Consequences of a hip fracture among old people

Monica Långström Berggren

Department of Community Medicine and Rehabilitation,
Geriatric Medicine
Umeå 2017
“Be aware of what you’ve got. A grateful mind is a powerful mind.”

Nico & Vinz
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This thesis has three related aims: to describe the comorbidities, complications and causes of death among a representative population of old people with hip fracture; to evaluate whether a successful care model using comprehensive geriatric assessment, which reduced in-hospital falls and complications such as delirium, decubital ulcers and infections, has an effect on falls after discharge; and to assess whether adding home rehabilitation to the existing care model has an effect on length of stay in hospital, walking ability, complications and readmissions after discharge.

Previous research does not represent the entire hip-fracture population since those living in institutions and those with dementia/cognitive impairment are often excluded. Furthermore, orthogeriatric care models have had limited effect after discharge, mortality has remained high and knowledge is sparse about causes of death and complications after discharge. In addition, there are few randomized controlled multi- or inter-disciplinary team-based home rehabilitation studies, and data concerning complications and readmissions after discharge in those studies are limited. Only half of the hip-fracture population regain their prefracture level of mobility, which calls for further rehabilitation studies.

An orthogeriatric care model was evaluated, to assess whether it had any continuing effect on falls after discharge, in a randomized controlled study comprising 199 people with acute femoral neck fracture aged ≥70 years. Falls and new fractures as well as fall-incidence rate were compared between an intervention and a control group during a one-year follow-up. Poisson regression adjusted for overdispersion and observation time was used in the analyses. Comorbidities, complications and causes of death were described, and a multivariate analysis adjusted for potential confounders was used to analyze risk factors for all-cause mortality during a 3-year follow-up. After one year 44 participants had fallen and there were 138 falls in the intervention group compared with 55 participants who fell and 191 falls in the control group. The crude postoperative fall incidence was 4.16/1 000 days in the intervention group vs. 6.43/ 1,000 days in the control group. The incidence rate ratio was 0.64 (95% CI: 0.40–1.02, p=0.063). In total, 136 participants suffered at least one urinary tract infection; 114 suffered 542 falls and 37 sustained 56 new fractures, including 13 hip fractures, during a 3-year follow-up, and 79 out of 199 participants (40 %) died. Cardiovascular events (23 %), dementia (24 %), hip-fracture (19 %) and cancer (13 %) were the most common primary causes of death. Multivariate analyses revealed that cancer, dependence in personal activities of daily living, cardiovascular disease and dementia at baseline, pulmonary emboli and cardiac failure during hospitalization were all independent predictors of 3-year mortality.
Individually designed Geriatric Interdisciplinary Home Rehabilitation (GIHR) aimed at early hospital discharge was compared to conventional geriatric care in a randomized controlled study including 205 people with an acute hip fracture, aged \( \geq 70 \) years. The use of walking devices and walking ability was assessed in interviews and gait speed was measured over 2.4 meters. Length of stay in hospital, complications, readmissions and days spent in hospital after initial discharge were compared between intervention and control groups. Binary logistic models adjusted for hypothetical confounders were used to analyze walking ability, the use of a walking device and the risk of falling after discharge.

No significant differences were observed in walking ability, use of walking device, and gait speed at the 3- and 12-month follow-ups between the groups. At 12 months, 56.3% of the intervention group and 57.7% of the control group had regained or improved their prefracture walking ability. The median postoperative length of stay in the geriatric ward was 6 days shorter for the intervention group (\( p = 0.003 \)). Between discharge and the 12-month follow-up, comparisons between participants in the GIHR group and the control group were as follows; 46 (43.4%) vs. 38 (40.9%) fell (\( p = 0.828 \)); 13 (12.3%) vs. 6 (6.5%) suffered an additional fracture (\( p = 0.250 \)); 36 (34.0%) vs. 30 (32.3%) presented with an infection (\( p = 0.917 \)); 12 (11.3%) vs. 6 (6.5%) suffered a cardiovascular event (\( p = 0.344 \)); 38 (35.8%) vs. 27 (29.0%) were readmitted to hospital (\( p = 0.383 \)); and the median number of days spent in hospital in total was 11.5 vs. 11.0 (\( p = 0.353 \)).

In conclusion, the successful care model, that reduced in-hospital falls and complications, did not have a prolonged effect on falls among older people with hip fracture, including people with cognitive impairment/dementia. This group of old people have multiple co-morbidities and suffer numerous complications. When home rehabilitation was added to the existing care model, regaining of walking ability in the short- and long-term was similar in both the GIHR participants and those receiving conventional geriatric care. In addition, the proportions of complications after discharge were no higher in the former group, even though their initial time in hospital was shorter. The results indicate that falls and complications after discharge are a major problem among old people with hip fracture. This thesis suggests that primary and secondary prevention of falls and fractures needs to become a part of routine care among old fall-prone people.

nya frakturer varav 13 höftfrakturer. Efter tre år hade 79 personer avlidit
och de vanligaste orsakerna till död var hjärtkärlhändelser, demens,
höftfraktur och cancer. Cancer, beroende av hjälp i personlig vård,
hjärtkärlsjukdom och demens samt att drabbas av propp i lungan och/eller att få hjärtsvikt var associerat till död.

Ett individuellt anpassat geriatriskt tvärvetenskapligt hem-
rehabiliteringsprogram utvärderades i en studie med 205 deltagare 70 år
och äldre med en nyttillkommen höftfraktur. Deltagarna lottades till delta
i hemrehabilitering efter utskrivningen eller sedvanlig geriatrisk vård.
Hemrehabiliteringsprogrammet syftade till att personen skulle skrivas
hem från sjukhuset tidigare och få fortsatt vård och rehabilitering i
hemmet. Gångförmågan och behovet av gånghjälpmedel undersöktes
med intervjuer dessutom mättes gångförmågan med självvald och
maximal gånghastighet över 2,4 meter. Gångförmåga, behovet av
gånghjälpmedel och gånghastighet skilde sig inte åt mellan grupperna vid
uppföljande bedömningar vid 3 och 12 månader efter fraktur. Vid 12
månader hade 56,3% i interventionsgruppen och 57,7% i kontrollgruppen
återfått eller förbättrat sin gångförmåga jämfört med innan frakturen.
Vårdtidens längd var 6 dagar kortare i interventionsgruppen jämfört med
kontrollgruppen vid jämförelse av medianvårdtid. Inga skillnader
avseende komplikationer, återinläggningar och antal dagar på sjukhuset
efter utskrivningen kunde noteras mellan interventions- och
kontrollgruppen.

Sammanfattningsvis hade det tvärvetenskapliga, multifaktoriella vård-
programmet som framgångsrikt minskat fallolyckor och komplikationer
under tiden på sjukhuset inga kvarvarande effekter på fall efter
utskrivningen. Ett geriatriskt tvärvetenskapligt hemrehabiliterings-
program kan vara ett komplement till vård och rehabilitering på sjukhus.
Deltagarna återfick sin tidigare gångförmåga på kort och lång sikt
jämfört med de som erhöll sedvanlig geriatrisk vård. Trots en kortare
vårdtid initialt fick deltagarna inte fler komplikationer efter
utskrivningen. Äldre personer med höftfraktur har många andra
sjukdomar, drabbas av många fall och komplikationer samt återinläggs
ofta på sjukhus. För att påverka detta bör fall och frakturförebyggande
åtgärder bli en del av rutinvården av äldre fallbenägna personer.
ABBREVIATIONS

ADL    Activities of Daily Living
ASA    American Society of Anesthesiologists
BBS    Berg Balance Scale
CCS    Charlson Comorbidity Score
CGA    Comprehensive Geriatric Assessment
CI     Confidence Interval
DHS    Dynamic Hip Screw
DSM-IV Diagnostic and Statistical Manual of Mental Disorder, fourth edition
DRD    Discharge-Ready Date
EpC    Centre for Epidemiology
FNF    Femoral Neck Fracture
FRAX   Fracture Risk Assessment Tool
GDS    Geriatric Depression Scale
GIHR   Geriatric Interdisciplinary Home Rehabilitation
HIFE   High Intensity Functional Exercise program
HR     Hazard Ratios
HR     Home Rehabilitation
I-ADL  Instrumental Activities of Daily Living
IRR    Incidence Rate Ratio
IQR    Interquartile Range
LIH    Lars Ingvar Hansson (hook pins)
LOS    Length of Stay
MMSE   Mini-Mental State Examination
NA     Non-Assessed
Nbreg  Negative binomial regression
NS     Non-Significant
NSQIP  National Surgical Quality Improvement Program
OBS    Organic Brain Syndrome
OR  Odds Ratio
OT  Occupational Therapist
P-ADL  Personal/Primary Activities of Daily Living
PT  Physiotherapist
PTF  Pertrochanteric Fracture
RCT  Randomized Controlled Trial
S  Significant
S-COVS  Swedish version of Physiotherapy Clinical Outcome Variables
SD  Standard Deviation
STF  Subtrochanteric Fracture
WHO  World Health Organization
The thesis is based on the following papers. In the text they will be referred to by their Roman numerals:


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INTRODUCTION

Among old people, a hip fracture is usually a low-energy trauma, that is, an injury sustained from a fall from standing height or less. It is a serious incident which may affect a person’s life in many ways. The typical hip fracture patient is a woman aged 82 years, living in her own home, with three or more comorbidities including cognitive impairment and/or a heart disease. She was able to walk independently indoors before the fracture, and the fracture was caused by a fall in her own home. After the fracture her prognosis is poor; she has a high risk of falling again, she might become dependent in Activities of Daily Living (ADL) and she might never regain her prefracture mobility level.
BACKGROUND

Hip fracture

Hip fracture epidemiology

Throughout the world the populations are “ageing”, due to declining mortality and to fertility rates; that is, the proportion of the population above a certain age is rising. In 2017 worldwide there were 962 million people aged 60 or over, comprising 13 per cent of the global population. This age group is increasing at a rate of 3.0 per cent per year. The structure of the Swedish population is also changing, with the number of older people growing as a result of increased life expectancy and the assumption is that it will increase further in the future. It is estimated that in 2045 more than one million people in Sweden will be aged 80 years or older and the annual number of hip fractures in the country is expected to almost double during the first half of this century.

With these demographic changes in mind, epidemiological studies have been carried out which show that the age-specific incidence rate in hip fractures rose during the last half of the twentieth century, and later reached a plateau or declined. The reasons for these changes are not entirely clear. A recent study from Norway describes a continuing age-adjusted decline in hip fracture rates, although the prevalence is still expected to rise in the future due to changes in population size and age distribution. A Swedish population-based study shows an increased incidence among the oldest old, partly due to a larger number of older individuals.

It is calculated that women in Sweden have a 20% lifetime risk of sustaining a hip fracture. Almost 18 000 people suffer a hip fracture each year in Sweden, at the mean age of 82 years and 68% are women. The proportion of men has increased from 28 % in 1996 to 32 % in 2011. Less than half of all those who sustain a hip fracture, (44 %) are living alone and 70% live in ordinary housing before the fracture. In addition, cognitive impairment/dementia is common among old people with hip fracture. In 2015, the mean length of stay in acute care in Sweden was 8.6 days and the median length of stay was 7 days in 2015.

Risk factors for hip fracture

A hip fracture in older individuals, caused by a “low energy trauma”, is usually defined as a fragility fracture and most of these individuals have a
low bone density, or osteoporosis, as an underlying risk factor for fracture. The fracture is a result of mechanical forces that would not ordinarily result in fracture (nice.org.uk). The Fracture Risk Assessment Tool (FRAX), which is used in clinical practice to calculate fracture risk, includes established risk factors such as; age, gender, body mass index, ethnicity, smoking, previous low trauma fracture, parental hip fracture, glucocorticoid use, rheumatoid arthritis, secondary osteoporosis, alcohol use and bone mineral density. However, FRAX does not include the individual’s risk of falling and the number of previous fractures. Having had a stroke or having dementia is also associated with a higher risk of hip fracture, probably due to the proneness to fall and, among individuals with stroke, bone loss on the paretic side. A large cohort study, including people ≥85 years, by Wiklund et al. also describes several risk factors for hip fracture. Age, Parkinson’s disease, currently smoking, underweight, delirium in the preceding month and help from no more than one person when walking indoors are all independent risk factors, whereas a bilateral hip prostheses seem to protect against hip fracture.

Consequences of hip fracture

Hip fracture is a significant cause of morbidity and mortality worldwide. Such a fracture might lead to considerable changes in a person’s life, with both personal and social consequences, and many become afraid of falling again. Only half of old individuals with hip fracture regain their pre-fracture level of mobility and only 40–70% regain their level of independence in basic activities, depending on population studied. These consequences might lead to old individuals losing their independence, and to some having to move into residential care facilities. Following acute care, 32% are discharged to ordinary housing, 18% to a residential care facility and 35% to a rehabilitation department, according to the Swedish National Hip Register. At four months after fracture 57% live in their own home.

