Clinical Nursing Research
http://cnr.sagepub.com/

Impact of Telehealth on Clinical Outcomes in Patients With Heart Failure

Kathryn H. Dansky, Joseph Vasey and Kathryn Bowles

Clin Nurs Res 2008 17: 182
DOI: 10.1177/1054773808320837

The online version of this article can be found at:
http://cnr.sagepub.com/content/17/3/182

Published by:
SAGE
http://www.sagepublications.com

Clinical Nursing Research
Volume 17 Number 3
August 2008 182-199

10.1177/1054773808320837
http://cnr.sagepub.com
hosted at
http://online.sagepub.com

Impact of Telehealth on Clinical Outcomes in Patients With Heart Failure

Kathryn H. Dansky
Joseph Vasey
Pennsylvania State University, University Park
Kathryn Bowles
University of Pennsylvania, Philadelphia

The purpose of this randomized field study was to determine the effects of telehomecare on hospitalization, emergency department (ED) use, mortality, and symptoms related to sodium and fluid intake, medication use, and physical activity. The sample consists of 284 patients with heart failure. The authors used logistic regression to study the effects of telehomecare on health services utilization and mortality and a general linear model to analyze changes in self-reported symptoms. On average, patients in the telehomecare groups had a lower probability of hospitalizations and ED visits than did patients in the control group. Differences were statistically significant at 60 days but not 120 days. Results show a greater reduction in symptoms for patients using telehomecare compared to control patients. The technology enables frequent monitoring of clinical indices and permits the home health care nurse to detect changes in cardiac status and intervene when necessary.

Keywords: *telemedicine; heart failure; hospitalization; monitoring, home care services*

Telehomecare is a telephone-based technology that enables individuals to transmit, electronically, health-related data to nurses and other health providers. The convergence of telephone systems and information technology has enormous implications for managing chronic illnesses such as heart failure (HF). Anecdotal reports suggest that telehomecare is appropriate for persons who need timely monitoring and feedback about their health status. However, research is needed to confirm these assumptions.

Authors' Note: This study was supported by the Robert Wood Johnson Foundation through the Health E-Technologies Initiatives.

This article discusses findings from an empirical study that tested the effects of a telehomecare intervention in a sample of Medicare-eligible persons with HF, a major health problem affecting more than 5 million Americans (National Heart Lung and Blood Institute, 2007). The economic burden of this disease is staggering; total medical expenditures for HF are estimated to be $33.2 billion in 2007, and elders with HF have the highest rehospitalization rate of all adult patients (American Heart Association [AHA], 2007). The major goals of treatment for persons with HF are to increase self-management, improve health status, and decrease the costly use of health services; thus, telehomecare appears to be a disease management strategy with much potential.

Background

A form of telemedicine, "telehomecare" is a telephone-based communication system with medical peripherals that is used in the home setting. Patients use the medical devices to assess their health status and transmit the data to clinicians for review and action. Nurses and other clinicians use the data to monitor patients' health and teach patients and their caregivers self-management behaviors. Measurement and transmission of blood pressure, temperature, weight, blood glucose levels, and pulse oximetry are possible with the newest generation of models. Some models also provide audio and video contact and digital stethoscopes.

Empirical studies of telehomecare are increasing, albeit slowly. Johnston, Wheeler, Deuser, and Sousa (2000) conducted the first published study of telemedicine in a sample of home health care patients and concluded that this technology is effective, well received by patients, and offers quality care while reducing costs. A review of the literature found several studies that tested for a specific relationship between telehomecare and hospitalization, with mixed results. Bondmass, Bolger, Castro, and Avitall (1999) and Benatar, Bondmass, Ghitelman, and Avitall (2003) studied the effects of home monitoring and found that admissions and length of hospital stay were significantly decreased for HF patients after the implementation of telehomecare. Cordisco, Beniaminovitz, Hammond, and Mancini (1999) evaluated a device that asks patients symptom-related questions, records their weight, and transmits the information to nurses for evaluation. Patients using the technology had lower rehospitalization rates and emergency department (ED) visits. Shaul (2000) tested telehomecare with elders who had one or more chronic illnesses and were at risk for rehospitalization and found that telehomecare patients had fewer hospitalizations, although results were not statistically significant. A study with diabetic home care patients found that those using telehomecare were significantly less likely to be rehospitalized (Bowles & Dansky, 2002; Dansky, Bowles, & Palmer, 2003).

