

**Costs of falls in an aging population:
a nationwide study from the Netherlands (2007-2009)**

Klaas A. Hartholt^{1,2}, Suzanne Polinder³, Tischa J.M. Van der Cammen², Martien J.M. Panneman⁴, Nathalie Van der Velde², Esther M.M. Van Lieshout¹, Peter Patka¹, Ed F. Van Beeck³

¹Department of Surgery-Traumatology

²Department of Internal Medicine - section Geriatric Medicine

³Department of Public Health

Erasmus MC, University Medical Center Rotterdam, Rotterdam, the Netherlands

⁴Consumer and Safety Institute, Amsterdam, the Netherlands

Corresponding author:

Ed F. van Beeck, MD, PhD

Erasmus MC, University Medical Center Rotterdam

Dept. of Public Health

Room Ae-230

P.O. Box 2040

3000 CA Rotterdam, the Netherlands

E-mail: e.vanbeeck@erasmusmc.nl

Tel: +31 10 703 8472

Abstract

Background: Falls are a common mechanism of injury in the older population, putting an increasing demand on scarce healthcare resources. The objective of this study was to determine healthcare costs due to falls in the older population.

Methods: An incidence-based cost model was used to estimate the annual healthcare costs and costs per case spent on fall-related injuries in patients ≥ 65 years, The Netherlands (2007-2009). Costs were subdivided by age, gender, nature of injury, and type of resource use.

Results: In the period 2007-2009, each year 3% of all persons aged ≥ 65 years visited the Emergency Department due to a fall incident. Related medical costs were estimated at €675.4 million annually. Fractures led to 80% (€540 million) of the fall-related healthcare costs. The mean costs per fall were €3,370, and were higher for women (€3,990) than men (€2,510) and increased with age (from €3,900 at ages 65-69 year to €14,600 at ages ≥ 85 year). Persons ≥ 80 year accounted for 47% of all fall-related Emergency Department visits, and 66% of total costs. The costs of long-term care at home and in nursing homes showed the largest age-related increases and accounted together for 54% of the fall-related costs in older people.

Discussion: Fall-related injuries are leading to a high healthcare consumption and related healthcare costs, which increases with age. Programs to prevent falls and fractures should be further implemented in order to reduce costs due to falls in the older population and to avoid that healthcare systems become overburdened.

Introduction

Falls and fall-related injuries are a major public health issue among older adults worldwide.¹⁻⁴ Approximately one third of people aged 65 years and older fall at least once each year, and one sixth fall recurrently.⁵ Many factors have been associated with an increased risk of falls, such as medication, co-morbidity, decreased mobility, female gender, and age.⁵⁻⁷

Older persons are at an increased risk for serious injuries even after a minimal trauma, such as a fall, due to underlying medical conditions like osteoporosis. Approximately a third of older fallers sustain fall-related injuries, which require medical treatment.⁸ Due to the large burden of injurious falls, fall incidents put a high⁸⁻¹¹ and increasing (*I*) demand on healthcare resources.

Populations worldwide are aging.¹² The Netherlands, a country with 16.5 million people, is facing the challenge of an aging population as well. The population of persons aged ≥ 65 years is expected to increase from 15% (2.4 million persons) in 2008 to 25% (4.5 million persons) around 2040.¹³ With an increasing population of older people, it might be expected that falls and the related healthcare consumption will grow accordingly. This could lead to an overburdening of the healthcare system due to scarcity of resources. In order to optimize healthcare policy and allocation in ageing populations, data on healthcare use and related costs are needed. The Netherlands is an ideal country to collect such data due to compulsory national health insurance and the availability of administrative databases with wide coverage.

The aim of this study was to determine healthcare use and costs due to falls in the older Dutch population. Costs were specified for gender, age, nature of injury, and type of resource use.

Methods

A previously developed incidence based model, the Dutch Burden of Injury Model, was used to describe healthcare consumption and costs resulting due to injuries occurring during a specified period.¹⁴ In this model, patient numbers, healthcare consumption, and related costs are calculated, specified by location and nature of injury.¹⁵ Healthcare consumption is split up in multiple categories, in which all types of healthcare resources (before, during, and after Emergency Department attendance) are taken into account. The model uses data from the Dutch Injury Surveillance System (LIS), the National Hospital Discharge Registry, and a patient follow-up survey conducted in 2007.^{14, 16-18} The study protocol was approved by the local IRB of the Erasmus MC, University Medical Center Rotterdam.