In addition, a hip fracture is also associated with increased mortality. It has been shown that older people have a 5- to 8-fold increased risk of dying during the first 3 months after a hip fracture, and most deaths occur within the first 6 months. In Sweden, 3.5% of those suffering a hip fracture die during acute hospital care. A review by Abrahamsen et al. reported in-hospital mortality ranging from 2.3% to 13.9 %. Five years after fracture the mortality is 20% above the expected level, a figure which has remained stable over the past 40 years. For society, hip fracture is already a huge economic burden and is predicted to continue to be so in the future.
‘Hip fracture’ as a term includes fractures of the upper (proximal) part of the femur, and the two main types are the femoral neck fracture (cervical fracture or intracapsular) and fractures distal to the femoral neck (extracapsular or trochanteric). The intermediate types are called basocervical fractures.\textsuperscript{32} Cervical fractures can be divided into displaced and undisplaced fractures according to the Garden classification.\textsuperscript{33} Garden I-II include undisplaced fractures and Garden III-IV include displaced fractures. Almost 50\% of hip fractures are cervical fractures and the remainder are trochanteric fractures, including 8\% subtrochanteric fractures.\textsuperscript{11} This thesis is concerned with cervical and trochanteric fractures (Figure 1).

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fractures.png}
\caption{Undisplaced and displaced cervical fracture, and trochanteric fracture.}
\end{figure}

During the study periods undisplaced femoral neck fractures were operated on using internal fixation, and displaced fractures using mainly hemiarthroplasty, where only the femoral part is replaced, while a dynamic sliding-screw device was used for the basocervical and pertrochanteric fractures (Figure 2). Since 2000, a medullary nail\textsuperscript{11} has been used more often for trochanteric fractures with two or more
fragments, and some of the participants in Papers III and IV (n=18) were treated using this method.

![Image of cervical fractures and hip fractures]

**Figure 2.** Undisplaced cervical fracture operated on using internal fixation, two Hook pins (LIH), displaced cervical fracture operated on using hemiarthroplasty (HAP) and trochanteric fracture operated on using dynamic sliding-screw device (DHS).

### Falls and fractures

#### Fall epidemiology

Approximately 30% of people above the age of 70 living in ordinary housing fall each year and around 4-6% of falls result in a fracture, with 1-2% of the falls causing a hip fracture. In almost all cases a hip fracture is the result of a fall. The risk of falling again after a hip fracture is substantial. In a study by Colon-Emeric et al. the risk of sustaining a subsequent fracture after an initial hip fracture was increased 2.5-fold, and in a population-based study 21% of those who had a hip fracture had previously suffered 2 or more hip fractures. Around 7% of those who suffer a hip fracture fell in hospital. In Sweden, more than 70000 people were hospitalized and approximately 1600 died due to fall accidents in 2013.
Risk factors for falls

The majority of falls are due to the interacting of multiple risk factors, only a few have a single cause.\textsuperscript{34} In a study by Campbell et al. 15\% of the falls resulted from an external event that would cause most people to fall, another 15\% could be attributed to a single identifiable cause such as syncope, and the remaining falls were caused by multiple interacting factors.\textsuperscript{45}

Risk factors for falls can be classified in a variety of ways. One is to differentiate between predisposing and precipitating factors, where the former represent “chronic factors” that increase the predisposition for falls, and the latter “acute factors” that trigger a fall. Another way of classifying risk factors for falls is to ascribe them to individually-related (intrinsic) or environmental factors (extrinsic).\textsuperscript{46} The category of intrinsic risk factors includes advanced age, previous falls, muscle weakness, gait and balance problems, poor vision and chronic diseases (for example; Parkinson’s, stroke, diabetes, dementia and incontinence), whereas the category extrinsic factors comprises environmental factors such as slippery or uneven surfaces, lack of hand rails, poor lighting, use of walking aids and poor footwear.\textsuperscript{47} There are also terms that have been used to describe both internal and external risk factors without any assessment of whether or not the risk factors are precipitating, “situational risk factors” or “circumstances that are hazardous regarding falls”.\textsuperscript{48,49}

Previous research identifies several fall-risk factors, such as co-morbidity, cognitive impairment, functional disability, previous falls, use of drugs, fear of falling and aging.\textsuperscript{34,47,50,51} Acute disease or symptoms of disease, such as infections and delirium are examples of precipitating factors that are present in 23-39\% of falls.\textsuperscript{36,52} Among in-patients 45\% of falls are associated with delirium,\textsuperscript{40} and more than three out of four falls in people with dementia are caused by drug side-effects and acute disease or symptoms of disease.\textsuperscript{53} Only a small proportion of falls are witnessed by someone else.\textsuperscript{49,54} In general, the more risk factors that apply to a person, the greater their risk of falling.\textsuperscript{34}

Fall prevention

Previous research shows that both single and multifactorial fall-prevention interventions for older people are successful,\textsuperscript{55,56} though in some cases the results are conflicting. Interventions have been carried out with individuals in various settings, including those living in residential
care facilities, in the community, and in hospital. Current guidelines all recommend multifactorial interventions to prevent falls.\textsuperscript{57-59} A multifactorial intervention includes an assessment of the individual’s risk factors for falling, followed by specific interventions targeting those risk factors and, consequently, the same combination of interventions is not applied to everyone.\textsuperscript{56} For example, one person may receive supervised exercise and home-hazard modification whereas another may receive home-hazard modification and a medication review.

According to a Cochrane report by Cameron et al., there is evidence that multifactorial interventions reduce the number of falls in hospitals. A possible benefit from multifactorial interventions in care facilities is suggested although the evidence is inconclusive. Exercise as a single intervention, appears effective in subacute hospital settings but, in contrast, the results from exercise interventions in care facilities are inconsistent and overall do not show any benefit.\textsuperscript{55} Fall interventions among individuals living in the community, such as exercise programs, home safety interventions, and multifactorial assessments and interventions, have reduced the rate of falls, according to a Cochrane report by Gillespie et al.\textsuperscript{56} Another approach to preventing fractures is to wear hip protectors. A multifactorial intervention program in residential care facilities resulted in a greater proportional reduction in hip fractures than in falls, suggesting that hip protectors contributed to the results, since no femoral fractures occurred among those wearing hip protectors.\textsuperscript{60} However, their effectiveness in preventing hip fractures in older people is questioned, and compliance is poor due to discomfort.\textsuperscript{61,62}

**Complications after hip fracture**

*Complication epidemiology*

In general, adverse in-hospital events occur in approximately 9% of all people admitted, of these, operation- and drug-related events comprised approximately 50%, according to a review by Vries et al.\textsuperscript{63} Complications after a hip fracture can be divided into orthopedic (hip related) and medical (general), and in some studies into major and minor. The incidence of complications among people suffering a hip fracture varies from 12-33%.\textsuperscript{64-67}

*Common complications and the impact of complications*

Previous research has reported postoperative complications using a wide range of definitions, making comparison difficult.\textsuperscript{68,69} In a study by
Merchant et al. delirium and infection were the most common postoperative complications,\textsuperscript{66} while in another cohort study heart failure and chest infections were found to be the most common.\textsuperscript{65} In a study by Hansson et al. complications were reported until 6 months after fracture, with falls, fractures and pneumonia being the most common complications. They also found that complications were associated with loss of function.\textsuperscript{70} A study by Molina et al. describes the most common complications after hip fracture surgery as being myocardial infarction, sepsis, urinary tract infection and pneumonia. They reported data from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP), a large database including complications up to 30 days post-surgery.\textsuperscript{71} In addition, complications have been found to be associated with a prolonged Length of Stay (LOS),\textsuperscript{66} and increased mortality.\textsuperscript{72}

\textbf{Risk factors for complications}

Several risk factors for postoperative complications have been described, for example: age, female gender, dependence in mobility,\textsuperscript{66} poor nutrition,\textsuperscript{73} and $\geq 3$ comorbidities.\textsuperscript{65,66} Belmont et al. reviewed data from the National Trauma Data Bank in the US. They reported risk factors such as shock, dialysis, obesity, respiratory disease, cardiac disease, diabetes and $\geq 2$ days’ delay in carrying out the procedure, were associated with postoperative complications.\textsuperscript{64} Age as a risk factor for complications after hip fracture, was confirmed by Jameson et al. who conclude that people $\geq 85$ years had a higher risk of post operative complications and a longer LOS than younger individuals.\textsuperscript{74}

It has also been shown that the American Society of Anesthesiologists (ASA) classification of medical co-morbidities is associated with complications, whereby people in a higher ASA class have a greater risk of complications compared to those in a lower ASA class.\textsuperscript{71,75,76} Furthermore, Sathiyakumar et al., analyzed complications reported in NSQIP and described different combinations of demographic and clinical risk factors as being associated with complications, depending on type of surgery.\textsuperscript{67} In addition, a cohort study by Roche et al. shows that cardiovascular disease is a strong predictor of post-operative cardiac failure and that respiratory disease predicts chest infection.\textsuperscript{65} A more recent study by Sathiyakumar et al., also using data from NSQIP, reports that several risk factors are significantly associated with adverse postoperative cardiac events: history of cardiac disease, stroke, chronic obstructive pulmonary disease, renal failure and peripheral vascular disease.\textsuperscript{77}
Risk factors for death and causes of death

Several risk factors have been associated with death following hip fracture: older age and male sex; severe systemic disease; pre-fracture functional impairment; cognitive decline; coronary heart disease and the number of co-morbidities.\textsuperscript{78-83} In an earlier Swedish study, a high ASA score was also shown to be associated with mortality.\textsuperscript{81} A large cohort study by Castronuovo et al.,\textsuperscript{84} reported that heart disease was a strong risk factor for mortality within 30 days but decreased beyond that. In addition, a study analyzing medications, found that the use of statins had a positive association with survival while the use of diuretics and a history of coronary heart disease were associated with death.\textsuperscript{83}

The causes of death are described in only a few studies.\textsuperscript{85-89} In one autopsy study of old people with hip fracture by Perez et al. the most common causes of death were chest infection, cardiac failure, myocardial infarction and pulmonary embolism.\textsuperscript{89} Among nursing-home residents with hip fracture the most common causes of death were infection, dementia and cardiac events\textsuperscript{86} and, in more recent studies, cardiac and infectious diseases.\textsuperscript{87,88} The causes of death vary depending on the time point. In a study examining post-mortem reports, among individuals who died within 30 days after hip fracture, respiratory infections and cardiovascular disease were found to be the main causes of death.\textsuperscript{88} These results are in line with earlier studies.\textsuperscript{85,89} During follow-up, infections, cardiovascular events, dementia and cancer are the most common causes of death according to previous studies.\textsuperscript{86,87,90}

Orthogeriatric care models

The role of the geriatrician in the management of older individuals with hip fracture was described in the United Kingdom more than 50 years ago.\textsuperscript{91} In the 1980s in Sweden, a study in Malmö randomized hip fracture patients to rehabilitation on a geriatric ward or to conventional care on an orthopedic ward, and reported that the alternatives were comparable.\textsuperscript{92} During the same decade, an intervention study was performed in Umeå, including a geriatrician at the orthopedic ward. The intervention focused on prevention, detection and treatment of complications associated with postoperative delirium and the result reported was a significantly lower incidence of delirium and shorter LOS.\textsuperscript{93} Furthermore, an orthogeriatric care model by Lundström et al. significantly reduced delirium and complications post-operatively.\textsuperscript{94} Subsequently, during the late 20\textsuperscript{th} and early 21\textsuperscript{st} centuries several intervention studies attempting to improve the care and rehabilitation for individuals suffering a hip fracture were conducted and the consensus concerning preoperative management, time
to surgery, operative management, surgical technique and postoperative care has led to today’s recommendations/guidelines, including a multidisciplinary team approach and an orthogeriatric care model.57,95-101

Both multidisciplinary and interdisciplinary teams are described in the literature. A multidisciplinary team works together with regular meetings and common goals; the team leader formulates the goals and outlines the treatment and rehabilitation process.102 The team members work within their own professional boundaries and with little knowledge of the other team members’ professions.103 The differences between multidisciplinary and interdisciplinary teams lie mainly in the process of decision-making, as the team members in interdisciplinary teams are more involved in formulating the goals.102 The current literature supports an interdisciplinary team approach, using Comprehensive Geriatric Assessment (CGA), where each team member is respected and decisions are made together.97,104 Most care models include both multidisciplinary and interdisciplinary elements,102 although, the exact nature of the relationship between team members is not always specified in earlier studies. In this thesis the terms multidisciplinary and interdisciplinary are used interchangeably.

CGA is defined as “a multidimensional, interdisciplinary diagnostic process focused on determining the medical, psychological, and functional capabilities of a frail elderly person to develop a coordinated and integrated plan for treatment and long-term follow-up” according to Rubenstein et al.105 Furthermore, CGA involves a geriatric team usually comprising a physician, a licensed practical nurse, a registered nurse, a physiotherapist, and an occupational therapist; a dietician, a social worker and a psychologist might also be included.102 According to Sletvold et al., the team work concerns checklists and scales used when performing assessments and also evaluation of the rehabilitation process. These instruments include a variety of areas, such as the individual’s performance in daily activities, gait, balance, cognitive function, nutrition, polypharmacy, vision and hearing, communication, incontinence, fall risk, sleep disturbances, affective disorders, oral health, abuse and social ties. During the rehabilitation process the team meet regularly to ensure appropriate treatment, rehabilitation and discharge planning for each individual.

