

Comprehensive geriatric care for patients with hip fractures: a prospective, randomised, controlled trial



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Summary

Background Most patients with hip fractures are characterised by older age (>70 years), frailty, and functional deterioration, and their long-term outcomes are poor with increased costs. We compared the effectiveness and cost-effectiveness of giving these patients comprehensive geriatric care in a dedicated geriatric ward versus the usual orthopaedic care.

Methods We did a prospective, single-centre, randomised, parallel-group, controlled trial. Between April 18, 2008, and Dec 30, 2010, we randomly assigned home-dwelling patients with hip-fractures aged 70 years or older who were able to walk 10 m before their fracture, to either comprehensive geriatric care or orthopaedic care in the emergency department, to achieve the required sample of 400 patients. Randomisation was achieved via a web-based, computer-generated, block method with unknown block sizes. The primary outcome, analysed by intention to treat, was mobility measured with the Short Physical Performance Battery (SPPB) 4 months after surgery for the fracture. The type of treatment was not concealed from the patients or staff delivering the care, and assessors were only partly masked to the treatment during follow-up. This trial is registered with ClinicalTrials.gov, number NCT00667914.

Findings We assessed 1077 patients for eligibility, and excluded 680, mainly for not meeting the inclusion criteria such as living in a nursing home or being aged less than 70 years. Of the remaining patients, we randomly assigned 198 to comprehensive geriatric care and 199 to orthopaedic care. At 4 months, 174 patients remained in the comprehensive geriatric care group and 170 in the orthopaedic care group; the main reason for dropout was death. Mean SPPB scores at 4 months were 5·12 (SE 0·20) for comprehensive geriatric care and 4·38 (SE 0·20) for orthopaedic care (between-group difference 0·74, 95% CI 0·18–1·30, $p=0\cdot010$).

Interpretation Immediate admission of patients aged 70 years or more with a hip fracture to comprehensive geriatric care in a dedicated ward improved mobility at 4 months, compared with the usual orthopaedic care. The results suggest that the treatment of older patients with hip fractures should be organised as orthogeriatric care.

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Introduction

Hip fractures are frequent in older people (>70 years) and represent a worldwide challenge.¹ Because of population ageing, fragility fractures are an increasing burden on health-care systems and societies.² Most older people who fracture a hip are frail, have comorbidities, and show a functional deterioration that is typical of geriatric patients.³ After a fracture, both short-term and long-term outlooks for patients are generally poor, with increased 1 year mortality (18–33%),⁴ and negative effects on activities of daily living and mobility. A review of long-term disability in patients with hip-fractures that summarised a weighted average of relevant studies estimates that 42% of survivors do not return to their prefracture mobility, 35% are incapable of walking independently, 20% are unable to shop independently,⁵ and about 20% enter a long-term care facility during the first year after a fracture.⁶ Hip

fractures have substantial socioeconomic effects and large, attributable costs, with acute and post-acute institutional care as the primary driver.⁶

Although surgical care is crucial for improving outcomes after a hip fracture, the proposal that a hip fracture in an older person represents a geriatric rather than an orthopaedic disorder calls for new clinical approaches.⁷ Comprehensive geriatric care is an alternative form of care; when practised in dedicated geriatric wards, it improves outcomes for frail older patients who are acutely admitted to hospital, and might be equally relevant for geriatric patients with hip fractures.⁸

Guidelines and recommendations have addressed the importance of combined geriatric and orthopaedic (orthogeriatric) care as an alternative to traditional treatment,⁹ although the optimum treatment model is unknown. As summarised in reviews,^{10,11} several in-hospital models of orthogeriatric care have been

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developed, including geriatric consultation teams, comanaged care between geriatricians and orthopaedic surgeons, and a range of interdisciplinary orthogeriatric care pathways. These models have had beneficial effects on delirium, complication rates, and mortality.

Most models of orthogeriatric care reported in the scientific literature are initiated after surgery and undertaken in orthopaedic contexts, and are linked to specific in-hospital and post-discharge rehabilitation programmes¹⁰. A few, non-randomised studies have investigated acute orthogeriatric care pathways for which all assessments and treatments except surgery were done within a geriatric ward by an interdisciplinary team. One of these studies⁷ showed important benefits for complication rates, walking ability, and mortality. Investigators from the Oslo Orthogeriatric Trial¹² reported a clinical pathway for patients with a hip fracture, for which the entire assessment and treatment programme, except surgery, took place in an acute geriatric setting; however, no effect was shown on cognition as the primary outcome.

The aim of our trial was to assess the effectiveness of comprehensive geriatric care versus usual orthopaedic care provided throughout an entire hospital stay, with only the fracture assessment and surgical treatment done by orthopaedic surgeons. We investigated both short-term and long-term outcomes in randomly assigned patients, with assessments done at 1, 4, and 12 months after surgery. Because immobility is an immediate result of a fracture and also later contributes to long-term functional deterioration,³ we chose mobility at 4 months as the primary outcome.

Methods

Study design and participants

We did a prospective, single-centre, randomised, controlled trial at St Olav University Hospital in Trondheim, Norway. St Olav is a central hospital for 300 000 inhabitants of Sør-Trøndelag County, with 25 municipalities and a total area of 18 848 km², and a regional centre for 696 000 inhabitants in mid-Norway. The health-care system in Norway is organised and financed by the public sector, and based on equal access to services irrespective of social or economic status. In Norway, most patients with hip fractures stay in hospital for at least 2 days after surgery. A few patients are discharged directly home, but most are transferred to dedicated rehabilitation facilities or nursing homes for short-term or long-term stays. Services after discharge are, in principle, provided according to needs.

The protocol and intervention programmes for the study have been published previously.^{13,14}

All patients admitted to the hospital with hip fractures were screened (briefly, a nurse approached all potentially eligible patients with a confirmed hip fracture in the emergency room, or their next-of-kin). Home-dwelling people aged 70 years or older who had been able to walk 10 m before the fracture were eligible. (Patients living in

their homes or sheltered housing, or who were staying temporarily in any kind of institution were defined as home-dwelling.) We excluded patients with pathological fractures, multiple traumas, or a short life expectancy, or who were living permanently in nursing homes or already participating in the investigation. The study was approved by the Regional Committee of Ethics in Medical Research (REK4.2008.335), the Norwegian Social Science Data Services (NSD19109), and the Norwegian Directorate of Health (08/5814). Patients or their next-of-kin gave informed written consent to be included in the study before participation.

Randomisation and masking

Provided eligibility criteria were confirmed, patients were enrolled and randomly assigned in a 1:1 ratio by a nurse to either the orthopaedic ward for orthopaedic care or the geriatric ward for comprehensive geriatric care. Patients were transferred to the allocated wards directly from the emergency department after treatment allocation.

The randomisation sequence was computer-generated in blocks of a size unknown to the investigators. We used a web-based, computer-generated service prepared by the Unit of Applied Clinical Research, Norwegian University of Science and Technology (NTNU).

Masking of the patients and staff delivering the treatment was not possible, and we were only partly able to accomplish masking of assessors during follow-up.

Procedures

The initial diagnosis of a hip fracture was made by an orthopaedic surgeon, who also established the type of operation that was needed. Preoperative and postoperative care was undertaken in the two wards by separate teams. Patients in both groups of the trial received care and physiotherapy in accordance with national and international guidelines.¹⁴ Geriatricians or other doctors with skills in the management of older people did not routinely visit the orthopaedic ward, and orthopaedic specialists did not routinely visit the geriatric ward. By request, for only a few patients, geriatricians briefly assessed patients receiving orthopaedic care; vice versa, the orthopaedic surgeon assessed a few patients receiving comprehensive geriatric care.

