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A cost–benefit analysis of three older adult fall prevention interventions☆,☆☆

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ABSTRACT

Introduction: One out of three persons aged 65 and older falls annually and 20% to 30% of falls result in injury. The purpose of this cost–benefit analysis was to identify community-based fall interventions that were feasible, effective, and provided a positive return on investment (ROI). *Methods:* A third-party payer perspective was used to determine the costs and benefits of three effective fall interventions. Intervention effectiveness was based on randomized controlled trial results. National data were used to estimate the average annual benefits from averting the direct medical costs of a fall. The net benefit and ROI were estimated for each of the interventions. *Results:* For the *Otago Exercise Program* delivered to persons aged 65 and older, the net benefit was $121.85 per participant and the ROI was 36% for each dollar invested. For *Otago* delivered to persons aged 80 and older, the net benefit was $429.18 and the ROI was 127%. *Tai chi: Moving for Better Balance* had a net benefit of $529.86 and an ROI of 509% and *Stepping On* had a net benefit of $134.37 and an ROI of 64%. *Conclusions:* All three fall interventions provided positive net benefits. The ROIs showed that the benefits not only covered the implementation costs but also exceeded the expected direct program delivery costs. These results can help health care funders and other community organizations select appropriate and effective fall interventions that also can provide positive returns on investment.

1. Introduction

Approximately one third of persons aged 65 and older fall annually (Tromp et al., 2001) and 20% to 30% of falls result in injury (Sterling, O'Connor, & Bonadies, 2001). Adjusted for inflation, the direct medical costs of fatal and nonfatal falls among people aged 65 and older exceeds $30 billion (Stevens, Corso, Finkelstein, & Miller, 2006). In 2005, Roudsari et al. estimated that the direct medical costs of an acute fall injury averaged $17,483 (Roudsari, Ebel, Corso, Molinari, & Koepsell, 2005).

The purpose of this cost–benefit analysis was to identify fall interventions that were feasible, effective, and provided a good return on investment (ROI). Such financial information can help organizations determine whether investing in specific interventions will translate into positive net financial benefits—that is, the benefits from averted direct medical costs outweigh the costs of implementing the intervention—and provide positive ROIs. This information also can help implementers identify the most appropriate interventions for their participants, thereby avoiding unnecessary costs without compromising effectiveness.

2. Method

This cost–benefit analysis used a third-party payer perspective to estimate the average costs and benefits of three effective community-based fall interventions. This perspective is relevant for any health care funder that bears the costs of treating fall injuries and may be considering providing a

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☆☆ Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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fall prevention program to enrollees as a preventive health service. This perspective was chosen because third-party funders have a strong financial incentive to prevent falls by their beneficiaries and these programs utilize staff that may be readily available to health care funders such as Medicare Advantage plans. However, these are not the only organizations that may have an incentive to fund fall prevention programs.

The methodology used here followed published guidelines for economic evaluation of fall prevention programs. (Davis, Robertson, Comans, & Scuffham, 2011). The costs of fatal and nonfatal injuries, derived from national vital statistics and claims data, were used to estimate the average annual benefits from averting the direct medical costs of a fall (Finkelstein, Corso, & Miller, 2006). The incidence of falls was estimated using data from the 2000 National Vital Statistics System, 2001 National Electronic Injury Surveillance System—All Injury Program, 2000 Health Care Utilization Program National Inpatient Sample and 1999 Medical Expenditure Panel Survey (Stevens et al., 2006). The average annual cost of a fall injury was estimated by dividing the total costs of fatal and non-fatal fall injuries by the number of injuries in 2000. All costs were adjusted for inflation to the year 2012 price level using the medical consumer price index (medical CPI). The timeframe for these cost estimates quantified costs for twelve months post injury.