More recently, a study conducted by a Veterans Affairs program found that telehomecare use resulted in greater improvements in mental health, but no statistically significant differences were found in inpatient admissions or ED visits (Hopp et al., 2006). Although the study was randomized, the sample size consisted of only 37 patients, all of whom had a variety of diagnoses. Jerant, Azari, and Nesbitt (2001) compared the use of home telehomecare to nurse telephone calls and usual outpatient care. Mean HF-related readmissions were lower in the telehomecare group and telephone group, but the between-group difference was not significant, suggesting that telehomecare may not offer incremental benefits beyond telephone follow-up and may be more expensive.

The studies described here consisted of small sample sizes, making it difficult to draw conclusions regarding the clinical efficacy of telehomecare. Bowles and Baugh (2007), in their review of telehomecare studies, suggest that a causal relationship between telehomecare and positive clinical outcomes has yet to be shown because most prior studies have had small sample sizes. Despite these difficulties, the increasing use of telehomecare in clinical agencies is a compelling reason to continue research on its efficacy and effectiveness.

In this article, we report empirical findings related to the effects of a telehomecare system on hospital and ED encounters, mortality, and HF symptoms in a sample of persons with HF. Furthermore, we describe the features of different types of telehomecare systems and compare clinical outcomes for each. No previous studies have examined differences in outcomes based on type of machine, a unique contribution of the current study.

Methods

Design

The research design was a prospective, randomized field experiment, with a treatment group and equivalent control group in 10 home health agencies (HHAs) located in one mid-Atlantic state. Patients in the treatment groups received a telehomecare system for the duration of their home health services, to be used in conjunction with usual home health care. (Note: The standard episode of home health services under Medicare regulations is 60 days. Patients may be discharged before then. If continued care is required, they are recertified for another 60-day episode.) Equipment was removed when the patient was discharged from home health services. Patients in the control groups received routine home visits only. Data on all patients were collected for 120 days.

Sample and Procedures

The study sample was drawn from a pool of patients admitted to the 10 participating HHAs for skilled home care. Patient enrollment began in March 2004 and ended December 31, 2005. All patients with primary or secondary diagnoses of HF and ability to communicate in conversational English were eligible to participate and were recruited for the study. During the admission visit, the home health nurse documented that the patient was cognitively intact, able to see and hear the equipment, and had a phone line in the home. The nurse explained the purpose of the study and obtained written consent making sure the patient understood that refusal would not affect their home care. (Procedures were approved by the university institutional review board and met Health Information Portability and Accountability Act requirements.) The project manager at each HHA randomly assigned the patient to the intervention or control group, using a sealed, opaque envelope technique. There was one intervention group and one control group at each HHA. Each patient in the study received a packet of information on HF, providing basic facts on the disease, guidelines on self-management, and specific instructions on when to notify his or her home care nurse or personal physician.

We conducted a series of training sessions with supervisors and registered nurses at each HHA. The purpose of these sessions was to review procedures for recruiting and enrolling patients, and to address quality of care issues. In addition, a nurse researcher on the study team reviewed the HF clinical pathways used at each HHA to determine if the pathways addressed specific guidelines recommended by the AHA and to assess congruence in care across agencies. We concluded that all agencies had clinical pathways in place that were similar and up to date with AHA guidelines. After enrollment began, we conducted monthly conference calls to address technical issues and emphasize consistency in patient care among the HHAs.

