Technology and Design to Promote Independence and Quality of Life

Presented by:

Professor Dr. William Mann,
Director of the University of Florida
Rehabilitation Engineering Research Center
on Technology for Successful Aging

November 9, 2013
Technology and Design

Promoting Independence
And Quality of Life as We Age
What we will cover

Bobbi’s questions
Brief demographics
What is assistive technology
Is assistive technology/design effective?
Is assistive technology advancing
The future
Being creative
Bobbi’s questions
Bobbi’s Questions

Top 10 assistive technology devices
What should our attorneys recommend in the way of devices to their clients
Demographics
Population 85+ 1910 to 2050
(in millions)
Percent of Population by Age Group Who Need Assistance with ADLs

- 15-64: 2.4%
- 65-69: 9.2%
- 70-74: 11%
- 75-79: 19.5%
- 80-84: 31.2%
- 85+: 49.5%
Number of Men per 100 Women by Age Group

- 65-69: 82.3
- 70-74: 76.3
- 75-79: 67.4
- 80-84: 55.4
- 85-89: 43.7
- 90-94: 33.5
- 95+: 26.5
Projected Increase in Number of People 65+ living Alone: 1990 - 2220

- 1990: 9.0
- 2005: 10.9
- 2220: 15.2
What is assistive technology
Hands-free, illuminated magnifiers
Print enlargement system
Vibrating, under pillow, alarm clock
Reachers

Tasks

Types
Hot Hand® Hand Protector and Jar Opener

Helps maintain a secure grip on hot or cold slippery items such as bottles, glasses and pans. Also helps as a gripper to unscrew tight jars and bottle caps. Recommended as a precaution against burns for people with hands that have reduced sensation to heat. It retains its flexibility over a wide temperature range.

The gripping surfaces are studded with small suction cups. End pockets fit the thumb and fingers. Measures 3 ¼ x 7 ½” (98 x 190mm) with hole tabs for hanging up.

F75359-0000 $13.50
Denture Brush Holder

For easy one-handed cleaning of dentures. Tightly press fit into a large suction cup this two sided denture brush will securely mount to any flat surface.

Redesigned

Shampoo-Aide™ Shampoo Tray

F74153-1000

$7.25
Rotating One Hand Button Aid (with Zipper Pull)

This button aid allows the user to complete the entire buttoning process with only one hand. The foam handle provides an excellent grip and rotates to provide flexibility in getting a grip on the button and pulling it through the button hole. It handles buttons up to $\frac{3}{8}$ (9mm) diameter. The brass hook at the other end is useful for pulling zippers. The handle is $1\frac{1}{2}$" in diameter (32mm) x 4" (102mm) long.

Developed by Denis Anson, OTR.

F73886-0005 $12.50
Temporary Ramp
Bath transfer bench
Arcorail
Toilevator

Toilevator is the safe, economical, and hygienic way to raise toilet seats

Raises toilet 3.5”

500 lb. capacity

www.uhnres.utoronto.ca/institutes/tgri/
Is AT Effective

**1995-1999 Randomized Controlled Trial:** Effectiveness of Comprehensive Approach to AT/Home Modifications Service Delivery
Mean Percent Decline on Measures of Functional Status by Group In Standard Scores

At 18 Months Post Initial Intervention
Mean Percent Decline on Measures of Mental Status and Pain In Standard Scores

At 18 Months Post Initial Intervention
### Mean AT/ Home Mods Cost/ Participant for 18 Months

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>At 18 Months Post Initial Intervention</td>
<td>$2620</td>
<td>$443</td>
</tr>
</tbody>
</table>
### Mean Total Institutional Cost/ Participant for 18 Months

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Control</th>
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<tbody>
<tr>
<td></td>
<td>$5,630</td>
<td>$21,847</td>
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</table>

*At 18 Months Post Initial Intervention*
Mean Total In-Home Care Cost/Participant for 18 Months

<table>
<thead>
<tr>
<th></th>
<th>Treatment</th>
<th>Control</th>
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<tbody>
<tr>
<td>Cost</td>
<td>$5,922</td>
<td>$9,320</td>
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</table>
Related Research

**Purpose:** This study sought to determine how often assistance reduces or even completely resolves health-related difficulties in everyday tasks.

**RESULTS / Conclusions:** “Equipment only” proves to be the most efficacious strategy for reducing and resolving limitations. Equipment's success may be due to greater perceived gains when people accomplish the assistance by themselves.

**Purpose:** Assess the benefit of a structured interdisciplinary assessment of people who have fallen in terms of further falls.

**Results/Conclusions:** Risk of falling significantly reduced in the intervention group, and the odds of admission to hospital were lower.
**PURPOSE:** To determine whether occupational therapist home visits targeted at environmental hazards reduce the risk of falls, using randomized controlled trial design.

**RESULTS/Conclusions:** Home visits by occupational therapists prevented falls among older people who are at increased risk of falling. Home visits by occupational therapists may also lead to changes in behavior that enable older people to live more safely in both the home and the external environment.
Purpose: To test the efficacy of a multicomponent intervention to reduce functional difficulties, fear of falling, and home hazards and enhance self-efficacy and adaptive coping in older adults with chronic conditions.

RESULTS: At 6 months, intervention participants had less difficulty than controls with ADLs and IADLs, with largest reductions in bathing and toileting. They also had greater self-efficacy, less fear of falling, fewer home hazards, and greater use of adaptive strategies. Benefits were sustained at 12 months for most outcomes.
The advance of technology

....so if simple technology can make a profound difference, what can we expect from the future....
Explore the history of a few devices. Is assistive technology advancing?

Wheelchairs
1300 B.C.

Oldest evidence of a wheeled chair – spoked wheels on chairs.
1933

First folding wheelchair, manufactured with metal.
Today

“High Tech,” light-weight materials
Improved design
Wheelchairs used for sports
Power Assisted Wheelchairs
Stair climbing wheelchairs
Smart Wheelchairs
Why support research and development in this area?

Hearing Aids
Early 1700’s

An ear trumpet.
Similar devices were used for thousands of years.
1940’s Vacuum tube model.
1953

Oticon Pocket model.
This unit could be concealed completely in the ear canal.
1990’s

Hearing aids with digital processing
Personal Emergency Response Systems (PERS)

Enable an individual to call for help in an emergency

Traditional PERS device (pendant, wristwatch, clip-on) contact emergency numbers stored in the PERS console for use at the press of a button

User must manually activate the system within approximately 150 feet of the console unit
Traditional PERS

Philips Lifeline: http://www.lifelinesys.com/content/lifeline-products
PERS

- 2-way communication between the user and the console
- Pendant contains a Digital Enhanced Cordless Telecommunication (DECT) speakerphone
- Wearer can talk to emergency contact up to 600 feet/183 meters from the console unit
PERS with Fall Detecting

Lifeline with AutoAlert:
http://www.lifelinesys.com/content/lifeline-products/auto-alert

Halo Monitoring:
http://www.halomonitoring.com

Wellcore:
www.wellcore.com
mPERS (Mobil PERS)

- GPS and 3G wireless based mobile devices
- Provide 2-way speakerphone communication, location/tracking capabilities including geofencing to assist with the management of wandering
- Typically linked to a monthly monitoring/service contract which may provide access to web-based tools to monitor activity
- Provide one button access to monitoring company, caregivers or emergency services
- Some devices incorporate automatic fall detection, waterproof enclosures
Examples of mPERS

Personal Assistant Link (PAL):
  ActiveCare
  http://www.activecare.com/pal

MobileHelp:
  http://www.mobilehelpnow.com/

VoCare:
Wandering alerts: EmFinders GPS

- Available in standard band and secure band (requires 2 hands to remove)
- Water resistant and submergible
- Requires 2 hour charge once a week
- When active by a caregiver call to the service, the device places a call to 911, reports its location, plays an audio message explaining the nature of the emergency, and an emergency response is provided by the appropriate responder organization.

- [http://www.emfinders.com](http://www.emfinders.com)
Examples: 3M Wireless Resident Monitoring Solutions

Products include:

• Resident emergency call
  – Fixed and resident-worn wireless call buttons
  – Alerts are directed to staff member pagers displaying resident name and real time location

• Wandering solution
  – Real-time indication of residents’ location by areas
  – Automatic alerts upon residents leaving or entering pre-defined areas
  – Door and exit alerts with staff notification
  – Watch-style transmitter with removal and cut-band alarms

• Wireless fall management of monitored seating or bed areas

• Wireless staff safety

• Community management and staff can generate resident behavioral and staff responsiveness reports

Examples: GE QuietCare
Living Independently Inc, acquired by GE, was a pioneer in the remote monitoring field

http://www.careinnovations.com/Products/QuietCare/Default.aspx
Examples: HealthSense
An integrated solution including passive remote monitoring, wireless emergency call/PERS with location tracking, nurse call system

http://www.healthsense.com/
Examples: GrandCare Systems

- 2-way web video conferencing
- Interactive touchscreen interface
- Manage chronic health conditions
- Remotely assess activities of daily living
- Entertainment
- Temperature monitoring and lighting control
- http://www.grandcare.com/ (also available for residential facilities)
GlowCaps use light and sound to signal when it is time to take a pill.
- sense when the bottle is opened and wirelessly relay their status to Vitality’s secure network.
- flash and play a ring-tone reminder
- wireless reminder light plugs into a kitchen or bathroom outlet and pulses orange when it is time to take a pill.
- If the bottle is not opened two hours after a scheduled dose, the user is automatically reminded with a telephone call or text message
Data generated by GlowCaps can be used to automatically refill prescriptions
Medication Management