The clinical pathway for comprehensive geriatric care (table 1) was organised both before and after the operation as a systematic and interdisciplinary process, with an emphasis on comprehensive medical assessment and treatment, initiation of rehabilitation through mobilisation, and planning of discharge started early. Individualised rehabilitation plans were developed for patients who were discharged directly home. The number of staff members per bed was higher in the comprehensive geriatric care unit than in the orthopaedic care unit (nurses 1·67 vs 1·48, doctors 0·13 vs 0·11, physiotherapist 0·13 vs 0·09, and occupational therapist 0·13 vs 0·00). The orthopaedic ward was relocated to a new hospital building on 1 Sept, 2009.

	Comprehensive geriatric care	Orthopaedic care
Department	Department of Geriatrics, Clinic of Internal Medicine	Department of Orthopaedic Surgery, Clinic of Orthopaedics and Rheumatology
Facilities*	Geriatric ward: Five one-bed rooms organised in a group together reserved for patients with hip fractures within a 15-bed ward	Orthopaedic trauma ward: One, two, or four-bed rooms in a 19-bed ward before, or single rooms in a 24-bed ward after relocation Mixed orthopaedic trauma patient population
Team members, †number per bed		
Geriatricians	0-13	..
Registered nurses, licensed practical nurses	1-67	1-48
Physiotherapists	0-13	0-09 (0-07 after relocation)
Occupational therapists	0-13	None
Orthopaedic surgeons	..	0-11 (0-08 after relocation)
Treatment	Structured, systematic interdisciplinary comprehensive geriatric assessment and care focusing on: somatic health (comorbidity management, review of drug regimens, pain, nutrition, elimination, hydration, osteoporosis, and prevention of falls); mental health (depression, delirium); function (mobility, p-ADL and i-ADL) and social situation Early discharge planning Early mobilisation and initiation of rehabilitation	Following of routines of Department of Orthopaedic Surgery

For both groups, management of standard treatment and surgery is the same: standard treatment consists of preoperative intravenous fluid, analgesia (preoperative femoral nerve block, regular paracetamol, opioids on demand), thromboembolic prophylaxis, perioperative antibiotic prophylaxis, use of pressure relieving mattresses to avoid decubitus ulcers, and preoperative assessments by an anaesthetist; surgery consists of spinal anaesthesia, two-screw fixation for non-dislocated femoral neck fractures, hemiarthroplasty for dislocated femoral neck fractures, and a sliding hip screw system for trochanteric and subtrochanteric fractures (some subtrochanteric fractures are fixed with antegrade intramedullary nailing). p-ADL=personal Activities of Daily Living. i-ADL=instrumental Activities of Daily living. *Orthopaedic care was relocated to a new hospital building after 219 of 397 patients were recruited. †Separate teams with no collaboration.

Table 1: Management in the comprehensive geriatric assessment and care and the orthopaedic care groups

After discharge from hospital the primary health-care services were responsible for follow-up in both groups, but neither group was routinely offered hospital-based follow-up after discharge. When needed, the orthopaedic surgeon arranged follow-up at the orthopaedic outpatient clinic for patients in both groups. For baseline registration of prefracture comorbidity we used the Charlson comorbidity index. The scores range from 0 to 30, with a high score suggesting high comorbidity.¹⁵ For the preoperative risk classification we used the Acute Physiology And Chronic Health Evaluation II severity of disease classification system (APACHE II), with scores ranging from 5 to 89, high scores suggesting a high risk.¹⁶ The minimum score with APACHE II is 5 points because all patients were aged 70 years or older.

Follow-up assessments were done on day 5 after the operation, and 1, 4, and 12 months after surgery. Assessments were done by assessors who were not associated with patient care. 4 month and 12 month assessments were undertaken at the hospital if possible. These assessments were not linked to medical assessments except for five emergency cases from both groups that were managed by a geriatrician. All 1 month assessments, and 4 month and 12 month assessments in very sick patients, were done wherever the patient resided. Whenever possible during data collection, patients were the primary informant. The exception was for Clinical Dementia Rating scores, which were collected from proxies by telephone for all patients, and scores for

the Barthel index and the Nottingham Extended ADL scale, which were collected from proxies by telephone for 10–20% of patients in both groups who were unable to provide the data.

Medical information, including complications, admissions to hospital, and visits to outpatient clinics was obtained from hospital records. Information about admissions to institutional rehabilitation centres was obtained from the Norwegian Patient Registry, visits to family doctors and physiotherapists from the Norwegian Health Economics Administration, and nursing home stays and other primary care services from the municipalities' records (appendix).

Outcomes

The primary outcome was mobility at 4 months after surgery measured by the Short Physical Performance Battery (SPPB),¹⁷ assessing standing balance, walking speed, and ability to rise from a chair, assessed in the intention-to-treat population. The total score ranges from 0–12; high scores suggest better mobility.

Secondary outcomes were mobility assessed by Timed Up and Go (TUG) measured as time in seconds to complete specific actions—a short time suggests better mobility,¹⁸ personal activities of daily living (ADLs) measured by the Barthel Index with a score range of 0–20 (a high score suggests increased independence),¹⁹ instrumental ADLs (i-ADL), measured by the Nottingham Extended ADL scale with a score of 0–66 (a

For the Norwegian Patient Registry see www.npr.no

See Online for appendix

high score suggests better ability to undertake instrumental i-ADL),²⁰ cognition assessed with the Clinical Dementia Rating scale scored with a sum of boxes with a range of 0–18 (a low score suggests better cognitive function)²¹ and the Mini Mental Status Examination (MMSE) with a score range of 0–30 (a high score suggests better cognition)²² and quality of life assessed by the EuroQoL-5 dimension-3L (EQ-5D-3L) questionnaire with a score range of –0.594 to 1 (a low score suggests a worse quality of life).²³ Fear of falling

was assessed by the Falls Efficacy Scale International-short form (FES-I-s) with a score range of 7–28 points, for which a low score suggests decreased fear,²⁴ and mood by the Geriatric Depression Scale, ranging from 0 to 15 points, for which a low score suggests a better mood.²⁵

Additional outcomes described in the protocol manuscript¹³ such as gait control and daily physical activity from the whole set of participants will be published in separate reports. Our choice of this wide range of outcome variables is, to a large extent, in line with published recommendations for studies assessing orthogeriatric comanagement of hip fractures.²⁶

Statistical analysis

Sample size was calculated from an estimated effect size of 1.0 point in mean SPPB score at 4 months after surgery. (1.0 point is regarded as a substantial meaningful change, and 0.5 points is a small meaningful change).²⁷ We expected a reduction of 10% in participants resulting from death and a 10% dropout because of withdrawals during