The Telehomecare Systems

Telehomecare systems were purchased or leased from vendors whose products are approved by the Food and Drug Administration and the Federal Communications Commission. The systems operate over telephone lines via a standard modem, linking a central station at the HHA to remote units in homes or other settings. Two types of systems were used in this study, a one-way (asynchronous) monitoring system and a two-way (synchronous) monitoring system. The HHA determined the type of system used.

The one-way monitoring system allows a patient to take his or her own measurements (e.g., blood pressure, pulse, weight) through peripheral devices and transmit the readings to the HHA. The one-way monitoring systems used in the study were either the HomMed Health Monitor or the ViTel Net system. The one-way systems are used independently by the patient and are typically programmed to be used every day at a predetermined time (usually 11:00 a.m.). If the nurse who checks the transmitted data observes abnormal values, he or she may call the patient or the home care nurse for further information or intervention.

The two-way system (Aviva) adds a video camera and digital stethoscope to the monitoring device, permitting two-way synchronous interaction between nurse and patient. Monitoring sessions are scheduled by the home care nurse according to the patient's condition and care plan, usually two to three times per week. Patients can use the system as often as they wish to monitor their condition, but for the model used in this study, the data were stored offline, and later transmitted to the nurse during the synchronous connection. During this live connection, the nurse reviewed all data downloaded from the patient's independent use of the equipment and discussed the results with the patient. The nurse also used the digital stethoscope to listen to the patient's heart and lungs. Vital signs, blood sugar, or pulse oximetry readings were collected as ordered by the physician. The nurse used the audio and video to interact with the patient to discuss symptoms, diet, medications, and physical activity.

Regardless of the type of system being used, a central station at the HHA tracks and displays data for analysis by the home health nurses and physicians. If a patient's clinical measurements fall outside of preset parameters, alarms enable immediate detection of problems. The central station also is designed to flag late or missing measurements to alert clinicians to a potential problem. An authorized clinician can access the patient's medical record data in the database viewing vital signs data and still images. Access to the electronic medical record is restricted to users who are on the internal network and who have authorized user names and passwords. Communications among the central station, network server, and electronic medical record database are encrypted for privacy. The systems in this study were not programmed to provide health instruction or educational material.

Instruments and Measures

Study data were collected on admission, 60 days later to coincide with a standard "episode of care" for home health services and 120 days after admission. Three research assistants who were blinded to the study group collected patient data via a telephone interview at each data point. The research assistants were all graduate students in health services and trained to use the instruments in the study.

Health services utilization data were collected at 60 and 120 days from the patient's medical record at the HHA. In addition, the research assistant asked the patient, during the telephone interviews, if any ED visits or hospitalizations had occurred. This self report was verified by a review of the hospital records for the appropriate time period.

The Omaha System Problem Rating Scale for Outcomes (PRSO) was used to measure symptoms of HF related to sodium and fluid intake, medication effectiveness, and physical activity. The PRSO is suited for assessing patients with a wide range of functioning. The internal consistency of the scales, tested in previous studies, ranges from .76 to .82 (Martin, Scheet, & Stegman, 1993). The instrument assesses symptoms that may be related to sodium and fluid intake, such as presence of edema, shortness of breath, and weight gain. For physical activity, the distance walked and severity of symptoms, such as shortness of breath on exertion, were assessed. Side effects and medication efficacy were assessed to determine symptom status related to medications. The blinded research assistant evaluated patient responses to probe questions in each area and assigned a numerical score ranging from 1 (*extreme symptoms*) to 5 (*no symptoms*). In this coding scheme, a higher score indicates more favorable status.

Additional data were collected from the HHAs to control for factors that may influence patient outcomes, including gender, age, race, number of comorbidities, and severity. The home health nurse collected these data using the Outcome and Assessment Information Set admission instrument (the standardized assessment tool mandated for all Medicare reimbursable HHA admissions).

Analysis and Results

Descriptive statistics were calculated for all variables of interest (see Table 1).