Automatic Dispensing Systems

- Store and releases medication on a set schedule
- Prevent overmedicating by accommodating "As Needed" medications ("PRNs")
- Provide patient reminders
- Alert caregiver or call center if the patient fails to take medication

TabSafe  http://www.tabsafe.com/  Dispense A Pill (DAP)

http://www.healthonemed.com
THE SINGULARITY IS NEAR
RAY KURZWEIL
AUTHOR OF THE NATIONAL BESTSELLER THE AGE OF SPIRITUAL MACHINES
Power Of Technology
APPS
Voice Dream Reader – Text to Speech app. For just $9.99, you can download one of the most comprehensive text to speech apps available on the iTunes market. This app will help those with both hearing and visual impairments, providing them with the option of communicating with others simply through the use of textual input or voice input. The app will either read aloud a message or, for those with hearing impairments, it can interpret spoken words into text.
Parking Mobility – Free (iPhone)
Finding disabled parking places has never been easier! Parking Mobility can clue you into disabled parking places around you by using iPhone's GPS capabilities. You can also leave notes for other travelers or residents about disabled parking spots that you've located that aren't currently on the map. The more you use it and update it, the more it helps others.
Trouble Hearing In A Noisy Room? There’s An App For That
Robotics......
Momoko – Experimental Theater
I’m back..... (robotic arm)
Creative Assistive Technology:
Bobbi’s Questions

Top 10 AT
What devices should you recommend?
Abledata.com is an excellent resource for information on assistive devices.

http://abledata.com/
Sponsors

National Institute on Disability and Rehabilitation Research
Veterans Health Administration
Centers for Disease Control and Prevention
Federal Highway Administration
AARP
Florida Dept. of Elder Affairs
Florida Dept. of Transportation
Donors
Advances in Personal Emergency Response and Detection Systems

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Advances in Personal Emergency Response and Detection Systems

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ABSTRACT Personal Emergency Response Systems (PERS) allow an individual to contact 911 or family members by pushing a button on a pendant which communicates with the PERS console to dial the emergency numbers. While simple to use, traditional PERS devices have limitations, some of which are overcome with more recently introduced home monitoring systems. This paper discusses PERS benefits, barriers to use, options, and alternatives that are currently available or in development.

KEYWORDS aging, aging in place, assistive devices, falls, technology

Personal emergency response systems (PERS), also known as medical alarms or medical emergency response systems, enable an individual to call for help in an emergency. A person using a traditional PERS device (pendant, wristwatch, clip-on), at the press of a button, can contact emergency numbers stored in the PERS console. The systems generally do not provide a means for contacting emergency assistance if the user is unable to manually activate the system because of injury, unconsciousness, or not wearing the call button, or if the user is outside the home.

The elderly population (adults over the age of 65) in the U.S. will increase from 38 million in 2009 to 54 million by 2020 and 80 million by 2050 (U.S. Census Bureau, 2001). Hamill, Young, Boger, and Mihailidis noted in 2009 that demands on long-term-care facilities will increase at an unprecedented rate as the baby boomer generation reaches retirement age. The number of elderly is projected to at least double in 20 states between 1995 and 2025 (U.S. Census Bureau, 2010). Since most seniors desire to age at home, PERS could help reduce the burden on an already strained long-term-care system and facilitate aging in place by providing easy access to emergency assistance and peace of mind both for elders and for their relatives. However, many potential PERS users and their families are unaware of the benefits of PERS and newer home monitoring systems. Further, PERS may be purchased and remain underused or unused, even in emergency situations.

PERS entered the mass market in 1974 when Lifeline Systems of Framingham, Massachusetts, currently the largest personal response service in North America, introduced its first system. Lifeline, now owned by
Philips Healthcare, serves 750,000 seniors and others in their homes. The company reports that it has helped over 6 million at-risk elders and their families “gain added peace of mind” (Philips Lifeline, 2011). There are several other PERS providers (including Life Alert, Med Alert, and Ready Response) that report an additional 750,000 users in the U.S., bringing the total current estimates of users in the U.S. to 1.5 million (Otto, 2010). PERS have been available for close to 40 years, and the technology continues to evolve. The purpose of this article is to provide a review of literature and a description of new and evolving PERS features, as well as trends in the development of related technology to monitor the well-being of home-based elders and other at-risk individuals.

Traditional PERS have three components: (a) a small radio transmitter, (b) a console connected to a telephone, and (c) an emergency response center (a PERS service center or public safety answering point [PSAP] and 911 call dispatch operator) that monitors calls. Transmitters are lightweight, battery-powered devices that are worn around the neck, the wrist, a belt, or the chest or placed in a pocket. In an emergency, the user presses the transmitter's help button, which sends a signal to the console. The console automatically dials an emergency telephone number. Most PERS are programmed to call an emergency response center. If the PERS service center is the primary emergency number, a call will be placed to the PERS service center and the center operator will determine the nature of the emergency. The operator might also review the user’s medical history and check to see if the patient’s physician should be notified.

Medicare and most insurance companies do not reimburse for PERS equipment (Medx Publishing, 2008). Medicaid payment regulations vary from state to state. While some states reimburse all or a portion of PERS expenses, other states exclude PERS reimbursements. In some states, Medicaid will pay for the PERS equipment and system for qualifying individuals under a Federal Home and Community Based Services waiver; however, most states have waiver waiting lists of several years’ duration (Centers for Medicare & Medicaid Services, 2010). Consequently, most PERS devices and monthly service fees are paid for out of pocket.

**HISTORY OF PERS**

The first PERS was designed in 1972, by Dr. Andrew Dibner, a professor at Boston University (Robinson, 1991). He conceived of a “timer-and-alert mechanism that would automatically tap into the telephone line and call for help if it was not reset by a person’s normal household routines, such as turning off lights or opening a refrigerator” (Lifeline Systems, 2011). Dibner continued to refine his design, building on findings from a 1980 PERS study conducted by Sherwood and Morris that found that “experimental subjects, compared to controls, exhibited reduced anxiety, greater confidence in living alone . . . and delayed entry into nursing homes” when using a Lifeline PERS (Dibner, 1981).

As a cost saving measure in 1988, the state of New York enacted legislation providing for Medicaid reimbursement for patients of certified home health agencies where PERS substituted for hours of safety monitoring by a personal care worker as part of the plan of care (Hyer & Rudick, 1994). This marked a recognition that PERS could substitute for hours of home health monitoring by home health aides. In 1992, the Visiting Nurse Service of New York initiated a grant-funded demonstration project that included 117 patients who were discharged from the hospital, physically and mentally able to use a PERS at home, and who required “hours” of in-home, personal care services. Patients were studied for at least a year unless they died, needed to enter a residential care home, or requested that the PERS be removed. Between February 1, 1992, and August 31, 1993, 34 PERS users (29% of the sample) used their PERS a total of 60 times. Nineteen activations notified responders to a life-threatening emergency; 16 were falls; 10 were other emergencies (non–life threatening); and 15 were either false alarms or the user was scared but otherwise unharmed when EMS personnel arrived.

Sixty-three percent (38) of the users who activated their PERS during this period needed to be taken to the hospital via ambulance. Health care cost savings were realized as a result of the reduced hours of in-home care recorded by home health aides. In the 19-month period, 94,000 hours of home health aide care was saved, resulting in a savings to Medicaid of $1.5 million. In most cases, a PERS was substituted for 12 hours of overnight safety monitoring by a home health aide. After 6 months of PERS use, each user (96
total satisfaction was 93%.

Bernstein (2000) reported that a relatively inexpensive, low-technology solution such as a PERS could be used by managed care organizations to improve outcomes and significantly reduce health care costs among community-residing, elderly patients. Bernstein pointed to a frequently cited clinical study (Sherwood & Morris, 1980) in which monitored PERS reduced mortality rates by nearly four times and reduced hospital utilization by 59% (Roush & Teasdale, 1995). In the Sherwood and Morris study, elderly tenants living in the Boston and Cambridge Massachusetts Housing Authority were separated into three groups depending on their degree of physical frailty and social isolation. A sample of 551 persons was randomly assigned to an experimental group (those offered Lifeline) or the control group (those not offered Lifeline). At the end of the 3-year study, a cost/benefit analysis was completed on the two samples, users and nonusers, resulting in a 7.19 benefit/cost ratio. This ratio indicated that for every dollar spent on Lifeline, there was a resulting health care cost savings of $7.19. Cost savings were also found in the delay of nursing home placement. For every 1 day of nursing home placement for the experimental group, the control group required 13 days. A 1991 Institute of Medicine report on research to reduce health care costs concluded that postponing the placement of older persons in nursing homes by 1 month could save $3 billion annually, minus the cost of home health services during the month.

In 1992, Roush and Teasdale (1995) conducted a study to determine the association between PERS use and hospital utilization rates for community-residing users. Inpatient hospital days decreased 59% from pre-PERS installation to 1 year post-PERS. In February 1992 and July 1993, patients who had subscribed to the Lifeline PERS program at Langley Memorial Hospital (Langley, British Columbia) for at least 1 year were identified (1992, \( n = 66 \); 1993, \( n = 44 \)), and hospitalization usage data were collected for 1 year before and 1 year after each patient received his or her PERS. The mean number of emergency department visits per person increased slightly, but not significantly, from 0.58 to 0.72. However, the number of hospital admissions and inpatient days decreased significantly during the 2 years studied.