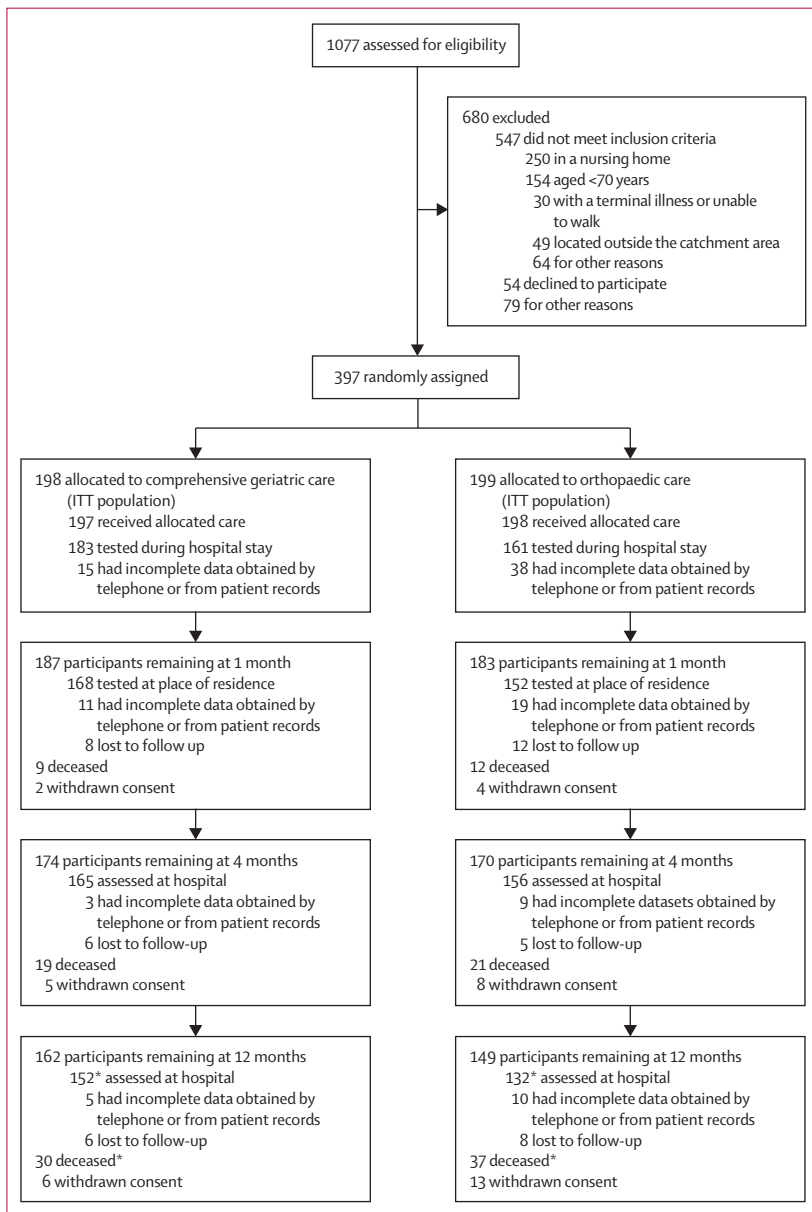


Figure 1: Trial profile

*One participant registered as deceased in the comprehensive geriatric care group and one in the orthopaedic care group finished their final tests before death. Data for health-care services and economics were available for all patients except one in the orthopaedic care group who withdrew consent to collect data from registries; therefore n=198 in both groups.

	Comprehensive geriatric care (N=198)	Orthopaedic care (N=199)
Age (years)	83.4 (5.4)	83.2 (6.4)
Female	145 (73%)	148 (74%)
Sheltered housing	26 (13%)	20 (10%)
Living alone	115 (58%)	124 (62%)
Barthel Index (0–20)	18.3 (2.3)	18.1 (2.8)
Nottingham Extended ADL scale (0–66)	42.5 (17.7)	41.9 (17.5)
Clinical Dementia Rating Scale (0–18)	2.7 (4.0)	2.7 (3.9)
APACHE II (5–89)	9.3 (3.3)	9.1 (2.9)
Charlson comorbidity index (0–30)	2.3 (2.3)	2.3 (2.0)
Previous diagnoses		
Heart disease	97 (49%)	89 (45%)
Stroke	49 (25%)	57 (29%)
Diabetes	23 (12%)	28 (14%)
Dementia	27 (14%)	26 (13%)
Cancer	53 (27%)	43 (22%)
Kidney disease	18 (9%)	9 (5%)
Fracture type		
Femoral neck	119 (60%)	127 (64%)
Trochanteric	66 (33%)	58 (29%)
Subtrochanteric	13 (7%)	14 (7%)
Surgical treatment		
Hemiarthroplasty	76 (38%)	88 (44%)
Screws	38 (19%)	32 (16%)
Bone plates and screws	69 (35%)	63 (32%)
Other	13 (7%)	14 (7%)
Died before surgery	2 (1%)	2 (1%)

Data are mean (SD) or n (%). ADL=activities of daily living, APACHE II=Acute Physiology And Chronic Health Evaluation disease severity classification II.

Table 2: Baseline characteristics

the first 4 months. With an α value of 0.05, 304 patients were needed for 80% power, but 380 patients were needed to allow for an estimated 20% dropout rate. We planned to stop recruiting participants by the end of 2010.

A statistical analysis plan was completed before doing any data analyses. Group allocation was masked during analysis of the primary outcome. All randomly assigned patients who met the inclusion criteria were included in the intention-to-treat population.

An independent clinical trials unit (Warwick Clinical Trials Unit, University of Warwick, Warwick, UK) reviewed emerging safety data (mortality and serious adverse events), and the assumptions underlying the sample-size calculation when 200 patients had been recruited. No planned or unplanned formal interim analyses were undertaken.

We used single imputation with the expectation maximisation algorithm for individual missing items on questionnaires and performance tests, with scores from the same timepoint as predictors.

We checked the normality of residuals by visual inspection of Q-Q plots. Results are reported as means, SE, and SD. Linear mixed models for repeated measurements were done with all outcome assessment scales as dependent variables, controlling for age, sex, and femoral neck fractures.²⁸ We analysed differences in the length of stay in the hospital between groups with linear regression. Differences between groups in the number of patients discharged directly home, admitted to hospital, or staying in nursing homes were analysed with Pearson's χ^2 test.

We assessed the effect of the move of the orthopaedic care unit to new facilities on SPPB, the Barthel index, and the Nottingham Extended ADL scale by use of a linear mixed model with an interaction product of group, before and after the move.

We regarded two-sided p values of less than 0.05 to be deemed statistically significant, and report 95% CIs when relevant.

We assessed cost-effectiveness from a broad health-care perspective. We calculated QALYs with the area-under-the-curve approach, with an assumption of a linear change in EQ-5D-3L values over time.²⁹ If a patient died, they were classified as having no previous decrease in quality of life. All patients were given an equal EQ-5D-3L baseline score based on a systematic review of osteoporosis-related utility values.³⁰ The different health states generated from the EQ-5D-3L were assigned values from the UK time-trade-off tariff²³ (ie, each health state was assigned a number between -0.594 and 1.000).

We imputed missing data for the EQ-5D-3L by multiple imputation using age, sex, fracture type, Charlson comorbidity index, APACHE II, the Barthel index, and MMSE as predictors. Imputations were done 100 times.

