Osteoporos Int (2016) 27:1999–2008
DOI 10.1007/s00198-016-3484-z

ORIGINAL ARTICLE

Total medical costs of treating femoral neck fracture patients with hemi- or total hip arthroplasty: a cost analysis of a multicenter prospective study

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Received: 26 May 2015 / Accepted: 4 January 2016 / Published online: 28 January 2016

Abstract
Summary The aim of this study was to determine the total medical costs for treating displaced femoral neck fractures with hemi- or total hip arthroplasty in fit elderly patients. The mean total costs per patient at 2 years of follow-up were €26,399. These results contribute to cost awareness.
Introduction The absolute number of hip fractures is rising and increases the already significant burden on society. The aim of this study was to determine the mean total medical costs per patient for treating displaced femoral neck fractures with hemi- or total hip arthroplasty in fit elderly patients.
Methods The population was the Dutch sample of an international randomized controlled trial consisting of femoral neck fracture patients treated with hemi- or total hip arthroplasty. Patient data and health care utilization were prospectively collected during a total follow-up period of 2 years. Costs were separated into costs for hospital care during primary stay, hospital costs for clinical follow-up, and costs generated outside the hospital during rehabilitation. Multiple imputations were used to account for missing data.
Results Data of 141 participants (mean age 81 years) were included in the analysis. The 2-year mortality rate was 19 %. The mean total cost per patient after 10 weeks of follow-up was €15,216. After 1 and 2 years of follow-up the mean total costs were €23,869 and €26,399, respectively. Rehabilitation was the main cost determinant, and accounted for 46 % of total costs. Primary hospital admission days accounted for 22 % of the total costs, index surgery for 11 %, and physical therapy for 7 %.
Conclusions The main cost determinants for hemi- or total hip arthroplasty after treatment of displaced femoral neck fractures (€26,399 per patient until 2 years) were rehabilitation and nursing homes. Most of the costs were made in the first year. Reducing costs after hip fracture surgery should focus on improving the duration and efficiency of the rehabilitation phase.

Keywords Arthroplasty · Cost analysis · Femoral neck fracture · Hip fracture · Medical costs

Electronic supplementary material The online version of this article (doi:10.1007/s00198-016-3484-z) contains supplementary material, which is available to authorized users.

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Introduction

The major complication of osteoporosis is the clinical manifestation of a hip fracture. Based upon global trends and demographic changes the worldwide number of hip fractures is expected to be over 7.3 million patients in the year 2050 [1, 2].

In The Netherlands the number of patients sustaining a hip fracture has more than doubled since 1981 to almost 19,000 patients in 2012 [3]. Almost 60 % of all proximal femoral fractures concern the femoral neck and 80 % of these fractures are displaced [4]. The Garden classification is frequently used for describing femoral neck fractures in the elderly [5]. Garden type 3 and 4 represent displaced fractures. Femoral neck fractures can be treated using a non-operative approach, internal fixation, or arthroplasty. The arthroplasty group includes hemiarthroplasty and total hip arthroplasty. Approximately 62 % of patients aged 65 years or older are primarily treated with arthroplasty; hemiarthroplasty is performed in this group in 78 % of patients on average [6]. Different insights into the preferred treatment of femoral neck fractures are the subject of ongoing international debate [7]. An international survey revealed that 75 % of the responding surgeons prefer primary arthroplasty for patients over 60 years of age with a displaced fracture. For patients under 60 years of age with a displaced fracture (Garden type 3 or 4), hemiarthroplasty was preferred by 11 % and 25 % of respondents, respectively [7]. Although initial costs for arthroplasty are higher than for internal fixation, arthroplasty has been proven to be a cost-effective therapy [8–11].

According to data of the Dutch Ministry of Health, Welfare and Sports, hip fracture-associated crude total cost in The Netherlands was €471.5 million in 2011 [12]. Insight into health care use and associated costs is gaining importance as the burden of health care costs threatens to exceed the financial resources available. Such insight may reveal options for cutting down health care expenses. Although surgeons are expected to have a general idea about the costs for treatments they provide, these data are not easily available [13–15]. Recently, data became available on the total medical costs of femoral neck fracture patients treated with internal fixation in The Netherlands [16]. To the best of our knowledge, detailed analysis of the costs of hemi- or total hip arthroplasty for femoral neck fractures in The Netherlands has not been published before. Therefore, the aim of this study was to provide a detailed overview of the costs consumed by patients with a displaced femoral neck fracture that was treated with hemi- or total hip arthroplasty.