**USER EXPERIENCES**

In 1992, Levine and Tideiksaar (1995) conducted a survey in the New York City metropolitan area to determine which factors associated with the use of PERS encouraged or discouraged older, community-residing subscribers to use the system. PERS subscribers who wore the portable help button when alone in the home were defined as being “compliant.” The average length of time the 106 respondents (average age 83, \( SD = 9 \)) had the system in their possession was 26 months (\( SD = 18 \)). Less than 50% of the subscribers were found to be fully compliant. Compliance was higher for those who had obtained the system themselves, had a history of falls, received positive responses to activations, used an assistive mobility device, or had received instruction on the system. Compliance was lower for users who had obtained the system at the request of a family member. Levine and Tideiksaar suggested that regular assessments by clinicians, clearer instructions for use, and/or changing the type of PERS system may increase use. However, there is no research on approaches to increasing PERS use.

In a 2002–2003 University of Cambridge survey, 90 women and 20 men were followed in a prospective study of falls for 1 year or until death, if sooner (Fleming & Brayne, 2008). Many of those in the study population had PERS. About a third had a PERS (usually a pendant) linked to a service center or a call bell installed in their room or apartment, and 12% had both types of alarm systems. Of those living alone in the community or in home care residences, 70% (57/81) had some form of call alarm. In 95% (209/219) of the falls that occurred when the individual was alone, and in 99% (141/143) of those who could not get up when they fell alone, the individual had some form of PERS in his or her home. However, in 80% (113/141) of the falls studied, the person who fell alone did not use his or her PERS transmitter to summon help. This was most often the case in institutional settings (94%; 62/66) but also the case for most of the falls occurring in the community (78%; 28/36) and in home care residences (59%; 23/39). Of 141 falls, 38 resulted in the individual lying on the floor for over an hour, despite an installed alarm system, and in all but one of the 38, the person who fell alone did not use his or her alarm to summon help.
Several themes emerged from the analysis of comments made by participants and caregivers about why the users had not activated their PERS. Barriers to using alarms arose at several crucial stages: not seeing any advantage in having such a system, not developing the habit of wearing the transmitter even if the system was installed, and, in the event of a fall, not activating the alarm—either because it could not be reached or because it would necessitate a trip to the hospital or cause undue worry to caregivers and family. Activating the PERS transmitter was often seen as an admission of not being able to “take care of the situation myself.”

Mann et al.’s 2002 study (Mann, Belchior, Tomita, & Kemp, 2005) surveyed 606 seniors and found 93 PERS owners (mean age 79.3 years) and 513 non-owners of a PERS (73.4 years). Of the 91 PERS owners who responded to the questionnaire, 85 were currently using it to some extent, and 6 had used a PERS in the past but were not currently using it. “Using” a PERS did not always mean wearing or carrying a PERS. The majority of study participants (55.6%; 35/63) wore (or carried) their PERS less than 1 time a week. Twenty-six participants (29.9%) wore their PERS 1–3 times a week. The reason most often given for not wearing/carrying the PERS more often was a lack of perceived need for the device (55.6%; 35/63). For the PERS users, although more than three quarters (82.8%) wore/carryed the device for only 0–3 times (hours) per week, the majority (66.7%; 54/81) stated that they were “very satisfied” with the device. Most (75.6%) received an “enhanced feeling of security” from wearing the device. Of the nonusers (513 seniors), 63% had no interest in using a PERS. Most felt that they had no need for the device, although the reasons presented for not needing a PERS in the future were almost evenly split between “cost” (46.4%) and “lack of perceived need” (44.4%). Additionally, 17.4% listed “lack of knowledge of the device” as a reason not to use a PERS in the future. Mann et al.’s questionnaire exclusively surveyed PERS owners and non-owners, not their relatives, friends, and neighbors.

In 2002 and 2003, two small surveys of frail, elderly women (sample sizes of 11 and 7) who lived alone examined their perceptions and opinions of PERS (Porter, 2003; Porter & Ganong, 2002). In the 2002 study, participants included 11 frail women (aged 81–94) who perceived a risk of “falling and not being found” and did not have a PERS. Seven of the women had a history of falls, including 4 who had fallen recently. In interviews with each woman, the subjects were asked to consider using a PERS, but responses varied from “getting by fine without it,” “waiting to get it until I really need it,” and “convincing myself that I might get it later” to “borrowing no more trouble than I already have.” The author reported that “there is a crucial need for home health nurses and case managers to take a proactive, health-promoting role” (pp. 197) in cases where the elder is at continued risk of falling. In several instances, family or home health caregivers mentioned PERS one time to the elder, and if met with resistance, dropped the subject. Porter suggested that consistent interventions by home care professionals might increase PERS utilization rates, but there is no research to support this.

In her 2003 study, Porter described older (83–96 years old), frail widows’ experiences of using a PERS. Over a 3-year period, Porter interviewed seven PERS users to determine their experiences with PERS in their homes. “Being certain that I can get help here quickly” was a factor in “deciding whom to put on my list (of first responders)” and “keeping the connection intact.” However, the women also experienced apprehension from the device itself. Almost all of the women wore the PERS pendant intermittently, even the ones who had experience using it for a medical emergency. Several took it off while sleeping, because they heard unexpected voices after accidentally pressing the button during sleep. Several preferred not to use their PERS when bathing (even though they’d been told they could keep it on). Most took it off if someone was with them in the house or if they were going out with someone. Most of the women did not enjoy wearing it, but did so because it made them feel more secure.

**PERS OPTIONS**

Traditional PERS are programmed to dial one number, the PERS service center, a service requiring a monthly fee. Newer PERS available in the market can be programmed with several personal emergency contact telephone numbers. In systems using several emergency numbers, the console dials the first contact and, once connected, plays a prerecorded emergency message. If the first emergency contact cannot be reached, the next emergency contact is dialed. A user can program family caregivers as the primary contacts and 911 as the secondary contact. Systems like these...
provide many of the benefits of a call center at a lower overall cost to the user.

One drawback of the majority of the commercially available PERS devices is the limitation on voice communication between the user and the call center when the user is not near the console unit. One approach, taken by some PERS vendors to address the voice communication limitation, is to offer voice extender modules for existing PERS (Philips Lifeline, 2010; AlertOne, 2010). The voice extender modules provide the benefits of two-way voice communication typically provided by the console unit in a secondary module that can be placed in another location in the home. This is a useful option for two-story or large homes. Other providers, such as LogicMark (Guardian Alert, Freedom Alert; LogicMark, 2010) and Medical Alarm Concepts (MediPendant, TelePendant; Medical Alarm Concepts, 2010), have recently introduced PERS that provide two-way communication between the user and the console using a pendant that contains a cordless speakerphone. These products use digital enhanced cordless telecommunication technology, similar to the technology of many household cordless telephones, providing robust voice communication that is generally immune to interference from common household electronics. A benefit of two-way communication pendants is that users can talk to the service operator, PSAP operator, or their designated emergency contact even though they may be up to 600 feet from the console unit. Pendants that incorporate voice communication also necessitate a larger pendant size and weight, decreased battery life, or decreased water resistance, which may be disadvantageous to some users.

FALL-DETECTING PERS

A limitation of most PERS devices is that the user must activate the system by pressing a button on the transmitter. This requires the user to be sufficiently alert, physically able, and willing to initiate the emergency help request following an emergency. If the user is unable or unwilling to activate the transmitter, emergency assistance may be delayed or not arrive at all. A number of companies have introduced enhanced pendants that detect health emergencies without user activation. A benefit of two-way communication pendants is that users can talk to the service operator, PSAP operator, or their designated emergency contact even though they may be up to 600 feet from the console unit. Pendants that incorporate voice communication also necessitate a larger pendant size and weight, decreased battery life, or decreased water resistance, which may be disadvantageous to some users.

V. Hessels et al.
PERS (mPERS), which combine one-touch emergency capabilities and voice communication and may include fall detection, are available (Laipac, 2010; Activecare, 2010) or under development (Dolan, 2010). mPERS, which can be wrist worn, holster worn, or carried and may resemble a simplified mobile phone, extend traditional PERS functions beyond the home by providing user position to a monitoring station operator. Depending on the features, battery life is approximately 24–48 hours. MobileHelp (MobileHelp, 2010) has combined a PERS with a GPS-enabled mobile speakerphone, using a traditional pendant when the user is in the home. When outside the home, pressing the alert button on the hand-held unit contacts an operator at the monitoring station, allowing two-way communication and utilizing GPS tracking capabilities for emergencies.

For use as a one-touch, readily available PERS device, a mobile phone with the capability to position the caller’s location might be an alternative to traditional PERS. Currently, 9 out of 10 U.S. adults use at least one mobile device, and 78% of adults over the age of 60 now use mobile phones (Experian Simmons, 2010). As of June 1, 2010, 94.7% of PSAPs, representing 96.9% of all mobile users in the U.S., had met requirements specifying that wireless network operators must route incoming 911 calls to an appropriate PSAP and provide the phone number, cellular tower, and caller’s location within 984 feet (National Emergency Number Association, 2010). However, the Federal Communications Commission (FCC) recommends that users should not program mobile phones and should disable one-touch or speed dialing of 911 to avoid unintentional 911 calls (FCC, 2010). Continued growth in smartphone sales likely will drive down costs of motion and position sensors, which should improve the availability of low-cost, high-quality components currently not available in traditional PERS. Although smartphones with fall detection and tracking applications may soon be widely available, phones require the user to have them close by at all times.