The sum of surgical treatment costs and length of stay multiplied by the cost per day constituted the cost per index stay, with costs per day for comprehensive geriatric

	Comprehensive geriatric care		Orthopaedic care		Difference	
	N	Mean (SE)	N	Mean (SE)	Estimate (95% CI)	p value
Hospital	198		199			
Mobility						
Short Performance Physical Battery	183	1.61 (0.19)	161	1.04 (0.20)	0.56 (0.20 to 1.10)	0.042
1 month	187		183			
Mobility						
Short Performance Physical Battery	173	3.59 (0.19)	160	3.09 (0.20)	0.50 (-0.05 to 1.05)	0.08
Timed Up and Go	140	31.32 (1.53)	120	32.80 (1.66)	-1.48 (-5.92 to 2.95)	0.51
Cognition						
Mini Mental Status Examination	168	23.43 (0.44)	152	22.40 (0.46)	1.03 (-0.22 to 2.27)	0.11
Activities of daily living						
Barthel Index	179	14.53 (0.28)	169	14.21 (0.29)	0.32 (-0.47 to 1.11)	0.43
Nottingham Extended ADL Scale	179	17.05 (1.25)	169	14.87 (1.29)	2.19 (-1.33 to 5.71)	0.22
Depressive symptoms						
Geriatric Depression Scale	169	4.81 (0.25)	154	4.84 (0.26)	0.03 (-0.74 to 0.68)	0.94
Fear of falling						
Falls Efficacy Scale International-short form	158	12.73 (0.35)	139	13.97 (0.37)	-1.24 (-2.24 to -0.24)	0.015
Quality of life						
EQ-5D-3L	176	0.46 (0.26)	165	0.40 (0.26)	0.05 (-0.02 to 0.12)	0.16
4 months	174		170			
Mobility						
Short Physical Performance Battery	165	5.12 (0.20)	160	4.38 (0.20)	0.74 (0.18 to 1.30)	0.010
Timed Up and Go	153	24.05 (1.47)	136	25.94 (1.56)	-1.90 (-6.09 to 2.31)	0.38
Cognition						
Clinical Dementia Rating scale	159	3.59 (0.35)	145	4.38 (0.36)	-0.79 (-1.70 to 0.20)	0.12
Mini Mental Status Examination	165	23.92 (0.44)	156	22.83 (0.46)	1.10 (-0.15 to 2.34)	0.08
Activities of daily living						
Barthel index	168	16.31 (0.29)	165	15.30 (0.29)	1.01 (0.21 to 1.81)	0.013
Nottingham Extended ADL Scale	168	33.59 (1.29)	164	27.42 (1.31)	6.17 (2.57 to 9.78)	0.001
Depressive symptoms						
Geriatric Depression Scale	165	4.32 (0.25)	155	4.75 (0.26)	-0.42 (-1.14 to 2.90)	0.24
Fear of falling						
Falls Efficacy Scale International—short form	154	11.31 (0.35)	144	12.57 (0.37)	-1.27 (-2.27 to -0.27)	0.013
Quality of life						
EQ-5D-3L	177	0.54 (0.26)	170	0.46 (0.26)	0.08 (0.01 to 0.15)	0.033

(Table 3 continues on next page)

	Comprehensive geriatric care		Orthopaedic care		Difference	
	N	Mean (SE)	N	Mean (SE)	Estimate (95% CI)	p value
(Continued from previous page)						
12 months	162		149			
Mobility						
Short Physical Performance Battery	151	5.30 (0.21)	133	4.61 (0.22)	0.69 (0.10 to 1.28)	0.023
Timed Up and Go	139	21.93 (1.54)	117	23.25 (1.68)	-1.32 (-5.79 to 3.15)	0.56
Cognition						
Clinical Dementia Rating scale	152	4.00 (0.36)	138	4.59 (0.37)	-0.59 (-1.59 to 0.41)	0.25
Mini Mental Status Examination	152	24.13 (0.46)	132	22.69 (0.49)	1.44 (0.12 to 2.77)	0.033
Activities of daily living						
Barthel Index	158	16.46 (0.29)	142	15.33 (0.30)	1.13 (0.31 to 1.96)	0.007
Nottingham Extended ADL Scale	158	35.20 (1.33)	142	28.81 (1.41)	6.39 (2.59 to 10.19)	0.001
Depressive symptoms						
Geriatric Depression Scale	151	4.10 (0.26)	131	4.82 (0.27)	-0.72 (-1.46 to 0.02)	0.06
Fear of falling						
Falls Efficacy Scale International-short form	149	10.81 (0.36)	119	12.03 (0.39)	-1.21 (-2.24 to -0.18)	0.021
Quality of life						
EuroQol-5d-3L	176	0.52 (0.22)	161	0.45 (0.23)	0.09 (0.02 to 0.16)	0.015
QALY 0-12 months	198	0.49 (0.02)	199	0.42 (0.02)	0.07 (0.01 to 0.13)	0.019

ADL=activities of daily living. QALY=quality-adjusted life-years.

Table 3: Clinical assessments

care and orthopaedic care calculated on the basis of differences in staff numbers. Patient use of services after discharge was combined with unit costs to calculate the cost per patient (appendix).

We evaluated cost-effectiveness by calculating the difference in mean costs and dividing by the difference in mean QALYs, assuming a theoretical threshold of €62 500 per QALY gained. We estimated any uncertainty about the incremental cost-effectiveness ratio (ICER) by bootstrapping the costs and effects 1000 times.³¹

Any patient who died during the course of the trial was allotted zero costs and zero health from the date of death and was not classified as censored.³² We did all analyses with the IBM SPSS statistics 20.0 program.

This trial is registered with ClinicalTrials.gov, number NCT00667914.

Role of the funding source

The funders of the study had no role in the study design, data collection, data analyses, or data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

Patients were recruited from April 18, 2008, to December 30, 2010 (the prespecified finishing timepoint). 1077 patients were screened for eligibility, of whom 397 were randomly assigned to receive either comprehensive geriatric care (n=198) or orthopaedic care (n=199) (figure 1). Most patients were randomly assigned in the emergency room before they were transferred to their assigned ward. 22 were randomly assigned in the orthopaedic ward within 24 h of

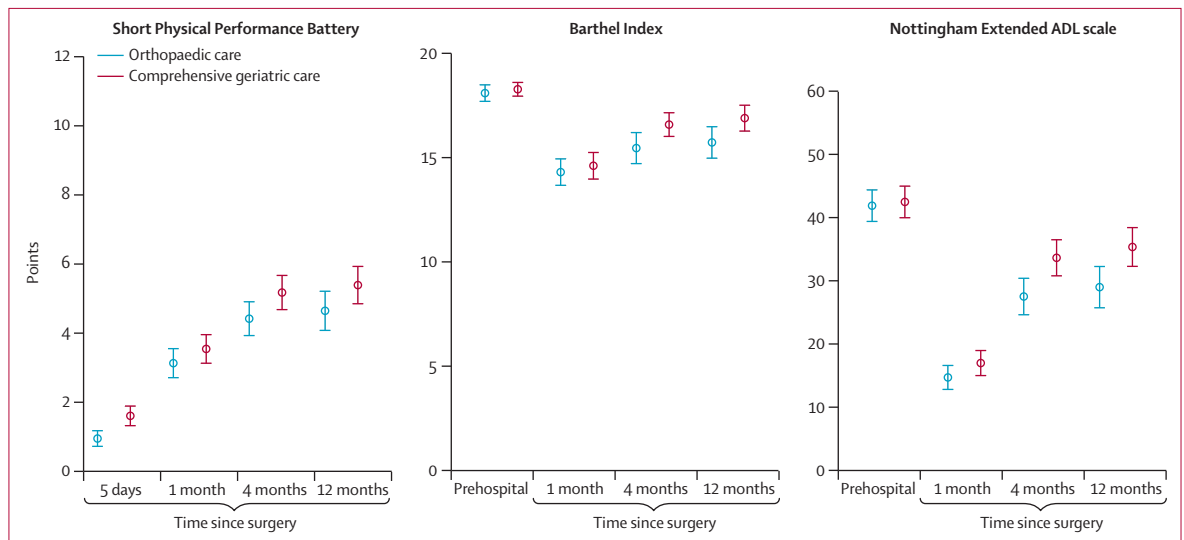


Figure 2: Mobility, activities of daily living, and instrumental activities of daily living
Data are mean, 95% CI. ADL=activities of daily living.

admission; ten of these were randomly assigned to comprehensive geriatric care and moved to the geriatric ward after surgery. The most common reason for ineligibility was that the patient resided permanently in a nursing home (250 [46%] of 547) or was too young (aged <70 years; 154 [28%] of 547). At 12 months, only 33 patients (8%) had withdrawn or were registered with missing data (lost to follow-up) and we noted no significant differences between the groups for withdrawn patients or missing data ($p=0.14$, 95% CI -8.70 to 3.70).