2.1. Fall interventions

Fall interventions were selected based on the following criteria: a high level of effectiveness shown in the randomized controlled trial (RCT); feasibility because the intervention had been translated into a program and implemented in community settings; and appropriate for older adults with differing levels of fall risk. Three effective community-based fall interventions (Stevens, 2010) were selected for this analysis:

1. The *Otago Exercise Program* (Campbell, Robertson, Gardner, Norton, & Buchner, 1999)
2. *Tai Chi: Moving for Better Balance* (Li et al., 2005)
3. *Stepping On* (Clemson et al., 2004)

2.2. The Otago Exercise Program

The *Otago Exercise Program* was first implemented in Dunedin, New Zealand. The program consisted of individually tailored muscle-strengthening and balance-retraining exercises of increasing difficulty combined with a walking program. A physical therapist or specially trained nurse made a one-hour visit and three half-hour visits over the first two months. The participant was prescribed a set of in-home exercises selected for appropriate and increasing levels of difficulty as well as a walking plan. The exercises took about 30 min. Participants were encouraged to complete the exercises three times a week and to walk outside the home at least twice a week.

A fall in this study was defined as, "unintentionally coming to rest on the ground, floor, or other lower level" (Campbell et al., 1999). When compared with controls, the fall rate among the *Otago Exercise Program* participants was reduced by 35% (incidence rate ratio [IRR] = 0.65, 95% confidence interval [CI] 0.57–0.75) (Robertson, Campbell, Gardner, & Devlin, 2002). When participation was restricted to adults aged 80 and older who had previously fallen, the intervention effectiveness was 40% (IRR = 0.60, 95% CI .45–0.81) (Robertson et al., 2002).

2.3. Tai Chi: Moving for Better Balance

Tai Chi: Moving for Better Balance consisted of one-hour sessions of Tai Chi movements that included a warm-up and cool down period. The program consisted of 24 Tai Chi forms that emphasized weight shifting, postural alignment, and coordinated movements. Classes were held three times a week for 26 weeks. The program was delivered by experienced Tai Chi instructors who followed the classical Yang style. The program was designed to be implemented in senior centers, adult activity centers, and community centers.

A fall in this study was defined as, "landing on the floor or the ground, or falling and hitting objects such as stairs or pieces of furniture, by accident" (Li et al., 2005). When compared with controls, the risk of falling among the *Tai Chi: Moving for Better Balance* participants was reduced 55% (risk ratio = 0.45, 95% CI 0.30–0.70) (Li et al., 2005).

2.4. Stepping On

Stepping On was developed in Australia. It consisted of seven weekly three-hour group sessions conducted in a community setting with follow-up home visits. The program was led by an occupational therapist (OT) who introduced the exercises and led or facilitated sessions about topics related to falls. Most sessions were attended by a volunteer subject matter expert who discussed topics such as managing medications, home and community safety, behavioral methods for sleeping better, and using hip protectors. This intervention has been translated by researchers at the University of Wisconsin at Madison in collaboration with the original researchers for implementation in the United States.

A fall in this study was defined as, "an event that results in a person unintentionally coming to rest on the ground, floor, or other lower level" (Clemson et al., 2004). Compared to controls, the fall rate among *Stepping On* participants was reduced by 31% (relative risk = 0.69, 95% CI 0.50–0.96) (Clemson et al., 2004).

2.5. Time frames

The time frame—the length of the intervention—differed for each intervention. The *Otago Exercise Program* lasted six months, the Tai Chi intervention lasted 26 weeks, and the *Stepping On* program lasted seven weeks. The time horizon—the length of time measured from the beginning of the intervention to the outcome assessment—also differed for each intervention. The effectiveness of the *Otago Exercise Program* and the Tai Chi program were measured at one year and the effectiveness of *Stepping On* was measured at 14 months.

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Table 1
The *Otago Exercise Program* for people aged 65 and older or 80 and older.

