmitting patient data, findings showed that CHF, COPD, and DM patients with documented highest healthcare resource use at VACT demonstrated positive coping mechanisms and patient satisfaction with a first-generation bulky home telehealth unit. A key lesson learned from the pilot study was the importance of uploading data from the patient's telehealth unit into the healthcare facility's electronic database. The design of the large-sample project reported here focused on achieving improved healthcare for homebound elderly through integration with the healthcare facility's electronic database.

The current project was conducted in real-world settings at an operational scale. It incorporated: (1) an active working relationship with a corporate partner, (2) home telehealth units placed in 47 homes, (3) use of the WEB (VA Intranet) and database server at VACT for data access and VISTA (VACT's electronic database) integration, (4) physiologic data integrated with VISTA, and (5) outcome data from educational resources also integrated with VISTA.

This single-blind, single-site, randomized, large-sample project was conducted at VACT. The target population comprised frail elderly veterans with CHF, COPD, and/or DM. Participation duration for each subject was at least 6 months. Inclusion criteria included documented high use of healthcare resources and barriers to accessing healthcare services due to geographic, economic, physical, linguistic, technologic, and/or cultural factors. Candidates who qualified for participation met these inclusion criteria and had been actively receiving nurse case management for at least 6 months preceding the study and throughout study participation. A needs assessment, derived from established VACT home-based nursing care protocols, determined whether patients qualified for nurse case management.

The control group ($n = 57$) received usual home healthcare services plus nurse case management. The intervention group ($n = 47$) received home telehealth plus nurse case management. Informed consent was obtained from all participants. Approval to conduct the study was granted by VACT's institutional review board. Participants were instructed to call 911 for emergencies because the home telehealth unit was not a life-saving device.[18] Subjective and objective quality-of-life measures were taken at baseline and quarterly. Cost data were collected for 6 months preceding study entry and 6 months during participation in the study. Data analysis included parametric and nonparametric tests and made use of the SPSS 10.0 software.

Vital sign data and answers to quizzes related to disease-specific education modules were acquired via the home-based telehealth units. These user-friendly devices feature a touch screen interface with 16-bit color, and step-by-step instructions using graphics, large text, and audio. FDA-approved peripheral devices plug into the telehealth unit and collect data for temperature, blood pressure, pulse, blood glucose, 3-lead electrocardiogram, stethoscope for heart and lung sounds, pulse oximetry, and weight. Pain level (0–9) is self-reported using a simple questionnaire. Data are transmitted over POTS (plain old telephone system) lines to VACT's Web-based Intranet system and directly into the facility's electronic database (VISTA). A patient-specific intake form was completed before deployment of the healthcare unit. The intake form addresses demographics and needs assessment for peripheral devices and safe range settings. Out-of-range patient data trigger VA alerts via the Web to nurse case managers. The device supports on-screen hospital-to-home messaging, scheduling, and advice from providers to patients. Incoming data were automatically written into the VA's electronic patient record to templated progress notes or the vital sign record. A digital camera (Nikon Coolpix 880) was used to monitor wound care with images transmitted to the Web server. Disease-specific patient education modules included pass/fail tests to demonstrate learning achieved. Patients completed on-screen assessment surveys for pain, well-being, and patient satisfaction.

This project involved multiple issues relating to information security. The system's design was examined and approved by computer system security professionals (Corbett Technologies, Inc.). A comprehensive security plan was implemented to ensure viability, confidentiality, and security of the system. The system's main security features include:

- The Telewall server allowing only preregistered phone numbers to connect to the system.
- An isolated network segment for the main system servers. These servers are protected from VACT's Intranet by a firewall.
- Virus protection software with scheduled updates running on all systems.

- A software maintenance program to ensure that all system security software is fully patched and updated.
- User authentication scheme whereby patients must log on to their home units with a unique password.
- Machine authentication scheme that requires a unique log on from the patient's terminal before server access is granted.

Maintaining a complete electronic patient record (EPR) was a fundamental goal of the telemedicine design team. The developers at VACT wrote a suite of applications that support data sharing between VISTA and the home telehealth unit. All vital sign data collected in the home are written to VISTA and available for clinicians within 10 minutes of being received. Results of disease management surveys and education assessments trigger the creation of VISTA progress notes and become part of the permanent record. This VISTA Integration Process uses the same software technology used for the VA Healthcare System's CPRS (Computerized Patient Record System). Data are passed from an SQL Server using the VISTA Integration software and written to VISTA with standard RPC (Remote Procedure Call) functions. This automated approach eliminates unnecessary documentation workloads, improves data accuracy, and helps make VA Telemedicine a fully supported extension of the VA Healthcare System's EPR. Patient confidentiality was maintained throughout the study. Instruments were coded for data entry. Demographic data were completed at baseline.

