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

A Randomized Controlled Trial

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Context: Home environmental interventions (EIs) 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 EIs 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 EIs. 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 EIs.

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TO 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 (EIs) 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 EIs, 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 EIs as "helpful," and the potential of AT is reflected in federal law, there has been little study of their effectiveness on increasing independence[1] 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.[2] 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.[3] 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 non–cognitively impaired, frail elderly persons.[4] 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.[5] 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 α level of .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 interdisciplinary 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 EIs) 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 EIs. 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[6]; and the Craig Handicap Assessment and Reporting Technique[7] (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.[8,9]

We also included pain and health care costs as dependent measures. Pain was assessed with the Functional Status Index.[10] 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 AI-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.[11]

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 the 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 χ^2 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.

Table 1. Comparison of Treatment and Control Groups at Initial Assessment: Demographic Variables

Variables	Total (N = 104)	Treatment (n = 52)	Control (n = 52)	Test for Significance of Differences
Age, mean (SD), y	73.0 (8.4)	74.3 (7.7)	71.6 (8.9)	$t_{102} = 1.65$
No. of children, mean (SD)	2.7 (2.6)	2.2 (1.8)	3.3 (3.1)	$t = 2.00$*
Sex, No. (%)				
M	**31** (29.8)	18 (34.6)	13 (25.0)	$\chi^2_1 = 1.149$
F	**73** (70.2)	34 (65.4)	39 (75.0)	
Race, No. (%)				
Minority	**30** (28.8)	12 (23.1)	18 (34.6)	$\chi^2_1 = 1.69$
White	**74** (71.2)	40 (76.9)	34 (65.4)	
Education, No. (%)	(n = 102)	(n = 52)	(n = 50)	
Less than high school	**32** (31.4)	17 (32.7)	15 (30.0)	$\chi^2_2 = 0.410$
High school and some college	**54** (52.9)	26 (50.0)	28 (56.0)	
College and above	**16** (15.7)	9 (17.3)	7 (14.0)	
Income, No. (%)	(n = 95)	(n = 45)	(n = 50)	
<$10 000	**54** (56.8)	23 (51.1)	31 (62.0)	$\chi^2_2 = 1.707$
$10 000-$19 999	**19** (20.0)	9 (20.0)	10 (20.0)	
≥$20 000	**22** (23.2)	13 (28.9)	9 (18.0)	
Marital status, No. (%)				
Married	**34** (32.7)	21 (40.4)	13 (25.0)	$\chi^2_2 = 3.257$
Widowed	**49** (47.1)	23 (44.2)	26 (50.0)	
Other	**21** (20.2)	8 (15.4)	13 (25.0)	
Living status, No. (%)				
Live alone	**55** (52.9)	28 (53.8)	27 (51.9)	$\chi^2_1 = 0.39$
Live with someone	**49** (47.1)	24 (46.2)	25 (48.1)	

*P≤.05.

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

Table 2. Comparison of Treatment and Control Groups at Initial Assessment: Health and Psychosocial Status