Group assignment was dummy coded for control (0) and telehomecare (1) initially, and then for control (0), one-way monitor (1), and monitor and video (2) in subsequent analyses. (To simplify terminology in this section, we refer to the one-way monitoring systems as "monitor" and to the monitor and video systems as "video".)

Student *t* tests were conducted to determine if the groups differed on any baseline characteristics such as age, race, or severity score. None of the

Table 1
Descriptive Statistics at Time 3 (120 Days)

			Intervention Group		
		Control	Monitor Only	Monitor and Video	Total
Number of skilled nursing visits	Valid *n*	112	127	45	284
	Mdn	10.50	11.00	11.00	11.00
	M	11.75	12.76	12.49	12.32
	SD	7.53	8.82	7.38	8.10
Hospitalizations during HHA episode of care	Valid *n*	110	126	45	281
	Mdn	0.00	0.00	0.00	0.00
	M	0.41	0.40	0.44	0.41
	SD	0.73	0.67	0.89	0.73
ED visits during HHA episode of care	Valid *n*	109	125	44	278
	Mdn	0.00	0.00	0.00	0.00
	M	0.39	0.30	0.30	0.33
	SD	0.64	0.57	0.85	0.65
Total hospitalizations (120 days)	Valid *n*	111	127	45	283
	Mdn	0.00	0.00	0.00	0.00
	M	0.60	0.54	0.53	0.56
	SD	0.91	0.78	0.97	0.86
Total ED visits (120 days)	Valid *n*	112	127	45	284
	Mdn	0.00	0.00	0.00	0.00
	M	0.48	0.35	0.42	0.42
	SD	0.75	0.58	0.87	0.70
Age	Valid *n*	112	127	45	284
	Mdn	78.00	79.00	79.00	78.00
	M	76.88	76.72	78.11	77.00
	SD	10.00	10.52	7.11	9.83

(continued)

Table 1 (continued)

		Intervention Group			
		Control	Monitor Only	Monitor and Video	Total
Severity (range = 1 to 4)	Valid *n*	110	126	44	280
	Mdn	3.00	3.00	2.00	3.00
	M	2.74	2.83	2.41	2.73
	SD	0.73	0.68	0.76	0.72
Diet (sodium and fluids) symptoms (range = 1 to 5 on PRSO)	Valid *n*	58	50	18	126
	Mdn	4.00	4.00	3.00	4.00
	M	3.43	3.74	2.89	3.48
	SD	1.27	1.21	1.08	1.24
Physical activity symptoms (range = 1 to 5 on PRSO)	Valid *n*	55	49	17	121
	Mdn	3.00	3.00	2.00	3.00
	M	2.87	3.49	2.47	3.07
	SD	1.06	2.53	0.87	1.82
Medication effectiveness symptoms (range = 1 to 5 on PRSO)	Valid *n*	56	49	18	123
	Mdn	4.00	4.00	4.00	4.00
	M	4.02	3.96	4.00	3.99
	SD	0.52	0.61	0.59	0.57

Note: HHA = home health agency; ED = emergency department; PRSO = Omaha System Problem Rating Scale for Outcomes.

demographic or clinical characteristics were found to be significantly different for the groups at baseline. At Time 3, patients in the telehomecare groups had a greater length of stay in home care (69 days versus 62 days). The number of days in home care (HHA days) was significantly correlated with several outcomes, and thus, was included as a control variable.

In three separate equations, logistic regression was used to predict the likelihood of hospitalization, ED visits, or death. The objective of these analyses was to determine the relationship between type of intervention and clinical outcomes, controlling for other significant factors. An advantage of this procedure is that logistic regression has no assumptions about the distribution of the predictor variables; they can be any combination of continuous, discrete, or dichotomous variables (Tabachnik & Fidell, 2001).

Hospitalizations

We conducted several analyses to test for differences in hospitalizations. First, we compared the proportions of patients in the three groups with regard to having none versus one or more hospitalizations during episodes of care and during the duration of the study. Table 2 shows a trend for telehomecare patients to be somewhat less likely than control patients to have had one or more hospitalizations, particularly during the entire study period, as opposed to the immediate episode of care. However, the differences among proportions are not statistically significant. Small sample size precluded the comparisons from achieving statistical significance—power is estimated at below .45.