Activity	Resource type	Type & units	Cost/unit	Annual cost	Cost per participant per year (n = 200)
Marketing	Labor & materials[a]	Advertising 10 h	$17.91/h	$358.20	$1.79
Training (10 PTs[c] per year)	Lead Trainer[b]	Instruction 10 h	$53.86/h	$269.30[d]	$1.34
	Materials	1 Instruction manual	$40.00 each	$40.00	$0.20
Intervention (2 programs per year)					
	PT labor	3 h per participant per session	$38.39/h	$23,034.00	$115.17
	PT travel time	5 h per participant per session	$38.39/h	$38,390.00	$191.95
	PT telephone calls	0.75 h per participant per session	$38.39/h	$5,758.50	$28.79
Totals				$67,850.00	$339.15

[a] 43-4199 Information and Record Clerks, All Other at: jttp://www.bls.gov/oes/current/oes434199.htm.
[b] 13-1151 Training and Development Specialists, at: http://www.bls.gov/oes/current/oes131151.htm.
[c] Physical therapist.
[d] Pro-rated over 2 years.

2.6. Estimates of costs and benefits

In this analysis, the financial or monetary cost was the price a third-party health care funder would pay for a resource. Consistent with this perspective, only the costs incurred by the program were included; we did not include travel or other costs possibly incurred by the participants.

Resource costs were obtained by multiplying the amount of resources used to implement the intervention by the resource unit price. Cost for each program was measured retrospectively using published descriptions of the interventions in the trials along with direct communication with program developers. Intervention costs included the resources used in pre-intervention training (e.g., training the Tai chi instructor) and post-intervention follow-up. Salary estimates were obtained from the *U.S. Occupational Outlook Handbook* (www.bls.gov/ooh/home.htm). The average cost per participant was calculated by dividing the total cost of the intervention by the number of participants.

The benefits from averting direct medical costs were estimated by subtracting the direct medical costs expected for an intervention participant from the direct medical costs expected for an individual who did not received the intervention. For these calculations, we assumed that a person who did not participate in a fall prevention program had a 30% risk of falling among people aged 65 and older, a 50% risk among people aged 80 and older (Kannus, Sievänen, Palvanen, Järvinen, & Parkkari, 2005), and a 33.4% likelihood of seeking medical care following a fall (Stevens et al., 2012). The effect of the program on the probability of a fall was calculated for each intervention, and this reduced probability was used to generate the lower expected medical cost.

The net benefit and ROI were estimated for the each of the three interventions. The net benefit was the benefit from averting fall-attributable medical costs after subtracting intervention costs, and the ROI was the percentage of return per each dollar invested. The magnitude of the ROI indicated the extent to which program benefits exceeded program costs, expressed in percentage terms.

Univariate sensitivity analyses were conducted to assess the effect on the ROIs of varying the effectiveness of the interventions. In addition, because it seemed reasonable that the average cost of a fall injury among persons aged 80 years and older would be higher than for all persons aged 65 and older, we also conducted a sensitivity analysis by varying the direct medical costs of a fall.

3. Results

Approximately 2,610,300 falls among people aged 65 and older occurred in 2000. In the same year, the direct medical costs of fatal and nonfatal falls totaled approximately $19.3 billion. Therefore, the direct medical cost of a fall was estimated to be $7,356 (Stevens et al., 2006). After adjusting for inflation to the year 2012 price level using the medical consumer price index (medical CPI), the average direct medical cost of a fall was estimated to be $11,502.

Table 2
Tai chi: moving for better balance.

Activity	Resource type	Type & units per session	Cost/unit	Annual cost	Cost per participant per year (n = 30)
Marketing[a]	Labor & materials	Advertising 10 h	$17.91/h	$358.20	$11.94
Training (5 instructors per year)	Master Trainer[b]	Instruction 8 h	$45.86/h	$183.44[c]	$6.11
	Materials	5 instruction manuals	$40.00 each	$200.00	$6.67
Intervention (2 sessions per year)					
	Tai chi instructor[d]	39 h per session	$15.25/h	$2379.00	$79.30
Totals				$3120.64	$104.02

[a] 43-4199 Information and Record Clerks, All Other at: http://www.bls.gov/oes/current/oes434199.htm.
[b] 11-3131 Training and Development Managers, at: http://www.bls.gov/oes/current/oes113131.htm.
[c] Pro-rated over 2 years.
[d] 39-9031 Fitness Trainers and Aerobics Instructors, at: http://www.bls.gov/oes/current/oes399031.htm.