A research nurse administered quality-of-life questionnaires at baseline and quarterly. Quality-of-life was assessed with a valid and reliable published instrument comprising two objective tools that measure cognitive status and functional level and two subjective tools that measure patient satisfaction with care and self-rated health status (the OARS Multidimensional Functional Assessment).[28] These instruments were chosen because results of research have shown a correlation between healthcare costs in elderly patients with co-morbidities in declining life and responses to subjective-objective surveys.[29] The OARS questionnaire derives from the Americans Resources and Services Program. The 4-construct tool uses a 5-point Likert scale with 5 = excellent and 1 = poor responses, yes/no responses, and responses based on current events. A sample question from the 10-item cognitive assessment asks: "Who is the president of the U.S. now?" A typical question from the 15-item functional level questionnaire asks: "Can patient take care of perineum/clothing at toilet?" A 28-item patient satisfaction question asks the patient to rate "thoroughness of treatment." A sample 37-item self-rated health status question asks: "During the past four weeks, have you accomplished less than you would like?"

Each study participant was assigned to the intervention (home telehealth unit) or control (usual healthcare services) group. Due to ethical concerns for this high-risk frail population, all subjects continued receiving nurse case management during study participation. VACT's electronic database was used to determine selection of qualified candidates. Participants who met inclusion criteria were highest users of healthcare services with complex chronic co-morbidities—CHF, COPD, and/or DM. Patient-centered care was maintained throughout the study.

Participation was skewed toward males because too few female veterans met inclusion criteria for study participation. Regression techniques were performed to establish a relationship between co-morbid conditions and healthcare use. Limitations were related to the small sample size in each group and diminishing participation in the study beyond 6 months. Means and standard deviations showed broad fluctuations. Therefore, statistical tests were selected on the assumption that data were distribution free. Parametric and nonparametric tests for independent groups and for paired groups were performed to compare length in study (baseline 3, 6, 9, and 12 months) with scores for healthcare resource use and scores for quality-of-life measures. Regression and analysis of variance were performed to determine whether a significant difference existed between intervention and control groups and according to disease conditions CHF, COPD, and DM.

Reliability of the difference in means among dependent and independent variables was limited due to small sample sizes for each disease condition and due to tapering effects of intervention and control group samples at 9 and 12 months. The *t* test, nonparametric tests, and logistic regression were performed to compare between- and within-group differences of scores for health resource variables BDOC, total visits, urgent visits (unscheduled clinic and emergency room visits), A1C levels for the diabetic sample, and RN home visits for 6 months preceding study entry and 6 months of study participation. The *t* test and nonparametric tests were performed to compare between- and within-group differences for scores for quality of life for four variables, at baseline, 3, 6, 9, and 12 months of study participation. Data analyses were performed for direct and indirect healthcare costs using a standard average cost for each variable. The *t* test and nonparametric tests were then performed to compare between- and within-group differences for healthcare use.

RESULTS

Table 1 shows demographic data. Of the 104 participants, 101 were males and 3 were females. Average age was 71 years old (range 54–90 years). Distribution of the participants' morbidities was as follows: one morbidity, CHF = 59, COPD = 35, and DM = 58; two comorbidities, CHF + COPD = 22, CHF + DM = 35, and COPD + DM = 13; and three, CHF + COPD + DM = 11.

The VACT electronic database was used to collect healthcare use for BDOC, total visits, urgent visits (unscheduled clinic and emergency room), A1C levels for the diabetic sample, and coumadin visits for the anticoagulated sample. Number of nurse home visits was collected from community agencies and VACT's home-based program. Data are shown in Tables 2 and 3.

At 6 months in study, BDOC decreased in the intervention group ($p < 0.001$) and the control group ($p = 0.001$). Urgent visits decreased for the intervention group ($p = 0.023$, $z = 0.003$) and increased for the control group ($p = 0.902$). Total visits also decreased for the control group ($z = 0.042$). The number of coumadin visits showed broad variability preceding and during study participation; variation was most likely related to varying risks of anticoagulation in this vulnerable population.