Baseline characteristics did not differ between the groups (table 2). For the 397 randomly assigned patients, the mean age was 83 years (SD 6.1), 293 (73%) were women, and 239 (60%) lived alone before the fracture. The proportion of patients with femoral neck fractures did not differ between groups (table 2). Mortality in the comprehensive geriatric care and orthopaedic groups at 12 months was 30 (15%) of 198 and 37 (18%) of 199 patients, respectively ($p=0.36$). We noted no differences in fracture-related or other complications during the index stay (data not shown). Mean prefracture personal-ADL Barthel index scores were 18.3 (SD 2.3) and 18.1 (2.8), and mean prefracture Nottingham Extended ADL scale scores were 42.5 (17.7) and 41.9 (17.5).

For the primary outcome of mobility at 4 months, the comprehensive geriatric care group had better mean SPPB scores than the orthopaedic care group, with a between-group difference of 0.74 points (95% CI 0.18–1.30, $p=0.010$; table 3, figure 2). The between-group difference at 12 months was 0.69 (0.10–1.28; $p=0.023$). 165 patients in the comprehensive geriatric care group and 160 in the orthopaedic care group were assessed for the primary outcome. Between-group differences in mean SPPB scores were in favour of comprehensive geriatric care on day 5 after the operation but were not significant at 1 month (table 3, figure 2). We noted no significant between-group differences for mobility TUG during follow-up (table 3).

The mean instrumental ADL score during the study was significantly better in the comprehensive geriatric care group than in the orthopaedic care group at 4 months and at 12 months (table 3). Mean p-ADL score at 4 and 12 months after surgery also favoured comprehensive geriatric care. Quality-of-life measures were higher in the comprehensive geriatric care group than in the orthopaedic care group; however, the difference at 1 month was not significant (table 3, appendix).

Cognitive function assessed by the MMSE at 4 months and the Clinical Dementia Rating Scale at any timepoint did not differ significantly between the groups (table 3). However, MMSE scores were better for comprehensive geriatric care at 12 months than for orthopaedic care (table 3).

Fear of falling was reduced in the comprehensive geriatric care group compared with the orthopaedic care

	Comprehensive geriatric care	Orthopaedic care	Difference	
			Estimate (95% CI)	p value
Preoperative waiting-time (h)	28.7 (26.1)	29.3 (20.6)	-0.6 (-5.3 to 4.1)	0.80
Length of stay (days)	12.6 (0.43)	11.0 (0.54)	1.7 (0.20 to 2.93)	0.025
Discharged directly home	47 (25%)	20 (11%)	13.9 (6.3 to 21.4)	0.001
Number of patients living at home				
1 month after treatment	171 (91%)	161 (87%)	3.9 (-2.5 to 10.4)	0.23
4 months after treatment	154 (86%)	141 (80%)	6.4 (-1.5 to 14.2)	0.14
12 months after treatment	140 (83%)	122 (76%)	7.6 (-1.2 to 16.2)	0.09
Patients admitted to hospital				
0–4 months after treatment	55 (29%)	58 (31%)	-2.2 (-11.4 to 7.0)	0.64
4–12 months after treatment	54 (30%)	66 (37%)	-7.1 (-16.7 to 2.7)	0.16
Rehabilitation				
0–4 months after treatment	121 (63%)	135 (72%)	-8.8 (-18.0 to 0.6)	0.07
4–12 months after treatment	13 (7%)	19 (11%)	-3.5 (-9.7 to 2.5)	0.25
Short-term stay in a nursing home				
0–4 months after treatment	44 (23%)	51 (27%)	-4.2 (-12.9 to 4.5)	0.34
4–12 months after treatment	17 (10%)	30 (17%)	-7.5 (-14.6 to -0.4)	0.038
Permanent stay in a nursing home				
0–4 months after treatment	28 (15%)	32 (17%)	-2.5 (-9.9 to 5.0)	0.51
4–12 months after treatment	36 (20%)	45 (25%)	-5.3 (-14.0 to 3.4)	0.22

Number included in the analyses for comprehensive geriatric care versus orthopaedic care: index stay 198 versus 198; discharge home 191 versus 187; place of residence at 1 month 188 versus 185, at 4 months 179 versus 177, at 12 months 168 versus 161; use of care after the index stay: 0–4 months 191 versus 187, 4–12 months 179 versus 177.

Table 4: Health-care use

	Comprehensive geriatric care (n=198)	Orthopaedic care (n=198)	Difference	
	Mean (SD)	Mean (SD)	Estimate (95% CI)	p value
Index stay	11 868 (4185)	9537 (4393)	2331 (1483 to 3178)	<0.0001
Hospital costs after discharge	7745 (15 006)	11 022 (20 119)	-3277 (-6784 to 230)	0.07
Rehabilitation stay	8 105 (9076)	9633 (11 125)	-1529 (-3535 to 477)	0.14
Nursing home stay	14 874 (30 153)	18 798 (32 959)	-3923 (-10 164 to 2318)	0.22
Other primary health and care services	11 741 (15 128)	10 496 (14 498)	1246 (-1683 to 4173)	0.40
Total cost	54 332 (38 048)	59 486 (44 301)	-5154 (-13 311 to 3007)	0.22

Costs are in euros for 2010.

Table 5: Cost per patient

group at 1 month, 4 months, and 12 months. We noted no significant between-group differences in symptoms of depression as measured by the Geriatric Depression Scale (table 3).

The mean preoperative waiting times were similar between groups; however, mean length of hospital stay was significantly longer in the comprehensive geriatric care group than in the orthopaedic care group (table 4). A significantly higher proportion of patients in the comprehensive geriatric care group was discharged directly home than in the orthopaedic care group