The average number of hospitalizations, controlling for the number of days in home care (HHA days), was similar for the control and treatment groups for both periods (60 and 120 days). Overall, there was a tendency for telehomecare patients, as a group, to have fewer hospitalizations at both points in time; however, the differences were statistically significant only at 60 days. Likewise, comparisons among groups for patients with one or more hospitalizations showed that patients in the control group had the highest number of hospitalizations in both time periods.

Within the telehomecare groups, patients with the video systems had the lowest number of hospitalizations at both points in time (see Table 2). However, the within-group comparisons were not statistically significant; small sample sizes precluding the analyses from achieving statistical significance (power is estimated at below .30). Similarly, logistic regression models did not identify significant predictors of the likelihood of having one or more hospitalizations at either 60 days or during the entire 120-day study period.

Table 2
Hospitalizations

	60 Days						Full Study Period (120 Days)					
	Percentage		Mean Number of Events		Logistic Model		Percentage		Mean Number of Events		Logistic Model	
	None	1 or More	Overall	1 or More	Odds Ratio	CI	None	1 or More	Overall	1 or More	Odds Ratio	CI
Intervention group												
Control	70.9	29.1	0.45	1.43	(referent group)		59.5	40.5	0.63	1.50	(referent group)	
Monitor only	70.6	29.4	0.40	1.37	0.98	0.55-1.77	62.2	37.8	0.54	1.42	0.88	0.51-1.15
Monitor and video	68.9	31.1	0.34	1.31	0.76	0.32-1.80	64.4	35.6	0.46	1.45	0.73	0.33-1.62
Home health days					1.01	1.00-1.01					1.00	0.99-1.01
RN visits					0.99	0.94-1.04					0.99	0.94-1.04
Home health visits					1.03	1.01-1.05					1.03**	1.00-1.05
Sex (female)					1.28	0.73-2.26					1.32	0.78-2.22
Age					1.00	0.97-1.03					0.98	0.96-1.01
Case severity					0.83	0.56-1.22					1.04	0.73-1.48
Logistic model fit χ^2					24.47***						13.98*	

Note: $N = 284$. CI = confidence interval.
*$p < .10$. **$p < .05$. ***$p < .01$.

Emergency Visits

Telehomecare patients had fewer ED visits than patients in the control group. At 60 days, approximately 30% of the control group had had an ED visit, compared to 24% of the monitor group and 18% of the video group. The differences are less striking at 120 days, but follow the same pattern: 36% of the control group had an ED visit, compared to 30% of the monitor group and 31% of the video group. On the whole, only 22% of the telehomecare patients (monitor or video) reported an ED visit during their 60-day episode of treatment. Because of the small sample size and resulting lack of statistical power, the difference in proportions did not achieve statistical significance ($z = 1.31$, $p = .09$).

Logistic regression models of ED visits at 60 and 120 days reflect these findings. Compared to the nonintervention (control) group, patients using either type of telehomecare system were less likely to have one or more ED visits. The difference between the nonintervention and video group was statistically significant at 60 days: The odds ratio (OR) for the video group was 0.35 ($p < .05$). The monitor group was also less likely to have had an ED visit (OR = 0.69, $p > .10$), but the size of the effect was not statistically significant. The ORs for both intervention groups were lower but not significantly different from the control group at 120 days. The tendency for telehomecare system users to have fewer ED visits persisted beyond the episode of care. During the entire study period (120 days), more than 36% of the control group patients had one or more ED visits, compared to 30.2% in the intervention group. However, this difference was not statistically significant ($z = 0.78$, $p = .22$)

These findings are echoed by a comparison of marginal means, controlling for number of HHA days, which showed a tendency for the control group to have, on average, more ED visits than either intervention group. Again, small sample size precluded the comparisons from achieving statistical significance—power is estimated at .42.