**IN-HOME MONITORING**

Perhaps the most fundamental limitation of traditional, basic PERS devices is that the user must wear or carry the device. As previously summarized, Mann et al. (2005) found that only 17.1% of users wore the device more than 3 hours/times per week, a user profile that severely limits the effectiveness of the system. In order to effectively provide emergency support for an event that could occur at any time, either 100% user cooperation is required, or the system must not rely upon user cooperation.

In-home monitoring systems can track users’ movements, assess daily living patterns, and use this information to determine when aid might be required. The user does not need to actively participate in the use of the system. Various sensors are placed in the home environment to track occupant movements and room use. The first of these systems to be introduced was QuietCare (GE Health Care, 2010), now owned by GE, but which is presently available for assisted and independent living facilities only. Other commercial systems from companies such as BeClose...
(BeClose, 2010), WellAware (WellAware, 2010), and CloseBy (CloseBy, 2011) are available for residential use. Potentially adverse events are detected through activity analysis and relayed to a family member or health care professional. These systems are only useful for single-occupant households since they are unable to differentiate between the movements and activities of multiple occupants; however, they can differentiate between people and pets. In most cases, in-home monitoring systems cannot provide the same immediate response as pressing the PERS button, which can be a disadvantage to many users and their families. Table 1 shows a range of PERS product offerings and their benefits and drawbacks.

**TABLE 1 PERS Options**

<table>
<thead>
<tr>
<th>PERS</th>
<th>Examples</th>
<th>Cost range</th>
<th>Benefits</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Call button activation: pendants, wristwatches, chest straps, clip on</td>
<td>Lifeline, Med Alert, Life Alert</td>
<td>Based on zip code</td>
<td>Help can be summoned, some are waterproof</td>
<td>Need to wear at all times, may elicit negative emotions; user may be unable or unwilling to press button</td>
</tr>
<tr>
<td>Two-way voice contact through pendant</td>
<td>Guardian Alert, MediPendant</td>
<td>No monthly fee to $99 monthly fee</td>
<td>Immediate voice contact by pressing button</td>
<td>Users may become startled by voices if activated by mistake</td>
</tr>
<tr>
<td>Fall-detecting PERS</td>
<td>Lifeline AutoAlert, America Fall Detection</td>
<td>Based on zip code</td>
<td>Need not press activator to summon help</td>
<td>Battery life may affect performance</td>
</tr>
<tr>
<td>Tracking PERS</td>
<td>SOS, Tracker, Location Alerts</td>
<td>May be free, based on phone charges</td>
<td>Detection not restricted to inside the home</td>
<td>To within 33 feet of actual location, GPS signals are weak indoors and when obstructed</td>
</tr>
<tr>
<td>In-home monitoring systems</td>
<td>CloseBy, WellAware</td>
<td>$399 small house installation to $600 large house, plus monthly fee</td>
<td>No user actions required</td>
<td>Monitoring appropriate for single-occupant households only, in-home only</td>
</tr>
<tr>
<td>Phones</td>
<td>GoPhone, Jitterbug</td>
<td>$25–$150</td>
<td>Easily accessible</td>
<td>Users must initiate emergency calls; GPS-associated disadvantages</td>
</tr>
<tr>
<td></td>
<td>iPhone, BlackBerry</td>
<td>$300–$500</td>
<td>Easily accessible, available with targeted features</td>
<td>Some applications in development</td>
</tr>
</tbody>
</table>

**DISCUSSION**

The PERS challenge is to provide a reliable, unobtrusive device that users want to use and will use while providing a sense of security to both the user and relatives. The literature demonstrates that PERS can be a lifesaver for older adults who live alone. The reasons seniors give for not wanting a PERS device range from the practical (too expensive, too cumbersome, and not needed) to emotional (means I am asking for help, I don’t want to give up my freedom, etc.). While device redesigns may alleviate some objections, emotional objections are more difficult to overcome. In most cases, PERS are purchased following a significant medical condition or at the insistence of a relative. As
Levine and Tideiksaar (1995) have shown, obtaining a PERS as the result of a family member's request is one of the least compelling reasons for actual use. In their 1992 study of compliance (actively wearing the PERS whenever the senior was alone), those who had obtained the device of their own accord were more likely to be compliant than those who had obtained the PERS at the request of a family member or a health care professional (p = .04). Other variables that increase the likelihood of compliance are (a) being at risk for falls, (b) receiving instruction on the use and operation of a PERS (which might help alleviate some fears of hitting it by mistake, rolling over it while sleeping, or taking it off to bathe), (c) receiving a positive response when using it previously during an emergency, and (d) using another assistive device.

Some seniors reject or refuse a PERS because of visual aesthetics and/or its bulkiness and obtrusiveness. In Porter's study (2003), one PERS user for 2 years said, “I hate this thing . . . it’s always on my neck.” Other seniors felt they had to hide it under clothing or take it off because it was unattractive. In the Mann et al. (2005) study, the majority of PERS users (52%) felt the pendant style was adequate, although 37% did not feel it was adequate, which may reveal a disliking of the styling or may encompass other, unspoken factors. For seniors who dislike the style of the pendant or do not like wearing something around their neck, the wristwatch style provides an alternative. However, the wristwatch style is more appropriate for men. In addition to education, more stylish, less utilitarian designs might increase the use of PERS.

As Mann et al. (2005) have shown, the primary reason (56%) for not wearing the PERS is lack of perceived need. If perceived need only increases as a senior's health problems increase and/or the occasions and need for use increase, the question becomes: “What information can health professionals present that will assist seniors to acknowledge a need for a PERS?” If the senior will wear a PERS but resists actually using it (pushing the button when needed) for fear of bothering others or being forced to go to the hospital (Fleming & Brayne, 2008), wearing the device becomes moot. Health care professionals can help provide additional information about the PERS emergency contact list and when a 911 call is appropriate, even if a 911 call may necessitate emergency care in a hospital. Most seniors can understand that a long wait on the floor is not a substitute for timely, emergency medical care. While seniors have explained their non-activation of a PERS because they were expecting someone who would be able to help them, education on the importance of timely medical care in specific situations may convince seniors to activate their PERS. Although wearing and using (activating) a PERS in an emergency situation may leave some seniors feeling “helpless,” the preparation for potential emergencies (PERS, smoke detectors, fire extinguishers, security alarms, etc.) can also, when presented appropriately, empower seniors to make decisions involving their own care and provide them with a proactive means of remaining at home and possibly living longer.

As Roush and Teasdale discovered in their 1992–1993 study, PERS users were admitted to a hospital less frequently than non-PERS users and, once admitted, stayed fewer days as an inpatient than non-PERS users. This information, when presented to seniors, may lessen their fears of activating their PERS button in the case of a medical emergency. Home health aides are needed less frequently, usually during the time the senior is asleep, because the PERS can be substituted for overnight safety monitoring. This information could give seniors who are resistant to PERS use an understanding of how they could achieve greater independence with a PERS. Another potential motivator is that PERS use can often reduce health care costs.

Delbaere, Close, Brodaty, Sachdev, and Lord (2010) assessed the risk of falls in a group of 500 men and women (70–90 years old) and found that while 11% had a low physiological risk of falling, their perceived risk of falling was high. Conversely, 20% of the group had a high physiological risk of falling, yet they had a low perceived risk. These disparities between physiological and perceived fall risk increased the risk of falls for both groups. So, although lack of knowledge of PERS has been shown to be a contributing factor in seniors’ not owning or fully using PERS (Mann et al., 2005), an elder’s realistic self-assessment of falling risk may contribute to acceptance of PERS information and eventual use. Delbaere et al. (2010) suggested that fall interventions should be tailored to elders’ fall risk perceptions, not only their actual fall risk; it follows that PERS education needs to be tailored as well.

Twenty-three percent of PERS non-owners in the Mann et al. (2005) study noted that lack of knowledge
of the device prevented them from using a PERS, while 17.4% indicated that lack of knowledge would likely prevent them from using a PERS in the future. Respondents also indicated that the systems seemed too complicated/hard to use or that training was not available. Comprehensive education for seniors about what services are provided, including opportunities for in-home installation, training by a PERS provider, and the knowledge that a PERS has the potential to make a senior’s life simpler and safer, might persuade some seniors to incorporate a PERS into their health care routine. Medical professionals, including primary care physicians and occupational therapists, can provide guidance and reassurance with the aim of facilitating seniors’ acceptance of PERS. Research is clearly needed to further explore these and other approaches to overcoming barriers to PERS use when an individual is at risk for falls.

CONCLUSIONS

Assessments by health care professionals can identify likely PERS candidates who may be unable or unwilling to use the user-activated devices, even after additional education interventions. In these cases, where active participation may be in question, fall detectors are an option, even though they must also be worn and can be viewed as intrusive. Advising seniors and their families on the available PERS options through printed materials and a user-friendly Web interface can provide information to a greater number of potential PERS candidates and present options beyond the traditional pendant PERS.

Although updated studies into the efficacy and cost savings of PERS are definitely warranted, central to the effective promotion of PERS by health care professionals is an assessment of their baseline knowledge about PERS, followed by educational opportunities to build on previous knowledge and provide access to new PERS products.

Although traditional PERS have emotional and physical limitations, as evidenced by some users’ resistance to actually wearing and/or admitting their use of PERS, on the whole, PERS use can provide many benefits. As the population ages (baby boomers retiring and elders living longer) and as elders prefer to remain in their homes as they grow older and as the costs of residential, hospital, and home care rise, PERS, passive monitoring systems, and smartphone-based emergency applications may play an increasingly important role in elder safety and quality of life. Education for seniors and their families, as well as for health care professionals who provide medical and social care for seniors, is an appropriate avenue to increase knowledge and understanding of the opportunities and advantages of PERS.

