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Reducing the Cost of Frequent Hospital Admissions for Congestive Heart Failure

A Randomized Trial of a Home Telecare Intervention

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BACKGROUND. The high cost of caring for patients with congestive heart failure (CHF) results primarily from frequent hospital readmissions for exacerbations. Home nurse visits after discharge can reduce readmissions, but the intervention costs are high.

OBJECTIVES. To compare the effectiveness of three hospital discharge care models for reducing CHF-related readmission charges: 1) home telecare delivered via a 2-way video-conference device with an integrated electronic stethoscope; 2) nurse telephone calls; and 3) usual outpatient care.

RESEARCH DESIGN. One-year randomized trial.

SUBJECTS. English-speaking patients 40 years of age and older with a primary hospital admission diagnosis of CHF.

MEASURES. Our primary outcome was CHF-related readmission charges during a 6-month period after randomization. Secondary outcomes included all-cause readmissions, emergency department (ED) visits, and associated charges.

RESULTS. Thirty-seven subjects were randomized: 13 to home telecare, 12 each telephone care and 12 to usual care. Mean CHF-related readmission charges were 86% lower in the telecare group ($5850, SD $21,094) and 84% lower in the telephone group ($7320, SD $24,440) than in the usual care group ($44,479, SD $121,214). However, the between-group difference was not statistically significant. Both intervention groups had significantly fewer CHF-related ED visits ($P = 0.0342$) and charges ($P = 0.0487$) than the usual care group. Trends favoring both interventions were noted for all other utilization outcomes.

CONCLUSIONS. Substantial reductions in hospital readmissions, emergency visits, and cost of care for patients with CHF might be achieved by widespread deployment of distance technologies to provide posthospitalization monitoring. Home telecare may not offer incremental benefit beyond telephone follow-up and is more expensive.

Key words: Telemedicine; heart failure; congestive; patient readmission; cost and cost analysis; home nursing. (Med Care 2001;39: 1234–1245)

More than 3 million Americans suffer from congestive heart failure (CHF),[1] and 400,000 are newly diagnosed annually.[2] It is the most common cause for hospitalization due to exacerbation of a chronic condition among adults aged 65 years and older in the United States,[3] leading to more than

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700,000 hospital admissions each year.[4] The high cost of caring for patients with CHF, which exceeds $10 billion per year,[1] is primarily due to frequent hospital readmissions for decompensation.[4] Readmission occurs in 20% to 50% of patients with CHF within 14 days to 6 months after discharge from an index admission.[5–9] Of these rehospitalizations 16% to 25% are due to CHF exacerbation.[6,8,10] Factors associated with an increased risk for readmission include unmarried status,[9] male gender,[8] index admission length of stay more than 7 days,[8] increasing comorbidity,[9] both low[9] and elevated systolic blood pressure,[7] under dosing of ACE inhibitors,[11] physician lack of knowledge regarding CHF management,[12] and dietary and medication nonadherence.[13] Conversely, no subgroup of hospitalized patients with CHF has been identified as being at "low risk" for readmission.[9]

Previous interventions to reduce CHF readmissions[7,9,14–24] have employed home nurses to provide disease and treatment education, bolster family support, and identify and manage early decompensation. In the most rigorously evaluated intervention, 90-day CHF readmission rates were reduced by 56% and cost savings of $460 per patient were realized.[7] Although these results are promising, the intervention costs of traditional home care strategies are high, and their broader application would present formidable challenges to health systems, leading to interest in using interactive video equipment to conduct "virtual" home visits.[25,26]

Home care delivered using such video technology is referred to as *home telecare* when provided by nurses, reserving the term *telemedicine* for remote care delivered by physicians.[27] Home telecare allows several patient encounters to occur in the same amount of time required to conduct one traditional visit, potentially reducing care costs. However, only case series[28–31] and quasi-experiments[32] involving home telecare have been reported. Rigorous trials comparing home telecare to "usual care" as well as "lower tech" approaches, such as patient education and treatment reminders delivered using regular telephones,[33,34] are required to determine if this technology offers clinical and cost benefits.[35]

Therefore, we conducted a pilot randomized trial comparing three care models for reducing CHF-related hospital readmission costs: 1) home telecare delivered via a 2-way video-conference device with an integrated electronic stethoscope; 2) nurse telephone calls; and 3) usual outpatient care. We hypothesized that during a 6-month period after randomization, CHF-related rehospitalization charges would be significantly lower in the telecare group than in the other groups.