Patients and methods

This cost study was conducted as a cohort study alongside the Dutch sample of the HEALTH trial (hip fracture evaluation with alternatives of total hip arthroplasty versus hemiarthroplasty, NCT00556842), an international randomized controlled trial comparing total hip arthroplasty and hemiarthroplasty on revision surgery and quality of life in patients with a displaced femoral neck fracture. The local medical research ethics committees of all participating centers approved the study. Informed consent was obtained from all individual participants included in the study.

Population

In The Netherlands, 14 hospitals participated and enrolled 150 patients between December 15, 2008 and February 14, 2011. Patients were eligible if they: (1) were adults aged ≥50 years, (2) had a (radiologically confirmed) displaced femoral neck fracture (ICD-10 code S72.0; Garden type 3 and 4) after a low energy impact and no other major trauma, (3) were operated within 3 days of presenting to the emergency room, and (4) were ambulatory pre-fracture (with or without aid). Patients provided informed consent. Patients were excluded if they: (1) were not suitable for treatment with arthroplasty (i.e., inflammatory arthritis, rheumatoid arthritis, pathologic fracture, or severe osteoarthritis of the hip), (2) had infection or retained hardware around the affected hip, (3) had a bone metabolism disorder other than osteoporosis, (4) were moderately or severely cognitively impaired pre-fracture, (5) had dementia or Parkinson's disease severe enough to compromise the rehabilitation process, or (6) were not likely to be able to complete follow-up.

Treatment and follow-up

Medical optimization was warranted for all included patients before surgery. Within 72 h after presenting to the emergency department, patients were treated with hemi- or total hip arthroplasty. The exact treatment including material choice (cemented or uncemented and unipolar or bipolar prosthesis) was left to the treating surgeon. Antibiotic prophylaxis and thromboprophylaxis were prescribed to all patients according to local protocols. Post-operative weight bearing was as tolerated and early mobilization was encouraged. All patients were screened and treated for osteoporosis if deemed necessary. Follow-up measurements were performed at 10 weeks and at 6, 9, 12, 18, and 24 months after the primary surgery.

Cost measurement

This study included the following categories for hip-related costs: (1) hospital costs during primary hospital stay, including emergency department visit, diagnostic evaluations, surgery, and admission days; (2) hospital costs during follow-up, including diagnostic evaluations, outpatient clinic visits, diagnosis and treatment of adverse events, revision surgery, and admission days; and (3) non-hospital costs of rehabilitation and aids.

Data on health care use were collected prospectively at each scheduled follow-up contact and at the close-out visit at the end of the study. Data were collected from the study case

report forms (items are listed in electronic supplementary material (ESM) Supplemental Table 1) and from the patient's hospital file. At each follow-up contact, patients were asked to complete a questionnaire on their health care use. This questionnaire was a customized version of the "Trimbos and iMTA questionnaire on Costs associated with Psychiatric illness" (Tic-P), which has been validated for use in health care cost studies [16, 17]. An English version of the TicP questionnaire is available online [18]. The questionnaire included questions on stay in a hospital, rehabilitation center or nursing facility, number of contacts with an intramural medical specialist or paramedical worker during admission and follow-up, medication use, comorbidity and use of walking aids. Missing data were collected during the close-out visit at each hospital.

The total number of consumption units per cost category was multiplied by the unit prices. All unit prices were indexed with the national consumer price index to 2012 and are presented in Table 1. Costs for the index surgery, including time spent in the operating room, theater personnel, overhead, anesthesia, and implant material and general equipment, was provided by two teaching hospitals and one academic hospital. Data from the teaching hospitals were averaged in order to obtain a realistic estimate of the average prices in the participating teaching hospitals. Reference cost prices of most other health care resources were derived from the Dutch manual on cost research, methods and standard costs in economic health care evaluations [19]. The NZa (Nederlandse Zorgautoriteit; Dutch Health care Authority) is the Dutch market regulator in care and advises the Minister on health care costs. This institute provided the unit prices for intramural diagnostic procedures. Costs of medication were derived from the CVZ (College voor zorgverzekeringen; Health Care Insurance Board), which is online accessible on www.medicijnkosten.nl. Costs of rehabilitation aids were obtained from a local home care firm that is a representation of national practice. Costs of aids were calculated according to the annuity method, applying an interest rate of 4.5 % and a 10-year write-off period. With over 90 % of the patients in the study being retired, the costs for production losses were considered of limited importance for this population, and were thus excluded. Home care was also excluded, since it was impossible to determine which proportion of the total home care received was due to the hip fracture. As done previously in a similar study on internal fixation of femoral neck fractures, costs of osteoporosis screening were included in radiology/diagnostic studies costs, costs of visits to an osteoporosis specialist were included in outpatient clinic-visit costs, and costs for osteoporosis treatment were included in medication costs.