The LIS database is a continuous monitoring system at the Emergency Department in which injury diagnoses and injury mechanisms are registered by using the International Classification of Diseases of the World Health Organization (ICD 10th revision). An unintended fall was defined using the codes for external causes of injuries (ICD 10th revision W00-W19). The LIS database is based upon 13 geographically distributed Emergency Departments, and provides a representative 12% sample of injury-related Emergency Department treatments in the Netherlands. An extrapolation factor was calculated by the Consumer and Safety Institute, by comparing the adherence population of the participating hospitals with the total population in the Netherlands to generate national estimates. A full description of the model has been published by the Consumer and Safety Institute previously

.¹⁴

Data on hospitalizations, in-hospital care and outpatient care were obtained from the National Hospital Discharge Registry, which has a nearly complete ($\geq 95\%$ coverage) national coverage. Healthcare costs of injuries were calculated by multiplication of incidence,

healthcare volumes (*e.g.*, length of stay in hospital or institution, number of outpatients visits, General Practitioner visits, home care hours, and physical therapy treatments), and unit costs (*e.g.*, costs per day in hospital, per visit, hour, or per treatment). Healthcare volumes were estimated with national registration data and a patient-follow-up survey. All unit costs were estimated according to national guidelines for healthcare costing.¹⁹ The proportions of patients who incurred emergency services and General Practitioner services preceding Emergency Department treatment were calculated with data from LIS. For each type of healthcare service the costs per volume unit that reflects the real resource was used (Table 1). For this study it has been assumed that healthcare fees were representative of real resource use for General Practitioner consultations, inpatient medical procedures, home care, and rehabilitative treatment. Unit costs of emergency and ordered transport, inpatient hospital days (excluding medical procedures), out patient visits, nursing home days, other rehabilitation services, physical therapy, pharmaceuticals, aids, and appliances were calculated from national production and financial statistics. For Emergency Department visits the full cost price was calculated consisting of detailed measurement of investments in manpower by injury group.

The Dutch Burden of Injury Model was applied to all persons aged 65 years and over who presented to the Emergency Department of a participating LIS hospital due to an unintended fall between the January 1, 2007 and December 31, 2009. Fall-related injuries were selected based upon the registered primary diagnosis. Incidence rates were expressed per 1,000 person years. All costs are expressed in 2009 Euros (NB: as at 19 March 2009 €1.00 = USD \$1.31).

Results

In the period 2007-2009, approximately 72,000 persons aged 65 years and over visited the Emergency Department annually with injuries due to an unintended fall. The costs of falls in the Netherlands were estimated to be €674.5 million per year (€281 per inhabitant aged 65 year and older), of which 85% (€574 million) occurred in the population aged over 75 years. The overall incidence rate of Emergency Department visits in older persons due to a fall was 30.0 per 1,000 person years, for 17.4 men and 39.4 women, respectively. For persons aged 80 years and older the incidence was at least three times the rate of those aged 65-69 years (65-69 years 16.0; ≥ 85 years 72.5 per 1,000 person years (Table 2). Approximately a sixth of the patients were treated and released after Emergency Department attendance. Half of all patients were referred to an outpatient clinic or to General Practitioner, and a one third of the patients were admitted to hospital after Emergency Department attendance.

Overall, the mean costs per fall were €9,370, and were higher for women (€9,990) than for men (€7,510) as shown in Table 2. Furthermore, the costs per fall increased with age (Figure 1). In women, the costs per fall increased from €3,830 in individuals aged 65-69 years old to over €13,000 per case in females aged 85 years and older. For men, the mean costs per case increased from €3,990 (65-69 year) to €11,470 (aged ≥ 85 years).

Injury groups representing the majority of fall-related healthcare costs are shown in Table 3. Hip and femoral fractures were most expensive (approximately €22,000 per case) followed by pelvic fractures (€14,000) and skull/brain injuries (€6,600). However, other injuries such as superficial injuries also resulted in high healthcare costs due to their frequent occurrence. Fractures accounted for 80% (€40 million) of the total fall-related expenses. Hip fractures made the largest contribution (€292 million) to fall-related healthcare costs, because of the high incidence rate combined with high costs per case.

