ABSTRACT
Telehealth, a clinical information system that transmits data over ordinary telephone lines, is used by individuals in their homes to communicate electronically with health care providers. This study investigated the influence of telehealth on self-management of heart failure in a sample of older adults. We hypothesized that the use of telehealth facilitates patient confidence, with subsequent effects on patients’ ability to manage their treatment regimen more effectively. Patients in the intervention groups received a telehealth system during their episode of care; patients in the control groups received routine home visits only. Analyses, using a repeated measures design, found that confidence is a predictor of self-management behaviors. In addition, we found that patients using a video-based telehealth system showed the greatest gain in confidence levels with time. Managers and policy makers responsible for creating and funding programs that support the use of health information technologies by older adults can benefit from these results.

A large proportion of the older adult population experiences at least one chronic illness that requires regular monitoring and some degree of self-management. Emergent technologies that use various telecommunications systems as part of health care delivery offer the potential to improve outcomes associated with chronic illness. But will older adults willingly adopt such systems? Stereotypes about the older population abound. In his essay on ageism and technology, Cutler (2005) described the stereotypical view of older adults being unable or unwilling to use modern electronic devices. We counter that view by suggesting that technology can be offered to older adults as part of their health care delivery.

In this article, we provide a framework for understanding the relationship between the use of one particular kind of technology—telehealth—and self-management of chronic illness. First, we describe the rationale for using telehealth to manage heart failure. Next, we present a model of self-care developed by Riegel, Carlson, and Glaser (2000) and propose that electronically monitoring health status enhances the ability to recognize and evaluate symptoms related to heart failure, critical antecedents of effective self-management behaviors. We then discuss the research design and method used to test hypotheses based on the model. Finally, we...
present empirical findings and offer recommendations for research and practice.

BACKGROUND

More than 35 million adults are older than age 65 (U.S. Census Bureau, 2007), and the number of older Americans is growing rapidly (Lakatta, 2002). At least 80% of older adults have at least one chronic condition, and 50% have at least two (National Center for Health Statistics, Centers for Disease Control and Prevention, 2003). The cost of medical care for Americans with chronic conditions was $470 billion in 1995, and it is estimated that the cost could be as high as $864 billion by 2040 (Robert Wood Johnson Foundation, 1996).

Among the most frequently occurring chronic conditions are hypertension, heart disease, diabetes, and chronic obstructive pulmonary disease. Once diagnosed with a chronic condition, patients may have difficulty managing complex medications and recognizing symptoms, and nonadherence results in a large proportion of rehospitalization and health care resource use. The need for multiple health care services and providers makes issues of continuity of care particularly salient for older adults (Kaluzny, Zuckerman, & Rabiner, 1998). With demands on health care providers to improve quality, efficiency, and cost-effectiveness, identifying the appropriate use of technology for different patient populations in the provision of health services is critical. Telehealth is one kind of technology that can be used in the home care setting to improve the management of chronic illness.

Home health services provide a critical link in the continuum of care. Home health and community health nurses work in a team, serving as a primary care nurse with other members of the home health care organization and other health care providers in the community. A primary function of home health nurses is to facilitate changes in patient behavior that will result in better management of chronic illnesses. As home health care becomes more prominent in the delivery of health services, it is imperative to study new kinds of service delivery, such as telehealth, and to translate research findings into health care practice and policy. By monitoring physiological functioning and intervening when appropriate, telehealth supplements the existing network of care, promoting independent living and reducing adverse health events.

TELEMEDICINE AND TELEHEALTH

Telemedicine is defined as “the use of electronic information and communications technologies to provide and support health care when distance separates the participants” (Institute of Medicine, 1996, p. 16). Originally used for medical consults, telemedicine is now used in a variety of settings; the label telehealth applies to this expansion in modalities.

Using personal computers and video equipment that transmit data over ordinary telephone lines, home health providers can monitor patients and provide care at a much lower cost than with technologies that use wider bandwidth telephone lines and more complex equipment. Medical devices attached to the patient’s unit are used to assess clinical problems and health status. Measurement and transmission of body temperature, weight, blood glucose levels, and pulse oximetry are all possible with the newest generation of models. Telehealth systems are either asynchronous (store information and forward later) or synchronous (interactive). With systems that operate in real time (synchronous), the addition of a camera permits face-to-face interaction, as well as wound assessment, and an electronic stethoscope enables clinicians to listen to patients’ heart and lung function. Figure 1 illustrates a synchronous telehealth system.