Variables	Total (N = 104)	Treatment (n = 52)	Control (n = 52)	Test for Significance of Differences
Health status				
Days in hospital past 6 mo, mean (SD)	5.3 (11.4)	6.2 (13.5)	4.3 (8.7)	$t_{102} = 0.82$
Physician visits last 6 mo, mean (SD)	5.9 (5.0)	5.3 (4.2)	6.9 (5.8)	$t_{102} = 1.32$
No. of medications, mean (SD)	6.0 (3.6)	5.8 (3.9)	6.3 (3.2)	$t_{102} = 0.73$
No. of chronic illnesses/conditions, mean (SD)	6.5 (2.9)	6.2 (2.7)	7.1 (3.3)	$t_{102} = 1.04$
Sick days in past 6 mo, No. (%)				
None	**42** (40.4)	21 (40.4)	21 (40.4)	$\chi^2_4 = 1.064$
<1 wk	**23** (22.1)	13 (25.0)	10 (19.2)	
1 wk–1 mo	**16** (15.4)	7 (13.5)	9 (17.3)	
>1 mo–3 mo	**18** (17.3)	8 (15.4)	10 (19.2)	
>3 mo	**5** (4.8)	3 (5.8)	2 (3.8)	
Psychosocial, mean (SD)				
Self-esteem	32.3 (5.5)	31.4 (5.7)	32.7 (5.3)	$t_{102} = 0.93$
Depression	13.0 (10.6)	14.3 (11.2)	12.5 (11.0)	$t_{102} = 0.65$
Social resources	3.0 (1.1)	3.1 (1.3)	3.0 (1.1)	$t_{102} = 0.29$
Quality of life, No. (%) (N = 102)				
Very good or good	**59** (57.8)	29 (55.8)	30 (60.0)	$\chi^2_1 = 0.57$
Neither	**32** (31.4)	18 (34.6)	14 (28.0)	
Pretty bad or very bad	**11** (10.8)	5 (9.6)	6 (12.0)	

Table 3. Changes in Functional Status Over Time*

	Initial	Test for Significance of Difference (*t*)	18-mo Follow-up	Difference Between Initial and Follow-up, *t* (*P*)†	Effect Size (d-Index)
IADL total					
Treatment	9.6 (3.1)	0.566	8.9 (3.2)	2.31 (.03)	0.53
Control	9.2 (3.1)		7.9 (4.1)	3.23 (.002)	0.72
FIM motor score					
Treatment	74.1 (14.2)	0.308	71.6 (16.2)	2.12 (.04)	0.44
Control	75.0 (13.4)		66.4 (19.1)	4.28 (<.001)	1.00
FIM cognitive score					
Treatment	34.6 (0.64)	1.157	33.2 (1.8)	5.46 (<.001)	1.20
Control	34.4 (1.2)		31.5 (6.2)	3.15 (.003)	0.74
FIM total score					
Treatment	108.8 (14.3)	0.222	104.8 (16.7)	3.19 (.003)	0.69
Control	109.4 (13.5)		97.9 (23.2)	4.21 (<.001)	1.02
MMSE					
Treatment	28.8 (1.7)	1.451	28.1 (2.6)	2.54 (.02)	0.49
Control	28.3 (1.8)		26.5 (5.3)	2.44 (.02)	0.61
FSI pain					
Treatment	14.6 (6.4)	1.164	14.6 (5.8)	0.03 (.98)	0.01
Control	16.1 (5.5)		18.2 (8.6)	2.05 (.05)	0.47
CHART: physical independence					
Treatment	78.3 (34.1)	1.282	79.1 (29.2)	0.19 (.85)	0.04
Control	85.8 (20.4)		73.3 (35.2)	2.11 (.04)	0.46
CHART: mobility					
Treatment	70.6 (23.5)	1.232	66.2 (25.2)	1.91 (.06)	0.39
Control	64.2 (26.0)		57.1 (31.5)	2.02 (.05)	0.45
CHART: occupation					
Treatment	35.5 (30.8)	0.574	33.0 (26.8)	0.60 (.55)	0.12
Control	39.1 (28.0)		31.5 (30.3)	2.15 (.04)	0.47
CHART: social integration					
Treatment	73.7 (24.7)	0.509	67.5 (26.9)	2.15 (.04)	0.45
Control	71.0 (25.4)		58.5 (28.7)	3.20 (.003)	0.70

**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.*

†For treatment df *= 47, and for control* df *= 41; percentage error rate = 6.25%.*

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 ($t_{88} = 6.57$, $P < .001$). **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