Healthcare costs are skewly distributed, with admitted patients in hospital and nursing homes accounting for approximately two-third of costs in all age-groups. Nursing home care accounted for 33.8% of total costs, followed by in-hospital treatment (31.6%) and long term care at home (20.2%). However, a shift in healthcare costs was seen for the different age-groups (Table 4). The costs of long term care at home and in nursing homes showed the largest age-related increases and together accounted for 54% of the fall-related costs in older people. Direct treatment costs, such as Emergency Department visits and ambulance transport costs were relatively higher in the younger age-groups, compared with the oldest old. In the oldest old, the costs of nursing home care were most substantial. For example, the average costs of fall-related injuries in admitted women aged 80 year and older were €21,000 per case, with €1,130 per case resulting from 43 days on average spent in a nursing home after injury.

Discussion

During the study period 3% of the Dutch population aged 65 years and older attended at the Emergency Department due to an unintended fall per year (2007-2009). The total healthcare expenses, including medical treatment, hospitalization and long term care, exceeded €674.5 million per year (€81 per inhabitant aged 65 years and older). The mean costs per fall were €9,370, and were higher for females than males and increased with age. Fractures alone accounted for more than three quarters of all costs of falls. Persons aged ≥ 80 year accounted for about half of all fall-related Emergency Department visits, but two-thirds of all costs. More than half of the fall-related healthcare expenses were due to long term care at home and in nursing homes.

A major strength of the present study is that it presents comprehensive estimates of healthcare costs, including all relevant healthcare sectors for all fall-related injuries. Because a uniform coding method has been used to estimate the costs, it was possible to compare the healthcare use and related healthcare costs of all types of fall-related injuries. Registries with national coverage were used to analyze the healthcare resources that are most important for injuries, such as hospital inpatient care, medical procedures, rehabilitation clinics, and care in nursing homes and long-term care at home.¹⁴

A possible limitation is that only patients were included who presented at an Emergency Department. The total number of fall-related injuries will be higher, due to the fact that patients who were fully treated by their General Practitioner were not included in this study. Furthermore, in case of multiple injuries, the primary injury in LIS was determined by application of an algorithm giving priority to spinal cord injury, skull/brain injury, lower extremity injury above injuries in other body parts, and to fractures above other types of injury to determine the most serious injury. However, this may only have caused a slight

underestimation of the total fall-related costs, since the majority of healthcare costs were related to in-hospital care, admission to nursing homes and long term care at home. For fall-related injuries such as permanent brain injury, spinal cord injury, and injuries involving joint damage this is relevant. However, the majority of injury related healthcare use and needs has been shown to occur in the first year post-injury.²⁰

Falls in older adults contributed to a significant amount of injury-related healthcare expenses, which is seen in other western countries as well.²¹ From an economic perspective falls are a more serious public health problem in older adults than other common diseases. For example, in another Dutch study the national budget spent on falls exceeded those of diabetes or heart failure for persons aged ≥ 65 years.¹⁶ Studies from the United Kingdom¹⁰, United States¹¹, and Australia²² underline the economic impact of falls and related healthcare demand. The results of our study, €281 per older inhabitant (65 years and older), are within the range of previous findings from those countries. Costs of falls among older adults in the United Kingdom have been estimated at 1 billion GBP (12.1 million persons ≥ 60 year, €133 per older inhabitant) in 1999, in the United States at \$19 billion (35 million persons ≥ 65 year, €372 per older inhabitant) in 2000, and in Western Australia at Australian-\$ 18 million (200,000 persons ≥ 65 year, €256 per older inhabitant), respectively.^{10, 11, 22}

The current study shows the breakdown of fall-related healthcare costs by age, gender, and type of healthcare resources. The high incidence rate of injurious falls combined with the high costs per fall resulted in an overrepresentation in the fall-related healthcare expenses of persons aged 80 and over, and women in this age group in particular. The higher healthcare costs in older women might potentially be explained by two mechanisms. First, the higher costs per fall-related injury could be due to differences in injury patterns between men and women.^{1, 3, 23, 24} Females present more often with a hip fracture than males, and consequently a larger proportion of hip fractures in women contributes to higher average costs per fall.^{1, 23}

Furthermore, due to differences in life expectancy, many older women live alone after surviving their partner. As a consequence, they are often dependent on rehabilitation care in nursing homes and long term home care, even in cases of less severe injury.

Over the last decades the number of fall-related hospitalizations is increasing rapidly, based upon an increasing number of older adults, as well as an increasing life expectancy.^{13,}

²⁵ Therefore, it might be expected that the number of falls, related injuries and related healthcare costs will largely increase in the future. The results of the current study show that fall-related healthcare costs result in a substantial part of total healthcare costs, which is not only based on costs of acute medical care, but also on long term healthcare costs.