Empirical studies of telehealth in the home setting are promising. Johnston, Wheeler, Deuser, and Sousa (2000) conducted the first published study of telemedicine in home health care. This exploratory study tested the effects of a telehealth system on patient outcomes, use of health services, patient satisfaction, and direct and indirect costs. The authors concluded that telehealth is effective and well received by patients and offers quality care while reducing costs. Some studies have focused on the role of nurses and nurses’ responses to a home telehealth system. Whit-
ten, Mair, and Collins (1997) studied nurses’ reactions to a telehealth system that used a cable network and concluded that the nurses overwhelmingly supported the system and believed it was effective for monitoring chronically ill patients. Dansky, Bowles, and Britt (1999) also reported that nurses respond favorably to telehealth systems.

The clinical efficacy of telehealth has been demonstrated in studies that report its use to manage patients with diabetes (Dansky, Bowles, & Palmer, 2003), congestive heart failure (Jenkins & McSweeney, 2001), and chronic wounds (Kobza & Scheurich, 2000). Lacking in the literature, however, is a conceptual framework for understanding how telehealth helps patients manage their illness more effectively. Attention to psychosocial factors will provide important clues about individuals’ ability and desire to access and use information in a home situation. This paradigm shift from provider control to patient control is necessary to make telehealth consumer driven.

One purpose of this study was to further our understanding of why telehealth improves patient outcomes. This study targeted older adults with heart failure, a major health problem affecting more than 4 million Americans (Artinian, Artinian, & Saunders, 2004). The economic burden of this disease is staggering: The estimated cost for heart failure in the United States was $29.6 billion in 2006 (American Heart Association, 2007). Older adults with heart failure have the poorest prognosis and highest rehospitalization rate of all adult patients. According to O’Connell, Brown, Hildreth, and Gray (2000), at least half of these readmissions could be prevented. The major goals of treatment for older adults with heart failure are to increase their control over their health condition, improve their health status, and decrease the costly use of health services.

This study focused on self-management of heart failure and related cardiovascular health status, mediated through a telehealth system. This approach is unique in that it focuses on a telecommunications system operated by patients in their own homes. Such an approach is critical to understanding alternatives for older adults who are ill and who may lack the visual or manual capacity to make extensive use of current computer technologies. This information is critical for moving telehealth from its current limited use to becoming an integral component of a health care delivery system.

THEORETICAL FRAMEWORK

The framework guiding this study is derived from behavioral science and supports links among and between cognitions about self-efficacy, health behaviors, and health status. The self-care model developed by Riegel et al. (2000) proposes a five-stage process:

- Stage 1: Symptom monitoring.
- Stage 2: Symptom recognition.
- Stage 3: Symptom evaluation.
- Stage 4: Treatment implementation.
- Stage 5: Treatment effectiveness.

This model is based on decision making in real-world settings, with recognition of symptoms as the key to self-care management. An underlying assumption of the Riegel model is that individuals with a chronic illness, such as heart failure, must understand and commit to the relationship between self-management and treatment interventions (Baas, Fontana, & Bhat, 1997; Glasgow & Osteen, 1992; Lev & Owen, 1996). We extended the Riegel model by adding the telehealth intervention as an instrumental component of symptom monitoring.

We proposed that the use of an electronic method of monitoring health and transmitting health information (Stage 1) facilitates patient confidence and ability to recognize symptoms (Stage 2), with subsequent effects on patients’ ability to evaluate the severity of symptoms (Stage 3) and manage their treatment regimen more effectively (Stage 4). Confidence is related, conceptually, to Bandura’s (1977) theory of self-efficacy, which posits that information is critical for enhancing beliefs in one’s ability to master a skill. To the extent that individuals perceive the behavior as being under their volition, self-efficacy becomes critical to determining behavior.

Studies have found that computer use by older adults enhances self-efficacy and feelings of productivity (McConatha, McConatha, & Dermigny, 1994; Purnell & Sullivan-Schroyer, 1997). The importance of personal control and self-determination in older adults is critical. McConatha et al. (1994) examined the effects of an interactive, computer-based education and training program on long-term care residents and found that the program increased the residents’ mental stimulation and challenges and led to increased competencies and autonomy.

The formal hypothesis of this study was that a telehealth intervention would facilitate patient confidence, a critical antecedent of effective self-care. The specific hypotheses that tested the relationships in the model were:

- Patients using telehealth will report greater confidence regarding the management of heart failure than will patients in the standard care group.
- Patients’ confidence scores will be positively related to self-management behaviors.
DESIGN AND METHOD

This study was conducted in collaboration with 10 home health agencies (HHAs) located throughout Pennsylvania. All HHAs are Medicare certified and accredited by the Joint Commission on Accreditation of Healthcare Organizations. A total of 284 patients (mean age = 77) were enrolled in the study after being admitted to one of the HHAs with a primary or secondary diagnosis of congestive heart failure. The intervention being tested in this study was the use of a telehealth system in the patient’s home.