Material and Methods

Study Population

Between July 1, 1999 and June 30, 2000, all patients admitted to the University of California Davis (UCD) Hospital with a primary admission diagnosis of CHF were screened for eligibility to participate in the trial. Patients with primary admission diagnoses of chronic obstructive pulmonary disease (COPD) exacerbation, dyspnea, and edema were also screened because CHF exacerbation may initially be confused with COPD or given a symptomatic diagnosis pending further evaluation. The UCD Human Subjects Committee approved the study protocol.

Eligible patients were aged 40 and older, had an active telephone line in their home, were English-speaking, and had a primary care provider (PCP) in the UCD Health System. PCP's included general internists and family physicians. In addition, potential subjects (or a designated caretaker) needed to have vision and hearing adequate to use a telephone or telecare equipment. For qualified patients, a research assistant (RA) contacted a physician from the admitting team to verify the primary admission diagnosis and then assessed the patient's symptom status utilizing the New York Heart Association (NYHA) classification.[36] Comorbid disease burden was then determined using the Charlson index.[37] Patients with a Charlson score of 6 or greater (equivalent to metastatic cancer, full-blown acquired immunodeficiency syndrome, or several chronic diseases with end-organ manifestations) were excluded. The RA next administered the 15-item Geriatric Depression Scale (GDS),[38] the Mini Mental Status Examination (MMSE),[39] and the Symbol Digit Modalities Test (SDMT), a 90-second test of cognition and manual coordination.[40] Patients who scored 7 or higher on the GDS, 20 or lower on the MMSE, or more than 2 standard deviations below age- and education-adjusted mean SDMT scores were excluded because such persons would generally not be able to adequately participate in a telecare encounter. Finally, Instrumental Activities of Daily Living (IADL) were also assessed[41] and IADL,

GDS, and MMSE scores were used to determine a global functional impairment index.[42]

During the first month of study recruitment, exclusion criteria varied slightly from those listed above. Patients were excluded from enrollment if they did not have capitated health insurance; had a Charlson score of 3 or higher; or had a Charlson score of 2 plus more than one functional impairment. However, these criteria eliminated too many otherwise eligible subjects (Fig. 1). Beginning with the second month of recruitment and for the remainder of the study, the capitation requirement was eliminated and the Charlson exclusion values were changed to those listed above.

Randomization and Nursing Intervention

For patients who agreed to participate, informed consent was obtained and random assignment to one of the three care models was achieved, before hospital discharge, using sealed envelopes containing randomly generated numbers. Patients in all groups received an in-person home nurse visit shortly after discharge and a second in-person home nurse visit approximately 60 days later. A single study nurse conducted nearly all home visits. In a few instances, when the study nurse was ill or on vacation a back-up nurse trained by the usual study nurse conducted visits. Patients randomized to usual care received only the care directed by their PCP in the period between in-person visits. Patients assigned to telephone care received scheduled phone calls from the study nurse in the intervening period, whereas those assigned to the video-based telecare group received scheduled home telecare visits. For urgent questions or problems occurring between 8 AM and 5 PM, Monday through Friday, patients in the telephone and telecare groups had access, via the medium appropriate to their group assignment, to the study nurse. These patients were provided with emergency contact numbers for usual methods of care during all other hours. Patients in the "usual care" group did not have access to the study nurse beyond the initial and terminal in-person visits but were also provided with usual emergency contact numbers.