Statistical analysis

Data were analyzed using SPSS (version 20.0, SPSS Inc., Chicago, IL, USA). Replacement of missing values for cost items was done with multiple imputations following the predictive mean matching method, using ten imputations [20]. The following variables were included in the imputation model: sex, age, ASA at baseline, walking independently at baseline, treatment, costs of initial surgery, and all other cost categories at 10 weeks and at 6, 9, 12, 18, and 24 months. Each of the ten complete datasets were further analyzed by non-parametric bootstrapping using 1000 bootstraps per dataset [21]. The 95 % confidence interval around the mean costs was determined by taking the 2.5th and the 97.5th percentile of these bootstrap replications. Costs were calculated for the total study population.

Results

Demographics

The 14 participating hospitals registered 592 consecutive patients with a femoral neck fracture, of whom 181 were eligible and 150 (25 %) subsequently gave informed consent (Fig. 1). One patient withdrew consent immediately, one patient died before surgery, and seven patients were treated with internal fixation rather than arthroplasty. A total of 141 patients remained for the current cost analysis, of whom 74 were treated with hemiarthroplasty and 67 with a total hip arthroplasty. The mean age was 81 (SD 7; range 57–100) years, 2 patients (1 %; both females) were younger than 60 years of age. A total of 96 patients (68 %) were female. The mean age was 80 (SD 8; range 57–100) years for females and 81 (SD 6; range 69–91) years for males. No patients (0 %) had ASA class 1 or class 5, 67 (48 %) patients had ASA class 2, 72 (51 %) ASA class 3, and 2 (1 %) ASA class 4. A total of 136 (97 %) patients were not institutionalized before the fracture, and 102 (72 %) patients were independently ambulatory before the fracture.

Clinical outcome and health care consumption

The mean duration of hospital admission was 10 days (SD 8). One patient with a complicated clinical course was discharged at 90 days after the initial surgery. Within 14 days after surgery, 87 % ($N=123$) of the patients were discharged. The discharge destination was a rehabilitation or nursing facility in 56 % of patients, and 44 % of patients went to their own house. Median stay per patient was 10 days (SD 28) in a rehabilitation facility, 14 days (SD 42) in a nursing facility, and 18 days (SD 62) in an elderly home. During rehabilitation, patients had a mean of 52 (SD 5) physical therapy sessions per patient.

A total of 118 adverse events (AEs) occurred; 77 patients (55 %) had no AE at all. The most frequent AEs were a subsequent fracture ($N=19$; 13 %), a superficial wound infection ($N=11$; 8 %), and dislocations ($N=10$; 7 %). Less than