REFERENCES

and-Sensors/News/Pages/iPhone-4-Sounds-Starting-Gun-for-Mobile-Handset-Gyroscope-Market.aspx
ORIGINAL CONTRIBUTION

Effectiveness of Assistive Technology and Environmental Interventions in Maintaining Independence and Reducing Home Care Costs for the Frail Elderly

A Randomized Controlled Trial

William C. Mann, OTR, PhD; Kenneth J. Otenbacher, OTR, PhD; Linda Fraas, OTR, MA; Machiko Tomita, PhD; Carl V. Granger, MD

Context: Home environmental interventions (EI) and assistive technology (AT) devices have the potential to increase independence for community-based frail elderly persons, but their effectiveness has not been demonstrated.

Objective: To evaluate a system of AT-EI service provision designed to promote independence and reduce health care costs for physically frail elderly persons.

Design: Randomized controlled trial.

Setting and Participants: A total of 104 home-based frail elderly persons living in western New York were assigned to 1 of 2 groups (52 treatment, 52 control).

Intervention: All participants underwent a comprehensive functional assessment and evaluation of their home environment. Participants in the treatment group received AT and EI based on the results of the evaluation. The control group received "usual care services."

Main Outcome Measures: Functional status as measured by the Functional Independence Measure (FIM) and the Craig Handicap Assessment and Reporting Technique; pain as measured by the Functional Status Instrument; and health care costs including the costs.

Results: After the 18-month intervention period, the treatment groups showed significant decline for FIM total score and FIM motor score, but there was significantly more decline for the control group. Functional Status Instrument pain scores increased significantly more for the control group. In a comparison of health care costs, the treatment group expended more than the control group for AT and EI. The control group required significantly more expenditures for institutional care. There was no significant difference in total in-home personnel costs, although there was a large effect size. The control group had significantly greater expenditures for nurse visits and case manager visits.

Conclusion: The frail elderly persons in this trial experienced functional decline over time. Results indicate rate of decline can be slowed, and institutional and certain in-home personnel costs reduced through a systematic approach to providing AT and EI.

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O OFFSET the impact of impairments resulting from chronic conditions and the aging process, many elderly persons rely on assistive technology (AT) devices such as canes, walkers, and bath benches. Environmental interventions (EI) such as the addition of ramps, lowering of cabinets, and removal of throw rugs also increase functional independence. Relatively few AT devices, and even fewer EI, are covered by third-party payers, nor are the services associated with assessing a frail elderly person or the home environment paid for by insurance. While there is general recognition of AT and EI as "helpful," and the potential of AT is reflected in federal law, there has been little study of their effectiveness on increasing independence and no study of their potential to reduce home health care costs.

In a preliminary study examining the use of AT and functional independence in noninstitutionalized elderly persons, our research team studied 364 frail elderly persons. From this sample, 117 pairs of study participants were matched on selected predictors and compared for levels of functional independence relative to use of assistive devices. For 60 pairs, subjects with the highest use of AT were more functionally independent than their counterparts who used fewer devices. The results of this
SUBJECTS AND METHODS

STUDY SUBJECTS

Study participants were referred by 1 of 3 sources: (1) Community Alternative Systems Agency, a medically directed county agency that provides services to Medicaid-eligible homebound elderly persons in western New York (n = 49, 20 treatment and 29 control group), (2) hospital physical medicine and rehabilitation programs, providing short-term rehabilitation (n = 49, 28 treatment and 21 control group), and (3) Western New York Visiting Nursing Association, serving both Medicare- and Medicaid-eligible persons (n = 6, 4 treatment and 2 control group). Participants from the Community Alternative Systems Agency were referred to the study at the point of their initial referral for in-home services. Participants from the hospital rehabilitation programs had received in-patient rehabilitation services in the year before the initial assessment for the study. Participants from the Visiting Nursing Association were receiving services at the time of the initial referral to the study. Each person referred was mailed a letter explaining the study. All who responded favorably underwent an initial assessment. Only elderly persons with scores greater than 23 on the Mini-Mental State Examination were included in the investigation. Those who met the study criteria were randomly assigned to 1 of the 2 groups by means of a computer-generated table of random numbers.

Earlier studies had reported that persons with cognitive impairments used fewer assistive devices and were generally more dissatisfied with them than were noncognitively impaired, frail elderly persons. Persons with Mini-Mental State Examination scores below 24 were more likely to have a family care provider, which complicates the interaction of personal support, use of devices, and functional independence. Since this was the first clinical trial of a system of AT-EI service delivery, we selected the population most likely to show a positive effect. All study participants had difficulty with 1 or more areas of the Functional Independence Measure (FIM) motor section. Forty study participants reported their vision as fair or poor; none was totally blind.

For adequate statistical power, we sought to have 90 elderly persons at the end of a 1.5-year follow-up. Based on a medium effect size (d = 0.50), power was assumed to be 80 with an alpha level of 0.05. We initially included 104 study participants, based on our experience with attrition in other longitudinal studies of frail elderly persons. At the end of 18 months we had lost 4 participants from the treatment group (4 died) and 10 from the control group (6 died and 4 withdrew from the study).

INTERVENTION

Standard Care

There is no single "standard" for home-based senior services, and considerable variety exists in the types of services potentially available for an older person in need of assistance. There are (1) medically directed services available after hospitalization and rehabilitation; (2) nursing-directed services, which typically provide home health care aids and some medically directed interventions; and (3) primarily nonmedical services provided through the Office for Aging agencies across the country. These nonmedical services may include Meals-on-Wheels and assistance with shopping, household chores, and personal care.

Intensive AT-EI Services

This approach to providing for the safety and independence needs of physically frail older persons included a comprehensive functional assessment of the person and the home by an occupational therapist, recommendations for needed assistive devices and/or home modifications (AT-EIs), provision of the devices and modifications, training in their use, and continued follow-up with assessment and provision of AT-EIs as needs changed. An interdisciplined team, which included a nurse and a technician experienced in home modifications, assisted the occupational therapist. (Details of the intervention protocol are available from the authors.)

OUTCOME MEASURES

The term independence is recognized as the ability to take responsibility for one's own performance and desires. Under this definition, a person can be independent with the use of tools (AT and EI) and with the management of supportive personnel. We used the concept of functional independence, which incorporates the same meaning as independence, with the exclusion of supportive personnel. In attempting to measure functional independence, we sought to determine how much of one's own performance needs and desires can be accomplished by the person without supportive personnel, but either with or without AT and EI.

For this study, measures of functional independence included the FIM Instrument, including 2 subsections, cognitive and motor, the Older Americans Research and Services Center Instrument, and the Craig Handicap Assessment and Reporting Technique (CHART), including 4 subsections, physical independence, mobility, occupation, and social integration. The reliability and validity of these instruments have been extensively investigated and reported in the literature.

We also included pain and health care costs as dependent measures. Pain was assessed with the Functional Status Index. Health care costs during 18 months included costs of AT-EIs; in-home personnel, including nurses, occupational therapists, physical therapists, speech-language pathologists, case managers, and personal care aides, and institutional costs, including hospitalization and nursing home stays. For AT-EIs, we included both the equipment cost and personnel costs associated with assessment, training, and follow-up. Personal care aide costs were calculated at $8.16 per hour; nurses, at $98 per visit; case managers, at $89 per visit; occupational therapists, physical therapists, and speech-language pathologists, at $90 per visit; nursing home stays, at $86 per day; and hospital costs, at $877.85 per day.

DATA COLLECTION

All participants were visited in their homes every 6 months to determine functional independence, health status, and measures of cost. Participants were also contacted by telephone every month to determine any new problems or services received, and to determine the treatment group's need for additional EI-AT services. In the monthly calls participants were asked to report any problems they were

Continued on next page
having. Project personnel kept a detailed accounting of all assistive devices purchased and their costs, home modifications, health care personnel time, and all time spent by study participants in hospitals or nursing homes. A project research associate who was unaware of the study participants' original group assignment administered the follow-up assessments to the study participants in their home environment. Blinding was difficult to maintain, as the research associate was sometimes aware subjects had received AT-EIs, either through observation of devices and home modifications or through subjects' comments regarding services.

The sequence of administration of the assessment instruments described above was randomly determined to prevent order or carryover effects. All data were coded by identification number, and final or total scores were not computed for any of the study participants until all were completed. Both groups were evaluated on all dependent measures.

For health costs data, the Community Alternative Systems Agency provided information on services for their patients directly to the project. Information on services received was also gathered through self-report in the monthly telephone calls. For calculating health care costs, information was available for all 52 treatment group subjects and 49 of the control group subjects. It is likely that the 3 control group subjects who withdrew from the study were more functionally impaired than the average, as they stated they were withdrawing because they were too ill to continue.

DATA ANALYSIS

We compared the treatment and control groups on demographic, health, psychosocial, and functional independence measures, and assistive device ownership, with the use of t tests for continuous data and χ² for nominal data.

Descriptive statistics and histograms were used to examine functional independence and pain and to graphically display differences between the treatment and control groups. We used analysis of covariance, calculating significance of difference at 18 months, controlling for initial score. In addition, paired t tests were used to determine changes over time. Effect sizes (d-indexes) for the difference found between the treatment and control groups were computed as a supplement to the t test. When multiple statistical tests (t tests) were performed, the percentage error rate statistic was computed. This statistic indicates the number of multiple tests resulting from chance.¹²

Mann-Whitney tests were applied to determine differences between health care costs for treatment and control groups. Effect sizes were also calculated.