During both initial and 60-day in-person visits, subjects completed the Medical Outcomes Study SF-36 questionnaire[43] and the Minnesota Living with Heart Failure Questionnaire (MLHFQ).[44,45] The SF-36 is a generic instrument that has been validated for assessing health status in a wide variety of populations and allows comparison of the impact of a variety of diseases on health status, whereas the MLHFQ is a CHF-specific instrument that has demonstrated sensitivity in detecting quality of life changes in pharmaceutical intervention trials. Patient satisfaction with care was also assessed at both in-person visits using the 8-item Client Satisfaction Questionnaire (CSQ).[46]

During all in-person, telecare, and telephone encounters, the study nurse used Visiting Nurse Association (VNA) CHF Care Steps[47] to guide patient assessment. This protocol includes assessment of items such as vital signs, activities of daily living, coping skills, medication use, dietary factors, and degree of signs and symptoms such as dyspnea and weight gain. Education is provided regarding each item, and patient-centered goals for the frequency and content of follow-up visits are developed. To help the study nurse better determine the adequacy of CHF drug regimens, the principal investigator (AFJ) developed a second set of algorithms drawn from national consensus recommendations[48] that were updated to include the emerging role of potassium-sparing diuretics in CHF therapy.[49] The algorithms were reviewed by a UCD cardiologist specializing in CHF care and were felt to be complete and accurate.

Following each encounter, the nurse reviewed her assessment with the principal investigator, and a summary letter containing any recommendations for improving subjects' CHF care was sent to the appropriate PCP. If the patient was unstable, recommendations were initially conveyed to the PCP by telephone.

Home Telecare Equipment

For patients randomized to telecare, an Aviva SL1010 Personal Telecare unit (American TeleCare, Eden Praire, MN) was installed at the initial in-person visit. The patient and, when applicable, lay caregivers were instructed in its use. These Food and Drug Administration-approved units operate over standard analog telephone lines and allow real-time video conferences to occur with the study nurse at a central monitoring computer at the medical center. A small camera on an extension cable allows observation of facial expressions, respiratory effort, lower-extremity edema, and objects, such as digital scale displays. A voice signal is transmitted simultaneously via a microphone. An

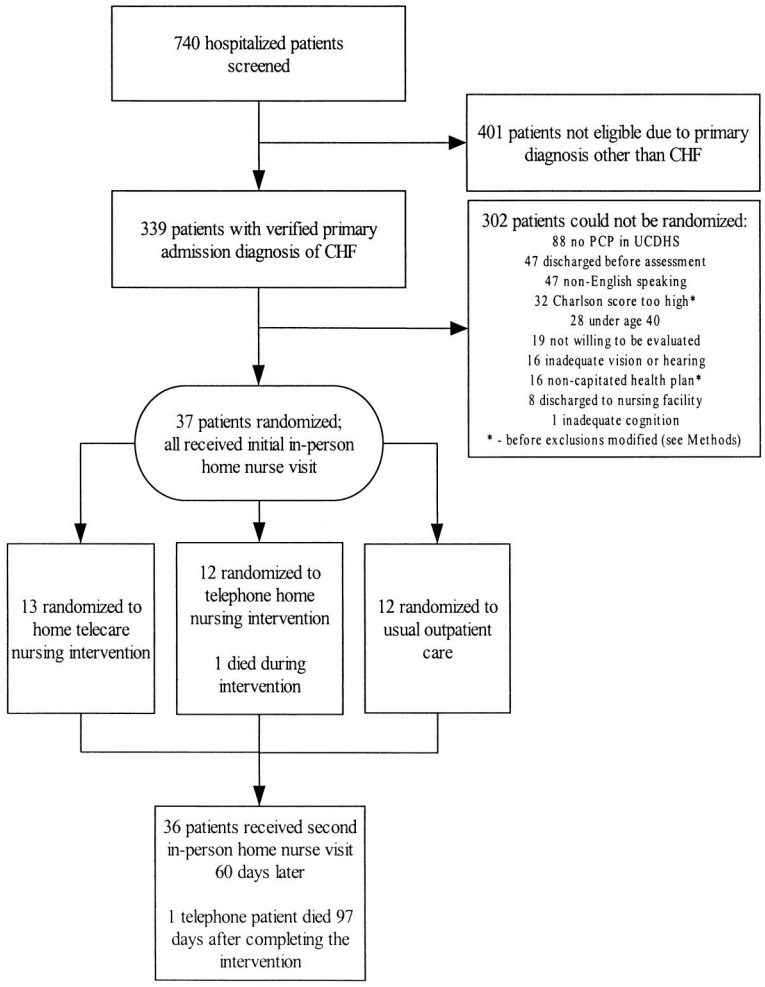

FIG. 1. Study participant flow diagram.

integrated electronic stethoscope is used by having the patient or caregiver apply the device to standard heart and lung auscultation points. Patients without a caregiver to assist them applied the device only to anterior and lateral auscultation points. Encounters were conducted in a similar fashion for patients randomized to telephone care. The study nurse estimated that 80% of protocol items could be assessed utilizing only audio information from a telephone.