The goal of geriatric rehabilitation is to restore the individual’s previous level of function and autonomy and also, if possible, to prevent or postpone functional decline and the need for institutional care.102 CGA in hospital settings has improved function, reduced mortality and the need for institutional care,106 and it has proven successful in both medical and
Orthogeriatric in-hospital units, according to a recent review by Pilotto et al.\textsuperscript{107} Furthermore, CGA is described as the most cost-effective orthogeriatric model of care.\textsuperscript{108}

Orthogeriatric care can be defined as “medical care for older patients with orthopedic disorders that is provided collaboratively by orthopedic services and programs catering for older people”.\textsuperscript{57} A variety of different care models have been reported but 4 main orthogeriatric care models appear in the literature.\textsuperscript{69,109,110} The first, usual/standard care, is where the patient is admitted to the orthopedic ward and a geriatric review is performed when requested. In the second model, there is regular input from a geriatric team on the orthopedic ward. The third model is one of geriatric-led care with orthopedic expertise is consulted when needed. The fourth, is co-managed orthopedic-geriatric care. To date, the best model of care for older persons with a hip fracture cannot be determined, although a model involving joint care is endorsed in current guidelines.\textsuperscript{57,98,100,101}

Among the reports on the third and fourth orthogeriatric care models, few have reported in-hospital falls as an outcome, one study reported a reduced fall rate\textsuperscript{111} but no effect was seen in two other studies.\textsuperscript{112,113} Falls after discharge have been reported in one study, but then with a significant risk reduction.\textsuperscript{114} Regarding complications, some studies show a significant reduction of in-hospital complications,\textsuperscript{112,115-120} while others do not,\textsuperscript{113,121-125} complications after discharge have been sparsely reported. The orthogeriatric care model in this thesis reduced in-hospital complications,\textsuperscript{126} including significantly fewer decubital ulcers and urinary tract infections, and a lower incidence of delirium. The number of readmissions after discharge was reduced in one study by Boddaert et al.,\textsuperscript{112} but several other studies have failed to confirm this.\textsuperscript{113,116,118,119,121,125,127-129}

Regarding in-hospital mortality, some studies report a significant effect,\textsuperscript{112,118,123,130,131} while others do not.\textsuperscript{111,113,116,117,119,122,125,127-129,132,133} Few studies report on 30-day mortality,\textsuperscript{119,123,134}, and only one shows a significant reduction.\textsuperscript{134} The results concerning significant differences in long-term mortality are inconsistent.\textsuperscript{112,115,118-121,129-131,135,136} Orthogeriatric care models are described in the literature under different names such as, orthogeriatric units, co-managed geriatric fracture centers and geriatric hip-fracture clinical care pathways. Likewise, the orthogeriatric care model presented in this thesis, using CGA in hospital and in participants’ homes, is described using different terms in the papers included, even though the underlying concept is the same. Table 1 presents an overview
of orthogeriatric care models among hip fracture patients, including models 3 and 4.
<table>
<thead>
<tr>
<th>Trial</th>
<th>Design</th>
<th>Selections</th>
<th>Outcomes and results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Miura 2009 USA (132)</td>
<td>Before-after prospective n=163 &gt;55</td>
<td><strong>Inclusion</strong>: proximal femur fracture</td>
<td><strong>S</strong> LOS, surgery &lt;24h, total costs NS in-hospital mortality NA complications, falls, mobility,</td>
<td>“Hip fracture service” Pre- and postoperative care 11% readmissions at 30 days after discharge, only reported for intervention group</td>
</tr>
<tr>
<td>3 Stenvall 2007 Sweden (111,126,137)</td>
<td>RCT n=199 &gt;70</td>
<td><strong>Inclusion</strong>: FNF  <strong>Exclusion</strong>: severe osteoarthritis, rheumatoid arthritis, renal failure, pathological fracture, bedridden before fracture</td>
<td><strong>S</strong> LOS, in-hospital complications, falls, regaining P-ADL, mobility <strong>NS</strong> mortality, readmissions</td>
<td>Preoperative care not included Assessors not blinded More patients walked indoors without walking aids at 12 months in intervention group</td>
</tr>
<tr>
<td>3 Adunsky 2003, 2011 Israel (135,138)</td>
<td>Prospective cohort n1=320 Retrospective n2=3114 ≥65</td>
<td><strong>Inclusion</strong>: FNF, PTF, stable medical status  <strong>Exclusion</strong>: rehab &lt;7 days</td>
<td><strong>S</strong> LOS, 1-year mortality, mobility at discharge <strong>NA</strong> complications, falls, readmissions</td>
<td>Admitted on availability on beds Assessors not blinded Participants older with more comorbidities at baseline in intervention groups</td>
</tr>
<tr>
<td>3 Mazzola 2011 Italy (124)</td>
<td>Observational quasi randomized n=261 ≥70</td>
<td><strong>Inclusion</strong>: hip fracture</td>
<td><strong>S</strong> time to mobilization <strong>NS</strong> complications, LOS <strong>NA</strong> readmissions, falls, mortality, mobility</td>
<td>Comparison of two groups of orthogeriatric care, one with preoperative start, reduced time to mobilization in preoperative group</td>
</tr>
<tr>
<td>3 Wagner 2012 Chile (113)</td>
<td>Prospective cohort, retrospective control n=275 &gt;65</td>
<td><strong>Inclusion</strong>: FNF  <strong>Exclusion</strong>: pathological and periprosthetic fracture</td>
<td><strong>S</strong> complications <strong>NS</strong> LOS, mortality,  <strong>NA</strong> falls, readmissions, mobility</td>
<td>Differences in diagnosis of delirium and anemia postoperative</td>
</tr>
<tr>
<td>Trial</td>
<td>Design</td>
<td>Selection</td>
<td>Outcomes and results</td>
<td>Comments</td>
</tr>
<tr>
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<td>----------</td>
</tr>
<tr>
<td>3 Della Rocca 2013 USA (127)</td>
<td>Before-after retrospective n=146 ≥65</td>
<td><strong>Inclusion:</strong> hip fracture</td>
<td>S LOS, costs NS mortality, readmissions NA falls, complications, mobility</td>
<td>“Hip fracture protocol” Small control group</td>
</tr>
<tr>
<td>3 Boddaert 2014 France (112)</td>
<td>Prospective cohorts, external validation cohort n=334 &gt;70</td>
<td><strong>Inclusion:</strong> hip fracture <strong>Exclusion:</strong> in-hospital, periprosthetic and metastatic fractures, patients transferred to another hospital before surgery</td>
<td>S LOS, mobility, 6-month mortality, 30-day readmissions, in-hospital complications NS in-hospital falls</td>
<td>Unit for Post-Operative Geriatric Care Orthopedic cohort had less comorbidities</td>
</tr>
<tr>
<td>3 Watne 2014 Norway (113)</td>
<td>RCT n=329 No age limit.</td>
<td><strong>Inclusion:</strong> FNF, PTF, STF. <strong>Exclusion:</strong> moribund on admission</td>
<td>S longer LOS, mobility at 4 months among those living in their own home NS mortality, readmissions, in-hospital complications, in-hospital falls</td>
<td>Stratified according to housing Pre- and postoperative care</td>
</tr>
<tr>
<td>3 Gupta 2014 UK (139)</td>
<td>Before-after Prospective N=494 ≥50</td>
<td><strong>Inclusion:</strong> hip fracture <strong>Exclusion:</strong> periprosthetic fracture</td>
<td>S LOS NA complications, mobility, mortality, readmissions, falls</td>
<td>Pre- and post-operative care</td>
</tr>
<tr>
<td>3 Prestmo 2015 Norway (121,140)</td>
<td>RCT N=397 ≥70</td>
<td><strong>Inclusion:</strong> hip fracture, able to walk 10 m <strong>Exclusion:</strong> pathological fracture, short life expectancy, living in nursing home</td>
<td>S longer LOS, mobility and ADL at 4 and 12 months NS in-hospital complications, 12 months mortality, readmissions, time to surgery NA falls</td>
<td>No blinding, only partly masked assessments Pre- and postoperative care</td>
</tr>
<tr>
<td>Trial</td>
<td>Design</td>
<td>Selection</td>
<td>Outcomes and results</td>
<td>Comments</td>
</tr>
<tr>
<td>-------</td>
<td>--------</td>
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<td>----------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Vidan 2005 Spain (118)</td>
<td>RCT n=319 ≥65</td>
<td><strong>Inclusion:</strong> hip fracture  <strong>Exclusion:</strong> dependency in all basic ADLs, pathologic fracture, terminal illness, inability to walk before fracture</td>
<td>S in-hospital mortality and medical complications, mobility at 3 months  NS LOS, long-term mobility, readmissions, 1-year mortality  NA falls</td>
<td>Stratified by prefracture ADL level</td>
</tr>
<tr>
<td>Khasraghi 2005 USA (117)</td>
<td>Before-after retrospective n=510 &gt;65</td>
<td><strong>Inclusion:</strong> FNF, PTF, STF  <strong>Exclusion:</strong> pathological fracture</td>
<td>S LOS, time to surgery, in-hospital medical complications  NS in-hospital mortality  NA falls, readmissions, mobility</td>
<td></td>
</tr>
<tr>
<td>Barone 2006 Italy (139)</td>
<td>Before-after prospective n=819 ≥70</td>
<td><strong>Inclusion:</strong> hip fracture  <strong>Exclusion:</strong> not reported</td>
<td>S in-hospital and long-term mortality  NS LOS  NA complications, mobility, readmissions, falls</td>
<td>One control group before and one after the intervention</td>
</tr>
<tr>
<td>Shyu 2005, 2008, 2010 Taiwan (114, 129, 141)</td>
<td>RCT n=162 ≥60</td>
<td><strong>Inclusion:</strong> hip fracture  <strong>Exclusion:</strong> severely cognitively impaired, weak muscle power, terminally ill</td>
<td>S mobility and P-ADL, risk of falls  NS LOS, mortality, readmissions  NA complications</td>
<td>Follow-up in homes by nurse and physiotherapist</td>
</tr>
<tr>
<td>Friedman 2009 USA (116)</td>
<td>Retrospective cohort n=314 ≥60</td>
<td><strong>Inclusion:</strong> proximal femur fracture  <strong>Exclusion:</strong> pathological, recurrent, periprosthetic, nonoperative fractures</td>
<td>S LOS, time to surgery, in-hospital complications  NS in-hospital mortality, 30-day readmissions  NA function, falls</td>
<td>Participants in Geriatric Fracture Center were older, had more comorbid conditions and dementia, and more lived in nursing homes</td>
</tr>
<tr>
<td>Cogan 2010 Ireland (131)</td>
<td>Before after Retrospective n=201 &gt;65</td>
<td><strong>Inclusion:</strong> hip fracture</td>
<td>S in-hospital mortality, longer LOS  NS 1-year mortality  NA falls, complications, readmissions, function</td>
<td>Significant differences in sources of admission and functional levels at baseline</td>
</tr>
</tbody>
</table>
Table 1. An overview of orthogeriatric care models among hip fracture patients, including models 3 and 4.

<table>
<thead>
<tr>
<th>Trial</th>
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</tr>
</thead>
<tbody>
<tr>
<td>4 Gregersen 2012 Denmark (128)</td>
<td>Before-after retrospective n=495 ≥65</td>
<td><strong>Inclusion:</strong> FNF, PTF</td>
<td><strong>S LOS</strong>&lt;br&gt;<strong>NS</strong> in-hospital and 3 month mortality, 3+6 months readmissions <strong>NA</strong> complications, falls, function</td>
<td>Higher rate of reoperations after discharge in intervention group</td>
</tr>
<tr>
<td>4 Gonzalez-Montalvo 2010 Spain (133)</td>
<td>Prospective quasi-randomized n=224 ≥65</td>
<td><strong>Inclusion:</strong> hip fracture</td>
<td><strong>S LOS</strong>&lt;br&gt;<strong>NS</strong> in-hospital mortality, mobility at discharge, discharge destination <strong>NA</strong> falls, readmissions, complications</td>
<td>Acute orthogeriatric unit&lt;br&gt;Admission to ward on call</td>
</tr>
<tr>
<td>4 Biber 2013 Germany (122)</td>
<td>Before-after retrospective n=283 &gt;60</td>
<td><strong>Inclusion:</strong> FNF with HPA</td>
<td><strong>S LOS</strong>, time to surgery&lt;br&gt;<strong>NS</strong> in-hospital surgical complications and mortality&lt;br&gt;<strong>NA</strong> medical complications, falls, readmissions, mobility</td>
<td>“Geriatric Fracture Center”&lt;br&gt;Surgical complications prolonged length of stay</td>
</tr>
<tr>
<td>4 Flikweert 2014 Netherlands (123)</td>
<td>Before-after prospective n=401 ≥60</td>
<td><strong>Inclusion:</strong> FNF, PTF</td>
<td><strong>S LOS</strong>, in-hospital mortality, fasting time&lt;br&gt;<strong>NS</strong> in-hospital complications, 30-day mortality&lt;br&gt;<strong>NA</strong> falls, readmissions, mobility</td>
<td>Comprehensive care pathway</td>
</tr>
<tr>
<td>4 Suhm 2014 Switzerland (119)</td>
<td>Before-after prospective n=493 ≥65</td>
<td><strong>Inclusion:</strong> femoral fracture&lt;br&gt;<strong>Exclusion:</strong> pathologic fracture</td>
<td><strong>S LOS</strong>, in-hospital complications&lt;br&gt;<strong>NS</strong> mortality, 30-day and 1-year readmissions&lt;br&gt;<strong>NA</strong> falls, mobility</td>
<td>“Care pathway” Intervention group had more comorbidities, a larger proportion of those who needed help in ADL and of those living in nursing homes&lt;br&gt;Complications graded</td>
</tr>
</tbody>
</table>
Table 1. An overview of orthogeriatric care models among hip fracture patients, including models 3 and 4.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Design</th>
<th>Selection</th>
<th>Outcomes and results</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Folbert 2017 Netherlands (120)</td>
<td>Prospective cohort n=1385</td>
<td><strong>Inclusion:</strong> hip fracture <strong>Exclusion:</strong> coxarthrosis, pathological and periprosthetic fractures,</td>
<td>S LOS, 1-year mortality, in-hospital complications NA falls, readmissions, mobility</td>
<td>Participants in intervention were older, had more severe comorbidities, and were more institutionalized</td>
</tr>
<tr>
<td>4 Henderson 2017 Ireland (130)</td>
<td>Before-after Prospective cohort n=454</td>
<td><strong>Inclusion:</strong> FNF <strong>Exclusion:</strong></td>
<td>S LOS, 1-year mortality NA complications, falls, readmissions, mobility</td>
<td></td>
</tr>
<tr>
<td>4 Lamb 2017 USA (125)</td>
<td>Before-after Prospective cohort n=437</td>
<td><strong>Inclusion:</strong> hip fracture</td>
<td>NS LOS, in-hospital complications and mortality, 30-day readmissions NA falls, mobility</td>
<td>A clinical pathway</td>
</tr>
</tbody>
</table>