Device Given or Acquired and Impairment Addressed	Treatment: Through Study	Treatment: Through Usual Services	Treatment: Total	Control: Through Usual Services
Motor impairment				
Environmental control device	5	0	**5**	0
Phone and accessories	50	1	**51**	7
Reacher/physical extension	28	2	**30**	3
Special switches and controls	30	0	**30**	3
Meal preparation	98	1	**99**	3
Balance aid	34	10	**44**	9
Wheelchair and accessories	6	3	**9**	5
Special seating system	13	3	**16**	2
Activities of daily living				
Bathing	104	4	**108**	12
Eating	25	0	**25**	0
Grooming	12	1	**13**	1
Dressing	50	0	**50**	1
Hygiene	23	7	**30**	7
Writing device	9	0	**9**	0
Homemaking	14	0	**14**	2
Rug gripper	10	0	**10**	1
Other: fine motor	19	0	**19**	2
Leisure	50	1	**51**	1
Other	4	5	**9**	6
Total	**584**	**38**	**622**	**65**
Hearing impairment				
Hearing aid	0	2	**2**	3
Assistive listening device	6	1	**7**	0
Total	**6**	**3**	**9**	**3**
Vision impairment				
Braille output device	1	0	**1**	0
Audio tactile system	1	0	**1**	0
Low-technology aids	41	1	**42**	1
Leisure	4	1	**5**	0
Total	**47**	**2**	**49**	**1**
Cognitive device, total	0	0	0	1
Other devices, total	44	5	**49**	10
Grand Total	**681**	**48**	**729**	**80**
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

Treatment Group (n = 48)		Control Group (n = 42)*	
< $100		<$100	
Kitchen modifications	2	Rug protector	1
Intercom doorbell	2	Lighting	1
Bathroom repair	10	Smoke detector	1
Cabinet/shelf	7	Wedge 1 step to bathroom	1
Floor lamp	2	**Subtotal**	**4**
Redirecting wires	1	$100-$500	
Ceiling fan	1	Bathroom modification	1
Chair repair	1	**Subtotal**	**1**
Subtotal	**26**	>$500	
$100-$500		Lighting installation	1
Hand railings	6	Railing	1
Intercom	3	Stair guide	1
Kitchen modification	2	**Subtotal**	**3**
Shelves/cabinet	4	**Total**	**8**
Bathroom modification	5		
Garage door opener	2		
Ramp	3		
Lighting	1		
Security	1		
Deadbolt	1		
Closet modification	1		
Door widened†	1		
Door replacement†	1		
Other	2		
Subtotal	**33**		
>$500			
Intercom	4		
Railing	2		
Ramp	2		
Door installation	1		
Air conditioner	1		
Subtotal	**10**		
Total	**69**		

**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.

jority 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 handles, car door 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 ($t_{88} = 4.1$, $P < .001$). **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.