Although the comparisons of proportions and means did not achieve statistical significance, the findings suggest that the use of the telehomecare system may have decreased the overall incidence of visits to the ED. At 60 days, the average number of ED visits for members of the control group (0.42) is 40% higher than the monitor group (0.30) and twice as high as the video group (0.21). These figures represent a potential savings in the number of ED visits that may be clinically and financially significant.

(text continues on page 196)

Table 3
Emergency Department Visits

	60 Days						Full Study Period (120 Days)					
	Percentage		Mean Number of Events		Logistic Model		Percentage		Mean Number of Events		Logistic Model	
Intervention Group	None	1 or More	Overall	1 or More	Odds Ratio	CI	None	1 or More	Overall	1 or More	Odds Ratio	CI
Control	69.7	30.3	0.42	1.28	(referent group)	64.3	35.7	0.51	1.36	(referent group)		
Monitor only	76.0	24.0	0.30	1.26	0.69	0.39-1.25	70.1	29.9	0.36	1.20	0.76	0.44-1.33
Monitor and video	81.8	18.2	0.21	1.49	0.35**	0.13-0.92	68.9	31.1	0.35	1.29	0.75	0.33-1.70
Home health days					1.01**	1.00-1.01					1.00	0.99-1.01
RN visits					0.98	0.93-1.03					0.99	0.94-1.04
Home health visits					1.03**	1.00-1.05					1.02	1.00-1.04
Sex (female)					1.08	0.61-1.94					1.05	0.62-1.78
Age					1.01	0.98-1.04					0.99	0.97-1.02
Case severity					0.99	0.67-1.47					1.12	0.78-1.61
Logistic model fit χ^2					20.53***						7.82	

Note: N = 284. CI = confidence interval.
*p < .10. **p < .05. ***p < .01.

Table 4
Changes in Self-Reported Clinical Status (Time 1 to Time 2)

	Time	*n*	*M*	*SD*	*F*	Sig.
Diet-related symptoms						
	1					
0—Control		49	3.04	1.172		
1—Monitor only		53	3.42	1.064		
2—Monitor and video		21	2.76	1.044		
	2					
0—Control		49	3.10	1.159		
1—Monitor only		53	3.53	1.295		
2—Monitor and video		21	3.14	1.276		
Intercept					429.367	.000
HHA days					0.820	.367
Intervention (monitor or monitor and video)					3.228	.043
Physical activity status						
	1					
0—Control		47	2.64	0.895		
1—Monitor only		51	2.63	0.894		
2—Monitor and video		19	2.58	1.017		
	2					
0—Control		47	2.70	0.976		
1—Monitor only		51	2.86	0.939		
2—Monitor and video		19	2.53	1.020		
Intercept					389.530	.000

(continued)

Table 4 (continued)

	Time	*n*	*M*	*SD*	*F*	Sig.
HHA days					0.325	.570
Intervention (monitor or monitor and video)					0.314	.731
Medication effectiveness						
	1					
0—Control		47	3.79	0.806		
1—Monitor only		52	4.19	0.687		
2—Monitor and video		20	4.00	0.649		
	2					
0—Control		47	3.81	0.741		
1—Monitor only		52	4.25	0.556		
2—Monitor and video		20	3.95	1.191		
Intercept					1862.97	.000
HHA days					0.089	.766
Intervention (monitor or monitor and video)					7.527	.001

Note: HHA = home health agency.

Mortality

We used logistic regression to model the likelihood of death at 120 days. Results show that the intervention group was not a statistically significant predictor of death. However, patients in the intervention groups tended to be less likely to die than patients in the control group, and that effect is much more pronounced for the one-way monitoring group ($p = .11$) than for the video group ($p = .47$). The statistical power of this analysis at the .05 level is estimated to be .65.