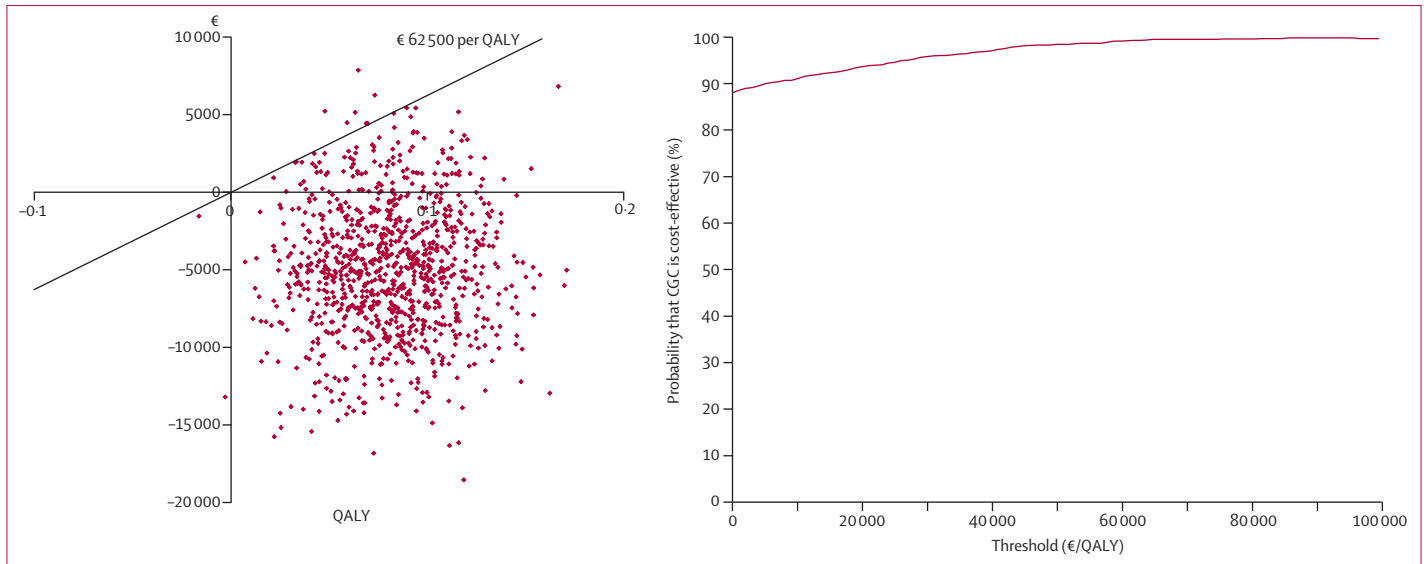


Figure 3: Cost per QALY analysis

The figure shows the cost-effectiveness plane and acceptability curve. CGC=comprehensive geriatric care. QALY=quality-adjusted life-years.

(table 4). Fewer patients receiving comprehensive geriatric care were admitted to short-term nursing home stays between 4 and 12 months after surgery than patients receiving orthopaedic care. Differences between groups in the proportions of patients living at home, or admitted to hospital or long-term nursing homes during follow-up were not significant (table 4).

The comprehensive geriatric care index stay was more costly than the orthopaedic care stay, with a mean difference of €2331 (95% CI 1483–3178), $p < 0.0001$. Differences between the groups for total costs per patient were non-significant (mean €–5154 [–13 311 to 3007], $p = 0.22$). Table 5 and appendix show further details about costs for other health services.

The number of QALYs was higher in the comprehensive geriatric care group than in the orthopaedic care group at 4 and 12 months (table 3).

The ICER was calculated to €–71751 per QALY gained. Bootstrap results suggest that comprehensive geriatric care has a 99% probability of being cost effective compared with orthopaedic care, with the assumption of a threshold of €62 500 per QALY gained. Comprehensive geriatric care has an 88% probability of being both less costly and more effective than orthopaedic care—ie, of being a dominant alternative (figure 3).

At the time that the orthopaedic care group relocated to a new hospital, 219 (55%) of 397 patients had been recruited. The interaction analyses of the effect of the orthopaedic care group moving to new facilities during the study period did not show significance at the 0.05 level for mobility (SPPB scores, $p = 0.078$), personal ADLs (Barthel index scores, $p = 0.13$), or instrumental-ADLs (Nottingham Extended ADL scale scores, $p = 0.19$).

Discussion

We investigated if any benefit was gained when patients with a hip fracture receive all assessments and treatments except surgery in an acute geriatric ward from an interdisciplinary team, rather than the usual orthopaedic care ward. For the primary outcome of mobility as measured by SPPB 4 months after surgery, the results were better with comprehensive geriatric care than with traditional orthopaedic care (see appendix for details). Most secondary outcomes were also better with comprehensive geriatric care than with orthopaedic care, including mobility and cognition at 12 months, activities of daily living, fear of falling, and quality of life at 4 and 12 months. The length of stay was significantly longer in the comprehensive geriatric care group, and significantly more patients in this group were discharged directly home, than were patients in the orthopaedic care group. Differences in the place of residence, and the number of patients admitted to hospital, rehabilitation, or long-term nursing-home care during 1 year of follow-up did not differ between groups, except for fewer patients in the comprehensive geriatric care group admitted for short-term stays in a nursing home 4–12 months after surgery than those in the comprehensive geriatric group. The analyses suggest a high probability of comprehensive geriatric care being both less costly and more effective than orthopaedic care for patients aged 70 years or older.

Mobility was chosen as the primary outcome because immobility is an immediate result of a fracture, and older patients with hip fractures often have a marked and permanent deterioration in their walking ability.⁵ SPPB is regarded as an objective outcome of physical performance, and also captures the health status of the participant.³³ Therefore the significant SPPB

between-group difference of 0.74 at 4 months, regarded as a clinically meaningful change,²⁷ and long-term improvement of mobility with comprehensive geriatric care, represent important findings. This result is consistent with the orthogeriatric study of Shyu and colleagues³⁴ done in an acute orthopaedic context (panel). Results from subgroup analyses in the Oslo Orthogeriatric trial¹² done in a geriatric context also indicated improved mobility with comprehensive geriatric care for home-dwelling patients. We noted, however, no between-group differences for the secondary mobility outcome of TUG. It seems that the TUG is less sensitive to change than the SPPB, possibly because patients who are unable to undertake this test are not given a score.

The significant and clinically meaningful benefits³⁵ of comprehensive geriatric care for instrumental-ADLs at 4 and 12 months have not been shown in previous studies of patients with hip fractures. The ability to complete instrumental-ADLs is an important need for independent living. In line with previous rehabilitation studies¹⁰ and results from the trial by Shyu and colleagues,³⁴ we showed a slight effect on ability to undertake personal-ADLs in favour of the comprehensive geriatric care group. The magnitude of the differences in quality of life at 4 and 12 months is roughly the mean of reported minimally important differences, which further supports the results of ADL benefits for the comprehensive geriatric care group.³⁶ The 1.44 point difference in mean MMSE scores at 12 months can be regarded as clinically significant at a group level in these frail, older patients, although a difference of 3 points is needed to be of clinical importance for individual patients with dementia.³⁷ We noted a significant and probably clinically important 1.2 point difference in FES-I-s scores at 1, 4, and 12 months in favour of the comprehensive geriatric care group.³⁸

The proportion of patients discharged directly home was significantly higher in the group receiving comprehensive geriatric care than in the group assigned to orthopaedic care. This finding could be attributed to a better in-hospital programme for discharge planning and mobilisation. On one hand, the notion of a better mobility programme in the comprehensive geriatric care group during the hospital stay is supported by patients spending more time in a standing position and walking in the comprehensive geriatric care group than the orthopaedic care group, as measured by use of body-worn sensors on day 4 after surgery.³⁹ On the other hand, length of stay in the hospital was significantly increased in the group receiving comprehensive geriatric care, compared with the group receiving orthopaedic care. These findings contrast with previous studies of orthogeriatric care, as summarised in a review.¹⁰ In our study context, periods of heightened need for trauma-ward beds in the orthopaedic care department might have increased the rate of discharge for this group. Another explanation for the discharge policy could be that comprehensive geriatric

Panel: Research in context

Systematic review

We searched the PubMed database, with no date restrictions, for English-language studies of orthogeriatric treatment models of hip fractures, especially new models focusing on long-term results of acute comprehensive geriatric assessment and care practised in geriatric wards. The search included studies with or without randomisation, reviews, and meta-analyses.