Table 1 Sources and unit costs of health care resources

Cost categories	Unit	Source of consumption data	Source of value	Unit price (€)
Hospital costs—primary stay				
Emergency department visit	Visit	Hospital registry	Cost manual[a]	160.34
Radiology/diagnostic modalities				
X-ray	X-ray	Hospital registry	NZa[b]	54.14
CT-scan pelvis	CT-scan	Hospital registry	NZa[b]	238.25
MRI scan pelvis	MRI scan	Hospital registry	NZa[b]	274.16
Ultrasound	Ultrasound	Hospital registry	NZa[b]	86.07
DEXA scan	DEXA scan	Hospital registry	NZa[b]	114.52
Skeletal scintigraphy	Scintigraphy	Hospital registry	NZa[b]	194.37
Surgery				
Surgeon	Hour	Study registry (CRF)	Cost manual[a]	143.88[c]/109.37[d]
Operating room[e]	Hour	Study registry (CRF)	Hospital/industry data[f]	738.60[c]/885.00[d]
Equipment and implant				
Cemented hemiarthroplasty	Operation	Study registry (CRF)	Hospital/industry data[f]	1362.00[c]/1197.73[d]
Cemented total hip arthroplasty	Operation	Study registry (CRF)	Hospital/industry data[f]	1465.75[c]/1684.45[d]
Uncemented total hip arthroplasty	Operation	Study registry (CRF)	Hospital/industry data[f]	NA/2041.80[d]
Admission days	Day	Study registry (CRF)	Cost manual[a]	610.57[c]/461.91[d]
Hospital costs—follow-up				
Radiology/diagnostic modalities				As described above
Outpatient clinic visits	Visit	Hospital registry + questionnaire[g]	Cost manual[a]	136.98[c]/67.96[d]
Adverse events				
Medication[h]	Dose per day	Hospital registry/questionnaire[g]	CVZ[i]	Variable
Emergency	Visit	Hospital registry	Cost manual[a]	160.34
Brace	Piece	Hospital registry/questionnaire[g]	Hospital/industry data[f]	440.39
Admission days	Day	Study registry (CRF)	Cost manual[a]	610.57[c]/461.91[d]
Revision surgery				
Surgeon	Hour	Study registry (CRF)	Cost manual[a]	143.88[c]/109.37[d]
Operating room[e]	Hour	Study registry (CRF)	Hospital/industry data[f]	738.60[c]/885.00[d]
Equipment and implant				
Cemented hemiarthroplasty	Operations	Study registry (CRF)	Hospital/industry data[f]	1362.00[c]/1197.73[d]
Cemented total hip arthroplasty	Operations	Study registry (CRF)	Hospital/industry data[f]	1465.75[c]/1684.45[d]
Uncemented total hip arthroplasty	Operations	Study registry (CRF)	Hospital/industry data[f]	NA/2041.80[d]
Cup revision	Operations	Study registry (CRF)	Hospital/industry data[f]	773.09
Open fenestration/bursectomy	Operations	Study registry (CRF)	Hospital/industry data[f]	524.20
Open reduction (OR)	Operations	Study registry (CRF)	Hospital/industry data[f]	333.96
Closed reduction (ER)	Operations	Study registry (CRF)	Hospital/industry data[f]	160.34
Antibiotic beads	Operations	Study registry (CRF)	Hospital/industry data[f]	324.83
Admission days	Days	Study registry (CRF)	Hospital/industry data[f]	610.57[c]/461.91[d]
Medication[j]	Dose per day	Hospital registry/questionnaire[g]	CVZ[i]	NA
Costs related to rehabilitation/changes in living situation				
Rehabilitation center/nursing home				
Elderly home	Days	Patient questionnaire[g]	Cost manual[a]	95.57
Nursing home	Days	Patient questionnaire[g]	Cost manual[a]	252.73
Rehabilitation clinic	Days	Patient questionnaire[g]	Cost manual[a]	361.04
Home nursing day	Days	Patient questionnaire[g]	Cost manual[a]	46.72
Physical therapy (outpatient)	Hour	Patient questionnaire[g]	Cost manual[a]	
Physical therapy	Session	Patient questionnaire[g]	Cost manual[a]	38.23
Use of aids				
Crutches	Day	Patient questionnaire[g]	Home care firm[k]	0.07
Walker	Day	Patient questionnaire[g]	Home care firm[k]	0.08–0.15
Wheelchair	Day	Patient questionnaire[g]	Home care firm[k]	0.27

Table 1 (continued)

Cost categories	Unit	Source of consumption data	Source of value	Unit price (€)
Electric scooter	Day	Patient questionnaire[g]	Home care firm[k]	0.70
Extra bed	Day	Patient questionnaire[g]	Home care firm[k]	1.22
Extra toilet facilities	Day	Patient questionnaire[g]	Home care firm[k]	0.10–0.20
Extra shower facilities	Day	Patient questionnaire[g]	Home care firm[k]	0.10–0.18

Reference unit costs anno 2012 were used, or costs were adjusted to 2012 costs by using the national consumer price index

NA not applicable

[a] Cost manual—manual on cost research, methods and standard costs in economic health care evaluations, version 2010 [16]

[b] NZa; Nederlandse Zorgautoriteit (Dutch Health care Authority) standard costs

[c] Academic hospital

[d] General hospital

[e] Including operating room personnel, anesthesia, and overhead costs

[f] Hospital/industry data; costs were requested from one academic hospital, three regional hospitals, and one surgical equipment and implant firm. Means were calculated and used as an estimation of the real costs in all participating sites