Outcome Measures

The 180-day tracking period for health care utilization outcomes for individual subjects began at the time of their first in-person home visit. The primary outcome was group mean CHF-related hospital readmission charges. Charges were used as a proxy for costs because the great majority of care for subjects was delivered within the UCD Health System. Charges were considered from the perspective of the health care system. Secondary outcomes included CHF-related hospital readmissions and mean length of stay; all-cause readmissions, mean length of stay, and associated charges; ED visits and associated charges; and SF-36, MLHFQ, and CSQ scores. Total care charges were also determined for each group by adding together hospitalization, ED visit, and nursing intervention charges. Nursing intervention charges included

visit charges and, for the home telecare group, equipment charges. Nursing visit charges were determined for each group by multiplying the standard UCD charge per home visit, $176.50, by the total number of nursing visits (in-person, telephone, and telecare) received. The total intervention cost for the home telecare group was then determined by calculating the manufacturer's charge to our institution for the 11 home telecare units ($5,500 each) and single nursing base unit ($10,000) and adding that figure to the total nursing visit charges for that group.

Health care utilization was ascertained in several ways. First, UCD Clinical Resource Management provided a report covering the 180-day tracking periods for all subjects. It included ED visits, hospital admissions, and associated charges within our institution for all patients and ED visits and admissions to other local facilities for capitated patients only. To verify the accuracy of the primary admission diagnoses in the report, the RA reviewed corresponding dictated admission notes and discharge summaries. To ensure capture of utilization outside of our health system for noncapitated patients, the RA phoned each noncapitated patient at the end of their tracking period to determine whether they had any ED visits or hospital admissions to outside facilities during that period and, if so, obtained documentation and charge totals.

Statistical Analysis

Calculations based on 1998 to 99 UCD Hospital CHF admission rates and charges indicated that a sample size of 69 (23 patients per group) would provide 80% power at a confidence level of 95% to detect a 45% difference in mean CHF-related readmission charges between groups. We used the standard power calculation procedure for analysis of variance using nQuery software. Categorical data analysis and contingency tables were used to compute *P* values for between group differences in most of the baseline demographic and CHF care variables listed in Tables 1 and 2. Analysis of variance was used to compute *P* values for between group differences in Charlson comorbidity score; CHF duration; weight; MLHFQ, SF-36, and CSQ scores; and all health care utilization variables listed in Table 3. In all cases, data were examined before analysis to ensure that the assumptions of statistical models were satisfied using Shapiro-Wilk statistics. For health care utilization outcomes, including number of hospital visits, hospitalization charges, emergency department charges, and total charges, the data failed to satisfy normality assumptions. Thus, these variables were transformed to the log scale and analyses were then performed on the log-transformed data. Given our small sample size, stratified covariate analyses were not conducted.

All health care utilization analyses were conducted on the basis of intention-to-treat. To estimate potential health care utilization for subjects who left the study before the end of their 180-day tracking period for any reason, a prorating procedure was used. Prorated values for all health care utilization outcomes were calculated for each of these subjects as follows: (total study population mean for outcome) × (number of intervention days completed/180). The prorated values were included in the calculation of group utilization outcome means, and the adjusted means were then used in subsequent statistical analyses.

Results

Enrollment, Demographics, and Health Status

Figure 1 illustrates the randomization, intervention, and tracking process. Following the early adjustment in study exclusion criteria, the most common reasons that subjects could not be enrolled were the following: no PCP at UCD; discharged before evaluation; and non-English speaking. Demographics, baseline functional status indicators, and comorbidity are summarized in Table 1. There were no statistically significant differences between the groups for any of these variables. Baseline CHF status and therapy are summarized in Table 2. Again, there were no significant differences between groups for these variables, although the difference in mean duration of CHF was close to statistical significance ($P = 0.0666$) and there were more black subjects in the home telecare group than the other groups. Baseline mean SF-36, MLHFQ, and CSQ scores were similar for all groups (Table 2), and no significant between-group differences in mean health status or satisfaction scores were observed at 60-day follow-up (data not shown).