We started the search on Feb 17, 2007, during the planning of the study and repeated it several times until Dec 15, 2013. The search terms were “hip fracture” combined with either “orthogeriatric” or “comprehensive geriatric assessment”. The last search identified 69 and 42 reports, respectively, of which we manually searched reference lists to identify relevant publications not found by the primary search. We excluded studies of long-term, in-hospital rehabilitation, events within an orthogeriatric environment that were not related to the treatment itself, consultation services after discharge, and rehabilitation were excluded.

We found two reviews^{10,11} describing an update of the scientific literature on orthogeriatric treatment of hip-fracture patients in various service contexts. We identified only one randomised trial focusing on both an acute care setting and a short-term comprehensive geriatric care programme investigating long-term effects on mobility and function.³⁴ However, this model was run in an orthopaedic context including specific elements of rehabilitation both in-hospital and after discharge.

Other publications presented protocols without results and some reported results from non-randomised trials. One such large study from Israel compared acute treatment of hip-fracture patients in a geriatric ward as compared with treatment in an orthopaedic ward and reported impressive short-term and long-term results in favour of the geriatric pathway. This study was the origin of our model.⁷ However, several limitations make the reliability of results from this kind of study questionable, the most important being related to the non-randomised design. A model similar to ours has been studied in the Oslo Orthogeriatric trial.¹² Although no effect on cognition was shown, subgroup analyses from this trial suggested improved mobility in the comprehensive geriatric care group.

Interpretation

Our trial showed that patients aged 70 years or more with hip fractures have significant and clinically important improvements in mobility, activities of daily living, and quality of life when they receive comprehensive geriatric assessment and care in a specialised orthogeriatric unit, compared with usual care on an orthopaedic trauma ward. Comprehensive geriatric care is also more cost effective than orthopaedic care. The strengths of the study were the size, the controlled design, and the care of the participants, and the main limitations are the absence of masking and the single-centre location.

To our knowledge this is the first time such an effect has been shown in a large, prospective, randomised, controlled trial. Our results are in accordance with findings from previous non-randomised studies of hip fractures and studies of acutely sick, frail, older patients without hip fractures, for which comprehensive geriatric assessment and care were implemented in dedicated geriatric wards.

care and discharge planning are time-consuming. Also, some extra days in hospital might have been sufficient for some patients to have been discharged directly home.

Costs separated by service categories show that the index stay was more costly in the comprehensive geriatric care group than in the orthopaedic care group; between-group differences of costs for later hospital stays, stays in rehabilitation facilities and nursing

homes, and costs for health-care services at home were not significant. The combined effect of differences in costs, mortality, and quality of life as captured by the ICER, shows that comprehensive geriatric care is a cost-effective alternative to orthopaedic care. To our knowledge, the cost-effectiveness of comprehensive geriatric care has not been reported in previous trials of orthogeriatric comanaged care in patients with hip fractures, although it has been shown in a non-randomised investigation.⁴⁰

The major strengths of our study are the randomised controlled design with the control group receiving usual orthopaedic care, the large sample size, the high retention rate, the focus on long-term functional outcomes and cost-effectiveness, and that our primary outcome measure was a detailed, performance-based test^{17,27} rather than the self-reported measures often used in previous studies.⁵ Analyses were done according to a prespecified statistical analysis plan and treatment allocation was masked during the first data analysis.

The main study limitation is related to masking and concealment of the treatment allocation. Masking of the patients and staff delivering the treatment was not possible, and we were only partly able to accomplish masking of assessors during follow-up. The absence of masking might potentially have affected results from performance-based tests and questionnaires. However, data collection for discharge destination, place of residence, and use of health-care services was undertaken with the group allocation concealed. The results on these outcomes and also the activity monitoring data assessed on day 4 after the surgery³⁹ support our results for the primary outcome. Therefore, despite the absence of masking, we argue that our results are robust.

Important limitations for the analysis of cost-effectiveness include the absence of baseline EQ-5D-3L measurements, making it impossible to control for any potential imbalances in baseline values.⁴¹ Data for costs were obtained from registries, which avoids any difficulties with recall and selection bias, but might be affected by incorrect coding or absence of registration. The economic evaluation is based on secondary outcomes; however, this trial was not powered adequately enough to show differences in costs.

Our study was a single-centre trial, which also raises the important question of generalisability and feasibility. Comprehensive geriatric care is a multifaceted, integrated assessment and treatment involving several people from different professions and backgrounds. Treatment effects are therefore not likely to result from the competence and skills of one person. The work was undertaken in a large hospital, with national and international guidelines applied by the Department of Orthopaedic Surgery. Thus, the treatment in the orthopaedic care group should be similar to such treatment in many other hospitals in northern Europe.

Furthermore, our study sample was large, and representative of home-dwelling, older patients with a hip-fracture and preserved walking ability, and constituted 397 (75%) of all 530 screened patients with hip fractures that were eligible. Patients were mainly excluded because they were too young and not regarded as in need of comprehensive geriatric care, or they were staying permanently in nursing homes and excluded because of the choice of primary and secondary outcomes. Furthermore, our results are supported by results from previous studies of orthogeriatric hip-fracture treatment,^{10,11} and also by results from studies of comprehensive geriatric care in frail, older patients in general.⁸ Accordingly, we think that our results are valid and that comprehensive geriatric care is feasible in other settings, although only multicentre studies can support this hypothesis.

This is the first trial to show benefit and cost-effectiveness when patients aged 70 years or older with hip fractures are admitted directly to a geriatric ward for comprehensive geriatric care. Existing guidelines suggest that treatment of older patients with fragility fractures should be organised as orthogeriatric care.⁹ The present study supports these recommendations for older patients with hip fractures, and shows that preoperative and postoperative orthogeriatric management of these patients improves outcomes for 4 months, and for at least 1 year after surgery, compared with treatment in traditional orthopaedic trauma wards.

Contributors

OS conceived the idea for the study and managed the project. OS, IS, JLH, PT, AP, and SEL designed the study. PT, KT, AP, TS, GH, and VH acquired and managed the data. SL and SEL supervised the statistical analyses, and AP, GH, and SL did the analyses. AP wrote the statistical analysis plan. VH, GH, TS, and LGJ were responsible for the health economics part of the study. AP, GH, IS, OS, and JLH wrote the final report. All authors interpreted the data and contributed to revisions of the report

Declaration of interests

We declare no competing interests.