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Table 3
Stepping on.

Activity	Resource type	Item & units	Cost per unit	Annual cost	Cost per participant per year (n = 48)
Marketing[a]	Labor & materials	Advertising 10 h	$17.91/h	$716.40	$14.92
Training	Materials	1 display table	$300 each	$300.00	$6.25
(20 OT[b] instructors per year)	Labor[c]	Instruction 20 h	$45.87/h	$857.40[d]	$19.11
	Materials	1 instruction manual	$90 each	$90.00	$1.88
Intervention (4 sessions per year)					
Registering participants & coordinating site	Labor[a]	8 h per session	$17.91/h	$573.12	$11.94
Prepping volunteer experts, organizing classes	Labor for PT[e]	35 h per session	$38.39/h	5374.60	111.97
	Labor for 3 volunteer experts	4.5 h per session	$0.00	0.00	0.00
Follow up home visit	Labor for OT	1 h per participant	$36.25/h	$1,740.00	36.25
Telephone booster session	Labor for OT	0.25 h per participant	$9.06/call	$435.00	9.06
Totals				$10,086.52	$211.38

[a] 43-4199 Information and Record Clerks, all other at: http://www.bls.gov/oes/current/oes434199.htm.
[b] Occupational therapist.
[c] Training and Development Manager, at: http://www.bls.gov/ooh/management/training-and-development-managers.htm.
[d] Training pro-rated over 2 years.
[e] Physical therapist.

The specific types and quantities of resources, price per resource unit, total costs, and average cost per participant for each intervention are shown in Tables 1, 2, and 3.

3.1. The Otago Exercise Program (Table 1)

Assumptions:

- The Leader would train a physical therapist (PT) in one hour; ten PTs would be trained each year.
- Each PT would conduct two six-month programs per year.
- Each PT would conduct four six-month programs before needing re-training.
- The *Otago Exercise Program* would be delivered to 200 participants per year.

Under these assumptions, the average cost of the *Otago Exercise Program* was $339.15 per participant.

Among persons aged 65 and older, the average expected benefit was estimated to be $461.00, the net benefit was $121.85, and the ROI was 36% for each dollar invested. Alternatively, if the $25 online Otago training course for PTs (available at: http://www.aheconnect.com/newahec/cdetail.asp?courseid=cgec3) was used rather than the train-the-trainer model, the average cost per participant was slightly lower—$338.53 per participant. In this situation, the net benefit was $122.47 and the ROI remained at 36%. The ROI for the *Otago Exercise Program* among persons aged 65 and older was positive if program effectiveness was at least 30% using either the train-the-trainer model or the online training.

Among persons aged 80 and older and using the train-the-trainer model, the average expected benefit was estimated to be $768.33, the net benefit was $429.18, and the ROI was 127% for each dollar invested. Using the online training, the net benefit became $429.80 and the ROI remained at 127%. Among this older age group, regardless of training method, the ROI was positive if effectiveness was at least 18%.

Because it seemed reasonable that a fall injury among persons aged 80 years and older would be more severe and more costly than for younger persons, we examined the effect on the ROI of a range of fall injury costs (data not shown). If the average cost of a fall injury for a person 80 years and older was increased by 50% (from $11,502 to $17,253), the ROI rose from 127% to 240%, an increase of 89%.

3.2. Tai Chi: Moving for Better Balance (Table 2)

Assumptions:

- The Master Trainer would train five instructors per year.
- An instructor would conduct two 26-week programs per year.
- An instructor would conduct four 26-week programs before needing re-training.
- Each *Tai Chi: Moving for Better Balance* class had 15 participants.
- The intervention would be delivered to 30 participants per year.