[g] Patient questionnaire—customized version of the "Trimbos and iMTA questionnaire on costs associated with psychiatric illness" [17]

[h] Mainly antibiotics and in-hospital thrombosis profylaxis

[i] CVZ—standard prices were used as described by the CVZ (College voor zorgverzekeringen; Health Care Insurance Board), online available on www.medicijnkosten.nl

[j] Hip fracture-related medication only (i.e., pain medication and anti-osteoporosis medication; see ESM Supplemental Table 2 for details)

[k] Home care firm; costs of aids were requested from a home care firm and costs per day were calculated based on the calculated daily annuity. These costs were used as an estimation of the real costs in all participating patients

ten patients had other AEs including pulmonary embolism, myocardial infarction, cerebral vascular accident, pneumonia, urinary tract infection, delirium, or decubitus. Eighteen revision surgeries were performed in ten patients (Table 2).

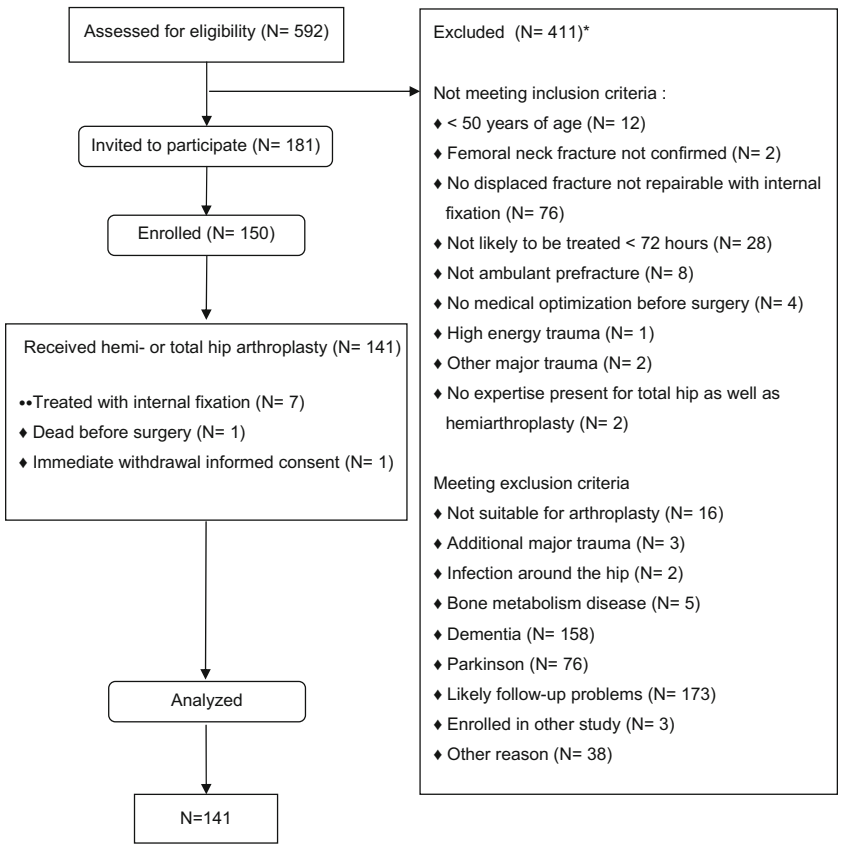

Fig. 1 Flow-chart of patient enrollment process. *Patients could meet more than one exclusion criterion

Table 2 List of revision surgeries performed

	Revision surgery 1	Revision surgery 2	Revision surgery 3	Revision surgery 4
Patient 1	Conversion to THA	Closed reduction ED	Closed reduction ED	Closed reduction ED
Patient 2	Arthrotomy and joint lavage	Arthrotomy and joint lavage	Arthrotomy and joint lavage	
Patient 3	Closed reduction ED	Closed reduction ED	Plate fixation periprosthetic frx	
Patient 4	Closed reduction OR	Closed reduction ED		
Patient 5	Conversion to THA			
Patient 6	Open reduction			
Patient 7	Closed reduction ED			
Patient 8	Arthrotomy			
Patient 9	Conversion to THA			
Patient 10	Closed reduction OR			

THA, total hip arthroplasty; *ED*, emergency department; *OR*, operating room

Dislocation was treated ten times; seven closed reductions were done in the emergency department, two in the operating room. One patient underwent an open reduction. Three conversions from hemiarthroplasty to total hip arthroplasty were performed. One patient suffered three dislocations after the conversion. One patient underwent an arthrotomy and joint lavage three times to treat a deep infection. One periprosthetic fracture was treated with plating. The 10-week mortality was 5 % ($N=7$), the 1-year mortality was 11 % ($N=16$), and the 2-year mortality was 19 % (N=27). Patients died mainly due to cancer ($N=9$), cardiovascular diseases ($N=6$), neurological diseases ($N=3$), and the bone cement implantation syndrome ($N=2$). The mean duration of follow-up was 22 months (SD 9).