Preliminary investigation suggested that increased use of AT was related to greater functional independence.

The purpose of the present investigation was to examine the effectiveness of an intervention program involving AT and EIs by means of a randomized clinical trial. It was hypothesized that there is a significant difference in functional independence and overall cost of health-related services between frail elderly persons receiving standard care (control group) and those receiving intensive AT and EI services (treatment group).

RESULTS

The 2 groups of 52 treatment and 52 control participants were equivalent on all measures at the start of the trial. The groups showed no significant differences for age, sex, race, education, income, marital status, or living alone or with someone else. The treatment group had fewer children (mean of 2.2 vs 3.3). For all measures of health, psychosocial status, and functional independence, the 2 groups were equivalent (Table 1 and Table 2). There was no significant difference in assistive device ownership at the start of the study, with the treatment group owning a mean (SD) of 12.0 (6.2) devices and the control group owning 10.4 (6.8). However, we could study functional independence only for subjects still alive and participating at the end of 18 months. The 90 study participants available to the study at the 18-month follow-up are described in Table 3.

Participants in the treatment group received a mean of 14.2 AT devices from the study (a total of 681 devices) and a mean of 1.0 from other sources (a total of 258 devices).
Table 2. Comparison of Treatment and Control Groups at Initial Assessment: Health and Psychosocial Status

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total (N = 104)</th>
<th>Treatment (n = 52)</th>
<th>Control (n = 52)</th>
<th>Test for Significance of Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health status</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days in hospital past 6 mo, mean (SD)</td>
<td>5.3 (11.4)</td>
<td>6.2 (13.5)</td>
<td>4.3 (6.7)</td>
<td>t_{50} = 0.82</td>
</tr>
<tr>
<td>Physician visits last 6 mo, mean (SD)</td>
<td>5.9 (5.0)</td>
<td>5.3 (4.2)</td>
<td>6.9 (5.6)</td>
<td>t_{50} = 1.32</td>
</tr>
<tr>
<td>No. of medications, mean (SD)</td>
<td>6.0 (3.6)</td>
<td>6.8 (3.9)</td>
<td>6.3 (2.2)</td>
<td>t_{50} = 0.73</td>
</tr>
<tr>
<td>No. of chronic illnesses/conditions, mean (SD)</td>
<td>6.5 (2.9)</td>
<td>6.2 (2.7)</td>
<td>7.1 (3.3)</td>
<td>t_{50} = 1.04</td>
</tr>
<tr>
<td>Sick days in past 6 mo, No. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>42 (40.4)</td>
<td>21 (40.4)</td>
<td>21 (40.4)</td>
<td></td>
</tr>
<tr>
<td>&lt;1 wk</td>
<td>23 (22.1)</td>
<td>13 (25.0)</td>
<td>10 (19.2)</td>
<td></td>
</tr>
<tr>
<td>1 wk–1 mo</td>
<td>16 (15.4)</td>
<td>7 (13.5)</td>
<td>9 (17.3)</td>
<td></td>
</tr>
<tr>
<td>&gt;1 mo–3 mo</td>
<td>18 (17.3)</td>
<td>8 (15.4)</td>
<td>10 (19.2)</td>
<td></td>
</tr>
<tr>
<td>&gt;3 mo</td>
<td>5 (4.8)</td>
<td>3 (5.8)</td>
<td>2 (3.8)</td>
<td></td>
</tr>
<tr>
<td>Psychosocial, mean (SD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-esteem</td>
<td>32.3 (5.6)</td>
<td>31.4 (5.7)</td>
<td>32.7 (5.3)</td>
<td>t_{50} = 0.33</td>
</tr>
<tr>
<td>Depression</td>
<td>13.0 (10.6)</td>
<td>14.3 (11.2)</td>
<td>12.5 (11.0)</td>
<td>t_{50} = 0.65</td>
</tr>
<tr>
<td>Social resources</td>
<td>3.0 (1.1)</td>
<td>3.1 (1.3)</td>
<td>3.0 (1.1)</td>
<td>t_{50} = 0.29</td>
</tr>
<tr>
<td>Quality of life, No. (%) (N = 102)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very good or good</td>
<td>59 (57.6)</td>
<td>29 (55.8)</td>
<td>30 (60.0)</td>
<td></td>
</tr>
<tr>
<td>Neither</td>
<td>32 (31.4)</td>
<td>18 (34.5)</td>
<td>14 (28.0)</td>
<td></td>
</tr>
<tr>
<td>Pretty bad or very bad</td>
<td>11 (10.6)</td>
<td>5 (9.6)</td>
<td>6 (12.0)</td>
<td></td>
</tr>
</tbody>
</table>

*Data are given as mean (SD). IADL indicates Instrumental Activities of Daily Living; FIM, Functional Independence Measure; MMSE, Mini-Mental State Examination; FSI, Functional Status Index; and CHART, Craig Handicap Assessment and Reporting Technique.

Table 3. Changes in Functional Status Over Time

<table>
<thead>
<tr>
<th>Variable</th>
<th>Initial</th>
<th>Test for Significance of Difference (t)</th>
<th>18-mo Follow-up</th>
<th>Difference Between Initial and Follow-up, t (/f)†</th>
<th>Effect Size (d-index)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IADL total</td>
<td></td>
<td>0.566</td>
<td>8.9 (3.2)</td>
<td>2.31 (.03)</td>
<td>0.53</td>
</tr>
<tr>
<td>Treatment</td>
<td>9.5 (3.1)</td>
<td></td>
<td>7.9 (4.1)</td>
<td>3.23 (.002)</td>
<td>0.72</td>
</tr>
<tr>
<td>Control</td>
<td>9.2 (3.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIM motor score</td>
<td></td>
<td>0.308</td>
<td>7.1 (16.2)</td>
<td>2.12 (.04)</td>
<td>0.44</td>
</tr>
<tr>
<td>Treatment</td>
<td>74.1 (14.2)</td>
<td></td>
<td>66.4 (19.1)</td>
<td>4.28 (&lt;.001)</td>
<td>1.00</td>
</tr>
<tr>
<td>Control</td>
<td>75.0 (13.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIM cognitive score</td>
<td></td>
<td>1.157</td>
<td>33.2 (1.8)</td>
<td>5.46 (&lt;.001)</td>
<td>1.20</td>
</tr>
<tr>
<td>Treatment</td>
<td>34.8 (3.6)</td>
<td></td>
<td>31.5 (3.2)</td>
<td>5.15 (.003)</td>
<td>0.74</td>
</tr>
<tr>
<td>Control</td>
<td>34.4 (4.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIM total score</td>
<td></td>
<td>0.222</td>
<td>104.8 (16.7)</td>
<td>3.19 (.003)</td>
<td>0.69</td>
</tr>
<tr>
<td>Treatment</td>
<td>108.5 (14.3)</td>
<td></td>
<td>97.9 (23.2)</td>
<td>4.21 (&lt;.001)</td>
<td>1.02</td>
</tr>
<tr>
<td>Control</td>
<td>109.4 (13.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMSE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>28.3 (1.7)</td>
<td></td>
<td>28.1 (2.8)</td>
<td>2.54 (.02)</td>
<td>0.49</td>
</tr>
<tr>
<td>Control</td>
<td>28.3 (1.8)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FSI pain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>14.6 (6.4)</td>
<td></td>
<td>14.6 (5.8)</td>
<td>0.03 (.68)</td>
<td>0.01</td>
</tr>
<tr>
<td>Control</td>
<td>16.1 (5.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHART: physical independence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>78.3 (24.1)</td>
<td></td>
<td>79.1 (29.2)</td>
<td>0.19 (.65)</td>
<td>0.04</td>
</tr>
<tr>
<td>Control</td>
<td>65.8 (20.4)</td>
<td></td>
<td></td>
<td></td>
<td>0.46</td>
</tr>
<tr>
<td>CHART: mobility</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>70.6 (23.5)</td>
<td></td>
<td>66.2 (23.2)</td>
<td>4.13 (.05)</td>
<td>0.39</td>
</tr>
<tr>
<td>Control</td>
<td>64.2 (20.6)</td>
<td></td>
<td></td>
<td></td>
<td>0.45</td>
</tr>
<tr>
<td>CHART: occupation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>35.5 (30.8)</td>
<td></td>
<td>33.0 (28.6)</td>
<td>0.62 (.05)</td>
<td>0.12</td>
</tr>
<tr>
<td>Control</td>
<td>39.1 (28.0)</td>
<td></td>
<td></td>
<td></td>
<td>0.47</td>
</tr>
<tr>
<td>CHART: social integration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>73.7 (24.7)</td>
<td></td>
<td>67.5 (28.9)</td>
<td>2.15 (.04)</td>
<td>0.45</td>
</tr>
<tr>
<td>Control</td>
<td>71.0 (25.4)</td>
<td></td>
<td></td>
<td></td>
<td>0.70</td>
</tr>
</tbody>
</table>

48 devices). Treatment group participants received a mean of 8.9 (5.6) visits from the study’s therapist and 2.4 (2.3) visits from the technician responsible for home modifications. Participants in the control group received a mean of 1.9 devices (a total of 80 devices) from other sources. This difference in total number of AT devices accumulated in 18 months is significant ($t_{23} = 6.57, P < .001$). Table 4 lists the types of AT devices provided. The ma-
Table 4. Assistive Devices Acquired During 18-Month Study Period by Treatment and Control Group Study Participants