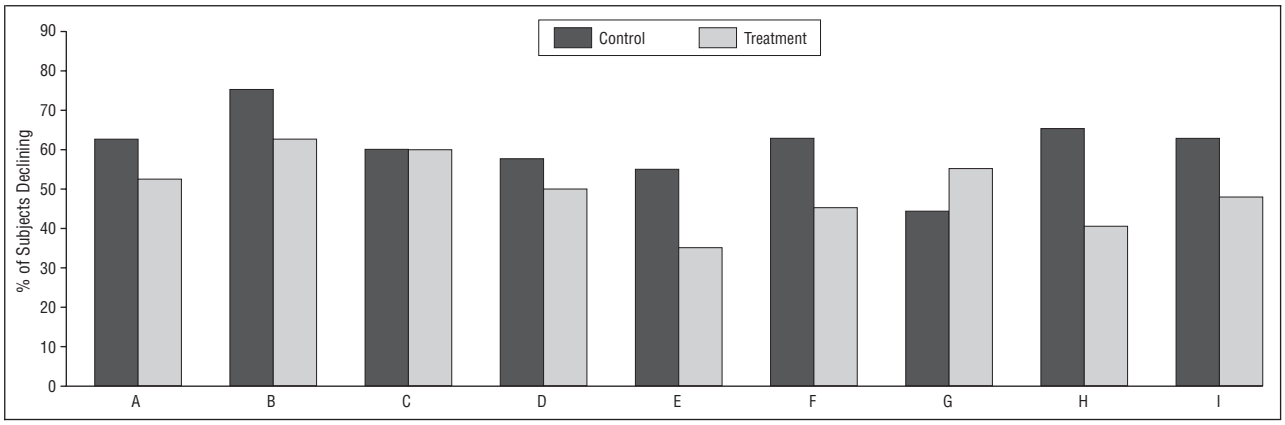

Figure 1. *Percentage of subjects whose scores on measures of functional status declined, by treatment group. A indicates Instrumental Activities of Daily Living (Older Americans Research and Services Center Instrument); B, Functional Independence Measure, motor; C, Functional Independence Measure, cognitive; D, Mini-Mental State Examination; E, Functional Status Index, pain; F, Craig Handicap Assessment and Reporting Technique, physical independence; G, Craig Handicap Assessment and Reporting Technique, mobility; H, Craig Handicap Assessment and Reporting Technique, occupation; and I, Craig Handicap Assessment and Reporting Technique, social independence.*

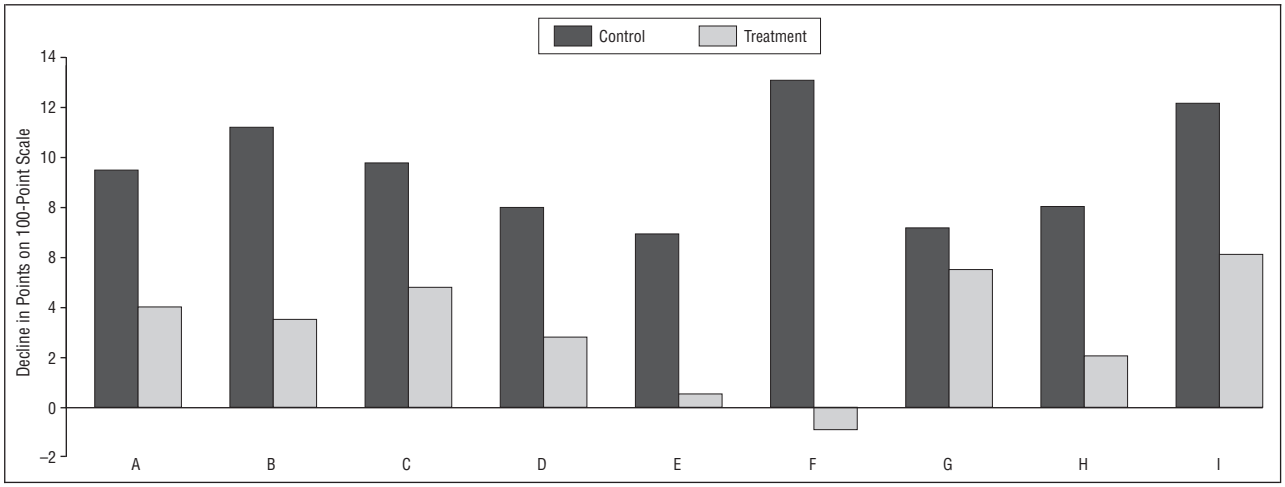

Figure 2. *Mean decline on measures of functional status by group in standard scores. A indicates Instrumental Activities of Daily Living (Older Americans Research and Services Center Instrument); B, Functional Independence Measure, motor; C, Functional Independence Measure, cognitive; D, Mini-Mental State Examination; E, Functional Status Index, pain; F, Craig Handicap Assessment and Reporting Technique, physical independence; G, Craig Handicap Assessment and Reporting Technique, mobility; H, Craig Handicap Assessment and Reporting Technique, occupation; and I, Craig Handicap Assessment and Reporting Technique, social independence.*

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 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 χ^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 scale. **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*