Costs

ESM Supplemental Table 3 shows the fraction of patients who used health care and the volume of health care use per user. These data were not imputed. Table 3 shows the calculated mean costs for used health care after multiple imputations of the missing data. The overall percentage of missing data was 17.8 % and the relative efficiency of the multiple imputations was 0.98. In the first 10 weeks after the fracture the mean total costs was €15,216, which was 58 % of the total costs. The most important cost category was primary hospital stay accounting for €9026. From this category, costs were predominantly related to hospital admission (€5732) and index surgery (€2915). Other important costs were incurred for rehabilitation facilities and nursing homes (€4707).

At 1 year of follow-up, the mean total costs per patient was €23,869 (95 % CI €19,157–€30,136), this was 90 % of the overall total costs. Fifty-five percent of costs were spent on rehabilitation and changes in living situation with a total amount of €13,138. Rehabilitation centers/nursing homes (€11,694) and physical therapy at the outpatient clinic (€1340) were the main cost determinants. After 2 years of follow-up, the total rehabilitation-related costs (€14,429) still accounted for 55 % of the total costs. The hospital costs for follow-up almost doubled from €1705 (7 % of the total costs) after 1 year to €2943 (11 %) after 2 years of follow-up. The main items were costs related to adverse events which increased by 181 % from €581 to €1052 and a 204 % increase in costs for revision surgery from €480 to €980 (Fig. 2).

Discussion

The mean total costs per patient after treatment with hemi- or total hip arthroplasty for femoral neck fracture were €23,869 (95 % CI €19,157–€30,136) at 1 year and €26,399 (95 % CI €21,101–€33,213) at 2 years after a fracture.

These costs are in line with the range of €12,952 to €43,671 (as adjusted to 2012) found in literature [8–10, 22–27]. This broad range can be explained by different variables used in the studies. All studies were performed in western countries, but with different health care systems, mean length of hospital stay, reference costs, and rehabilitation facilities. The populations studied had a relatively small sample size ranging from 32 to 180 patients. One study, involving 19,808 patients, used a Markov decision model [22]. Although most of the costs are generated in the first year, the two studies with the lowest costs had a follow-up of 1 year [23, 25], not taking into consideration the late and costly complications. One study [9] did not include treatment with hemiarthroplasty and two studies only reviewed the costs for patients treated with hemiarthroplasty [23, 24]. Also, previous studies used different types of costs e.g., in-hospital costs only [8], the included populations differed in age, or included only women [25]. Results of the current study correspond best with the results of the two largest studies (adjusted costs €29,834 and €29,807, respectively), both including both types of arthroplasty [10, 22].

In addition, from a prospective cohort study of 10,275 Dutch persons, the estimated incremental costs of medical care were $9540 (adjusted to € in 2012: €11,715) in the first

Table 3 Mean costs of femoral neck fracture patients treated with hemi- or total hip arthroplasty ($N = 141$)