Implementation of programs to prevent falls and/or fractures are needed, not only in order to limit the number of falls and fractures, but also to reduce the required healthcare demand and related costs, and to improve the quality of life for the individual patient. Multiple strategies for prevention have been developed and several prevention programs have already been shown to be effective.²⁶ Implementation of some of those effective interventions has the potential to contribute to a reduction of fall-related healthcare consumption in the near future.

In conclusion, the success of aging of populations is accompanied by the presence of age-related consequences such as an increased fall- and fracture-risk, and the use of required healthcare resources. In order to control for the economic burden of fall-related healthcare costs the number of falls and related injuries should be reduced. Multiple prevention strategies have been developed over the last decades and time for implementation has arrived.

Table 1. Unit costs

Unit Costs	€
General Practitioner	
Visit	40
Consultation by telephone	20
Home visit	79
Ambulance	
Emergency journey	514
Scheduled journey	197
Hospital	
Admission (University Medical Center), per day	600
Admission, per day	439
Intensive Care Unit, per day	1,672
Day care, per day	620
Outpatient visit, per visit	170
Emergency Department visit	
Costs per visit	288
Long term care	
Admission in nursing home, per day	253
Day care, per day	133
Physical therapy, per visit	28
Home care	
Household assistance, per hour	29
Nursing care, per hour	65

Table 2. Annual number of registered, national estimated cases, incidence and costs of fall-related injuries in the older (≥ 65 years) Dutch population (2007-2009)

	Cases [†]	Estimated cases [‡]	Incidence [*]	Costs per case [#]	Total costs ⁺
Age-group, year					
≥ 65	13,504	71,958	30.0	9,370	674.5
65-69	2,163	11,525	16.0	3,880	44.7
70-74	2,260	12,050	20.4	4,660	56.1
75-79	2,612	13,906	29.1	9,130	127.0
80-84	2,827	15,046	44.0	10,830	163.0
≥ 85	3,642	19,430	72.5	14,600	283.7
Gender					
Males	3,365	17,916	17.4	7,510	134.6
Females	10,139	54,042	39.4	9,990	539.9
Injury group					
Fracture	7,797	41,557	17.3	13,000	540.2
Concussion/Contusion	3,146	16,758	7.0	4,130	69.3
Laceration	1,196	6,358	2.6	3,020	19.2
Internal injury	38	201	0.1	9,450	1.9
Strain / Sprain	826	4,401	1.8	4,770	21.0
Other	409	2,192	0.9	7,800	17.1
Unknown	92	491	0.2	11,810	5.8

ED, Emergency Department; [†]Mean number of registered cases in the LIS database per study year; [‡]National estimated cases; ⁺Incidence rate per 1,000 person years; [#]costs per case are rounded at 10 Euro; ^{*}Healthcare expenses in million Euro's 2009

Table 3. Fall-related annual incidence, costs per case and total costs by injury diagnosis for men and women (≥ 65 years) separately (2007-2009)

	Men				Women			
	Number	Incidence*	Costs per case [#]	Total costs ⁺	Number	Incidence*	Costs per case [#]	Total costs ⁺
Superficial Injury	4,143	3.9	2,380	10.3	10,697	7.6	3,680	41.4
Hip fractures	2,607	2.4	19,730	60.1	8,565	6.1	23,280	232.1
Wrist fractures	827	0.8	2,670	2.4	7,292	5.2	4,170	32.9
Wound head/face	1,371	1.3	2,030	2.8	1,914	1.4	2,690	5.2
Upper arm fracture	470	0.4	5,320	3.0	2,665	1.9	7,130	22.5
Clavicle/Scapula fracture	683	0.6	4,880	3.7	2,257	1.6	6,930	17.4
Skull/brain injury	1,508	1.4	6,690	11.1	2,266	1.6	7,470	18.4
Fracture hand/fingers	590	0.6	2,220	1.4	1,778	1.3	3,170	5.8
Elbow/forearm fracture	283	0.3	4,230	1.4	1,857	1.3	6,040	12.8
Ankle fracture	480	0.4	5,440	3.1	1,777	1.3	9,080	19.5
Open wounds	649	0.6	1,720	1.1	1,251	0.9	3,030	3.9
Femur shaft fracture	406	0.4	21,250	9.8	1,316	0.9	23,730	36.0
Pelvic fracture	251	0.2	14,180	3.8	1,527	1.1	14,410	23.4
Knee/lower leg fracture	317	0.3	7,380	2.5	1,181	0.8	12,710	16.7
Subtotal	14,585	13.6		116.5	46,343	32.9		488.0
Other	3,330	3.1	5,090	18.1	7,697	5.5	6,330	52.1
Total	17,915	17.4	7,510	134.6	54,040	39.4	9,110	540.1