Procedures

Once admitted to HHAs, patients with a primary or secondary diagnosis of heart failure were recruited for participation in the study. During the admission home visit, the home health nurse (RN) discussed the study with the patient (and the family, if appropriate) and requested voluntary participation. A complete description of the study, including its risks and benefits, was provided. If the patient consented to participate, the RN gave a fact sheet about the study and a written copy of the signed informed consent to the patient. (Patients who did not wish to participate continued to receive standard home health care.) Patients who consented were then randomly assigned by the clinical coordinator into one of two groups. The intervention (telehealth) group received standard home care, enhanced with a telehealth system placed in the patient’s home for the duration of home health care (mean duration = 62 days). The control group received standard home care services only.

The systems used in this study were purchased or leased by the HHAs from vendors whose products are approved by the U.S. Food and Drug Administration. The systems are designed to operate over a standard telephone system, connecting a central station at the HHA to remote stations in homes or other community-based settings. All patient units include a monitor with a data port for peripheral devices that allow patients to take their own measurements and transmit the readings to the HHA. Two kinds of systems are currently in use: video (synchronous) systems that promote live interaction between nurse and patient, and monitoring (asynchronous) systems that are initiated by the patient.

As part of the patient admission process, the RN completed the appropriate assessment and documentation forms required by the HHA. If the patient was assigned to the telehealth group and the nurse determined that there were no impediments to using the telehealth system (e.g., inadequate telephone wiring, safety issues), the nurse installed the telehealth unit in the patient’s home and provided instruction about using the system to the patient and family. In addition, a patient instruction manual was given to the patient. When possible, the unit was installed during the first or second home visit. Patients were instructed to use the devices daily. The data were transmitted to the HHA, and patients could see the results as well. Nurses and patients acted on abnormal readings as needed. For example, nurses might call patients to discuss their symptoms or instruct them to take an extra diuretic, if necessary. Care proceeded as usual for patients assigned to the control group.

During each standard home visit, RNs assessed patient vital signs, weight, heart sounds, lung sounds, mental status, emotional status, ankle swelling/edema, body temperature, pain/discomfort, and dyspnea; reviewed medication schedules; assessed other body systems; instructed on disease process, diet, and fluid restriction; and performed any other treatments ordered by the physician.

Instruments and Measures

Research assistants blinded to the study group collected data from patients via telephone interview at three different data points: Time 1 (admission to the HHA [baseline]), Time 2 (60 days), and Time 3 (120 days).

The Self-Care of Heart Failure Index (SCHFI) instrument (Riegel et al., 2000) was used to measure confidence and self-care maintenance and management behaviors, as reported by the patient. The instrument, which takes approximately 10 minutes to administer, was chosen because it is congruent with the study’s theoretical framework and is based on a definition of self-management that includes the process of maintaining health through positive health practices and managing heart failure through a process of recognizing heart failure symptoms, evaluating symptoms, treating symptoms, and evaluating the treatments chosen. The scales in the SCHFI have been validated, with Cronbach’s alpha coefficients ranging from 0.56 to 0.82 (Riegel et al., 2004).

The SCHFI includes 4 items that measure confidence in the ability to self-manage heart failure, specifically, confidence to:

- Evaluate the importance of symptoms.
- Recognize changes in health status.
- Do something that will relieve symptoms.
- Evaluate the effectiveness of self-management and treatment.

These 4 items were used (after validation) to calculate the patient’s confidence score. Higher scores indicated greater confidence.

Self-management was assessed, initially, with 9 items from the SCHFI. Five items measure routine self-care
maintenance activities: weighing self daily, following a low-salt diet, engaging in regular physical activity, maintaining desired weight, and receiving an annual influenza vaccine. Four items measure self-care management when symptomatic: reducing salt, reducing fluids, taking an extra diuretic, and calling the doctor or nurse.

**Data Analysis**

Descriptive statistics were calculated for patient demographics and major variables of interest. Means and standard deviations were calculated for all three data collection points; descriptive statistics from Time 3 are presented in Table 1.

Analysis of variance (ANOVA) was used to test for equality of the intervention and control groups. Tests of differences on the basis of race, age, and illness severity were conducted. No significant differences were found between the intervention and control groups, indicating that the groups were equivalent.