Cost categories	Cost until 10 weeks (€)	Costs until 1 year (€)	Costs until 2 years (€)
A) Hospital costs—primary stay			
Emergency department visit	160 (160–160)	160 (160–160)	160 (160–160)
Radiology/diagnostic modalities	219 (206–232)	219 (206–232)	219 (206–232)
Surgery	2,915 (2,798–3,023)	2,915 (2,798–3,023)	2,915 (2,798–3,023)
Admission days	5,732 (4,452–7,966)	5,732 (4.452–7,966)	5,732 (4,452–7,966)
Total	9,026 (7,706–11,295)	9,026 (7,706–11,295)	9,026 (7,706–11,295)
B) Hospital costs—follow-up			
Radiology/diagnostic modalities	115 (103–128)	240 (212–270)	344 (278–427)
Outpatient clinic visits	120 (109–133)	297 (263–336)	416 (355–494)
Adverse events	200 (66–392)	581 (280–1,056)	1,052 (568–1,781)
Revision surgery	396 (61–990)	480 (112–1,100)	980 (345–1,940)
Medication	82 (74–92)	106 (93–121)	151 (125–182)
Total	914 (499–1,541)	1,705 (1,102–2,563)	2,943 (1,894–4,308)
C) Costs related to rehabilitation/changes in living situation			
Rehabilitation center/nursing home	4,707 (3,627–5,874)	11,694 (8,132–16,350)	12,240 (8,542–17,008)
Physical therapy (outpatient)	549 (470–640)	1,340 (1,162–1,537)	1,975 (1,627–2,370)
Use of aids	20 (17–25)	105 (78–139)	214 (166–270)
Total	5,276 (4,200–6,467)	13,138 (9,486–17,956)	14,429 (10,461–19,552)
D) Total costs	15,216 (13,051–18,323)	23,869 (19,157–30,136)	26,399 (21,101–33,213)

Costs are presented as mean costs at each follow-up moment with 95 % uncertainty interval between brackets

The data have been imputed. If a patient had not consumed health care, costs for that item were recorded as €0

year after a hip fracture and $1017 (€1248) in the subsequent year [28]. These incremental costs are comparable with the €14,844 (first year) and €2529 (subsequent year) found in the current study. De Laet et al. [28] found higher costs, but that study did not include detailed costs of adverse events, revision surgeries, and costs of diagnostic modalities. The

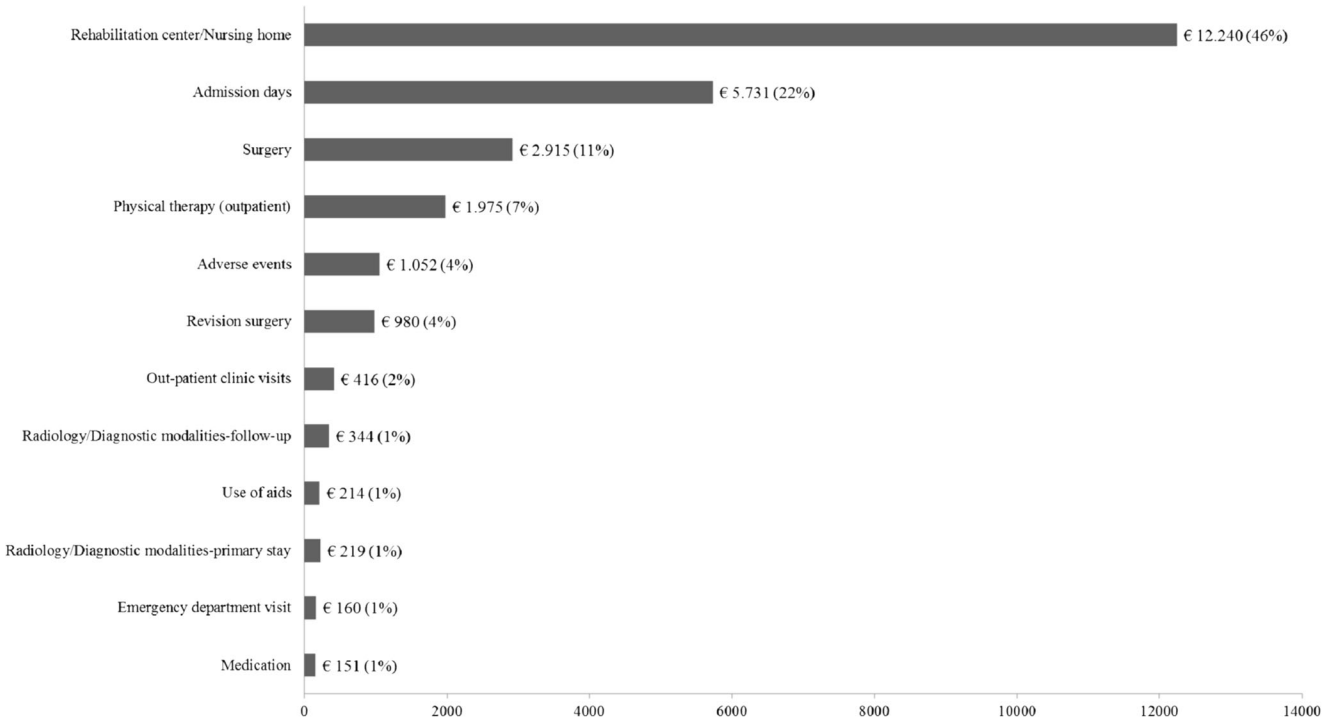

Fig. 2 Relative contribution of costs categories to the total treatment costs of patients until 2 years of follow-up

in-depth method of our study can be considered more specific as the total costs are presented in more detail.