Table 4 shows results for A1C levels for 51 participants with active diabetes; seven participants were not included in the data analysis because diabetes was not active, no A1C levels were performed, and no hypoglycemic agent was prescribed. At baseline, A1C levels were higher for the intervention group ($M = 8.30$) and lower for the control group ($M = 7.03$). At 6 months in study, the intervention group showed a strong statistically significant decrease

Table 1. Demographic Data for the Total Sample

Variable	*Total (n = 104)*	*Intervention (n = 47)*	*Control (n = 57)*
Age[a] (Mean)	71	72	70
Sex			
Males	101 (97%)	44 (42%)	57 (55%)
Females	3 (3%)	3 (3%)	0
Caregiver	24 (23%)	24 (23%)	0
CHF[b]	59 (57%)	31 (30%)	28 (27%)
COPD[c]	35 (35%)	17 (16%)	18 (17%)
DM[d]	58 (56%)	25 (24%)	33 (32%)
CHF + COPD	22 (21%)	12 (12%)	10 (10%)
CHF + DM	35 (34%)	14 (13%)	11 (11%)
COPD + DM	13 (13%)	6 (6%)	7 (7%)
CHF + COPD + DM	11 (11%)	6 (6%)	5 (5%)

[a]Age = 54–90 years.
[b]CHF, Congestive heart failure.
[c]COPD, Chronic obstructive pulmonary disease.
[d]DM, Diabetes mellitus.

Table 2. Cost Data for the Total Sample

Variable	*Total events*	*Intervention*	*Control*
BDOC[a]	n = 64 (62%)	n = 26 (25%)	n = 38 (36%)
Pre[b]	842	317	525
Post[c]	243	49	194
Total Visits[d]	n = 102 (98%)	n = 46 (44%)	n = 56 (54%)
Pre	1613	682	931
Post	1520	682	838
Urgent Visits[e]	n = 98 (94%)	n = 44 (42%)	n = 54 (52%)
Pre	622	320	302
Post	544	237	307
Coumadin[f]	n = 26 (25%)	n = 11 (11%)	n = 15 (14%)
Pre	187	79	108
Post	146	82	64
RN Home Visits	n = 21 (20%)	n = 12 (26%)	n = 9 (6%)
Pre	223	119	104
Post	197	94	103

[a]Bed-days of care.
[b]Six months pre-study.
[c]Six months in study.
[d]Scheduled specialty and primary care clinic visits.
[e]Unscheduled clinic and emergency room visits.
[f]Coumadin Clinic scheduled visits.

in A1C levels ($M = 7.30$; $p < 0.001$), whereas the control group showed a strong statistically significant increase in A1C levels ($M = 7.83$; $p = 0.002$). Results for logistic regression for each cost variable showed p values > 0.05; change in R^2 was not statistically significant.

Findings for quality-of-life scores are shown in Tables 5–8. Results for cognitive level showed no differences at 6 months in the study for either group. The standard deviation decreased for each group from baseline to 12 months. Between-group analysis showed a statistically significant difference at 12 months ($p < 0.001$) with the 8 remaining participants in the intervention group achieving perfect cognitive scores. Mean average score for the control group did not change at 12 months ($M = 19.43$) compared to baseline ($M = 19.43$). Results for functional level showed no between-group difference and no within-group difference from baseline to 12 months.

Findings for patient satisfaction showed wide variability in average mean and standard deviation for each group throughout the 12-month study period. Scores for the control group showed a statistically significant improvement at 3 months ($p = 0.001$) and 6 months ($p = 0.020$) compared to the intervention group. At 12 months, a significant improvement was shown within the control group ($p = 0.004$).

Results for self-rated health status showed no between-group difference and no within-group difference from baseline to 12 months. The intervention group showed a higher average mean and standard deviation from baseline ($M = 81.32$ and SD = 13.07) at 12 months ($M = 88.00$; SD = 22.16). In contrast, the control group at 12 months showed a lower average mean and standard deviation ($M = 82.21$; SD = 10.81) than at baseline ($M = 84.86$; SD = 15.33).