<table>
<thead>
<tr>
<th>Device Given or Acquired and Impairment Addressed</th>
<th>Treatment Through Study</th>
<th>Control Through Study</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Through</td>
<td>Usual</td>
<td>Total</td>
</tr>
<tr>
<td>Motor impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental control device</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Phone and accessories</td>
<td>50</td>
<td>1</td>
<td>51</td>
</tr>
<tr>
<td>Reacher/physical extension</td>
<td>28</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Special switches and controls</td>
<td>30</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Meal preparation</td>
<td>93</td>
<td>0</td>
<td>93</td>
</tr>
<tr>
<td>Balance aid</td>
<td>34</td>
<td>10</td>
<td>44</td>
</tr>
<tr>
<td>Wheelchair and accessories</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Special seating system</td>
<td>13</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Activities of daily living</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bathing</td>
<td>104</td>
<td>4</td>
<td>108</td>
</tr>
<tr>
<td>Eating</td>
<td>25</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Grooming</td>
<td>12</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Dressing</td>
<td>50</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>Hygiene</td>
<td>23</td>
<td>7</td>
<td>30</td>
</tr>
<tr>
<td>Writing device</td>
<td>9</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>Homemaking</td>
<td>14</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>Rug gripper</td>
<td>10</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>Other fine motor</td>
<td>19</td>
<td>0</td>
<td>19</td>
</tr>
<tr>
<td>Leisure</td>
<td>50</td>
<td>1</td>
<td>51</td>
</tr>
<tr>
<td>Other</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>584</td>
<td>38</td>
<td>622</td>
</tr>
<tr>
<td>Hearing impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hearing aid</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Assistive listening device</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>Vision impairment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Braille output device</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Audio tape system</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Low-technology aids</td>
<td>41</td>
<td>1</td>
<td>42</td>
</tr>
<tr>
<td>Leisure</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Total</td>
<td>47</td>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>Cognitive device, total</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other devices, total</td>
<td>44</td>
<td>5</td>
<td>49</td>
</tr>
<tr>
<td>Grand Total</td>
<td>681</td>
<td>48</td>
<td>729</td>
</tr>
</tbody>
</table>

Average/person                                      | 14.2    | 1.0   | 15.2  | 1.9     |

Table 5. Environmental Interventions During 18-Month Study Period by Treatment and Control Group Study Participants

<table>
<thead>
<tr>
<th>Treatment Group (n = 48)</th>
<th>Control Group (n = 42)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; $100</td>
</tr>
<tr>
<td>Kitchen modifications</td>
<td>2</td>
</tr>
<tr>
<td>Intercom doorbell</td>
<td>2</td>
</tr>
<tr>
<td>Bathroom repair</td>
<td>10</td>
</tr>
<tr>
<td>Cabinet/shelf</td>
<td>7</td>
</tr>
<tr>
<td>Floor lamp</td>
<td>2</td>
</tr>
<tr>
<td>Redirecting wires</td>
<td>$100-$500</td>
</tr>
<tr>
<td>Ceiling fan</td>
<td>1</td>
</tr>
<tr>
<td>Chair repair</td>
<td>1</td>
</tr>
<tr>
<td>Subtotal</td>
<td>26</td>
</tr>
<tr>
<td>$100-$500</td>
<td></td>
</tr>
<tr>
<td>Hand railings</td>
<td>6</td>
</tr>
<tr>
<td>Intercom</td>
<td>3</td>
</tr>
<tr>
<td>Kitchen modification</td>
<td>2</td>
</tr>
<tr>
<td>Shelving/cabinet</td>
<td>4</td>
</tr>
<tr>
<td>Garage door opener</td>
<td>2</td>
</tr>
<tr>
<td>Ramp</td>
<td>3</td>
</tr>
<tr>
<td>Lighting</td>
<td>1</td>
</tr>
<tr>
<td>Security</td>
<td>1</td>
</tr>
<tr>
<td>Deadbolt</td>
<td>1</td>
</tr>
<tr>
<td>Closet modification</td>
<td>1</td>
</tr>
<tr>
<td>Door widening</td>
<td>1</td>
</tr>
<tr>
<td>Door replacement</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
</tr>
<tr>
<td>Subtotal</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
</tr>
</tbody>
</table>

*All provided by self or other.

†Provided by self or other and not included in subtotal or total; all other interventions in the treatment group were provided by study.

The majority of devices (87%) addressed motor impairment, and, of these, the largest category was devices for bathing, followed closely by devices for meal preparation. Other frequently provided devices were related to dressing, leisure, and use of the telephone. Devices listed as addressing fine motor impairment included special scissors, door handles, bag openers, and faucet extenders. For vision, low-technology aids frequently included magnifying glasses, lamps, low-vision watches, and electronic devices with larger buttons or dials. Devices listed in Table 4 as “supportive devices” include positioning pillows, egg-crate mattresses, back braces, incontinence pads, and medical alert bracelets.

Participants in the treatment group received a mean of 1.44 EIs from the study (a total of 69 interventions) and an additional 0.04 from other resources (a total of 2 interventions). Participants in the control group received a mean of 0.19 EIs (a total of 8 interventions). This difference in total number of EIs is significant (t = 4.1, P <.001). Table 5 lists the types of EIs provided. Two of the most frequent were addition of handrails and addition of shelves and cabinets. Intercom and security systems were provided to 9 participants.

**FUNCTIONAL INDEPENDENCE**

**Change Over Time**

Table 3 summarizes the changes in functional status for each group during the 18-month period. Both groups declined on the Older Americans Research and Services Center Instrument Instrumental Activities of Daily Living measure, the FIM instrument, and each of the 2 subdomains of the FIM, motor and cognitive. For the Function Status Index pain measure, only the control group showed a significant increase in pain at the end of 18 months. On the CHART, there were no significant differences over time for the physical independence or occupation subscales, but for the mobility subscale the control group showed significant decline, and for social integration both groups showed significant decline.
Difference Between Treatment and Control Groups at 18 Months

We initially used descriptive statistics to examine differences between the 2 groups at 18 months. We first asked: Were there more study participants who experienced functional decline in the control group than in the treatment group? The results are shown in Figure 1. For 7 of the 9 functional outcome measures, a larger percentage of participants in the control group declined than in the treatment group. For the mobility section of the CHART, more treatment group subjects declined than control group subjects, and, on the cognitive section of the FIM instrument, the same percentage of subjects in each group declined. For the 7 measures where the larger proportion of control group participants showed decline, the difference in percentage of participants declining ranged from 9% on the Mini-Mental State Examination to 24% on the occupation section of the CHART. Analysis by $\chi^2$ applied to these findings suggests significant differences only for CHART occupation and Functional Status Index pain (and approaching significance for CHART physical independence). The combined results suggest overall greater decline in functional independence for the control group.

We standardized the scores to a 100-point scale for each of the measures and then graphed the mean change from initial to 18-month follow-up for the treatment and control groups (Figure 2). For every measure, the control group declined more than the treatment group. The smallest mean difference between the 2 groups was 2.7 for CHART mobility. The largest difference was 13.3 points for CHART physical independence.

Significant differences between the treatment and control groups were found for FIM total score, FIM motor score, and Functional Status Index pain score. Table 6 summarizes this analysis. For the FIM total score, both groups declined, but there was significantly more decline for the control group. There was no signifi-
Table 6. Comparison of Treatment and Control Groups at 18 Months*  

<table>
<thead>
<tr>
<th>Variables</th>
<th>Initial</th>
<th>18-mo</th>
<th>ANCOVA, F(P)</th>
<th>Effect Size of ANCOVA (I)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CARS-IADL</td>
<td>9.8 (3.1)</td>
<td>8.9 (3.2)</td>
<td>2.35 (1.10)</td>
<td>0.15</td>
</tr>
<tr>
<td>Treatment</td>
<td>9.2 (3.1)</td>
<td>7.9 (4.1)</td>
<td>6.05 (0.01)</td>
<td>0.22</td>
</tr>
<tr>
<td>Control</td>
<td>7.4 (14.2)</td>
<td>71.6 (16.2)</td>
<td>2.56 (1.1)</td>
<td>0.16</td>
</tr>
<tr>
<td>FIM Motor</td>
<td>75.0 (13.4)</td>
<td>66.4 (19.1)</td>
<td>7.02 (1.01)</td>
<td>0.28</td>
</tr>
<tr>
<td>Treatment</td>
<td>34.6 (6.0)</td>
<td>33.2 (1.8)</td>
<td>4.26 (0.04)</td>
<td>0.22</td>
</tr>
<tr>
<td>Control</td>
<td>34.4 (1.2)</td>
<td>31.5 (6.2)</td>
<td>4.26 (0.04)</td>
<td>0.22</td>
</tr>
<tr>
<td>FIM Total</td>
<td>109.8 (14.3)</td>
<td>104.8 (16.7)</td>
<td>1.67 (0.20)</td>
<td>0.15</td>
</tr>
<tr>
<td>Treatment</td>
<td>109.8 (14.3)</td>
<td>97.9 (23.2)</td>
<td>1.67 (0.20)</td>
<td>0.15</td>
</tr>
<tr>
<td>Control</td>
<td>39.8 (1.7)</td>
<td>28.1 (2.6)</td>
<td>2.16 (0.15)</td>
<td>0.15</td>
</tr>
<tr>
<td>MMSE</td>
<td>29.3 (1.5)</td>
<td>26.5 (5.3)</td>
<td>0.78 (0.38)</td>
<td>0.09</td>
</tr>
<tr>
<td>Treatment</td>
<td>14.6 (6.4)</td>
<td>14.6 (5.8)</td>
<td>0.54 (0.46)</td>
<td>0.08</td>
</tr>
<tr>
<td>Control</td>
<td>16.1 (5.5)</td>
<td>18.2 (6.0)</td>
<td>0.54 (0.46)</td>
<td>0.08</td>
</tr>
<tr>
<td>CHART: Physical Independence</td>
<td>78.3 (34.1)</td>
<td>70.1 (29.2)</td>
<td>2.16 (0.15)</td>
<td>0.15</td>
</tr>
<tr>
<td>Treatment</td>
<td>85.8 (20.4)</td>
<td>73.9 (35.2)</td>
<td>2.16 (0.15)</td>
<td>0.15</td>
</tr>
<tr>
<td>Control</td>
<td>70.6 (23.5)</td>
<td>66.2 (25.2)</td>
<td>0.78 (0.38)</td>
<td>0.09</td>
</tr>
<tr>
<td>CHART: Mobility</td>
<td>64.2 (20.0)</td>
<td>57.1 (31.5)</td>
<td>0.54 (0.46)</td>
<td>0.08</td>
</tr>
<tr>
<td>Treatment</td>
<td>39.5 (10.2)</td>
<td>33.0 (26.8)</td>
<td>0.54 (0.46)</td>
<td>0.08</td>
</tr>
<tr>
<td>Control</td>
<td>39.1 (20.0)</td>
<td>31.5 (30.2)</td>
<td>0.54 (0.46)</td>
<td>0.08</td>
</tr>
<tr>
<td>CHART: Social</td>
<td>73.7 (24.7)</td>
<td>67.5 (26.9)</td>
<td>2.52 (0.12)</td>
<td>0.17</td>
</tr>
<tr>
<td>Integration</td>
<td>71.0 (25.4)</td>
<td>58.5 (28.7)</td>
<td>2.52 (0.12)</td>
<td>0.17</td>
</tr>
</tbody>
</table>