Under these assumptions, the average cost of *Tai Chi: Moving for Better Balance* was $104.02 per participant. The average expected benefit was estimated to be $633.90, the net benefit was $529.86, and the ROI was 509% for each dollar invested. The ROI remained positive for all levels of effectiveness 10% or higher.

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3.3. Stepping On (Table 3)

Assumptions:

- The PT leader would train ten OTs at a time or 20 OTs per year.
- Each OT would teach four sessions per year.
- Each OT would teach eight sessions before needing retraining.
- *Stepping On* would be delivered to 48 participants per year.

Under these assumptions, the average cost of *Stepping On* was $211.38 per participant. The average expected benefit was estimated to be $345.75, the net benefit was $134.37, and the ROI was 64% for each dollar invested. The ROI remained positive if program effectiveness was 19% or higher.

4. Discussion

This cost–benefit analysis showed that all three fall prevention interventions, the *Otago Exercise Program*, *Tai Chi: Moving for Better Balance*, and *Stepping On*, demonstrated positive net benefits—that is, the benefits from averted direct medical costs outweighed the costs of implementing the intervention. All three interventions were cost-saving.

Two interventions, *Tai Chi: Moving for Better Balance* and the *Otago Exercise Program* delivered to persons aged 80 and older, yielded ROIs greater than 100%, which are substantial returns. The magnitude of these benefits may be underestimated, in part because this analysis only included benefits from averting direct medical costs and did not include benefits from averting other costs such as productivity losses or material costs caused by a fall.

While the ROIs for all three interventions were positive, it would be important for an aging services organization thinking of implementing a fall prevention program to consider their client population. Some older adults are more likely to benefit from one intervention than from another. For example, older frail individuals likely would benefit most from the individualized approach of the *Otago Exercise Program*.

Tai chi: Moving for Better Balance had the highest ROI and this program appears to be most appropriate for healthy older adults (Logghe et al., 2011). This program also might appeal to companies, since up to 27% of older adults continue working after they retire (RCS—Retirement Confidence Survey, 2012). If a business implemented *Tai chi: Moving for Better Balance*, it could reduce falls among older employees, reduce absenteeism and increase productivity.

The financial measures presented in this analysis hold strictly to the assumptions used for estimating the average intervention costs and expected benefits from averting direct medical costs. The average intervention cost was highly influenced by both personnel salary costs and the intervention format. An intervention delivered in a group setting, where costs are distributed across a number of participants, had a lower cost per participant than an intervention delivered on a one-on-one basis such as with home visits. Interventions delivered two or three times a week by staff hired part-time or on an hourly basis would lower costs per participant and produce higher ROIs than interventions delivered by full time staff. Lastly, the cost of staff training needs to be amortized across several consecutive iterations of the program.

The estimates of net benefit were based on the interventions' effectiveness reported in the RCTs. In an RCT, all study participants must meet strict selection criteria (e.g., age and functional abilities), receive the same intervention, and, ideally, complete the entire program. However a fall prevention program implemented at a community center is typically offered to everyone over the age of 60. Participants may attend classes as often as they wish and the program may or may not continue as long as the original intervention. As a result, effectiveness will likely be reduced. However, the sensitivity analyses showed that the ROI was positive for the *Otago Exercise Program* delivered to persons aged 80 years and older if the program reduced falls among participants by at least 17%, well below the 40% reported for the RCT. Similarly, the ROIs for both *Tai Chi: Moving for Better Balance* and *Stepping On* were positive if the effectiveness of these programs was at least 20%.

The financial measures also were influenced by the estimated cost of a medically treated fall. This study did not take into account the possibility that the intervention, while reducing the risk of falling, also might affect the percentage of falls resulting in injury. Providing interventions to age groups with a higher likelihood of falling will improve financial performance. Not included in this analysis were the qualitative benefits for those communities offering the programs or for the program participants. For example, Li et al. (2005) reported that, in addition to reducing falls, *Tai Chi: Moving for Better Balance* improved balance and walking speed and reduced fear of falling, all of which would improve the participants' quality of life. In addition, using only the direct medical costs in this analysis underestimated the full cost of older adult falls and injuries, such as those associated with caregiving and home health care.