Healthcare costs of participants were retrieved from VACT's electronic database for resource utilization. Healthcare costs were compared between groups and within groups for 6 months preceding study and for 6 months enrolled in study as shown in Table 9. Current year 2002 was used to compute cost for each variable: Round-trip transportation cost between the patient's home and VACT, $69.00; RN home visit, $93.00; BDOC, $1286 (average admission and discharge days plus integral days as inpatient); ER, $50.00; Specialty Clinic, $50.00; Primary Care, $15.00; Coumadin Clinic, $15.00; use of telehealth unit for 36 months, $10,000.00 (6-month/participant, $1666.00). Costs shown are for fiscal year 2002 VA defined costs for services listed. These values were used to calculate the cost for each cost item in Table 9 for both patient groups pre- and post-study.

TABLE 3. RESULTS OF TWO-TAILED *t* TESTS AND WILCOXON SIGNED RANK TESTS FOR TWO INDEPENDENT GROUPS AND PAIRED SAMPLES WITHIN-GROUP AT 6 MONTHS IN STUDY: EFFECT SIZE ON VA AND NON-VA BDOC, TOTAL CLINIC VISITS, URGENT VISITS, AND COUMADIN VISITS SHOWING SIGNIFICANT AND NON-SIGNIFICANT FINDINGS

Cost variables	M	SD	t	p	z
			VA and Non-VA BDOC		
Baseline					
Between groups			−0.564	0.575	0.295
Intervention	12.19	11.95			
Control	13.82	10.27			
6 Months					
Between groups			−1.760	0.085	0.495
Intervention	1.88	3.33	4.902	0.0001	0.0001
Control	5.11	10.54	3.656	0.001	0.0001
			Total clinic visits		
Baseline					
Between groups			−0.727	0.469	0.496
Intervention	14.51	10.49			
Control	16.33	14.60			
6 Months					
Between groups			−0.053	0.958	0.609
Intervention	14.83	11.28	0.000	1.000	0.831
Control	14.96	15.09	+1.137	0.260	0.042
			Urgent visits		
Baseline					
Between groups			+1.676	0.097	0.055
Intervention	7.27	5.12			
Control	5.59	4.69			
6 Months					
Between groups			−0.257	0.798	0.701
Intervention	5.39	5.50	+2.364	0.023	0.003
Control	5.69	6.01	−0.124	0.902	0.898
			RN home visits		
Baseline					
Between groups			+0.642	0.522	0.487
Intervention	2.53	5.90			
Control	1.82	5.19			
6 Months					
Between groups			+0.192	0.848	0.377
Intervention	2.00	4.60	+0.660	0.512	0.563
Control	1.81	5.66	+0.027	0.979	0.953

Total sample, $n = 104$; intervention group, $n = 47$; control group, $n = 57$.

TABLE 4. DIABETIC A1C LEVELS

A1C	n	M	SD	t	p	z
At baseline						
Between groups	51 (49%)			+3.233	0.003	0.004
Intervention group	23 (22%)	8.30	1.61			
Control group	28 (27%)	7.03	1.08			
At 6 Months						
Between groups	51 (49%)			−1.228	0.225	0.260
Intervention group	23 (22%)	7.30	1.47	+4.242	0.0001	0.001
Control group	28 (27%)	7.83	1.65	−3.398	0.002	0.006

Results of two-tailed *t* tests and Wilcoxon signed rank tests for two independent groups and paired samples for within-group at baseline and 6 months in study. Effect size on A1C levels showing a statistical significant difference within each group and no significant difference between groups.

TABLE 5. QUALITY-OF-LIFE MEASURE: COGNITIVE STATUS

Cognitive status	n	M	SD	p	z
Baseline					
Between groups	104			0.751	0.844
Intervention group	47	19.31	1.71		
Control group	57	19.42	1.51		
3 Months					
Between groups	104			0.578	0.440
Intervention group	47	19.62	1.06	0.227	0.123
Control group	57	19.46	0.169	0.699	0.341
6 Months					
Between groups	104			0.921	0.157
Intervention group	47	19.70	1.06	0.115	0.056
Control group	57	19.68	0.69	0.171	0.135
9 Months					
Between groups	42			0.234	0.441
Intervention group	15	19.80	0.414	0.028	0.034
Control group	27	19.56	0.892	0.032	0.074
12 Months					
Between groups	22			0.006	0.019
Intervention group	8	20.00	0.000	0.095	0.102
Control group	14	19.43	0.646	0.635	0.763

Results of two-tailed *t* tests and Wilcoxon signed rank tests for two independent groups and paired samples for within-group at 3, 6, 9, and 12 months in study. Effect size on cognitive status showing significant and nonsignificant findings.