TABLE 1. Demographics, Baseline Function, and Comorbidity

Characteristic	Telecare (n = 13)	Group Telephone (n = 12)	Usual Care (n = 12)	*P*
Age, mean (SD)	66.6 (10.9)	71.3 (14.1)	72.7 (11.4)	0.4316
Gender, (%)				0.9194
Female	7 (54)	7 (58)	6 (50)	
Male	6 (46)	5 (42)	6 (50)	
Race, (%)				0.4882
Black	8 (62)	5 (42)	4 (33)	
White	4 (31)	7 (58)	7 (58)	
Hispanic	1 (8)	0 (0)	1 (8)	
Primary health insurer, (%)				0.6379
Blue Cross	1 (8)	1 (8)	2 (17)	
Commercial capitated	3 (23)	7 (58)	5 (50)	
MediCal capitated	2 (15)	0 (0)	1 (8)	
MediCal fee-for-service	6 (46)	3 (25)	4 (33)	
Medicare	1 (8)	1 (8)	0 (0)	
Residence distance from UCDMC, miles, mean (SD)	9.6 (7.0)	12.4 (16.8)	12.3 (8.4)	0.7910
Charlson comorbidity score, mean (SD)	1.8 (1.2)	2.1 (1.5)	1.8 (0.9)	0.7989
Functional impairment, number (%)				0.5427
Intermediate	3 (23)	3 (25)	5 (42)	
High	10 (77)	9 (75)	7 (58)	

Health care utilization

Health care utilization is summarized in Table 3. Two subjects randomized to telecare required a total of three in-person visits in addition to their planned initial and final in-person visits to exchange malfunctioning telecare units. Thus, the mean number of in-person visits for the telecare group was 2.3 rather than the expected 2.0. A third telecare subject received one visit via telephone, also due to equipment problems. Finally, one subject in the telephone group died before his second in-person nurse visit, resulting in the mean number of in-person visits for that group being 1.9 rather than the expected 2.0.

Mean CHF-related hospital readmission charges were 86% lower in the telecare group ($5,850, SD $21,094) and 84% lower in the telephone group ($7320, SD $24,440) than in the usual care group ($44,479, SD $121,214). However, the between group difference was not statistically significant ($P = 0.2620$). Significantly less CHF-related ED visits ($P = 0.0342$) and charges ($P = 0.0487$) were observed for both intervention groups as compared with usual care. There were also trends toward fewer CHF related and all-cause readmissions, lower all-cause hospitalization charges, shorter mean hospital lengths of stay, fewer all-cause ED visits, and lower all-cause ED visit charges in both intervention groups compared with usual care. Finally, mean total care charges were 68% lower in the home telecare group ($29,701, SD $49,219) and 69% lower in the telephone group ($28,888, SD $38,799) than in the usual care group ($93,686, SD $192,976), but this difference was also not statistically significant.

Morbidity and Mortality

Two subjects, both randomized to the telephone group, died during the study. The first, a 77 year-old woman with systolic dysfunction, died due to a severe CHF exacerbation 41 days into her 180-day tracking period. At her last telephone visit 2 weeks before death, her weight, edema, and orthopnea had been decreased compared with prior assessments whereas her exertional and par-