HF Symptoms

We used a General Linear Model to analyze changes in symptoms of HF. Very small sample sizes at Time 3 precluded analyses of data across the three data points; thus, we analyzed changes from Time 1 to Time 2 only. Controlling for HHA days in each of the models from Time 1 to Time 2 (diet-related symptoms, physical activity status, and medication effectiveness) we found that telehomecare patients reported fewer symptoms than control group patients, although the differences were not always statistically significant. Further post hoc analysis found that patients in the one-way monitoring group showed significantly greater improvement in self-reported symptoms related to diet and medications than patients in either the video group or control group (see Table 4).

Limitations

A limitation to this study is the sample size. Using Cohen's (1988) power analysis method, a conservative effect size of 0.2 would require a sample size of 394 to achieve statistical power of .80. Despite aggressive recruiting efforts, repeated training sessions for managers and nurses, and an extended study period, we were not able to meet recruiting goals in several of the HHAs. Our final sample size was 284 at Time 3. Patient failure to complete telephone interviews at either Time 2 or Time 3 further reduced the sample size. The small number of participants in some of the models greatly reduced the statistical power.

A second limitation is that there was no control on what type of system the participant received because the intervention was dependent on the systems used by the HHA. Random assignment to a type of system would further enhance the rigor of this design.

Conclusions

Our findings add to the growing body of evidence that telehomecare has positive effects on outcomes related to HF. Regarding symptoms, the repeated measures analysis of symptom scores found that telehomecare patients improved more than control group patients, for symptoms related to sodium and fluid intake, and in medication effectiveness, but not for physical activity status. We suggest that the monitoring provides a feedback mechanism that supports appropriate behaviors to manage HF.

The score for physical activity symptoms evaluated the patient’s ability to walk or climb stairs without shortness of breath or fatigue. Study findings suggest it may be difficult to achieve improvements in physical activity with telehomecare monitoring and that in-person physical therapy may be needed to address the debilitating effects of HF on physical activity.

Patients who used a telehomecare system experienced fewer hospitalizations than those who did not, and patients in the video group had the lowest number of hospitalizations during the 120-day study period and during the home health episode of care. We conclude that the frequent monitoring of clinical measures enabled the nurse to assess cardiac status and intervene in a timelier manner than home visits alone would permit. Furthermore, the increased number of nurse encounters via the video system facilitates other important nursing activities, such as teaching, providing feedback, and offering psychosocial support. We did not test this relationship and recommend that the structure and content of video visits be studied.

For persons with HF, study findings suggest that telehomecare monitoring may reduce ED use. As noted in Table 4, approximately 70% of patients who used telehomecare had no ED events during the 120 days, compared to 64% of patients in the control group. Furthermore, the adjusted mean number of events was lower for telehomecare patients at both 60 days and 120 days. The ability for the nurse to act quickly on symptoms that otherwise would lead to a costly ED visit or hospitalization is clearly a clinical benefit of using the telehomecare system. Because statistically insignificant results do not rule out the possibility of clinically important results, and given the difficulty of fielding large studies of home care patients, we suggest that future research investigate the clinical importance of telehomecare as an intervention. The minimally important clinical difference of a therapy is defined as the smallest treatment effect that would result in a change in patient management, given its costs and inconveniences (Jaeschke, Singer, & Guyatt, 1989).

The future of telehomecare is promising. Emergent technologies that use the Internet offer research opportunities to study home-based management of chronic illnesses. Although similar to telephone-based technologies, they are different in that they require visual and manual skills to use a computer and adequate health literacy. As noted by Nguyen, Carrieri-Kohlman, Ranki, Slaughter, and Stulbarg (2004), these resources may be beyond the reach of disadvantaged individuals or those with limited reading levels. Thus, an empirical study comparing Internet-based and telephone-based technologies would be an important step in advancing chronic illness management.

In summary, we suggest that telehomecare, as an intervention, improves quality of care because it provides frequent monitoring of clinical indices that signal changes in cardiac status. The system permits the nurse to detect changes and intervene when appropriate. In addition, the system provides feedback to the patient, possibly facilitating self-management behaviors, such as taking additional diuretics or decreasing fluid intake, that ameliorate clinical symptoms before a crisis.