DISCUSSION

Combining home telehealth, nurse case management, and patient-centered care has the potential to control healthcare costs effectively and optimize wellness, especially for an increasing elderly population with shortened life spans and with complex, chronic co-morbidities.[29] A primary goal of our project was to implement a coordinated telecommunication monitoring system for detecting early signs of instability and implement early intervention

TABLE 6. QUALITY-OF-LIFE MEASURE: FUNCTIONAL LEVEL

Functional level	n	M	SD	p	z
Baseline					
Between groups	104			0.035	0.04
Intervention group	47	37.02	9.25		
Control group	57	40.19	4.47		
3 Months					
Between groups	104			0.780	0.058
Intervention group	47	37.17	9.15	0.801	0.601
Control group	57	39.88	5.38	0.546	0.959
6 Months					
Between groups	104			0.146	0.073
Intervention group	47	37.91	9.22	0.138	0.162
Control group	57	40.19	5.81	1.00	0.558
9 Months					
Between groups	42			0.195	0.125
Intervention group	15	38.67	5.63	0.646	0.624
Control group	27	40.96	4.83	0.597	0.452
12 Months					
Between groups	22			0.799	0.868
Intervention group	8	37.63	6.21	0.107	0.089
Control group	14	38.29	4.78	0.417	0.440

Results of two-tailed t tests and Wilcoxon signed rank tests for two independent groups and paired samples for within-group at 3, 6, 9, and 12 months in study. Effect size on functional level showing nonsignificant findings.

TABLE 7. QUALITY-OF-LIFE MEASURE: PATIENT SATISFACTION

Satisfaction with care	n	M	SD	p	z
Baseline					
Between groups	104			0.154	0.066
Intervention group	47	103.55	17.54		
Control group	57	98.70	16.63		
3 Months					
Between groups	104			0.001	0.001
Intervention group	47	110.8	18.32	0.001	0.001
Control group	57	98.98	17.24	0.825	0.834
6 Months					
Between groups	104			0.020	0.018
Intervention group	47	106.38	20.99	0.226	0.335
Control group	57	97.14	18.22	0.403	0.819
9 Months					
Between groups	42			0.119	0.152
Intervention group	15	109.13	23.21	0.454	0.451
Control group	27	98.11	16.58	0.032	0.074
12 Months					
Between groups	22			0.125	0.110
Intervention group	8	109.75	21.40	0.427	0.574
Control group	14	95.57	14.74	0.004	0.006

Results of two-tailed t tests and Wilcoxon signed rank tests for two independent groups and paired samples for within-group at 3, 6, 9, and 12 months in study. Effect size on patient satisfaction showing significant and nonsignificant findings.

measures to prevent costly and unnecessary resource use. Reinforcement and compliance were coupled to VACT's VA alert system, which triggered patient feedback for out-of-range data. We used subjective and objective quality-of-life tools to measure cognitive status, functional level, patient satisfaction with care, and self-rated health status. We expected that outcome quality-of-life data would not necessarily correlate with healthcare costs for BDOC, total clinic visits, urgent visits, and A1C levels in an aging high-risk population, with

TABLE 8. QUALITY-OF-LIFE MEASURE: SELF-RATED HEALTH STATUS

Health status	n	M	SD	p	z
Baseline					
Between groups	104			0.207	0.208
Intervention group	47	81.32	13.07		
Control group	57	84.86	15.33		
3 Months					
Between groups	104			0.755	0.590
Intervention group	47	81.34	13.71	0.984	0.728
Control group	57	82.25	15.83	0.070	0.129
6 Months					
Between groups	104			0.353	0.296
Intervention group	47	82.47	12.89	0.447	0.392
Control group	57	85.14	16.28	0.885	0.944
9 Months					
Between groups	42			0.596	0.763
Intervention group	15	84.40	13.23	0.980	0.776
Control group	27	82.11	13.34	0.757	0.893
12 Months					
Between groups	22			0.506	0.616
Intervention group	8	88.00	22.16	0.110	0.159
Control group	14	82.21	10.81	0.150	0.124

Results of two-tailed *t* tests and Wilcoxon signed rank tests for two independent groups and paired samples for within-group at 3, 6, 9, and 12 months in study. Effect size on self-rated health status showing nonsignificant findings.