TABLE 2. Baseline Congestive Heart Failure Status and Therapy

Characteristic	Telecare (n = 13)	Group Telephone (n = 12)	Usual Care (n = 12)	*P*
Decreased systolic function	7 (54%)	6 (50%)	3 (25%)	0.2944
CHF duration, months, mean (SD)	11.0 (16.5)	54.8 (71.2)	30.4 (30.0)	0.0666
Weight, kg, mean (SD)	88.2 (23.6)	81.8 (22.0)	84.0 (39.2)	0.8531
NYHA II	9 (69%)	8 (67%)	7 (58%)	0.6873
III	3 (23%)	4 (33%)	5 (42%)	
IV	1 (8%)	0 (0)	0 (0)	
MLHFQ score, mean (SD)	64.1 (29.0)	54.0 (27.1)	58.3 (28.3)	0.6715
SF-36 scores, mean (SD)				
Mental component	41.9 (9.4)	42.1 (6.3)	42.9 (12.9)	0.9841
Physical component	30.5 (11.4)	30.3 (12.6)	31.1 (7.3)	0.9775
Ongoing CHF specialty care	10 (77%)	9 (75%)	6 (50%)	0.2848
CHF contributors				
Alcoholism	1 (8%)	1 (8%)	2 (17%)	0.7282
Hypertension	11 (85%)	11 (92%)	8 (67%)	0.2715
Ischemic heart disease	3 (23%)	2 (17%)	5 (42%)	0.3570
Obesity	4 (31%)	2 (17%)	0 (0)	0.1136
Medication use				
ACE inhibitor	10 (77)	6 (50)	8 (67)	0.3661
Angiotensin II blocker	0 (0)	0 (0)	1 (8)	—*
Beta-blocker	6 (46)	5 (42)	3 (25)	0.5226
Calcium channel blocker	4 (31)	4 (67)	5 (42)	0.8393
Digoxin	0 (0)	1 (8)	0 (0)	—*
Hydralazine	0 (0)	1 (8)	0 (0)	—*
Long-acting nitrate	5 (38)	7 (58)	3 (25)	0.2464
Loop/proximal tubule diuretic	11 (85)	12 (100)	11 (92)	0.3709
Potassium-sparing diuretic	4 (31)	4 (67)	2 (17)	0.6104
Lifestyle factors				
Alcohol 1 or more drinks/day	2 (15%)	0 (0)	2 (17%)	0.3390
Dietary sodium > 3 grams/day	10 (77%)	6 (50%)	6 (50%)	0.2814
Exercise < 20 min, 3–4 days/wk	12 (92%)	9 (75%)	12 (100%)	0.1293
Smoking	2 (15%)	3 (25%)	3 (25%)	0.7945

*Unable to calculate due to small numbers.

oxysmal nocturnal dyspnea were unchanged. Daily weight monitoring, sodium restriction, exercise, and medication use had been reviewed. The second, a 90 year-old male with preserved systolic function and COPD, died due to respiratory failure 149 days into the 180-day tracking period.

Technical Issues

Ninety-two telecare encounters (76%) were limited by at least one technical problem. Poor video resolution was noted in 77 encounters (64%), making the assessment of leg edema difficult. This problem was eventually partly rectified by substituting a camera with an adjustable iris for the standard camera, by using indirect illumination, and by imaging objects in front of a dark, uniformly-colored background. Video problems were judged to be severe in only five encounters (4%), and heart and lung sound resolution was inadequate in only two encounters (2%).