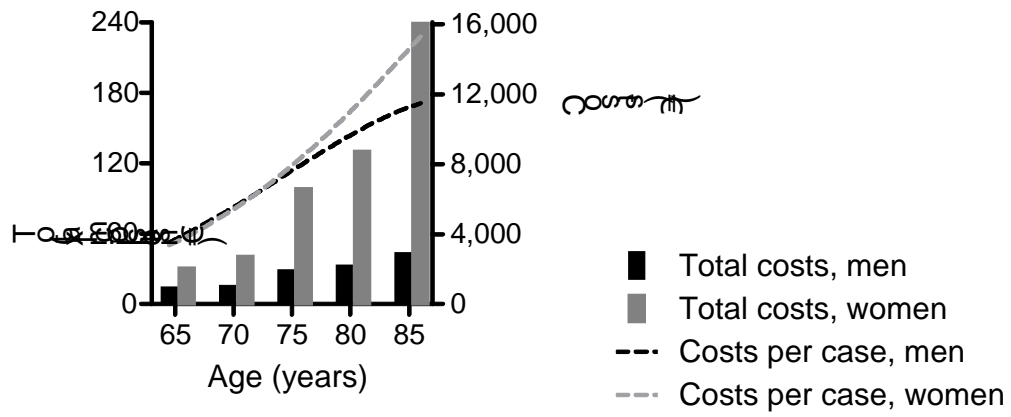
*Incidence rate is expressed per 1,000 person years; ⁺Total costs in million Euro; [#]Costs per case are rounded at 10 Euro.

Table 4. Mean fall-related healthcare costs[#] and care volumes by type of resource use in the Dutch population aged ≥ 65 years (2007-2009)

Healthcare resource	Men						Women					
	Care		Care		Care		Care		Care		Care	
	Costs	Volume	Costs	Volume	Costs	Volume	Costs	Volume	Costs	Volume	Costs	Volume
	≥ 65		65-79		≥ 80		≥ 65		65-79		≥ 80	
Ambulance Journey, <i>r</i>	220	0.5	180	0.4	270	0.6	220	0.5	160	0.4	270	0.6
ED visit, <i>v</i>	280	1	270	1	290	1	290	1	280	1	300	1
Hospital inpatient, <i>d</i> *	5,280	10	4,690	9	5,9230	11	5,500	10	4,840	10	5,900	10
Outpatient attendance, <i>v</i>	270	1.6	290	2	240	1	300	2	330	2	280	2
GP consultations, <i>v</i>	100	2.3	90	2	110	3	110	3	100	2	120	3
Nursing care at home, <i>hr</i>	820	18	530	12	1,230	27	1,950	48	1,190	31	2,680	66
Nursing home, <i>d</i> *	6,870	27	5,150	20	8,770	34	9,410	34	6,570	25	11,130	43
Physiotherapy, <i>v</i>	200	7.3	200	7	210	8	300	11	290	10	310	11

*Mean cost and length of hospital and/or nursing home stay calculated for admitted patients only; *r*, ride; *v*, visit; *d*, days; *hr*, hours; [#]costs per case are rounded at 10 Euro

Figure 1. Total healthcare costs of injury and costs per patient by age and sex due to falls among the older population in the Netherlands (2007-2009)



Acknowledgements

None

Competing Interests

None

Funding

Klaas Hartholt is a research fellow at the Erasmus MC, appointed on a research grant from “The Netherlands Organization for Health Research and Development” (ZonMw), project number 170.885.607. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