S = significant, NS = non-significant, NA = non-assessed, RCT = Randomized Controlled Trial, LOS = Length of Stay, CCS = Charlson Comorbidity Score, FNF = Femoral Neck Fracture, PTF = Pertrochanteric Fracture, STF = Subtrochanteric Fracture, HAP = Hemiarthroplasty.
Team-based home rehabilitation

Since LOS in hospital has been shortened during the last few decades, accelerated discharge has been promoted and Home Rehabilitation (HR) teams have been set up. Evidence to support this organization of care is sparse. Most HR studies for individuals with hip fracture describe training supervised to varying degrees by a physiotherapist, but multi- or inter-disciplinary HR studies are few in the literature. Even though a substantial proportion of the hip fracture population are cognitively impaired and live in residential care facilities, they are underrepresented in earlier studies.

Interdisciplinary team rehabilitation can improve performance in ADL and physical activity, a finding that is supported by Donohue et al. who found a trend towards successful outcomes in support of multidisciplinary HR after acute care. Studies have also found that older individuals, in ordinary housing and without severe cognitive impairment who participate in HR, can increase their independence and confidence in performing ADL without falling and that the burden on their caregivers is reduced. Falls, mortality and readmissions after discharge have been reported in a few studies though none show significant effects.

A significant effect on walking ability has been reported in some HR studies, while others found no effects. Furthermore, studies have reported that HR can reduce hospital stay but some have not. According to a Swedish review no effect on mortality has been shown and scientific data concerning complications are deficient.

Table 2 presents an overview of team-based HR studies.
<table>
<thead>
<tr>
<th>Trial</th>
<th>Design and settings</th>
<th>Selection</th>
<th>Outcomes</th>
<th>Intervention</th>
<th>Conclusion</th>
</tr>
</thead>
</table>
| Tinetti 1999 USA   | RCT, home-based vs. usual care n=304 ≥65 | **Inclusion:** hip fracture  
**Exclusion:** dementia, terminal illness, >25 miles from hospital, >100 days in rehab  
Stratified by functional level and discharge location | S arm strength at 6 months  
NS LOS, falls, readmissions, in-hospital complications, ADL, mobility, mortality | **Intervention:** Median length of intervention was 12 weeks. 6 and 12 months follow-ups | Systematic multicomponent rehab program no better than usual care |
| Kuisma 2002 Hong Kong | RCT, home-based vs. institutional n=81 >50 | **Inclusion:** hip fracture  
**Exclusion:** concomitant serious condition, living alone, >4 hours alone/day | S mobility  
NS LOS  
NA falls, readmission, complications, ADL, mortality | **Intervention:** Mean 4.6 visits by PT, 1.5 visits by nurse  
Control group mean 36.2 days in rehab. 4, 8 and 12-month follow-up by telephone interviews | Better community ambulation at 1-year follow-up |
| Crotty 2002-03 Australia | RCT, home-based vs. conventional hospital care n=66 ≥65 | **Inclusion:** hip fracture, medical stable, mental and physical capacity to participate, suitable home environment  
**Exclusion:** inadequate social support, no telephone, lived to far away | S LOS, ADL, falls efficacy  
NS falls, readmissions, mobility  
NA complications, mortality | **Intervention:** Median 13.6 visits. 4 and 12 month follow-up | Improvement in ADL and greater confidence in avoiding falls at 4 months Reduced caregiver burden at 12 months |
| Ryan 2006 UK       | RCT, home-based vs. intensive home-based n=160(71) ≥65 | **Inclusion:** hip fracture and stroke  
**Exclusion:** dementia, Parkinson’s | NS ADL, mobility  
NA readmissions, mortality, falls, complications, LOS | **Intervention:** 6 visits/week, mean visits 24.4, max 12 weeks  
Mean 42 days in hospital prior to rehabilitation at home, 3 month follow-up | No significant differences for hip patients |
**Table 2.** An overview of team-based home rehabilitation studies.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Design and settings</th>
<th>Selection</th>
<th>Outcomes</th>
<th>Intervention</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ziden 2008-10 Sweden (144,145)</td>
<td>RCT, home-based vs. conventional care n=102 ≥65</td>
<td><strong>Inclusion:</strong> hip fracture <strong>Exclusion:</strong> severe medical illness, expected survival &lt;1 year, drug or alcohol abuse, mental illness, severe cognitive impairment</td>
<td>S ADL, mobility <strong>NS</strong> LOS, falls, mortality <strong>NA</strong> readmissions, complications</td>
<td><strong>Intervention:</strong> Mean 4.9 visits, max 3 weeks, 1-, 6- and 12-month follow-ups</td>
<td>Improvement in ADL, greater balance confidence and physical function</td>
</tr>
<tr>
<td>Salpakoski 2014-15 Finland (149,150)</td>
<td>RCT, home-based vs. conventional care n=81 &gt;60</td>
<td><strong>Inclusion:</strong> FNF, PTF <strong>Exclusion:</strong> &lt;18 on MMSE, alcoholism, severe cardiovascular-, pulmonary- or other progressive disease, severe depression</td>
<td>S mobility <strong>NS</strong> falls, ADL, mortality <strong>NA</strong> LOS, readmission</td>
<td><strong>Intervention:</strong> 1-year long program, participants assigned mean 42 days after discharge, 5-6 PT visits, 3-, 6- and 12-month follow-ups</td>
<td>Reduced perceived difficulties in negotiating stairs</td>
</tr>
</tbody>
</table>

S = significant, NS = non-significant, NA = non-assessed, RCT = Randomized Controlled Trial, LOS = Length of Stay, ADL = Activities of Daily Living, PT = Physiotherapist, FNF = Femoral Neck Fracture, PTF = Pertrochanteric Fracture.
RATIONALE

As the population grows older, there will be an increasing number of people at risk of falls and consequently an increased number of hip fractures. Thus, there is an urgent need to develop preventive strategies for falls. People with cognitive impairment/dementia as well as people living in residential care facilities have been underrepresented in earlier studies, even though a substantial and increasingly proportion of individuals with hip fracture have dementia or cognitive impairment. Their inclusion is important to ensure that the sample studied will be representative of the group of older people with hip fracture today. Previous orthogeriatric care models for older individuals with hip fracture report a shortened LOS, reduced morbidity and mortality in the short term, but effects after discharge were limited, and mortality remained high. The prognosis for individuals with hip fracture is still poor, and knowledge about falls, complications and readmissions in the long-term, as well as causes of death is sparse. In this thesis we have tried to gain deeper knowledge by further investigating these outcomes among old people.

The care for older people with hip fracture has changed over the last few decades, LOS has shortened and HR teams have been developed to meet the need for rehabilitation. However, the evidence to support HR is limited, and there are few randomized controlled multi- or inter-disciplinary HR-studies in the literature. Furthermore, data in team-based HR studies concerning complications and readmissions after discharge have only been provided in a few studies. The goal of rehabilitation is for the person to regain their ability to walk as they could prior to the fracture, even so, only half of the hip fracture population achieved this goal, which implies the need for further research.
AIMS

This thesis has three aims. The primary aim is to describe the comorbidities, complications and causes of death among a representative population of old people with hip fracture. A secondary aim is to evaluate whether a successful care model, that reduced in-hospital falls and complications, had any effect on falls after discharge. The third aim is to evaluate whether adding home rehabilitation to the existing care model has an effect on LOS, walking ability, complications, and readmissions after discharge.

The specific aims are:

**Paper I.**
The aim is to evaluate whether an orthogeriatric care model using CGA, that reduced inpatient falls and injuries, had any continuing effect after discharge.

**Paper II.**
The aim is to describe the prevalence of co-morbidities, complications and the causes of death over three years among old people with femoral neck fracture.

**Paper III.**
The aim is to investigate whether Geriatric Interdisciplinary Home Rehabilitation (GIHR) could improve walking ability for older people with hip fracture and shorten the LOS in hospital.

**Paper IV.**
The aim is to evaluate whether GIHR could affect the number of complications, readmissions and total days spent in hospital after discharge.
## METHODS

### Table 3. Thesis at a glance.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Design and setting</th>
<th>Sample Data collection</th>
<th>Statistics</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Study 1</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper I (published)</td>
<td>RCT, Orthopedic and Geriatric clinic, University Hospital in Umeå, Sweden 00-02</td>
<td>199 people with femoral neck fractures aged 70 years or older.</td>
<td>Structured interviews, assessments, medical charts, follow-ups at 4 and 12 months</td>
<td>Poisson regression, Negative binomial regression (Nbreg), Student’s t-test, Pearson’s chi-square test, Fisher’s exact test, Mann-Whitney U test.</td>
</tr>
<tr>
<td>Paper II (published)</td>
<td></td>
<td>Data collection as in Paper I with the addition of 36 months follow-up.</td>
<td>Cox regression, Student’s t-test, Pearson’s chi-square test, Fisher’s exact test, Mann-Whitney U test.</td>
<td>Prevalence of co-morbidities, complications and causes of death</td>
</tr>
<tr>
<td><strong>Study 2</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paper III (published)</td>
<td>RCT, Geriatric clinic, University Hospital in Umeå, Sweden 08-11</td>
<td>205 people with hip fracture, aged 70 or older.</td>
<td>Structured interviews, assessments, medical charts, follow-ups at 3 and 12 months.</td>
<td>Binary logistic regression, Student’s t-test, Pearson’s chi-square test, Mann-Whitney U test.</td>
</tr>
<tr>
<td>Paper IV (submitted)</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

RCT = Randomized Controlled Trial

This thesis is based on data from two randomized controlled intervention studies including older people with hip fracture, conducted at Umeå University Hospital. The first included 199 persons with cervical hip fracture (study 1) and the second 205 persons with cervical or trochanteric fracture (study 2).
Ethical approval

All participants were given oral and written information and in those cases where they were not able to answer themselves their next of kin was also asked. Written informed consent was required for participation in the studies. The studies were approved by the Ethical Committee of the Faculty of Medicine at Umeå University, DNR 00-137 and DNR 08-053 M. Study 2 was registered at Current Controlled Trials Ltd (ISRCTN 15738119).

Study 1 (Papers I and II)

Settings and participants
Papers I and II are based on a randomized controlled trial which included 199 participants with femoral neck fracture aged 70 years or older consecutively admitted to the Orthopedic Department at the University Hospital in Umeå, Sweden. The participants were analyzed as one group in Paper II. The inclusion period started in May 2000 and ended in December 2002. The exclusion criteria were: severe rheumatoid arthritis, severe hip osteoarthritis and pathological fractures due to the surgical method planned in the study protocol. The surgeon on duty decided whether the operation planned according to the study protocol was appropriate for the participant. The anesthesiologist assessed the participant’s medical status and excluded those with severe renal failure. Participants who were bedridden before the fracture were also excluded. The inclusion criteria were met by 258 patients, 11 of whom declined to participate and 48 were not invited to participate due to failures in the inclusion routines or because they had sustained the fracture in hospital. These 59 individuals were more likely to be men (p=0.033), and live in their own house/apartment (p=0.009) but there was no difference in age (p=0.354) compared to the participants who were included.
Figure 3. Flow chart for Paper I.