TABLE 3. Health Care Utilization

Care setting	Telecare (n = 13)	Group Telephone (n = 12)	Usual Care (n = 12)	*P*
Nursing intervention				
All visits, mean (SD)	11.7 (2.5)	8.6 (1.2)	2 (0)	**0.0001**
In-person	2.3 (0.6)	1.9 (0.3)	2 (0)	—
Telephone	0.1 (0.3)	6.1 (1.3)	0 (0)	—
Telemedicine	9.3 (2.5)	0 (0)	0 (0)	—
Days from enrollment to initial visit, mean (SD)	6.2 (4.0)	9.2 (5.1)	6.7 (5.6)	0.2938
Length of intervention, days, mean (SD)	62.5 (6.1)	59.4 (17.0)	n/a	n/a
Median charges	$ 7541	$ 1500	$ 353	**0.0001**
Mean charges (SD)	$ 7487 (441)	$ 1514 (206)	$ 353 (0)	**0.0001**
Hospitalizations				
CHF-related	1	1	4	
Mean (SD)	0.1 (0.3)	0.1 (0.3)	0.3 (0.5)	0.1559
Mean LOS (SD)	0.7 (2.5)	0.7 (2.3)	3.0 (7.2)	0.3624
Median charges	$ 0	$ 0	$ 0	0.2394
Mean charges (SD)	$ 5850 (21,094)	$ 7320 (24,440)	$44,479 (121,214)	0.2620
Non-CHF-related	8	4	11	
Mean (SD)	0.6 (1.7)	0.3 (0.5)	0.9 (1.8)	0.6242
Mean LOS (SD)	2.1 (5.9)	1.4 (2.2)	4.9 (10.6)	0.4402
Median charges	$ 0	$ 0	$ 0	0.6099
Mean charges (SD)	$13,237 (38,481)	$16,221 (23,810)	$40,697 (77,537)	0.6145
All-cause	9	5	15	
Mean (SD)	0.7 (1.7)	0.5 (0.7)	1.2 (1.9)	0.4590
Mean LOS (SD)	2.7 (6.2)	2.1 (3.3)	7.9 (17.2)	0.3473
Median charges	$ 0	$ 0	$11,920	0.2616
Mean charges (SD)	$19,087 (42,822)	$23,541 (34,616)	$85,176 (190,405)	0.2188
Emergency department visits				
CHF-related	1	2	8	
Mean (SD)	0.1 (0.3)	0.2 (0.4)	0.7 (0.9)	**0.0342**
Median charges	$ 0	$ 0	$ 1561	0.0744
Mean charges (SD)	$ 399 (1438)	$ 1036 (2387)	$ 2882 (4166)	**0.0487**
Non-CHF-related	8	5	14	
Mean (SD)	0.6 (1.4)	0.5 (0.7)	1.2 (2.6)	0.6094
Median charges	$ 0	$ 0	$ 0	0.8982
Mean charges (SD)	$ 2727 (6440)	$ 2640 (4904)	$ 5628 (14,764)	0.8908
All-cause	9	7	22	
Mean (SD)	0.7 (1.4)	0.7 (0.8)	1.8 (2.5)	0.1784
Median charges	$ 0	$ 1062	$ 4872	0.2086
Mean charges (SD)	$ 3126 (6716)	$ 3676 (5253)	$ 8510 (14,288)	0.2012
Total care				
Median charges	$ 7487	$ 4117	$21,595	0.5673
Mean charges (SD)	$29,701 (49,219)	$28,888 (38,799)	$93,686 (192,976)	0.7144

Discussion

We found that 60 days of home nursing care following an index hospitalization for CHF, delivered using either the telephone or video-based home telecare, resulted in a statistically nonsignificant but clinically promising trend toward lower CHF-related readmission charges in a 6-month period after randomization as compared with usual outpatient care. We also found statistically significant and clinically meaningful differences in CHF-related ED visits and charges as well as all-cause ED visits for both intervention groups as compared with usual care. Finally, we also found statistically nonsignificant but promising differences in average length of hospital stay and total care charges for both intervention groups.

We believe that Type II error, related to a smaller than anticipated sample size, is the most likely reason for the lack of statistically significant differences between groups for many of our outcomes. Although it is possible that no advantage exists for the intervention groups for these outcomes, the consistency of our findings, which were noted for all utilization endpoints (Table 3), suggests otherwise. Following an in-person home nursing intervention, Rich and colleagues reported a significant 56.2% difference in CHF-related readmissions and a nonsignificant 28.5% difference in non-CHF readmissions.[7] The similarity of these findings to ours also suggests that the advantages noted for our intervention groups were not due simply to chance.

For subjects with systolic dysfunction, we found no increase in the mean number of patients taking an ACE inhibitor, β-blocker, or potassium-sparing diuretic following the intervention, and no significant changes in the dosing of these medications (data not shown). Therefore, we speculate that the differences in care utilization resulting from the intervention were not due to physician-related factors, such as the prescription of more optimal drug regimens, but were instead due to repeated patient education regarding self-care and lifestyle modifications provided by the study nurse.