To test the study hypotheses of changes in confidence levels as a consequence of the intervention, a repeated measures design of a general linear model (GLM) was used. To measure the effect of confidence on the self-management behaviors, a series of regression equations were used. Outcome (dependent) variables were regressed on the independent variables, taking the form \[ Y = B_0 + B_1X_1 + B_2X_2 + \cdots + E. \]

**RESULTS**

The first hypothesis predicted that patients using telehealth would report greater confidence regarding the management of heart failure than would patients in the standard care group. To test this hypothesis, changes in confidence levels over time were examined using a GLM. The intervention group was further divided into two subgroups to reflect differences between the asynchronous (monitoring) and interactive (video) systems. Patient groups were coded 0 (control), 1 (monitoring), and 2 (video). Results showed that all groups improved over time, although the trend lines differed. The video group showed the most improvement overall, with the greatest gain occurring between Time 1 and Time 2. The monitoring group did not differ significantly from the control group. The GLM results for changes occurring between Time 1 and Time 2, as well as for differences between the Time 1 and Time 3 are shown in Table 2.

The post-hoc analysis, using the Tukey test, indicated that changes in the video group were significantly different from the changes in either the control group or the monitoring group. A significant time effect (within participants), a significant group effect (between participants), and a marginal time-intervention effect \( p = 0.098 \) was evident. The plot (Figure 2) shows that the video group started at a substantially lower point than did the other two groups, but had closed the gap by Time 3.

The second hypothesis tested the relationship between confidence and self-management behaviors. In nine separate ordinary least squares regressions, the confidence scale score was tested as a predictor of self-management behaviors, with the dependent variable operationalized as the score for each self-care measure. Results at Time 3 indicate that confidence, overall, was a positive predictor of five of nine patient self-management behaviors (Table 3).

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td><strong>Descriptive Statistics at Time 3 (120 Days)</strong></td>
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<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>Days from admission to discharge</td>
</tr>
<tr>
<td>Number of skilled nursing visits</td>
</tr>
<tr>
<td>Number of total home health agency visits</td>
</tr>
<tr>
<td>Patient age</td>
</tr>
<tr>
<td><strong>Rated Variable</strong></td>
</tr>
<tr>
<td>Illness severity</td>
</tr>
<tr>
<td>Weighed self daily</td>
</tr>
<tr>
<td>Followed a low-salt diet</td>
</tr>
<tr>
<td>Engaged in regular physical activity</td>
</tr>
<tr>
<td>Maintained desired weight</td>
</tr>
<tr>
<td>Received annual influenza vaccine</td>
</tr>
<tr>
<td>Reduced salt in diet</td>
</tr>
<tr>
<td>Reduced fluid intake</td>
</tr>
<tr>
<td>Took extra diuretic</td>
</tr>
<tr>
<td>Called doctor or nurse</td>
</tr>
<tr>
<td>Evaluated symptoms</td>
</tr>
<tr>
<td>Recognized change</td>
</tr>
<tr>
<td>Knew what to do for symptoms</td>
</tr>
<tr>
<td>Evaluated effectiveness of treatment</td>
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</tbody>
</table>

\(^a\) Scores on a range of 1 (low score) to 4 (high score).
The strengths of this study include the randomized design and the time period under investigation, both difficult to achieve in field studies. However, several characteristics of this study limited the ability to arrive at meaningful conclusions.

First, the small samples constrained our ability to estimate effect sizes. Optimal sample size was calculated at the beginning of the study by first determining the expected effect size for each outcome variable. For two-sided tests with an overall 0.05 significance level, adjusted by the Bonferroni correction, and 80% statistical power (thus allowing for a 10% dropout/nonadherence rate), 150 participants per group would be required, with a total sample of 300. With a sample of 284, we approached adequate power. However, the sample was reduced considerably over time due to patients’ inability to respond or lack of adherence in responding to the telephone interviews. Attrition due to patient deaths further decreased the sample.

Second, the setting (HHAs) may have limited the external validity of the study. The patients were all homebound (as prescribed by Medicare Conditions of Participation) and elderly, and required physicians’ signatures and cooperation. Outcomes of using a telehealth system may vary among different patient populations.

Third, examination of the effects of the telehealth interventions on specific behaviors was not possible due to samples ranging from 13 to 42. By Time 3 (120 days), we clearly lacked the power to show differences in these outcomes. Future study with larger samples is needed to examine this important component of self-care management and the advantage video encounters may hold over patient-directed encounters. Perhaps a dose effect, based on the number of times patients used the machines to self-monitor and the number of in-person visits, should be noted in case the amount of in-person contact across all groups has some effect.