353 Participants assessed for eligibility

154 excluded
95 did not meet inclusion criteria
11 refused to participate
27 missing due to failure of inclusion routines
21 suffered the fracture in hospital

199 randomized

102 assigned to intervention program
6 died during hospitalization
18 falls during hospitalization
0 new fractures

92 assessed at 4 months
3 died after discharge
1 declined to continue
58 falls after discharge
0 new fractures

84 assessed at 12 months
7 died between 4-12 months
1 declined to continue
62 falls between 4-12 months
7 new fractures

97 assigned to control ward
8 died during hospitalization
60 falls during hospitalization
4 new fractures

83 assessed at 4 months
5 died after discharge
1 moved to another city
65 falls after discharge
3 new fractures

76 assessed at 12 months
5 died between 4-12 months
2 declined to continue
66 falls between 4-12 months
4 new fractures
**Procedure**

In the emergency room the potential participants were asked orally and in writing whether they were willing to participate in the study. If they were cognitively impaired their next of kin were also asked to consent. While the participants were still in the emergency room, sealed opaque envelopes were used to randomly assign them to conventional postoperative care in an orthopedic ward or to a postoperative
intervention program conducted on a geriatric ward. To ensure that all participants were subject to the same preoperative routines, the envelopes were not opened until immediately before surgery. A nurse on duty on the orthopedic ward who was not involved in the study, opened the envelopes.

The participants were stratified according to operation method. Undisplaced femoral neck fractures were treated with two hook-pins (Swemac Orthopedica®, Linköping, Sweden), displaced femoral neck fractures were treated with bipolar hemiarthroplasty (Link®, Hamburg, Germany) and the basocervical fractures were operated on using a Dynamic Hip Screw (DHS) (Stratec Medical®, Oberdorf, Switzerland). One participant died before surgery and one had a resection of the femoral head due to deterioration in medical status (they were both in the control group). In most cases (174/198, 88%) the operation was performed under spinal anesthesia. The stratification in study 1 is shown in Table 4.

### Table 4. Stratification in study 1.

<table>
<thead>
<tr>
<th>Operation methods</th>
<th>Study 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention group n=102</td>
</tr>
<tr>
<td>Two hook-pins</td>
<td>38</td>
</tr>
<tr>
<td>Bipolar hemiarthroplasty</td>
<td>57</td>
</tr>
<tr>
<td>Dynamic hip screw</td>
<td>7</td>
</tr>
</tbody>
</table>

**Data collection**

Within three to five days after the operation a structured interview covering various assessments was performed by two registered nurses employed half-time in the study. The participants were interviewed concerning their medical history, social and functional status before the fracture. Data, including morbidity and complications, were also collected from relatives, staff and medical records. One nurse from the orthopedic ward carried out the assessments and interviews in the intervention group while the nurse from the geriatric department assessed and interviewed the participants in the control group.

At discharge the functional ability was measured by the Physiotherapist (PT) and Occupational Therapist (OT) on duty. At 4, 12 and 36 months after surgery the participants were followed up and similar assessments were performed. A PT and an OT accompanied the nurses at the follow-ups. At the four-month follow-up a physician collected data and assessed the participants in the intervention group; this was not done in the control group. An overview of all assessments in study 1 are presented in Table 5.
Table 5. Assessments in study 1.

<table>
<thead>
<tr>
<th>Assessments</th>
<th>Study 1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paper I</td>
</tr>
<tr>
<td>Staircase of ADL</td>
<td>X</td>
</tr>
<tr>
<td>S-COVs</td>
<td>X</td>
</tr>
<tr>
<td>ASA</td>
<td>X</td>
</tr>
<tr>
<td>Vision and hearing</td>
<td>X</td>
</tr>
<tr>
<td>MMSE</td>
<td>X</td>
</tr>
<tr>
<td>OBS</td>
<td>X</td>
</tr>
<tr>
<td>GDS</td>
<td>X</td>
</tr>
<tr>
<td>BBS</td>
<td>X</td>
</tr>
<tr>
<td>Chair stand test</td>
<td>X</td>
</tr>
</tbody>
</table>

**Assessments**

**Diagnoses, complications and medications**

A specialist in geriatric medicine, who was not involved in the patient care and was unaware of group allocation, analyzed the documentation concerning diagnoses, medications and the assessments performed by the OT, PT and the nurse for final diagnosis. The geriatrician also determined whether the participants met the Diagnostic and Statistical Manual of Mental Disorder, fourth edition (DSM-IV) criteria for dementia, delirium and depression.

A geriatrician not blinded to group allocation and employed on the ward, registered and analyzed complications by reviewing the participant’s assessments and charts after each study was finished. The definitions of complications were chosen after reviewing the literature and a predefined list of complication criteria was used for the classification. Complications included both orthopaedic complications and medical incidents. The complications chosen were classified dichotomously (present or absent). The total number of times a complication occurred was also counted. If the participant had a cardiac failure at baseline and was treated by a doctor during the follow-up period due to an exacerbation/aggravation of the disease he/she was judged to have cardiac failure as a complication. Myocardial infarction and cardiac failure are referred to in the study as cardiovascular events. Five groups of infections were defined; urinary tract infections, chest infections, superficial and deep wound infections and other infections.

For those participants who died during the study, medical records were reviewed and all complications and the “history of death” were noted. If a
participant died between follow-ups, complications that occurred between last follow-up and death were forwarded, meaning they were registered at the next follow-up.

Reoperation is defined as an operation in the same area as the index fracture, due to infection, luxation, and failure to heal or material failure. An operation caused by a new fracture during follow-up is not considered to be a reoperation. The medications were classified according to the Anatomical Therapeutic Chemical classification system. The prescriptions were recorded as ‘yes’ or ‘no’, but no doses were registered, and pro re nata drugs were not included.

Falls

Falls and number of falls were registered from participants’ charts during hospitalization. At the assessments, the participants were asked if they had sustained any falls since discharge, or their last assessment. Information about falls was also collected from next of kin, staff and medical charts. The incident was defined as a fall when the participant unintentionally came to rest on the floor or ground and syncopal falls were included.60

Causes of death

Every citizen in Sweden has a unique 10-digit personal identification number which makes it possible to obtain date and cause of death from the Centre for Epidemiology (EpC), National Board of Health and Welfare, Sweden. Diagnoses are coded according to the International Classification of Diseases, a validated and international standard set by the World Health Organization (WHO).156 According to the international standards, a death within 30 days after a fracture would be coded as related to the trauma, irrespective of the actual cause of death, and the fracture diagnosis would be given as the primary cause of death. As an example, a person suffering a myocardial infarction which led to death within 30 days of sustaining a hip fracture would have the myocardial infarction cited as a secondary cause of death.

The primary and secondary causes of death were obtained from death certificates. Medical records concerning the person’s “history of death” were also reviewed. Two specialists in geriatric medicine assessed information retrieved from death certificates and medical records and then established the causes of death; disagreements were resolved through discussion, although inter-rater agreement was not tested. Fifteen out of 79 causes of death stated on the death certificates were
altered after the person’s medical records were analyzed. Two out of 15 were changed as a result of autopsy statements, three more were changed after information was retrieved from the medical records and another ten were changed from the first into the second cause on the death certificate. An example of a change to a second cause concerns terminal pneumonia in a person suffering from advanced dementia. This was stated as the primary cause of death on the death certificate but we judged the person to have died as a result of dementia rather than pneumonia.

*Readmissions and days in hospital*

Total number of days spent in hospital after discharge and the number of readmissions were registered up to the end of the study or until the participant declined to continue, died or left the study for other reasons.

*Activities of Daily Living*

Functional status of ADL performance prior to the fracture was measured retrospectively using the staircase of ADL\textsuperscript{157} including the Katz ADL index.\textsuperscript{158} This scale measures both Personal/Primary Activities of Daily Living (P-ADL) (bathing, dressing, toileting, transfer, continence, and feeding), and Instrumental Activities of Daily Living (I-ADL) (cleaning, shopping, transportation, and cooking). The score ranges from 0-10, with a high score indicating greater ADL dependence. Independence in P-ADL (bathing, dressing, toileting, transfer, continence and feeding) was presented as a binary variable.

*Walking ability*

Walking ability indoors and outdoors was assessed using the Swedish version of Physiotherapy Clinical Outcome Variables (S-COVS), a scale with seven levels, where 1 indicates no functional ability or the need for assistance from two people and 7 indicates normal function.\textsuperscript{159} Walking ability prior to fracture was dichotomized as capacity for independence indoors, irrespective of eventual need for a walking aid, using one item from S-COVS. The use of a walking device was also registered.

*ASA*

The ASA classification is a risk assessment instrument. The general health of all participants was assessed by the attending anesthesiologist before surgery according to the ASA classification. ASA 1 indicates a healthy person; ASA 2, a person with a mild systemic disease; ASA 3, a person with severe systemic disease; ASA 4, a person with an
incapacitating disease that is a constant threat to life; ASA 5, a moribund person who is not expected to live 24 h with or without surgery. The ASA results were categorized as ASA 1-2 and ASA 3-4. None of the people included were classified as ASA 5.

Vision and hearing

The participants’ hearing and vision were tested by their ability to hear a normal speaking voice from a distance of one meter and to read five millimeter block letters with or without glasses.

Cognitive impairment

Two different assessment scales were used to validate the participants’ cognitive status. The Mini-Mental State Examination (MMSE)\textsuperscript{161} is a screening test used to assess cognition among older people. It has a score from 0-30 where a score of less than 24 indicates cognitive impairment.\textsuperscript{162} The other scale used was a modified version of the Organic Brain Syndrome Scale (OBS),\textsuperscript{163} adjusted for persons with hip fractures, where variables affected by the hip fracture per se are excluded. The scale can help establish a person’s orientation and awareness. It consists of two subscales, a disorientation subscale with 12 items, a questionnaire with a maximum score of 36 (a high score indicating disorientation) and a confusion subscale with 21 items based on clinical observations and interviews with participants and caregivers. The confusion subscale can describe a person’s cognitive, emotional, perceptual and personality changes and fluctuations in clinical state.

Depression

The Geriatric Depression Scale (GDS-15, a shorter version)\textsuperscript{164,165} is a screening tool for depressive disorders among older people. It has 15 items and a score of between five and nine indicates a mild depression while a score of ten or more indicates a moderate to severe depression. Depression before hospitalization was diagnosed based on current treatment and earlier diagnosis, documented in the participant’s records. During hospitalization depression was diagnosed if the participant received ongoing treatment with antidepressants or if depression was indicated by the results on the GDS-15 scale in combination with depressive symptoms registered on the OBS-scale.
**Balance**

Balance was assessed using the Berg Balance Scale (BBS) which is well-established, reliable and valid in older people, including those with cognitive impairment.\textsuperscript{166,167} The scale covers 14 tasks common in everyday life, e.g. sitting, standing, turning and reaching. Each task is scored 0 to 4, with a maximum score of 56; a higher score indicates better balance/functional capacity. The ability to perform tasks in a safe and controlled manner gives the maximum score, whereas those who exceed a specified time limit or require supervision, physical or verbal guidance are given lower scores.

**Chair stand test**

A modified version of the Chair stand test\textsuperscript{168} was performed by testing the participant’s ability to rise three times from a straight-backed chair with the help of the arms.

**Intervention**

**Control group.**

The participants in the control group received their postoperative care at a specialized orthopedic unit following conventional postoperative routines. Those who were in need of a longer rehabilitation period were transferred to a geriatric unit, though not the one where the intervention was conducted. The staffing at the orthopedic unit was 1.01 nurses/aids per bed and at the geriatric unit it was 1.07.

**Intervention group.**

Before the study started an intervention program was constructed based on a literature review and previous studies concerning the care of old people with hip fracture. The program was implemented before the study started with a four-day course in caring, teamwork, rehabilitation and medical knowledge about prevention and treatment of postoperative complications.

The participants were admitted to a geriatric unit specializing in geriatric orthopedic patients where this program had been implemented. It was a 24-bed unit and the staffing level was 1.07 nurses/aids per bed. The staff worked as a team applying CGA, and the intervention program focused on prevention, detection and treatment of postoperative complications, early...
mobilization and daily training in personal ADL and ambulation. Special attention was given to preventing, detecting and treating delirium.

The PTs supervised individualized functional strength- and balance training, for example ambulation, in-bed transfers and stair climbing. Assessment and training in performance of P-ADL and inquiries about the patients’ home environment were carried out by the OTs. The PT and the OT made home visits together with the patients before discharge, if it was considered necessary. Discharge was carefully planned, to meet the participants’ further needs.

After discharge the participants could be referred to primary healthcare or to an out-patient rehabilitation unit connected to the Geriatric Department for additional training. For those living in residential care facilities the PTs and OTs in charge were contacted by phone before discharge and informed of the participants’ needs regarding help and further training. A home training program was offered to the participants who were not assigned to any other kind of rehabilitation/were able to train by themselves or with the help of their next of kin.

The participants received a telephone call two weeks after discharge from a PT or an OT, checking for additional needs. The nurse and a PT or an OT assessed the need for rehabilitation, assistive devices, modifications of the home environment and they also checked for nutritional problems four months postoperatively. The follow-up took place either in the geriatric out-patient clinic or, if the participant’s condition was poor, a home visit was made. The doctor checked for fall-risk factors such as inappropriate medication, low blood pressure and other complications. The intervention study was known to the staff on the intervention ward and the staff working with the control group were aware that a new care program was being implemented and evaluated.

Table 6 presents an overview of the intervention program and the conventional care in study 1.
Table 6. Overview of the intervention program and the conventional care in study 1 (Papers I and II). A modified version from B Olofsson’s and M Stenvall’s thesis.