References

1. Hartholt KA, van der Velde N, Looman CW, et al. Trends in fall-related hospital admissions in older persons in the Netherlands. *Arch Intern Med.* May 24 2010;170(10):905-911.
2. Kannus P, Parkkari J, Koskinen S, et al. Fall-induced injuries and deaths among older adults. *Jama.* May 26 1999;281(20):1895-1899.
3. Stevens JA, Sogolow ED. Gender differences for non-fatal unintentional fall related injuries among older adults. *Inj Prev.* Apr 2005;11(2):115-119.
4. Hartholt KA, Stevens JA, Polinder S, van der Cammen TJM, Patka P. Increase in fall-related hospitalizations in the United States, 2001-2008. *Journal of Trauma.* Jul 2011;71(1):255-258.
5. Chen JS, Simpson JM, March LM, et al. Risk factors for fracture following a fall among older people in residential care facilities in Australia. *J Am Geriatr Soc.* Nov 2008;56(11):2020-2026.
6. Alexander BH, Rivara FP, Wolf ME. The cost and frequency of hospitalization for fall-related injuries in older adults. *Am J Public Health.* Jul 1992;82(7):1020-1023.
7. Coutinho ES, Fletcher A, Bloch KV, Rodrigues LC. Risk factors for falls with severe fracture in elderly people living in a middle-income country: a case control study. *BMC Geriatr.* 2008;8:21.
8. Stevens JA, Mack KA, Paulozzi LJ, Ballesteros MF. Self-reported falls and fall-related injuries among persons aged ≥ 65 years--United States, 2006. *J Safety Res.* 2008;39(3):345-349.
9. Meerding WJ, Mulder S, van Beeck EF. Incidence and costs of injuries in The Netherlands. *Eur J Public Health.* Jun 2006;16(3):272-278.
10. Scuffham P, Chaplin S, Legood R. Incidence and costs of unintentional falls in older people in the United Kingdom. *J Epidemiol Community Health.* Sep 2003;57(9):740-744.
11. Stevens JA, Corso PS, Finkelstein EA, Miller TR. The costs of fatal and non-fatal falls among older adults. *Inj Prev.* Oct 2006;12(5):290-295.
12. United Nations. *World Population Prospects, The 2006 Revision* New York 2007 2007.
13. Statistics Netherlands (CBS). *Population prognosis.* The Hague, The Netherlands: Statistics Netherlands;2009.
14. Consumer and Safety Institute. *The Dutch Burden of Injury Model.* Amsterdam: Consumer and Safety Institute; October 2005.
15. Lyons RA, Polinder S, Larsen CF, et al. Methodological issues in comparing injury incidence across countries. *Int J Inj Contr Saf Promot.* Jun 2006;13(2):63-70.
16. Meerding WJ, Bonneux L, Polder JJ, Koopmanschap MA, van der Maas PJ. Demographic and epidemiological determinants of healthcare costs in Netherlands: cost of illness study. *Bmj.* Jul 11 1998;317(7151):111-115.
17. Mulder S, Meerding WJ, Van Beeck EF. Setting priorities in injury prevention: the application of an incidence based cost model. *Inj Prev.* Mar 2002;8(1):74-78.
18. Polinder S, van Beeck EF, Essink-Bot ML, et al. Functional outcome at 2.5, 5, 9, and 24 months after injury in the Netherlands. *J Trauma.* Jan 2007;62(1):133-141.
19. Oostenbrink JB, Koopmanschap MA, Rutten FF. Standardisation of costs: the Dutch manual for costing in economic evaluations. *Pharmacoeconomics.* 2002;20:443-454.
20. Leigh JP, Markowitz SB, Fahs M, Shin C, Landrigan PJ. Occupational injury and illness in the United States. Estimates of costs, morbidity, and mortality. *Arch Intern Med.* Jul 28 1997;157(14):1557-1568.

21. Heinrich S, Rapp K, Rissmann U, Becker C, Konig HH. Cost of falls in old age: a systematic review. *Osteoporos Int*. Jun 2010;21(6):891-902.
22. Hendrie D, Hall SE, Arena G, Legge M. Health system costs of falls of older adults in Western Australia. *Aust Health Rev*. Dec 13 2004;28(3):363-373.
23. Hartholt KA, van Beeck EF, Polinder S, et al. Societal Consequences of Falls in the Older Population: Injuries, Healthcare Costs, and Long-Term Reduced Quality of Life. *J Trauma*. Nov 1 2010;71(3):748-753.
24. Hartholt KA, van Lieshout EM, Polinder S, Panneman MJ, van der Cammen TJ, Patka P. Rapid increase in hospitalizations due to fall-related head injury in older adults in the Netherlands 1986-2008. *J Neurotrauma*. May 2011;28(5):739-744.
25. Perenboom RJM. [*Healthy life expectancy: does healthy life expectancy change in the Netherlands?*]. Bilthoven, the Netherlands: National Institute for Public Health and the Environment (RIVM); 23 Sept 2005.
26. Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. *Cochrane Database Syst Rev*. 2009(2):CD007146.