Variables	Initial	18-mo Follow-up	ANCOVA, F (*P*)	Effect Size of ANCOVA (f)
OARS-IADL			2.35 (.13)	0.16
Treatment	9.6 (3.1)	8.9 (3.2)		
Control	9.2 (3.1)	7.9 (4.1)		
FIM motor			6.65 (.01)	0.28
Treatment	74.1 (14.2)	71.6 (16.2)		
Control	75.0 (13.4)	66.4 (19.1)		
FIM cognitive			2.56 (.11)	0.16
Treatment	34.6 (0.64)	33.2 (1.8)		
Control	34.4 (1.2)	31.5 (6.2)		
FIM total			7.02 (.01)	0.28
Treatment	108.8 (14.3)	104.8 (16.7)		
Control	109.4 (13.5)	97.9 (23.2)		
MMSE			1.67 (.20)	0.13
Treatment	28.8 (1.7)	28.1 (2.6)		
Control	28.3 (1.8)	26.5 (5.3)		
FSI pain			4.26 (.04)	0.22
Treatment	14.6 (6.4)	14.6 (5.8)		
Control	16.1 (5.5)	18.2 (8.6)		
CHART: physical independence			2.16 (.15)	0.15
Treatment	78.3 (34.1)	79.1 (29.2)		
Control	85.8 (20.4)	73.3 (35.2)		
CHART: mobility			0.78 (.38)	0.09
Treatment	70.6 (23.5)	66.2 (25.2)		
Control	64.2 (26.0)	57.1 (31.5)		
CHART: occupation			0.54 (.46)	0.08
Treatment	35.5 (30.8)	33.0 (26.8)		
Control	39.1 (28.0)	31.5 (30.3)		
CHART: social integration			2.51 (.12)	0.17
Treatment	73.7 (24.7)	67.5 (26.9)		
Control	71.0 (25.4)	58.5 (28.7)		

**Data are given as mean (SD). OARS 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%.*

cant difference between the 2 groups on 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 $21 846 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 $14 173 and the control group, $31 610. 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 7-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 assist—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[13] and 4.1 minutes per day for acutely ill patients with neurologic disabilities.[14]

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 prevention of 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,[15] 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

Cost Factor	Treatment Group (n = 52)				Control Group (n = 49)				Test of Significance, *U**	Effect Size (d-Index)
	Mean (SD)	Median	Range	Mean (SD) Cost, $	Mean (SD)	Median	Range	Mean (SD) Cost, $		
In-home personnel										
Nurse visits	4.4 (7.3)	1	0-37	426 (717)	8.6 (14.8)	6	0-86	842 (1451)	869†	0.36
Case manager visits	1.2 (1.8)	0	0-10	110 (164)	2.2 (1.6)	3	0-6	193 (138)	812†	0.55
Occupational therapist visits	6.9 (23.9)	0	0-144	620 (2147)	10.2 (30.4)	0	0-163	918 (2734)	1274	0.12
Physical therapist visits	13.1 (29.3)	0	0-144	1182 (2636)	18.4 (43.7)	0	0-216	1622 (3894)	1205	0.14
Speech-language pathologist visits	0 (0)	0	0-0	0 (0)	0.4 (2.3)	0	0-16	31 (206)	1222	0.21
Aide hours	439.4 (700.2)	137	0-2828	3585 (5714)	700.3 (937.4)	108	0-3528	5714 (7650)	1136	0.32
Subtotal				**5923** (7133)				**9320** (10 861)	1091	0.40
Institutional care										
Nursing home stays, d	7.4 (35.6)	0	0-209	633 (3063)	11.9 (59.2)	0	0-394	1020 (5094)	1245	0.09
Hospitalizations, d	5.9 (13.2)	0	0-62	4997 (11 599)	23.7 (46.5)	0	0-223	20 826 (40 801)	911†	0.53
Subtotal				**5630** (1207)				**21 846** (41 197)	901†	0.53
Assistive technology and environmental interventions				2620				443	183‡	1.69
Total: All Costs				**14 172** (13 761)				**31 610** (42 239)	1085	0.56

**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.[16(p838)]

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-EIs, and the interaction of AT-EIs 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-EIs 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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