Our study had several strengths. To our knowledge, this is the only report to date of a randomized, controlled trial of a video-based home telecare intervention. The largest evaluation of this technology to date[32] had a quasi-experimental design. In addition, unlike previous CHF disease management efforts, our trial did not exclude patients with mild to moderate disease comorbidity.[7,50] Because most patients with CHF suffer from 1 or more additional chronic illnesses, our findings should be more generalizable to the larger population of English-speaking patients with CHF in the United States. Furthermore, this is the only report of a CHF disease management program designed, implemented, and evaluated exclusively by primary care providers. This also increases the generalizability of our findings, because most patients with CHF in the United States are managed principally by primary care providers rather than cardiologists.[51]

Finally, we included a telephone group to better assess the incremental benefits of video-based home telecare. Such a comparison group has been absent from prior home telecare evaluations, despite studies demonstrating that telephonic follow-up can reduce unnecessary health care utilization.[33,34] No obvious differences were noted between the video-based home telecare and telephone care groups for any outcome (Table 3). Based on our findings, a randomized trial with a much larger sample size will be required to detect any potential advantage of home telecare as a cost-saving tool.

We believe there are two likely reasons why video-based home telecare may be no more effective than telephone follow-up in reducing unnecessary utilization for patients with CHF. First, CHF home care may be a largely "non-visual" entity. Vital CHF status indicators such as dyspnea, blood pressure, and weight can be collected reliably from most patients via standard telephone. Remote video and stethoscopic monitoring may not provide additional information to enhance the early detection of CHF exacerbation. Perhaps video-based home telecare would offer greater benefit when applied to a more "visual" problem, such as decubitus ulcer therapy and monitoring. Second, technological limitations in current home telecare units greatly reduce their usefulness. For example, the equipment did not offer adequate resolution to detect subtle changes in edema status in a majority (64%) of encounters. Significant equipment improvements must occur before the broader application of home telecare can be confidently endorsed.

The differences in mean total care charges we observed between the telecare and usual care groups ($63,985) and telephone and usual care groups ($65,151) were much greater than the difference in per patient care cost ($460 per patient) observed between the in-person home nurs-

ing intervention and control group in the study of Rich et al.[7] However, it must be emphasized that out cost analysis was not exhaustive. For example, charges associated with outpatient continuity clinic visits were not included. Furthermore, health care charges, particularly at an academic medical center, are much higher than actual health-care costs and are not directly comparable to charges in other health care systems. Thus, our results cannot be used to precisely predict the impact of these distance interventions on real care costs in actual practice. Nevertheless, even though actual cost savings for our intervention groups could not be determined, because nearly all utilization in our study occurred within a single health care system, the *relative* charge differences reported here will be useful to health care providers and administrators in other settings. Furthermore, even if one assumes actual care costs to be as low as 5% of charges—a conservative figure—the resulting lower total cost of care due to either intervention would still have been $3,000 per patient. This figure is much larger than the $460 figure observed by Rich et al,[7] probably due to the lower intervention costs associated with telecare and telephonic home nursing as compared with traditional home nurse visits. Nursing intervention costs were much lower for the telephone group because initial equipment costs placed the telecare intervention at an economic disadvantage in our relatively brief trial. Because each unit can be used serially to care for many patients, and because equipment costs can be depreciated over time, the intervention cost for an established home telecare program would be lower than the conservative estimate reported here. Furthermore, as more manufacturers enter the market, the cost of home telecare equipment will probably decrease. These findings should be of great interest because home telecare is an allowable service under the new Medicare Prospective Payment System for home care services.[52,53]

Although a larger trial would be required to determine whether either modality is associated with improvements in patient satisfaction or health status, the lack of a significant difference in CSQ scores between groups in our study suggests that neither telephone nor telecare follow-up adversely impact on patient satisfaction. Similar qualitative observations have been reported in other small studies.[54,55] Given the paramount importance of patient satisfaction and health status as outcomes for home care patients, agencies should be cautious about choosing telephone follow-up over home telecare based on cost alone.

Conclusion

We have outlined a rigorous methodology for conducting home telecare evaluations that should be applied in larger studies and conducted in diverse populations to more definitively investigate the efficacy of home telecare. Based on this "first step" randomized trial of a home telecare intervention, we conclude that video-based home telecare may not offer incremental benefits beyond those resulting from frequent telephone follow-up in reducing frequent hospital readmissions and ED visits for patients with CHF. Most importantly, we have demonstrated that significant reductions in hospital readmissions, ED visits, and cost of care for patients with CHF might be achieved by the widespread deployment of posthospitalization home telecare or telephonic nursing supervised by primary care physicians.

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