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References

- 1 Cheng SY, Levy AR, Lefavre KA, Guy P, Kuramoto L, Sobolev B. Geographic trends in incidence of hip fractures: a comprehensive literature review. *Osteoporos Int* 2011; **22**: 2575–86.
- 2 Hernlund E, Svedbom A, Ivergard M, et al. Osteoporosis in the European Union: medical management, epidemiology and economic burden. A report prepared in collaboration with the International Osteoporosis Foundation (IOF) and the European Federation of Pharmaceutical Industry Associations (EFPIA). *Arch Osteoporos* 2013; **8**: 136.
- 3 Auais M, Morin S, Nadeau L, Finch L, Mayo N. Changes in frailty-related characteristics of the hip fracture population and their implications for healthcare services: evidence from Quebec, Canada. *Osteoporos Int* 2013; **24**: 2713–24.
- 4 Bentler SE, Liu L, Obrizan M, et al. The aftermath of hip fracture: discharge placement, functional status change, and mortality. *Am J Epidemiol* 2009; **170**: 1290–99.
- 5 Bertram M, Norman R, Kemp L, Vos T. Review of the long-term disability associated with hip fractures. *Injury Prev* 2011; **17**: 365–70.
- 6 Nikitovic M, Wodchis WP, Krahn MD, Cadarette SM. Direct health-care costs attributed to hip fractures among seniors: a matched cohort study. *Osteoporos Int* 2013; **24**: 659–69.
- 7 Adunsky A, Arad M, Levi R, Blankstein A, Zeilig G, Mizrachi E. Five-year experience with the 'Sheba' model of comprehensive orthogeriatric care for elderly hip fracture patients. *Disabil Rehabil* 2005; **27**: 1123–27.
- 8 Ellis G, Whitehead MA, O'Neill D, Langhorne P, Robinson D. Comprehensive geriatric assessment for older adults admitted to hospital. *Cochrane Database Syst Rev* 2011; **7**: CD006211.
- 9 British Orthopaedic Association. The care of patients with fragility fracture. British Orthopaedic Association, 2007.
- 10 Kammerlander C, Roth T, Friedman SM, et al. Ortho-geriatric service—a literature review comparing different models. *Osteoporos Int* 2010; **21** (suppl 4): S637–46.
- 11 Giusti A, Barone A, Razzano M, Pizzonia M, Pioli G. Optimal setting and care organization in the management of older adults with hip fracture. *Eur J Phys Rehabil Med* 2011; **47**: 281–96.
- 12 Watne LO, Torbergsen AC, Conroy S, et al. The effect of a pre- and postoperative orthogeriatric service on cognitive function in patients with hip fracture: randomized controlled trial (Oslo Orthogeriatric trial). *BMC Med* 2014; **12**: 63.
- 13 Sletvold O, Helbostad JL, Thingstad P, et al. Effect of in-hospital comprehensive geriatric assessment (CGA) in older people with hip fracture. The protocol of the Trondheim Hip Fracture Trial. *BMC Geriatr* 2011; **11**: 18.
- 14 Saltvedt I, Prestmo A, Eimarsen E, Johnsen LG, Helbostad JL, Sletvold O. Development and delivery of patient treatment in the Trondheim Hip Fracture Trial. A new geriatric in-hospital pathway for elderly patients with hip fracture. *BMC Res Notes* 2012; **5**: 355.
- 15 Sundararajan V, Henderson T, Perry C, Muggivan A, Quan H, Ghali WA. New ICD-10 version of the Charlson comorbidity index predicted in-hospital mortality. *J Clin Epidemiol* 2004; **57**: 1288–94.
- 16 Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. *Crit Care Med* 1985; **13**: 818–29.
- 17 Guralnik JM, Ferrucci L, Pieper CF, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. *J Gerontol A Biol Sci Med Sci* 2000; **55**: M221–31.
- 18 Podsiadlo D, Richardson S. The timed "Up & Go": a test of basic functional mobility for frail elderly persons. *J Am Geriatr Soc* 1991; **39**: 142–48.
- 19 Mahoney FI, Barthel DW. Functional evaluation: the Barthel Index. *Md State Med J* 1965; **14**: 61–65.
- 20 Gladman JR, Lincoln NB, Adams SA. Use of the extended ADL scale with stroke patients. *Age Ageing* 1993; **22**: 419–24.
- 21 O'Bryant SE, Waring SC, Cullum CM, et al. Staging dementia using Clinical Dementia Rating Scale Sum of Boxes scores: a Texas Alzheimer's research consortium study. *Arch Neurol* 2008; **65**: 1091–95.
- 22 Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res* 1975; **12**: 189–98.
- 23 Dolan P. Modeling valuations for EuroQol health states. *Med Care* 1997; **35**: 1095–108.
- 24 Kempen GI, Yardley L, van Haastregt JC, et al. The Short FES-I: a shortened version of the falls efficacy scale-international to assess fear of falling. *Age Ageing* 2008; **37**: 45–50.
- 25 Yesavage JA. Geriatric Depression Scale. *Psychopharmacol Bull* 1988; **24**: 709–11.
- 26 Liem IS, Kammerlander C, Suhm N, et al. Identifying a standard set of outcome parameters for the evaluation of orthogeriatric co-management for hip fractures. *Injury* 2013; **44**: 1403–12.
- 27 Perera S, Mody SH, Woodman RC, Studenski SA. Meaningful change and responsiveness in common physical performance measures in older adults. *J Am Geriatr Soc* 2006; **54**: 743–49.
- 28 Twisk JW, de Vente W. The analysis of randomised controlled trial data with more than one follow-up measurement. A comparison between different approaches. *Eur J Epidemiol* 2008; **23**: 655–60.
- 29 Brazier J, Ratcliffe J, Salomon JA, Tsuchiya A. Measuring and valuing health benefits for economic evaluation. Oxford University Press, 2007.
- 30 Peasgood T, Herrmann K, Kanis JA, Brazier JE. An updated systematic review of Health State Utility Values for osteoporosis related conditions. *Osteoporos Int* 2009; **20**: 853–68.
- 31 Glick HA, Briggs AH, Polsky D. Quantifying stochastic uncertainty and presenting results of cost-effectiveness analyses. *Expert Rev Pharmacoecons Outcomes Res* 2001; **1**: 25–36.
- 32 Cook J, Drummond M, Heyse JF. Economic endpoints in clinical trials. *Stat Methods Med Res* 2004; **13**: 157–76.
- 33 Volpato S, Cavalieri M, Guerra G, et al. Performance-based functional assessment in older hospitalized patients: feasibility and clinical correlates. *J Gerontol A Biol Sci Med Sci* 2008; **63**: 1393–98.
- 34 Shyu YI, Liang J, Wu CC, et al. Two-year effects of interdisciplinary intervention for hip fracture in older Taiwanese. *J Am Geriatr Soc* 2010; **58**: 1081–89.
- 35 Wu CY, Chuang LL, Lin KC, Lee SD, Hong WH. Responsiveness, minimal detectable change, and minimal clinically important difference of the Nottingham Extended Activities of Daily Living Scale in patients with improved performance after stroke rehabilitation. *Arch Phys Med Rehabil* 2011; **92**: 1281–87.
- 36 Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. *Qual Life Res* 2005; **14**: 1523–32.
- 37 Stein J, Luppia M, Maier W, et al. Assessing cognitive changes in the elderly: reliable change indices for the Mini-Mental State Examination. *Acta Psychiatr Scand* 2012; **126**: 208–18.
- 38 Hauer KA, Kempen GI, Schwenk M, et al. Validity and sensitivity to change of the falls efficacy scales international to assess fear of falling in older adults with and without cognitive impairment. *Gerontology* 2011; **57**: 462–72.
- 39 Taraldsen K, Sletvold O, Thingstad P, et al. Physical behavior and function early after hip fracture surgery in patients receiving comprehensive geriatric care or orthopedic care—a randomized controlled trial. *J Gerontol A Biol Sci Med Sci* 2014; **69**: 338–45.
- 40 Ginsberg G, Adunsky A, Rasooly I. A cost-utility analysis of a comprehensive orthogeriatric care for hip fracture patients, compared with standard of care treatment. *Hip Int* 2013; **23**: 570–75.
- 41 Manca A, Hawkins N, Sculpher MJ. Estimating mean QALYs in trial-based cost-effectiveness analysis: the importance of controlling for baseline utility. *Health Econ* 2005; **14**: 487–96.