<table>
<thead>
<tr>
<th>Intervention group</th>
<th>Control group</th>
</tr>
</thead>
</table>
| **Individual care planning** | - Individualized care planning was used, though not routinely, as in the intervention ward  
- There was weekly individual care planning at the geriatric rehabilitation unit |
| **Prevention, detection and treatment of complications** | - Individualized care planning was used, though not routinely, as in the intervention ward  
- There was weekly individual care planning at the geriatric rehabilitation unit |
| - The participant was assessed by all team members, usually within 24 hours, to start an individualized care plan  
- Team meetings twice a week to evaluate the rehabilitation process and goals | - No routine analysis of why the patients had fractured their hips; no attempt made to systematically prevent further falls  
- No routine prescription of calcium and vitamin D  
- Assessments for postoperative complications were made by checking e.g. saturation, hemoglobin, nutrition, bladder and bowel function, home situation etc. but not carried out systematically as in the intervention group |
| - Pulse, blood pressure, temperature and saturation were measured during the first postoperative days  
- Oxygen-enriched air in the first postoperative day and longer if necessary  
- Blood test and urinary sample the first day after operation to screen for anemia, signs of kidney failure, infections etc.  
- Urinary catheters were discontinued within 24 hours postoperatively  
- Risk factors for falls were analyzed and global ratings of the participant’s fall risk were made every week at team meetings  
- Regular screening for urinary retention, and prevention and treatment of constipation  
- Blood transfusion if B-hemoglobin, g/l, was <100 or <110 for those at risk of delirium/delirious  
- Calcium and vitamin D, and other pharmacological treatments for osteoporosis/reduced bone density if indicated  
- Anti-thrombosis pharmacological treatment and anti-thrombosis stockings the first two postoperative weeks, and longer if indicated |
<table>
<thead>
<tr>
<th></th>
<th>Assessment, analysis and treatment of sleeping problems</th>
<th>Systematic screening for delirium, assessment and treatment of underlying causes</th>
</tr>
</thead>
</table>
| **Nutrition**       | - Food and liquid registration, and protein- and energy-enriched meals, the first four days postoperatively, longer if necessary  
                     - Served nutritional and protein drinks daily  
                     - Food consistency adapted if necessary  
                     - Problems that effected the appetite, such as pain and bad oral hygiene were analyzed and appropriate actions taken  
                     - Consultation with dietician if necessary | - No dietician available at the orthopedic unit  
                     - No routine nutrition registration or protein-enriched meals for the patients |
| **Rehabilitation**  | - Mobilization within the first 24 postoperative hours  
                     - Basic ADL performance training around the clock by caring staff  
                     - Specific exercises and rehabilitation procedures by PT and OT  
                     - Rehabilitation based on functional retraining, with special focus on fall-risk factors  
                     - Home visit by OT and/or PT  
                     - The PT/OT co-operated with colleagues working in community service for further consultation after the patient was discharged from hospital  
                     - All patients were offered further out-patient rehabilitation after discharge  
                     - Patients were followed up by PT or OT with a phone call two weeks after discharge and a home visit four months postoperatively | - Mobilization usually within the first 24 hours  
                     - The PT on the ward mobilized the patients together with the caring staff  
                     - The PT aimed to meet the lucid patients every day  
                     - Functional retraining in ADL situations was not always given  
                     - The OT at the orthopedic unit only met the patients for consultation  
                     - No home visits were made by staff from the orthopedic unit  
                     - The geriatric control ward had both specific exercise and other rehabilitation procedures delivered by a PT and OT, similar to that given at the intervention ward  
                     - No follow-up by a physician at four months |
Four months postoperatively a physician met the patients to detect and prevent complications.

| Teamwork | - No corresponding teamwork at the orthopedic unit  
|          | - The geriatric ward, where some of the control group patients were cared for, used teamwork similar to that in the intervention ward |
|          | Team included Registered Nurses, Licensed Practical Nurses, Physiotherapists, Occupational Therapists, a dietician and geriatricians  
|          | Close cooperation between orthopedic surgeons and geriatricians in the medical care of the patients |

PT = Physiotherapists, OT = Occupational Therapists, ADL = Activities of Daily Living.
**Statistical analyses**

All data were analyzed using the statistical software package SPSS version 12.01 and 23.0 (SPSS Inc., Chicago, USA) and STATA 9. All tests were two-tailed and a p-value <0.05 was regarded as statistically significant in all analyses. The analyses were based on the intention-to-treat principle, including all randomized patients, according to their original allocation, and regardless of level of attendance. In Paper I data, including the one-year follow-up, are analyzed and in Paper II data up to three-year follow-up are analyzed.

**Paper I**

The power calculation was performed a posteriori, based on data from previous studies, assuming that 50% of the participants in the control group would fall. The sample size of 199 participants provided a power of 30% at $\alpha = 0.05$ to detect a 20% reduction in falls between intervention and control group. Differences regarding baseline characteristics and mortality between control- and intervention groups were analyzed using; Student’s t-test for independent samples when comparing normally distributed continuous variables; Pearson’s chi-square test and Fisher’s exact test when dichotomous data were compared; and the Mann-Whitney U test for continuous variables not normally distributed.

The fall incidence was compared in two ways between intervention and control groups; first an unadjusted comparison was made regarding the number of participants who fell and the numbers of fractures using Pearson’s chi-square test and Fisher’s exact test. Secondly, a comparison was performed by calculating the fall incidence rate in the intervention and control groups and then estimating the fall Incidence Rate Ratio (IRR) using Negative binomial regression (Nbreg), a generalization of the Poisson regression model, with adjustment for over-dispersion and observation time. The observation time was calculated from the day of admission until the day of final follow-up. As an example, if the participant had died or declined between the 4- and 12-month follow-ups, only observation days up to 4 months were calculated. In the Poisson regression model, baseline characteristics were considered as covariates if they had a p-value <0.15 (depression and dementia) when comparing intervention and control groups. Since these variables only had a marginal effect on the IRR values they were not included in the presentation of the data.
Pearson's chi-square test, Fisher's exact test and the Mann–Whitney U test were used to analyze differences between the intervention and control groups and between the deceased and the survivors regarding complications. Univariate and multivariate Cox proportional hazard regression was used to analyze associations between baseline variables and complications during hospitalization and all-cause mortality during the 3-year follow-up. All baseline variables and complications during hospitalization associated with time to death (p < 0.05) in univariate analyses were included in two separate multivariate models (Model A and B in Table 11). Correlations between baseline variables and among complications during hospitalization were tested using Pearson's and Spearman's coefficients; the covariate Living in residential care facilities before fracture was removed due to its strong correlation with Dependence in P-ADL (r >0.6). Step-wise backward deletion was performed manually until only significant variables remained in the models. The proportionality of hazards was tested using Schoenfeld residuals and time-dependent variables in extended Cox regression models. A final multivariate model adjusted for age, sex and remaining significant variables from the two separate multivariate analyses was performed (Model C in Table 11).

**Study 2 (Papers III and IV)**

**Settings and participants**
Papers III and IV are based on a randomized controlled study including 205 persons with acute hip fracture (cervical- and trochanteric fracture) consecutively admitted to the Geriatric Department at the University Hospital in Umeå, Sweden. The inclusion started in May 2008 and ended in June 2011. The one-year follow-up ended in 2012. The participants were aged 70 years or older, living in the municipality of Umeå, in independent housing or in residential care facilities. Dementia and cognitive impairment were not exclusion criteria. Those who fractured their hip in hospital and those with pathological fractures, however, were not included.

A total of 466 persons were screened for eligibility but 187 people did not meet the inclusion criteria, 37 declined to participate and 33 were missed due to failure in the inclusion process. The group that declined or were missed did not differ significantly in age or sex from those included in the study. Two participants died and two declined before the first assessment, leaving 205 people to be included in the study.
Figure 5. Flow chart for Paper III.

466 people with hip fracture

257 Excluded
- 187 did not meet inclusion criteria
  (152 lived outside Umeå, 13 fractured their hip in hospital, 4 had pathologic fractures, 18 were too young)
- 7 declined to participate
- 33 missing due to failure of inclusion routines

209 randomized
108 to Geriatric Interdisciplinary Home Rehabilitation, 101 to Conventional Care and Rehabilitation

- 1 declined to participate before first assessment

Geriatric Interdisciplinary Home Rehabilitation
n = 107

95 assessed at 3 months
- 9 died
- 1 declined to participate
- 2 were lost to follow-up

80 assessed at 12 months
- 12 died
- 1 declined to participate
- 1 moved to another town
- 1 was lost to follow-up

107 included in primary analysis

Conventional Geriatric Care and Rehabilitation
n = 98

89 assessed at 3 months
- 6 died
- 3 declined to participate

79 assessed at 12 months
- 10 died

98 included in primary analysis
Procedure

Everyone eligible for inclusion was admitted to the orthopedic ward and operated on. In accordance with the usual clinical pathways in the hospital, those with cervical fractures were transferred to a geriatric ward specializing in orthopedic geriatric care directly after surgery and those with trochanteric fractures were given acute postoperative care on the orthopedic ward. Those with trochanteric fractures who needed a longer period of rehabilitation were transferred to the geriatric ward after being assessed by a geriatrician.
An independent researcher was responsible for the randomization and the participants were randomized to the control group, with conventional geriatric care, or to the intervention group, with conventional geriatric care and GIHR after early discharge. The randomization was stratified according to housing (living in residential care facilities or in community dwellings) and to type of fracture (cervical or trochanteric).

The surgical method used depended on the type of fracture, hemiarthroplasty was used for displaced femoral neck fractures and internal fixation for the un-displaced cervical fractures. Trochanteric fractures were operated on using dynamic sliding screw devices such as DHS and Twinhook or with intramedullary nails. The stratification in study 2 is shown in Table 7.

<table>
<thead>
<tr>
<th>Type of fracture</th>
<th>Community dwelling</th>
<th>Residential care facility</th>
<th>Community dwelling</th>
<th>Residential care facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical</td>
<td>49</td>
<td>29</td>
<td>46</td>
<td>24</td>
</tr>
<tr>
<td>Trochanteric</td>
<td>22</td>
<td>7</td>
<td>25</td>
<td>3</td>
</tr>
</tbody>
</table>

All participants were asked orally and in writing if they were willing to participate in the study and in those cases when they were unable to answer their next of kin was asked. Written consent was required and they were informed that they could withdraw at any time from the study without prejudice. All participants were randomized before arrival on the geriatric ward; a concealed numbered envelope was drawn by the nurse on call when the ward was informed that a new patient was to be admitted. This means that a person with a cervical fracture was randomized before even being asked to participate in the study. This was done for logistical reasons. Those with trochanteric fractures were asked to participate when still on the orthopedic ward, before randomization. The providing of information and asking about willingness to participate was often done by a geriatrician while it was mostly the independent researcher who gave information about group allocation. The geriatric ward had two wings; the control group (conventional care) was placed in one and the intervention group (GIHR) in the other.
Data collection
During hospitalization, within five days of randomization, the participants were assessed by two experienced researchers (one PT and one nurse) who were blinded to group allocation and had no contact with the ward during the study. On the ward, the assessments were made in a neutral place in order not to reveal group allocation. The assessments were also carried out at 3 months after randomization and 12 months postoperatively by the same researchers. At the three-month follow-up group allocation was exposed in 27 times but the assessments were completed and at the 12-month follow-up the assessor was changed. Medical data were collected from medical and nursing records and through asking participants, relatives and medical staff. An overview of all assessments in study 2 is presented in Table 8.

Table 8. Assessments in study 2.

<table>
<thead>
<tr>
<th>Assessments</th>
<th>Study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Paper III</td>
</tr>
<tr>
<td>Barthel ADL index</td>
<td>X</td>
</tr>
<tr>
<td>Staircase of ADL, Katz index</td>
<td></td>
</tr>
<tr>
<td>S-COVS</td>
<td>X</td>
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<td>ASA</td>
<td>X</td>
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<tr>
<td>MMSE</td>
<td>X</td>
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<tr>
<td>OBS</td>
<td>X</td>
</tr>
<tr>
<td>GDS</td>
<td>X</td>
</tr>
<tr>
<td>Gait speed test</td>
<td>X</td>
</tr>
</tbody>
</table>

Assessments
In study 2 (Papers III and IV) the participants were assessed with regard to medical diagnosis, falls, complications and readmissions as in study 1. The assessment and scales (Staircase of ADL, Katz index, S-COVS, ASA, MMSE, OBS, and GDS) used are described under Assessments in the method section for study 1 (Papers I and II) (above). The assessments not described in the previous section are presented below.

Activities of Daily Living

The participant or, if there was cognitive impairment, the next of kin or a nurse’s aide, were asked about ADL prior to the fracture, using the Barthel Index. This is a 10-item index covering primary activities of daily living (eating, grooming, toileting etc.), adding up to a total score ranging from 0 to 20. The maximum score of 20 indicates independence in P-ADL.
LOS

In Paper III postoperative LOS was recorded in 3 different ways. Total LOS includes the time spent in all departments in the hospital from after surgery until discharge. In addition, LOS was measured from admission to the geriatric ward until discharge, as well as LOS from admission to the geriatric ward until the discharge-ready date (DRD).

Gait speed

In Paper III self-chosen and maximum gait speed (m/s) over a distance of 2.4 meters, was recorded at the 3- and 12-month follow-up visits in the participants’ homes. These measurements were taken from a standing start and with the participant’s usual walking aid. The stopwatch was started on the command “Go” and was stopped when the first foot crossed the finishing line. The mean of 2 tries was used for self-chosen gait speed, and the faster of 2 tries was used for maximum gait speed.