TABLE 9. TOTAL HEALTH-CARE COSTS AND AVERAGE/PARTICIPANT HEALTH CARE COSTS FOR INTERVENTION AND CONTROL GROUPS AT 6 MONTHS PRE-STUDY AND 6 MONTHS ENROLLED IN STUDY

Cost item	*Intervention pre-study* (n = 15)	*Control pre-study* (n = 57)	*Intervention post-study* (n = 47)	*Control post-study* (n = 57)
RN/home visits	$11,067	$9,672	$8,742	$9,579
BDOC	$273,918	$567,126	$46,296	$204,474
Coumadin[a]	($1,185)	($1,620)	($1,230)	($960)
Total visits[b]	$34,100	$46,550	$34,100	$41,900
Urgent visits[c]	$16,000	$15,100	$11,850	$15,350
Transport,[d] VA cost	$35,811	$44,816	$32,258	$40,538
Transport, cost patient	$18,186	$22,759	$16,381	$20,586
Telehealth Unit	$0	$0	$78,302	$0
Total cost/Participant	$8,278	$12,386	$4,849	$5,832

Total sample, $n = 104$; intervention group, $n = 47$; control group, $n = 57$.

[a]Coumadin Clinic visits listed to demonstrate real-world costs without an approved, alternative safe, valid, and reliable method.

[b]Total Clinic visits represent all scheduled visits.

[c]Urgent Clinic visits represent all unscheduled visits.

[d]Criteria for VA-paid transportation: Category C (low income), service-connected disability and unstable medically. An average of 50% participants in each group met inclusive criteria and received VA-paid transportation. The remaining 50% of participants used private sources for transportation to the health-care facility.

chronic and complex co-morbidities, shortened life span, and fluctuating perceptions of well-being.

Although our data show that BDOC dropped for the intervention and control groups (an expected effect of nurse case management), the telehealth group showed a significant additional drop in BDOC and a significant drop in unscheduled (urgent) visits at 6 months.

Health and quality of life are multidimensional constructs that are weighted differently by each individual during health and illness and during end-of-life stages. Satisfaction with care and self-rated health status belong to a particular moment in time and represent shifting areas of life deemed important by the individual.[26] Psychological, social, and spiritual elements are interwoven and impact well-being, functional level, and satisfaction with life.[27] This complex, personal, and varying character may explain why, in our study, quality of life outcomes did not correlate with each other or with outcomes for health resource use. The intervention group showed improved cognitive status at 12 months whereas three other measures for quality of life showed no improvement. In contrast, the control group showed improved patient satisfaction with care whereas three other measures for quality of life showed no improvement. It may be that for the intervention group, operating the telehealth unit functions provided mental stimulation but not intrinsic motivation. It required repetitive task completion and commitment regardless of the desire to perform the functions because noncompliance with prescribed telehealth unit tasks triggered VA alerts and follow-up telephone calls to the patient. This kind of regular reinforcement strategy is known to improve compliance and health outcomes but does not correlate with satisfaction with care.[14]

Similar reasoning applies to the significant decrease in A1C levels observed in the intervention group but not for the control group. Diabetics in both groups performed home fingerstick glucose monitoring, but compliance was more likely with telehealth participants because glucose readings outside preset ranges triggered VA alerts and follow-up phone call inquiries. Other studies have found that telehealth works as an effective reinforcement tool for promoting long-term compliance for diabetics through human motivation, perceptions of diabetic patient centeredness, perceived autonomy self-determination, and perceptions of providers' autonomy supportiveness.[15]

Caregivers were skewed toward the intervention group and might have been expected to bias outcome data for quality of life and resource use. Nevertheless, no relationship was shown between functional level, satisfaction with care, or self-perceived health status and the presence or absence of caregivers. Only cognitive status showed significant improvement at 12 months for the few remaining active participants in the intervention group.

Participants receiving home telehealth used fewer RN home visits, BDOC, unscheduled (urgent) visits, and transportation to the healthcare facility. Telehealth added $1666.00 to outcome costs during 6 months in study. Nevertheless, healthcare costs decreased by 58% for the telehealth group. Participants in the control group with usual home healthcare services fewer BDOC, scheduled (total) visits, and transportation to the healthcare facility during 6 months in the study. Health-care costs dropped by 47% for the control group. Nurse case management was the variable shared by the intervention and control groups and was expected to alter healthcare costs for both groups.