*Data are given as mean (SD). CARS indicates Older Americans Research and Services Center Instrument; IADL, Instrumental Activities of Daily Living; FIM, Functional Independence Measure; MMSE, Mini-Mental State Examination; FSI, Functional Status Index; CHART, Craig Handicap Assessment and Reporting Technique, and ANCOVA, analysis of covariance. df = 1.87 for all tests; percentage error rate, 16.7%.

significant difference between the 2 groups in the cognitive section of the FIM, but there was a significant difference for the FIM motor section. Pain as measured by the Functional Status Index was significantly higher for the control group.

**COST ANALYSIS**

In comparing health care costs, the treatment group expended more for AT-EIs (mean and median for the treatment vs control group, $2620 and $2233 vs $443 and $0; U = 183, P < .001). The control group required significantly more expenditures for institutional care (mean and median for the treatment vs control group, $5630 and $0 vs $21846 and $3511; U = 901, P < .01). There was no significant difference in total in-home personnel costs, but the control group had significantly greater expenditures for nurse visits (mean and median for the treatment vs control group, $426 and $98 vs $842 and $588; U = 869, P < .01) and case manager visits ($110 and $0 vs $193 and $267; U = 812, P < .001). The effect size for total in-home personnel costs was moderate (d = 0.4). There was no significant difference for overall total costs, but the effect size for total of all costs measured was large (d = 0.56), with the treatment group expending a mean of $11473 and the control group, $31610. Information on factors related to cost are summarized in Table 7.

**COMMENT**

While both the treatment and control groups declined in functional status over time, the decline was greater for the control group participants. The control group declined more than the treatment group on every measure, with difference in percentage decline on each of the measures ranging from 2.7 to 13.3 percentage points.

In looking at individual items on the FIM instrument and comparing them with the types of AT provided, the differences in decline between the 2 groups appear to be directly related to the interventions. For example, the control group showed significant decline in the FIM walking item (from 5.43 [1.22] to 4.77 [1.72]), while the treatment group participants who received ambulation equipment and instruction did not show a significant decline. Similarly, for the dressing item on the FIM instrument, there was no significant decline for the treatment group, but the control group declined from 5.29 (1.66) to 4.09 (2.28). A 1-point decline on the 17-point FIM scale represents a change in the amount of care required. For example, a change in rating from 5 to 4 represents a change from "supervision only" to "minimal assistance-subject does 75% of the task." Studies have shown that a 1-point change on the FIM represents an average of 2.19 minutes of help per day for discharged stroke patients and 4.1 minutes per day for acutely ill patients with neurologic disabilities.

The impact of reduced decline in functional status and pain appears to be reflected in lower health care costs, including costs related to institutional care, and in-home nursing and case manager visits; however, the small sample size makes these results more suggestive than definitive. The link between AT-EIs in the home and institutional costs could be related to prevent injuries. We examined reasons for hospitalizations and found that serious falls accounted for 4 hospitalizations in the treatment group and 11 in the control group. The link between AT-EIs and hospital costs could also be related to increased feeling of responsibility for one's health care, and more interest on the part of the hospital or nursing home patient in getting back home, resulting in shorter stays. This is an area that requires further investigation.

Assistive technology and EIs are a relatively inexpensive service generally not provided through existing service systems. Managed care offers the promise of more integrated services, including those that are preventive and support maintenance of independence at the lowest level of care. If managed care providers offer fewer home health visits, however, capitated systems may actually impact negatively on the provision of AT-EIs.
Table 7. Comparison of Treatment and Control Groups on Factors Related to Cost

<table>
<thead>
<tr>
<th>Cost Factor</th>
<th>Treatment Group (n = 52)</th>
<th>Control Group (n = 49)</th>
<th>Test of Significance, U*</th>
<th>Effect Size (d-Index)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD) Median Range</td>
<td>Mean (SD) Cost, $</td>
<td>Mean (SD) Median Range</td>
<td>Mean (SD) Cost, $</td>
</tr>
<tr>
<td>In-home personnel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurse visits</td>
<td>4.4 (7.3) 0 0-37</td>
<td>8.6 (1.8) 6 0-36</td>
<td>676 (139)</td>
<td>812</td>
</tr>
<tr>
<td>Case manager visits</td>
<td>1.2 (1.8) 0 0-10</td>
<td>2.2 (1.6) 3 0-6</td>
<td>193 (138)</td>
<td>812</td>
</tr>
<tr>
<td>Occupational therapist visits</td>
<td>6.9 (23.9) 0 0-144</td>
<td>10.2 (30.4) 0 0-163</td>
<td>916 (2734)</td>
<td>1274</td>
</tr>
<tr>
<td>Physical therapist visits</td>
<td>13.1 (28.3) 0 0-144</td>
<td>18.4 (43.7) 0 0-215</td>
<td>1622 (389)</td>
<td>1205</td>
</tr>
<tr>
<td>Speech-language pathologist visits</td>
<td>0 (0) 0 0 0</td>
<td>0.4 (2.9) 0 0-16</td>
<td>31 (209)</td>
<td>1222</td>
</tr>
<tr>
<td>Aide hours</td>
<td>439.4 (700.2) 137 0-2828</td>
<td>700.3 (337.4) 108 0-328</td>
<td>5714 (750)</td>
<td>1136</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5923 (713)</td>
<td>9320 (10.6)</td>
<td>1001</td>
<td>0.40</td>
</tr>
<tr>
<td>Institutional care</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursing home stays, d</td>
<td>7.4 (35.6) 0 0-209</td>
<td>11.9 (53.2) 0 0-391</td>
<td>1020 (3069)</td>
<td>1245</td>
</tr>
<tr>
<td>Hospitalizations, d</td>
<td>5.9 (13.2) 0 0-62</td>
<td>23.7 (46.5) 0 0-223</td>
<td>20826 (40801)</td>
<td>9111</td>
</tr>
<tr>
<td>Subtotal</td>
<td>5630 (1207)</td>
<td>21846 (41197)</td>
<td>9011</td>
<td>0.53</td>
</tr>
<tr>
<td>Assistive technology and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>environmental interventions</td>
<td>2620</td>
<td>443</td>
<td>153</td>
<td>1.69</td>
</tr>
<tr>
<td>Total: All Costs</td>
<td>14172 (13761)</td>
<td>31610 (42239)</td>
<td>1055</td>
<td>0.58</td>
</tr>
</tbody>
</table>

*Percentage error rate = 12.0%.
†P < .01.
‡P < .001.

In describing funding policy regarding geriatric rehabilitation, Torres-Gil (former director of the Department of Health and Human Service's Administration on Aging) and Wray wrote:

As the older population grows in relation to the overall population, and the incidence of chronic disabling conditions rises, the need for rehabilitative and long-term care services will also increase. The current overreliance on high-cost, high-technology interventions may delay mortality while increasing morbidity. Accordingly, preventing or postponing morbidity is often cited as an important public health goal. [Ref 21]

Low-cost AT and EIs may prevent and postpone morbidity. More research is needed to examine the intensity of service provision, training, types of AT-Es, and the interaction of AT-Es and personal assistance. We are following up the sample reported in this article to determine functional status and health-related cost differences in the 2 groups over time. Additional research is necessary to confirm the impact of AT-Es on physically frail, cognitively alert elderly persons. The impact of AT and EIs on cognitively impaired elderly persons also remains to be investigated.

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The FIM instrument is a trademark of the Uniform Data System for Medical Rehabilitation, a division of UB Foundation Activities Inc, Buffalo, NY.

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REFERENCES