Intervention

Control group.

An orthogeriatric care model, comprising a multidisciplinary and multifactorial intervention program, was implemented on the ward in the year 2000 (Study 1.). Thus conventional care and rehabilitation on the geriatric ward included this program, which had been successful in reducing in-hospital falls and complications, such as delirium, infections and decubital ulcers, and had become part of the regular ward routine. The staff worked in teams to apply CGA, with regular meetings and individual care planning for each participant. The program included active prevention, detection and treatment of postoperative complications, early mobilization, daily training and a carefully planned discharge, as previously described in study 1. Participants in ordinary housing, in need of further rehabilitation were referred to primary healthcare after discharge, and 3 months after fracture, they could also receive rehabilitation at a geriatric out-patient rehabilitation unit. Those living in residential care facilities in need of further actions after discharge were referred to PTs and OTs in those facilities.

Intervention group.

The participants who were randomized to GIHR received care during hospitalization according to the same multidisciplinary and multifactorial program as the control group, but the aim was early discharge
from hospital and continuation of the rehabilitation in the participants’ homes. The participants could be discharged from hospital when no medical obstacles existed and when they could manage basic transfers and had access to the care they required at home. A member of the GIHR team met the participant before discharge, giving information about the team, and inquiring whether one of the team members needed to accompany the participant home. The meeting between the team member and the participant before discharge was partly done to attempt to alleviate anxiety about leaving hospital.

The GIHR team was made up of an OT, two PTs and a nurse who regularly visited the participants. A geriatrician had medical responsibility, and a social worker and a dietician could be consulted when needed. The team worked using CGA with regular meetings, individual care planning and rehabilitation individually designed according to the participants’ own goals. The prevention, detection and treatment of complications and falls, were given special priority. During the first few days at home the team members usually made daily visits to the participant, but later the number of visits per week was in accordance with the participants’ needs. The team also worked in close contact with relatives and social home service or staff in the residential care facilities. The maximum duration of GIHR was ten weeks.

The physiotherapist trained the participant’s functional strength and balance according to the High-Intensity Functional Exercise program (HIFE).173,174 The goal was usually for the participants to regain their previous walking ability, both indoors and outdoors. Those who had the capacity to exercise on their own or with support from others were given individually designed exercise programs. The OT focused on independence in personal and instrumental ADL, trying out assistive devices and modifications of the home environment. The aim was to prevent new falls and to make everyday activities safer. The nurse and the geriatrician were responsible for medical issues after the hip fracture, for example treatment of pain, supervision of the operation wound and evaluation of the participants’ ability to manage their medicines safely. All team members reported symptoms, for example, delirium, pain and sleeping disturbances to the nurse and geriatrician who assessed and treated the participant in order to minimize further complications. The participants’ nutrition was also evaluated by the nurse with aspects that might have an effect on nutrition, such as constipation, pain, or oral problems, being considered.

GIHR was ended, when the participants achieved their goals, or the team members could not contribute to progress in the participant’s further
rehabilitation, or the time limit was up. When GIHR ended, participants in need of further actions were referred to primary healthcare, staff in the residential care facilities or to a geriatric out-patient rehabilitation unit.

**Statistical analyses**

All data were analyzed using the statistical software package SPSS version 22.0 and 23.0 (IBM SPSS Statistics, IBM Corporation, Chicago, IL)/(SPSS Inc., Chicago, USA). All tests were two-tailed and a p-value <0.05 was regarded as statistically significant in all analyses. The analyses were based on the intention-to-treat principle, including all randomized patients according to their original allocation, and regardless of level of attendance. A group of seven people randomized to GIHR never received the team-based intervention. Six of these participants remained in hospital because of the unavailability of social services and were judged not to need GIHR once they were discharged. One participant was missed. All seven participants were, nevertheless, included in the analysis. A power calculation was performed with the number of days that patients with hip fracture spent in the hospital during a year from a previous study. Assuming a power of 80% and with a 24% reduction in hospital days, the total sample size was estimated to be 206 participants.

**Paper III**

The Student t test, Pearson’s chi-square test, or the Mann-Whitney U test were used to analyze group differences in prefracture characteristics and for outcomes, as appropriate. Data concerning physical assistance and walking devices were dichotomized, and a binary logistic regression method was used to analyze the odds ratio (OR) of walking ability and the use of walking devices for the groups. The regressions were adjusted for age, sex, and prefracture status of the outcome variable and for significant differences between the groups at baseline (antidepressants, analgesics). The Mann-Whitney U test was used for postoperative LOS as the data were not normally distributed and because of differences between the groups regarding the extreme outliers.

**Paper IV**

Baseline characteristics, complications, readmissions and days in hospital were compared between the GIHR and control groups. Student’s t-test for independent samples was used when comparing normally distributed continuous variables. Pearson’s chi-square test or Fisher’s exact test were used for dichotomous data. The Mann-Whitney U test was used for non-normally distributed continuous variables. Observation time used in the regression model was registered as time from discharge until the end of
the study or until the participant declined to continue, died or left the study for other reasons.

A binary logistic model was used to analyse the OR of falling after discharge according to group allocation. Correlations between the covariates in the model were tested using Pearson’s and Spearman’s coefficients. The first model was adjusted for age and gender. The final model was adjusted for age, gender, observation time and significant differences between the GIHR and control groups at baseline (e.g., analgesics, antidepressants, Parkinson medication).
RESULTS

At baseline, most of the patients included in studies 1 and 2 were women, who were living alone in ordinary housing and walked independently indoors before the fracture, though only four out of ten were independent in P-ADL before the index hip fracture. Approximately half of the population had a heart disease, and an ASA score of ≥3 or higher at baseline. The participants in study 1 had more cancer at baseline, 15% vs. 6% in study 2. Whereas dementia (32% vs. 50%) and having ≥3 comorbidities (40% vs. 59%) were more common among participants in study 2. Depression and the use of antidepressants differed significantly between intervention and control groups at baseline in study 1, and the use of analgesics, antidepressants and Parkinson medications differed significantly between groups in study 2 (Table 9).
## Table 9. Basic characteristics and assessments among participants in studies 1 and 2.

<table>
<thead>
<tr>
<th></th>
<th>Study 1</th>
<th>Study 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention (n=102)</td>
<td>Control (n=97)</td>
</tr>
<tr>
<td><strong>Intervention</strong> (n=102)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean age, mean ± SD</td>
<td>82.3±6.6</td>
<td>82.0±5.9</td>
</tr>
<tr>
<td>Females</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>Independent living</td>
<td>66</td>
<td>60</td>
</tr>
<tr>
<td>Independent in P-ADL</td>
<td>42</td>
<td>42</td>
</tr>
<tr>
<td>Independent walking indoors</td>
<td>85(101)</td>
<td>85(94)</td>
</tr>
<tr>
<td>Health and medical problems</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>15</td>
<td>14(92)</td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>57(101)</td>
<td>53(93)</td>
</tr>
<tr>
<td>Dementia</td>
<td>28</td>
<td>36</td>
</tr>
<tr>
<td>Depression</td>
<td>33</td>
<td>45(95)*</td>
</tr>
<tr>
<td>Diabetes</td>
<td>23</td>
<td>17(95)</td>
</tr>
<tr>
<td>Stroke</td>
<td>29</td>
<td>20(93)</td>
</tr>
<tr>
<td>Previous hip fracture</td>
<td>16</td>
<td>14(96)</td>
</tr>
<tr>
<td>Previous wrist fracture</td>
<td>16(101)</td>
<td>23(95)</td>
</tr>
<tr>
<td>≥3 comorbidities</td>
<td>37</td>
<td>42(97)</td>
</tr>
<tr>
<td>Medications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of drugs, mean ± SD</td>
<td>5.8±3.8</td>
<td>5.9±3.6</td>
</tr>
<tr>
<td>Analgesics</td>
<td>30</td>
<td>32</td>
</tr>
<tr>
<td>Antidepressants</td>
<td>29</td>
<td>45*</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>21</td>
<td>25</td>
</tr>
<tr>
<td>Calcium/Vitamin D</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Neuroleptics</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>Parkinson medications</td>
<td>10*</td>
<td></td>
</tr>
<tr>
<td>Assessments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ASA grade 3-4</td>
<td>54</td>
<td>55(95)</td>
</tr>
<tr>
<td>Barthel ADL index, median (IQR)</td>
<td>18(13-20)(105)</td>
<td>18(12.5-20)(97)</td>
</tr>
<tr>
<td>GDS, median (IQR)</td>
<td>4.0 (2-7)</td>
<td>4.0 (2-6.8)</td>
</tr>
<tr>
<td>MMSE, median (IQR)</td>
<td>19.0 (12.5-23)</td>
<td>17.0 (8-23.2)</td>
</tr>
<tr>
<td>SCOVS, need of assistance, median (IQR)</td>
<td>6(5-7) (101)</td>
<td>6(5-7) (94)</td>
</tr>
<tr>
<td>Staircase of ADL, median (IQR)</td>
<td>5 (1-7.8) (92)</td>
<td>5 (0.3-7) (88)</td>
</tr>
</tbody>
</table>

*p< 0.05 IQR = Interquartile Range, ADL = Activities of Daily Living, ASA = American Society of Anesthesiologists, S-COVS = Swedish version of Physiotherapy Clinical Outcome Variables, SD = standard deviation, P-ADL = Personal Activities of Daily Living, GDS = Geriatric Depression Scale, MMSE = Mini Mental State Examination. If details are not given for the complete group, the number of subjects is given in parenthesis.
No significant differences between intervention and control groups could be seen when comparing falls and new fractures from discharge to the 4-month follow-up, nor between the 4- and 12-month follow-ups, nor cumulatively at the 12-month follow-up. Analysis of the data from the 4-month follow-up showed that a total of 26/92 participants in the intervention group had sustained 58 falls and 26/82 participants in the control group had sustained 65 falls. The crude fall-incidence rate was 6.30/1 000 days in the intervention group vs. 9.07/1 000 days in the control group. Using a Poisson regression (Nbreg), adjusting for over-dispersion, the IRR was 0.55 (95% CI: 0.27–1.12, p=0.100). Among participants with dementia, 8 in the intervention group sustained 22 falls and 11 in the control group sustained 38 falls. Between four and twelve months the crude fall-incidence rate was 2.96/1 000 days in the intervention group vs. 3.54/1 000 days in the control group. The IRR was 0.85 (95% CI: 0.48–1.50, p=0.577) (Table 10).

Between admission and the 12-month follow-up 44 participants in the intervention group sustained 138 falls (range 1–11) and 55 participants in the control group sustained 191 falls (range 1–31). The crude fall-incidence rate was 4.16/1 000 days in the intervention group vs. 6.43/1,000 days in the control group. IRR was 0.64 (95% CI: 0.40–1.02, p=0.063). Among participants with dementia (diagnosed at baseline) 12 sustained 41 falls in the intervention group and 22 sustained 104 falls in the control group during one year (Table 10). The crude fall-incidence rate was 5.16/1 000 days in the intervention group vs. 9.52/1 000 days in the control group. IRR was 0.48 (95% CI: 0.21–1.09, p=0.079).

The new fractures at 4 months were one hip fracture, one nose fracture and one fracture of the scapula. All these fractures occurred in the control group. Between 4 and 12 months four participants in the control group sustained new fractures - one hip fracture, one pelvic fracture, one proximal humerus fracture and one vertebral fracture. In the intervention group, seven participants suffered two pelvic fractures, one proximal humerus fracture, three wrist fractures, one rib fracture, one proximal tibia fracture, one dens fracture and one face fracture. Three out of seven participants in the intervention group sustained two fractures each. The differences in fracture rate between control and intervention groups were not significant at the 4- and 12-month follow-ups. After one year, 16 out of 102 (16%) participants in the intervention group and 18 out of 97 (19%) participants in the control group had died (p=0.591).

Prescription of calcium and vitamin D was 55% in intervention group compared to 20% in control group at 4-month follow-up.
### Table 10. Falls after discharge in study 1, at 4- and 12-month follow up and cumulatively at 12 months.

<table>
<thead>
<tr>
<th></th>
<th>Discharge - 4 months</th>
<th>4 - 12 months</th>
<th>Admission - 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention n=92</td>
<td>Control n=83**</td>
<td>Intervention n=84</td>
</tr>
<tr>
<td>Number of fallers</td>
<td>26</td>
<td>26(82)</td>
<td>31</td>
</tr>
<tr>
<td>Recurrent fallers, ≥ 2 falls</td>
<td>13</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Total number of falls</td>
<td>58</td>
<td>65</td>
<td>62</td>
</tr>
<tr>
<td>Number of fallers among people with dementia</td>
<td>8(24)</td>
<td>11(30)</td>
<td>8(19)</td>
</tr>
<tr>
<td>Recurrent fallers among those with dementia</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Total number of falls among people with dementia</td>
<td>22</td>
<td>38</td>
<td>18</td>
</tr>
<tr>
<td>Number of fallers with fractures due to falls</td>
<td>0</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Number of demented fallers with fractures due to falls</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Observation time (days)</td>
<td>9206</td>
<td>7169</td>
<td>20932</td>
</tr>
<tr>
<td>Crude fall incidence rate</td>
<td>6.30/1000</td>
<td>9.07/1000</td>
<td>2.96/1000</td>
</tr>
<tr>
<td>Incidence rate ratio with 95% CI</td>
<td>IRR 0.55* (0.27-1.12)</td>
<td>IRR 0.85* (0.48-1.50)</td>
<td>IRR 0.64* (0.40-1.02)</td>
</tr>
</tbody>
</table>

* Negative binomial regression analyses adjusted for over-dispersion and controlled for dementia and depression.