Finally, the results reported in this article focus on group-level changes. More in-depth analyses should consider individual variations over time. A model of analysis of variance growth might suggest whether reactions to the intervention are more influenced by interindividual or intraindividual changes.
Use of Telehealth to Manage Heart Failure

DISCUSSION

This study investigated the influence of telehealth on self-management of heart failure in a sample of older adults. We proposed that the use of telehealth facilitates patient confidence, with subsequent effects on patients’ ability to manage their treatment regimen more effectively. Brennan, Moore, and Smyth (1991) were the first to report an increase in confidence related to information technology use in the home, and dementia patient caregivers’ confidence in decision making increased with the use of online support, e-mail, and electronic information. In addition, the ACTION program in Europe, during which caregivers of frail older adults used videophones and computer resources, increased caregiver confidence and reduced social isolation (Magnusson, Hanson, & Nolan, 2002). In this study, the use of the telemonitoring devices, even without online support and information as provided in the other studies, led to increased confidence in patients’ ability to manage congestive heart failure. This finding supports earlier work reporting nurses’ perceptions of increased empowerment in patients who used telemonitoring devices (Dansky, Bowles, & Palmer, 1999). Future research that combines telemonitoring with online support and electronic medical information might achieve even greater gains in patient confidence.

The first hypothesis—that telehealth would improve patients’ confidence levels—was partially supported. Patients in the video group showed the greatest increase in scores at Time 3 (120 days). This trend was significantly different from the results for patients in the control group or the monitoring group, suggesting that nurse interaction, as part of the telehealth encounter, may play an important role in increasing patients’ confidence levels.

The second hypothesis—that confidence was positively related to self-management of heart failure—was supported. Although this finding is not surprising, given the theoretical links between self-efficacy and behavior, it does encourage further development of a conceptual framework for using telehealth to manage chronic illness. This finding supports the need to involve patients more in self-care. Telehealth is a clearly a tool to involve patients and their caregivers in their care, and it helps them understand the relationship between symptoms and action. From a clinical perspective, more emphasis may be needed on teaching patients the importance of weighing themselves daily and reducing their fluid intake, because we did not find a significant relationship between these critical self-care management behaviors and confidence in managing heart failure.

CONCLUSION

Overall, the study results are encouraging, despite the paucity of significant findings. Of particular interest is the relationship between patient confidence and self-management behaviors. Confidence is, overall, a positive predictor of self-management. This finding should encourage the development of interventions that focus on building self-care confidence in heart failure patients.

### Table 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>β</th>
<th>F</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weighed self daily</td>
<td>120</td>
<td>0.115</td>
<td>1.58</td>
<td>0.210</td>
</tr>
<tr>
<td>Followed a low-salt diet</td>
<td>120</td>
<td>0.222</td>
<td>6.19</td>
<td>0.014</td>
</tr>
<tr>
<td>Engaged in regular physical activity</td>
<td>118</td>
<td>0.317</td>
<td>13.030</td>
<td>0.000</td>
</tr>
<tr>
<td>Maintained desired weight</td>
<td>119</td>
<td>0.161</td>
<td>3.158</td>
<td>0.078</td>
</tr>
<tr>
<td>Received annual influenza vaccine</td>
<td>117</td>
<td>0.025</td>
<td>0.072</td>
<td>0.788</td>
</tr>
<tr>
<td>Activities when symptomatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced salt in diet</td>
<td>116</td>
<td>0.351</td>
<td>16.125</td>
<td>0.000</td>
</tr>
<tr>
<td>Reduced fluid intake</td>
<td>114</td>
<td>0.127</td>
<td>1.844</td>
<td>0.177</td>
</tr>
<tr>
<td>Took extra diuretic</td>
<td>118</td>
<td>0.251</td>
<td>7.893</td>
<td>0.006</td>
</tr>
<tr>
<td>Called doctor or nurse</td>
<td>115</td>
<td>0.288</td>
<td>10.291</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Note: The total sample was 284. Of that number, 115 to 120 people completed the interviews at Time 3.
that the video group showed the greatest improvement in confidence is worthy of further exploration. An analysis of the content of those video encounters, compared with patient-directed monitoring or usual care, might explain how or why this effect was achieved. Perhaps the nurses, using the video contacts, are able to verbally reinforce teaching more effectively or more often than can be afforded by in-person care or self-monitoring alone. Future studies should follow patients for a longer time period to examine any long-term effects on confidence, as this study’s follow up ended at 120 days.

The results of this telehealth study clearly contradict the stereotype that older adults are unable or unwilling to use technology. No significant relationships between age and any of the outcome variables of interest were found. We encourage health care practitioners and managers to consider the use of health information technologies as an integral component of a patient-focused health care system for older adults with chronic illness.

REFERENCES