Home telehealth supported by nurse case management and a comprehensive EPR enables homebound patients to participate actively in their healthcare through feedback and healthcare provider collaboration. Unstable events are deemed preventable inasmuch as early symptoms and signs of instability are targeted with early intervention measures through automated, electronic, VA-alert systems. Reductions in healthcare costs showed a direct relationship between home telehealth and elimination of unnecessary RN home visits, urgent visits, emergency room visits, and hospitalization.

Time-saving and cost-saving strategies improve efficiency and productivity in multiple interrelated ways: (1) data collection with peripheral device in the home environment, (2) transmission of data over POTS lines, (3) automatic electronic medical entry of within-range data, (4) automatic VA alert and pager activation of nurse case manager for out-of-range data, (5) trigger of out-of-range data into electronic templated progress notes with intervention strategies and patient education, (6) patient/specific nurse case manager/provider collaboration, and (7) patient-specific disease feedback. Time from data transmission to templated progress note drops to 10 minutes, which saves 90–120 minutes of RN time and eliminates unnecessary home visits for monitoring vital signs. Home telehealth prevents unnecessary primary care clinic visits through early detection, diagnosis, and intervention, a saving of 30 or more minutes of primary care clinician's time.

A reduction in number of home visits, clinic visits, and bed-days-of-care enhances productivity for healthcare team members by opening time frames to enroll larger numbers of homebound patients into home-based RN programs and expand caseloads for clinicians. Fewer hospitalized patients translates to greater flexibility for hospital-based personnel to care for in-patients with the greatest healthcare needs.

We collected Coumadin cost data to demonstrate high costs for traditional methods of performing anticogulation tests. Variation in total number of Coumadin Clinic visits for each group pre-study and during the study reflected high risks associated with anticogulation and frequency rates for blood tests from weekly to monthly depending on INR levels. All of the three traditional methods are costly: (1) An RN home visit for blood drawing, (2) blood tests in the healthcare facility, or (3) blood tests in a community laboratory. Each method significantly increases healthcare costs. Currently there is no approved safe, valid, and reliable method for INR/PT to be performed at home using telehealth.

CONCLUSION

This project targeted an elderly population with congestive heart failure, COPD, and DM—three of the highest users of healthcare resources. Outcomes demonstrated that connecting homebound patient data with the healthcare facility's electronic database provides mechanisms for early intervention, efficient reinforcement strategies, increased patient compliance, and decreased unnecessary resource use. The home telehealth unit added an additional cost. Nevertheless, a significant decrease in healthcare costs was shown for the intervention group.

Home telehealth did not influence patient satisfaction. In our pilot study, the home telehealth unit was equipped with a video screen for viewing by nurses at the central station. Patients communicated by voice with nurses in the central station. The pilot study telehealth group showed higher satisfaction with care than the control group. Videoconferencing adds a supportive link between patient and provider and supports the assumption that videoconferencing between patient and healthcare provider directly influences patient sat isfaction.[10] Socioeconomic, technological, political, and professional barriers impede implementation of high-quality, two-way, video-image conferencing between remote patients and healthcare facility-based providers. The infrastructure at state and national levels lacks uniform policies and standards for healthcare facilities and for patient confidentiality issues. A national licensing system could eliminate legal and regulatory inconsistencies that block the current system. Corporate economic strategies add additional barriers through competition, arbitrary boundaries for services, and high costs to support broadband connectivity. Public and private payers' reluctance to establish reimbursement policy at lower levels adds another obstacle to broader deployment of real-world telemedicine.[4]

We recommend that researchers conduct multiple-site, large-sample, home telehealth studies with videoconferencing between patient and provider in particular studies that target high resource users, build on knowledge already learned, and analyze cost effectiveness for real-world application.[30,31] Safe, valid, reliable, low-cost methods to perform home INR/PT levels should significantly reduce healthcare costs and reduce risks of bleeding among elderly patients requiring anticoagulation.[32]

Managing the health complications of disability is costly and preventable. Research studies are recommended to meet rehabilitation needs of homebound people through telerehabilitation. Videoconferencing and video streaming provide the means to enhance patient education in rehabilitative therapeutics. Video streaming enables clinicians to offer intensive rehabilitative services for homebound patients. Videoconferencing lets providers view and assess functionality and rehabilitative exercise regimens, and enhances patient satisfaction. Home telerehabilitation encourages shortened rehabilitation hospital stays, less use of expensive community rehabilitative practitioners, and transparent teleconsultation by specialists. Concurrently, telehealth is used to monitor medical conditions and prevent signs of instability.[33]

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