Our results will add to the growing body of literature that will inform and guide managers and policymakers who are responsible for integrating telehomecare into chronic disease protocols, funding health care programs, and creating policies that encourage the use of technology to support health care services. This information is critical for moving telehomecare from its current limited use to becoming an integral component of the nation's health care delivery system.

References

American Heart Association. (2007). Heart disease and stroke statistics—2007 update. A report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation, 115,* e69-e171.

Benatar, D., Bondmass, M., Ghitelman, J., & Avitall, B. (2003). Outcomes of congestive heart failure. *Archives of Internal Medicine, 163,* 347-352.

Bondmass, M., Bolger, N., Castro, G., & Avitall, B. (1999). The effect of physiologic home monitoring and telemanagement on chronic heart failure outcomes. *Internet Journal of Advanced Nursing Practice, 3*(2), 17.

Bowles, K. H., & Baugh, A. C. (2007). Applying research evidence to optimize telehomecare. *Journal of Cardiovascular Nursing, 22,* 5-15.

Bowles, K. H., & Dansky, K. H. (2002). Teaching self-management of diabetes via telehomecare. *Home Healthcare Nurse, 20,* 36-42.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* New York: Lawrence Erlbaum.

Cordisco, M. E., Beniaminovitz, A., Hammond, K., & Mancini, D. (1999). Use of telemonitoring to decrease the rate of hospitalization in patients with severe congestive heart failure. *American Journal of Cardiology, 84,* 860-862.

Dansky, K. H., Bowles, K. H., & Palmer, L. (2003). Clinical outcomes of telehomecare for diabetic patients. *Journal of Information on Technology in Healthcare, 1,* 61-74.

Hopp, F., Woodbridge, P., Subramanian, U., Copeland, L., Smith, D., & Lowery, J. (2006). Outcomes associated with a home care telehealth intervention. *Telemedicine Journal and eHealth, 12,* 297-307.

Jaeschke, R., Singer, J., & Guyatt, G. H. (1989). Measurement of health status: Ascertaining the minimal clinically important difference. *Controlled Clinical Trials, 10,* 407-415.

Jerant, A. F., Azari, R., & Nesbitt, T. S. (2001). Reducing the cost of frequent hospital admissions for congestive heart failure: A randomized trial of a home telecare intervention. *Medical Care, 39*(11), 1234-1245.

Johnston, B., Wheeler, L., Deuser, J., & Sousa, K. H. (2000). Outcomes of the Kaiser Permanente tele-home health research project. *Archives of Family Medicine, 9,* 40-45.

Martin, K., Scheet, N., & Stegman, M. (1993). Characteristics, outcomes of care, and nursing interventions. *American Journal of Public Health, 83,* 1730-1734.

National Heart Lung and Blood Institute. (2007). *Heart failure*. Retrieved July 13, 2007, from http://www.nhlbi.nih.gov/health/dci/Diseases/Hf/HF_WhatIs.html

Nguyen, H. Q., Carrieri-Kohlman, V., Ranki, S., Slaughter, R., & Stulbarg, M. (2004). Supporting cardiac recovery through ehealth technology. *Journal of Cardiovascular Nursing, 19*(2), 200-208.

Shaul, M. P. (2000). What you should know before embarking on telehome health: Lessons learned from a pilot study. *Home Healthcare Nurse, 18,* 470-475.

Tabachnik, B. G., & Fidell, L. S. (2001). *Using multivariate statistics* (4th ed.). Boston: Allyn & Bacon.

Kathryn H. Dansky, PhD, is an associate professor of health policy and administration at Pennsylvania State University.

Joseph Vasey, PhD, is an assistant professor of health policy and administration at Pennsylvania State University.

Kathryn Bowles, PhD, is an associate professor of nursing at the University of Pennsylvania.