5. Conclusion

This cost–benefit analysis found that three evidence-based fall interventions provided positive net benefits and were cost-saving. The ROIs for these interventions showed that the benefits not only covered the implementation costs but also exceeded the expected direct medical costs. *Tai Chi: Moving for Better Balance* had the highest ROI with a return of 509% per each dollar invested. The *Otago Exercise Program* delivered to persons aged 80 and older had a return of 127%, *Stepping On* had a return of 64%, and the *Otago Exercise Program* delivered to persons aged 65 and older had a return of 36%. These results may be useful to a number of audiences: community-based organizations interested in implementing fall prevention programs; policy-makers concerned about the efficient use of resources; and health care organizations who want to prevent falls among their members.

These results can help community organizations and policy makers select appropriate and effective fall interventions that also will provide positive returns on investment.

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Curtis S. Florence is the lead health economist for the National Center for Injury Prevention and Control (NCIPC). He received his doctorate in economics from the University of North Carolina at Chapel Hill. Prior to joining NCIPC, Dr. Florence served as a faculty member in Rollins School of Public Health at Emory University and the Tulane University School of Public Health and Tropical Medicine. His research covers a wide range of topics in health economics, including the economics of injury and violence prevention, private and public health insurance systems, determinants of health care spending and the economics of health promotion.

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(Bonita) Lynn Beattie, PT, MPT, MHA served as the Vice President for Injury Prevention of the National Council on Aging until retiring in December 2013. She continues in a consultant capacity to serve NCOA's National Falls Prevention Resource Center, enfolding the Falls Free® Initiative which she created and facilitated. Falls Free® includes a nationwide network of 70 national organizations and professional associations, a growing robust 42 member State Coalitions on Fall Prevention Workgroup, and the CDC Experts Panel of Physical Therapists in Fall Prevention advising both CDC and APTA. Achievements include passage of federal legislation, increases in federal investment in fall prevention and since 2008 annual Senate proclamations of Fall Prevention Awareness Day.

Lynn previously retired from the Army Medical Department as the Chief of Physical Therapy Section and joined NCOA in 1999. She has her undergraduate degree in health and physical education, and masters' degrees from Baylor University in physical therapy (1972) and in health care administration (1979). In 1998 she completed the master's level, gerontology certificate program at the University of Maryland before joining NCOA to promote healthy aging.

Ileana Arias, PhD, serves as Principal Deputy Director for CDC and ATSDR. In this role, she serves as the principal advisor to the director on all scientific and programmatic activities of CDC/ATSDR. Dr. Arias is responsible for advising the director in the executive responsibilities of shaping policies and plans for CDC/ATSDR, including overseeing the organizational improvement activities.

Dr. Arias became the Director of the National Center for Injury Prevention and Control (NCIPC) in July 2005, where she has worked to prevent injuries and violence and reduce their consequences. Previously, she served as acting director of the Center since June 2004, and was the chief of the Etiology and Surveillance Branch in NCIPC's Division of Violence Prevention.

She began her career as a research associate at the State University of New York at Stony Brook and then joined the University of Georgia in Athens as an assistant professor. Prior to joining CDC in 2000, Dr. Arias was the director of clinical training and professor of clinical psychology at the University of Georgia.
She is a well-respected clinical psychologist with research expertise in intimate partner and family violence. She has authored numerous peer-reviewed articles in professional journals and has given presentations across the United States and in several foreign countries.

Dr. Arias is on the editorial boards of the Journal of Aggression, Maltreatment, and Trauma; the Review of Aggression and Violent Behavior; and Violence and Victims; and serves as a reviewer for 11 professional journals.
Dr. Arias holds a BA, from Barnard College, and a MA and PhD, both in psychology, from the State University of New York at Stony Brook.

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