Recently, a similar study was published involving Dutch elderly patients with a femoral neck fracture (50 years or older) who were primarily treated with internal fixation [16]. Both studies had the same design and used identical research methods, questionnaires, statistics, and resources, making it suitable for direct comparison. After two years of follow-up the costs, adjusted to 2012 for the total internal fixation group were €20,368 (original data: €19,425; 95 % CI €5,237–€58, 874). The relative contributions of the different cost categories were very comparable with respect to rehabilitation (46 % of total costs for arthroplasty and 49 % for internal fixation) and hospital admission days (both 22 %), with higher absolute costs in the current arthroplasty study. These differences can be explained by the generally older population in the arthroplasty group based on baseline characteristics. In the current study, the mean age was 10 years older (81 versus 71), patients were more often ASA 3–4 (54 versus 13 %), used aids pre-fracture more often (28 versus 13 %), and had a displaced fracture more often (100 versus 46 %). It is likely that older patients are admitted to a rehabilitation facility more often longer. Moreover, the mean number of hospital admission days (10 versus 7 days) was longer in the arthroplasty group. Subgroup analysis of 67 patients (27 %) who underwent revision to arthroplasty after primary internal fixation resulted in adjusted costs of: €28,031 (€26,733; 95 % CI €9465–€80, 029), which exceeds the costs of primary arthroplasty. This emphasizes the need to carefully select primary treatment for hip fractures as conversion from internal fixation to arthroplasty is even more costly than primary arthroplasty.

This study had some limitations. First, the population has been selected, based upon the eligibility for arthroplasty. Therefore it is a specific subset of the total population which presented to the emergency department of the participating hospitals. The patients were relatively healthy, fit, and most were independent walkers before the fracture. Patients with dementia or Parkinson's disease were excluded, but these patients represent a substantial part of the general hip fracture population. These patients may have complex needs and incur higher costs, consequently leading to an underestimation of the mean costs presented. Costs are based on Dutch prices and may vary depending on the health care system used. However, by comparing with published costs from other Western countries, we showed that the results are applicable to other settings as well. Secondly, the actual costs are expected to be even higher as costs for pre-hospital care, costs for routine blood analysis at the emergency department and wards, and perioperative consultation by other medical specialists and, although not routinely applied, forensic autopsy were not included. On the other hand, the number of visits for follow-up and X-rays are lower in general practice than in a trial setting. Also, the amounts used in the cost price manuals used may differ from the actual costs. However, these costs are not expected to be substantial. Finally, costs for home care and general practitioner (GP) visits were not included as for most patients it was impossible to discriminate which part of the post-fracture home care and GP visits was actually due to the hip fracture and not due to care for other pre- or post-fracture conditions. With these limitations in mind the results of the current study are in line with previous international publications.

In conclusion, the treatment of displaced femoral neck fractures with hemi- or total hip arthroplasty is costly with mean total costs after one year of €23,869 and €26,399 after 2 years of follow-up. Rehabilitation and nursing homes account for almost half of the total medical costs, revision surgery, and adverse events not even 10 %. Focus on improvements of the rehabilitation phase can result in reducing costs.

Acknowledgments *Steering Committee*: Mohit Bhandari (Chair), PJ Devereaux, Thomas A. Einhorn, Lehana Thabane, Emil H. Schemitsch, Kenneth J Koval, Frede Frihagen, Rudolf W. Poolman, Kevin Tetsworth, Ernesto Guerra-Farfán, Stephen D. Walter, and Gordon H Guyatt.

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Compliance with ethical standards

Conflicts of interest None.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Funding Members of the research team received a grant from The Netherlands Organization for Health Research and Development (ZonMw; grant number 17088.2503), Canadian Institutes of Health Research (CIHR; grant number MCT-90168) and National Institutes of Health (NIH; grant number 1R011AR055130-01A1). The funding agencies were not involved in the study design, data collection, data analysis, manuscript preparations or publication decisions for this manuscript.

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