**One person missing, declined at 4-month follow-up but was followed up at 12 months.

If details are not given for the complete group, the number of subjects is given in parenthesis.
Paper II

A history of cardiovascular disease, cancer, dependence in P-ADL, dementia, having three or more co-morbidities, dependence in walking, having an ASA score of 3 or higher, living in residential care facilities, male gender, depression and pulmonary disease were all independently associated with time to death in univariate Cox regression analyses (Table 11). The results from multivariate Cox regression analyses are also displayed in the columns to the right of Table 11. The hazard ratios (HR) and 95% confidence intervals (CI) are presented for the significant variables remaining in the multivariate models. Analysis of the associations between baseline variables and time to death shows that cancer, cardiovascular disease, dependence in P-ADL and dementia were associated with time to death in a Cox proportional hazard regression model adjusted for age and sex (Table 11. Model A). In a second model (Table 11. Model B.), complications during hospitalization were analyzed; pulmonary emboli, pneumonia, cardiac failure and delirium were all associated with time to death. In the final model (Table 11. Model C.) all significant variables in the two multivariate models above were combined; pulmonary emboli (HR 69.396, CI: 7.107–677.632), cancer (HR 3.393, CI: 1.959–5.877), cardiac failure (HR 2.221, CI: 1.148–4.294), cardiovascular disease (HR 2.026, CI: 1.160–3.539), dementia (HR 1.883, CI: 1.091–3.250) and dependence in P-ADL (HR 2.362, CI: 1.271–4.387) remained independently associated with all-cause mortality adjusted for age and gender.

Mortality was 13/199 (6%) at 30 days and 34/199 (17%) at 1 year after the index hip fracture. Twenty-six out of 51 (51%) men died compared to 53/148 (36%) women. After discharge, a total of 65 participants died during the 3 years of follow-up. From admission until 3-year follow-up 79 out of 199 participants (40%) died. (Table 12).

In this study 13 participants died within 30 days of sustaining the index hip fracture. Ten of these 13 died during hospitalization: one before the operation, due to myocardial infarction; two on the day of operation, due to cardiovascular events; two the day after the operation (one due to gastrointestinal bleeding and one to myocardial infarction); one suffered a cerebrovascular event during the operation and never regained consciousness; one suffered a myocardial infarction after a week; two died of pneumonia and one died due to an intestinal infarction. The participants who died during hospitalization due to a cardiovascular event all had a history of cardiovascular disease. The three participants who died after discharge but within 30 days of the index hip fracture did so due to
a cerebrovascular event, a myocardial infarction and a pulmonary emboli, respectively. The secondary cause of death within 30 days of the index fracture was due to a cardiovascular event in 6/13 (46 %) cases (Table 13).

In addition, four participants died within 30 days after sustaining a new fracture. One of these participants fell and suffered a new hip fracture while still in hospital and then died due to an infection. After discharge one participant suffered a hip fracture and died due to pneumonia, one sustained a head trauma with a face fracture and died due to intracerebral bleeding and one had a knee fracture and died due to rupture of the aorta (Table 13.). Cardiovascular events (18/65), dementia (19/65), cancer (10/65), fractures (6/65) and cerebrovascular events (4/65) were the most common primary causes of death after discharge (Table 12).

In total, from admission until 3-year follow-up, 166 participants suffered from 583 infections, including 136 participants who suffered 363 urinary tract infections. Seventy-four participants suffered 111 cardiovascular events during the 3 years following the hip fracture. One-hundred and fourteen participants suffered 542 falls. Thirty-seven participants suffered 56 new fractures, including 13 new hip fractures, seven wrist fractures and seven rib fractures. Forty-nine participants suffered 60 decubital ulcers. During follow-up 96 participants had 234 hospital admissions with a total of 3984 days spent in hospital. Infections and cardiovascular events were more common after discharge among those who died. No differences in the incidence of complications between intervention and control group in study 1 was seen (data not shown).
Table 11. Baseline characteristics and complications among participants and differences among deceased and survivors. Univariate and multivariate Cox regression analyses.

<table>
<thead>
<tr>
<th>Baseline characteristics:</th>
<th>All cases</th>
<th>Deceased</th>
<th>Survivors</th>
<th>Univariate</th>
<th>Multivariate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=199(%)</td>
<td>n=79</td>
<td>n=120</td>
<td>P¹</td>
<td>P²</td>
</tr>
<tr>
<td>Age, mean ± SD</td>
<td>82.2 ±6.2</td>
<td>82.9±5.8</td>
<td>81.7±6.5</td>
<td>0.233</td>
<td>0.435</td>
</tr>
<tr>
<td>Female</td>
<td>148(74%)</td>
<td>53</td>
<td>95</td>
<td>0.029</td>
<td>0.052</td>
</tr>
<tr>
<td>Living in residential care facilities</td>
<td>73(37%)</td>
<td>37</td>
<td>36</td>
<td>0.028</td>
<td></td>
</tr>
<tr>
<td>Living alone</td>
<td>146(74%)</td>
<td>59</td>
<td>87</td>
<td>0.696</td>
<td></td>
</tr>
<tr>
<td>Current smoker(n=169)</td>
<td>6(4%)</td>
<td>2</td>
<td>4</td>
<td>0.955</td>
<td></td>
</tr>
<tr>
<td>Dependence in walking (n=195)</td>
<td>25(13%)</td>
<td>15</td>
<td>10</td>
<td>0.004</td>
<td></td>
</tr>
<tr>
<td>Dependence in P-ADL</td>
<td>115(58%)</td>
<td>59</td>
<td>56</td>
<td>&lt;0.001</td>
<td>0.005</td>
</tr>
<tr>
<td>Cardiovascular disease(n=194)</td>
<td>110(57%)</td>
<td>55</td>
<td>55</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Dementia</td>
<td>64(32%)</td>
<td>37</td>
<td>27</td>
<td>0.001</td>
<td>0.016</td>
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<tr>
<td>Depression(n=197)</td>
<td>78(40%)</td>
<td>39</td>
<td>39</td>
<td>0.040</td>
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<tr>
<td>Diabetes(n=197)</td>
<td>40(20%)</td>
<td>22</td>
<td>18</td>
<td>0.059</td>
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</tr>
<tr>
<td>Kidney disease(n=194)</td>
<td>21(11%)</td>
<td>10</td>
<td>11</td>
<td>0.321</td>
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<tr>
<td>Pulmonary disease(n=194)</td>
<td>33(17%)</td>
<td>17</td>
<td>16</td>
<td>0.049</td>
<td></td>
</tr>
<tr>
<td>Stroke(n=195)</td>
<td>49(25%)</td>
<td>23</td>
<td>26</td>
<td>0.184</td>
<td></td>
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<tr>
<td>ASA grade 3-4(n=197)</td>
<td>109(55%)</td>
<td>51</td>
<td>58</td>
<td>0.007</td>
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</tr>
<tr>
<td>Internal fixation</td>
<td>69(35%)</td>
<td>33</td>
<td>36</td>
<td>0.420</td>
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<tr>
<td>Hemiarthroplasty</td>
<td>111(56%)</td>
<td>37</td>
<td>74</td>
<td>0.228</td>
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<tr>
<td>Dynamic hip screw</td>
<td>17(9%)</td>
<td>7</td>
<td>10</td>
<td>0.998</td>
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</tr>
<tr>
<td>Other</td>
<td>1(0.5%)</td>
<td>1</td>
<td>0</td>
<td>0.345</td>
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<tr>
<td>No of. comorbidities:</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>31(16%)</td>
<td>3</td>
<td>28</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>37(19%)</td>
<td>7</td>
<td>30</td>
<td>0.260</td>
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</tbody>
</table>
Table 11. Baseline characteristics and complications among participants and differences among deceased and survivors. Univariate and multivariate Cox regression analyses.

<table>
<thead>
<tr>
<th></th>
<th>All cases</th>
<th>Deceased</th>
<th>Survivors</th>
<th>Univariate</th>
<th>Multivariate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=199(%)</td>
<td>n=79</td>
<td>n=120</td>
<td>P¹</td>
<td>P²</td>
</tr>
<tr>
<td>No of. comorbidities:</td>
<td></td>
<td></td>
<td></td>
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<td>2</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>52(26%)</td>
<td>25</td>
<td>27</td>
<td>0.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>79(40%)</td>
<td>44(56%)</td>
<td>35(29%)</td>
<td>0.001</td>
</tr>
<tr>
<td>≥3</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Complications during hospitalization:</td>
<td></td>
<td>Model B.</td>
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<tr>
<td>Pneumonia/chest infection</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>0.001</td>
<td>0.021</td>
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<tr>
<td>Urinary tract infection</td>
<td>82</td>
<td>38</td>
<td>44</td>
<td>0.241</td>
<td></td>
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<tr>
<td>Other infection</td>
<td>34</td>
<td>15</td>
<td>19</td>
<td>0.528</td>
<td></td>
</tr>
<tr>
<td>Wound infection</td>
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<td>1</td>
<td>0</td>
<td>0.054</td>
<td></td>
</tr>
<tr>
<td>Deep wound infection</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0.054</td>
<td></td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>17</td>
<td>12</td>
<td>5</td>
<td>0.001</td>
<td>0.010</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>0.052</td>
<td></td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0.050</td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0.002</td>
<td>0.001</td>
</tr>
<tr>
<td>Stroke</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0.072</td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0.120</td>
<td></td>
</tr>
<tr>
<td>Gastric ulcer</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>0.538</td>
<td></td>
</tr>
<tr>
<td>Delirium</td>
<td>129</td>
<td>63</td>
<td>70</td>
<td>0.005</td>
<td>0.018</td>
</tr>
<tr>
<td>Fallers</td>
<td>38</td>
<td>19</td>
<td>19</td>
<td>0.267</td>
<td></td>
</tr>
<tr>
<td>Number of falls</td>
<td>78</td>
<td>41</td>
<td>37</td>
<td>0.262</td>
<td></td>
</tr>
<tr>
<td>Fracture</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>0.609</td>
<td></td>
</tr>
<tr>
<td>Luxation</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>0.416</td>
<td></td>
</tr>
<tr>
<td>Reoperation</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>0.926</td>
<td></td>
</tr>
<tr>
<td>Decubital ulcers</td>
<td>30</td>
<td>16</td>
<td>14</td>
<td>0.044</td>
<td></td>
</tr>
</tbody>
</table>
Table 11. Baseline characteristics and complications among participants and differences among deceased and survivors. Univariate and multivariate Cox regression analyses.

<table>
<thead>
<tr>
<th>Combining baseline and complication factors:</th>
<th>All cases</th>
<th>Deceased</th>
<th>Survivors</th>
<th>Univariate</th>
<th>Multivariate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=199(%)</td>
<td>n=79</td>
<td>n=120</td>
<td>P¹</td>
<td>P²</td>
</tr>
<tr>
<td>Age</td>
<td>0.705</td>
<td>1.008</td>
<td>0.968-1.049</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.118</td>
<td>0.655</td>
<td>0.386-1.113</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependence in P-ADL</td>
<td>0.007</td>
<td>2.362</td>
<td>1.271-4.387</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td>&lt;0.001</td>
<td>3.393</td>
<td>1.959-5.877</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiovascular disease</td>
<td>0.013</td>
<td>2.026</td>
<td>1.160-3.539</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dementia</td>
<td>0.023</td>
<td>1.883</td>
<td>1.091-3.250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumonia/chest infection</td>
<td>0.018</td>
<td>2.221</td>
<td>1.148-4.294</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac failure</td>
<td>&lt;0.001</td>
<td>69.396</td>
<td>7.107-677.632</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delirium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ p according to univariate Cox regression model
² p according to multivariate Cox regression model
SD = Standard Deviation
P-ADL = Personal Activities of Daily Living
ASA = American Society of Anaesthesiologists classification
HR = Hazard Ratio
CI = 95% Confidence Interval
### Table 12. Primary causes of death.

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>During hospitalization</th>
<th>Discharge - 4 months</th>
<th>4 - 12 months</th>
<th>12 – 36 months</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiovascular</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>Dementia</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Hip fracture</td>
<td>11</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Cancer</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Cerebrovascular</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Infection</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Deep infection</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Renal failure</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Fracture</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Gastrointestinal bleeding</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Ruptured aortic aneurysm</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Parkinson’s disease</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Pancreatitis</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Gangrene</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td><strong>14</strong></td>
<td><strong>8</strong></td>
<td><strong>12</strong></td>
<td><strong>45</strong></td>
<td><strong>79</strong></td>
</tr>
<tr>
<td>Autopsy</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>15</td>
</tr>
</tbody>
</table>
Table 13. Secondary causes of death.

<table>
<thead>
<tr>
<th>Cause of death</th>
<th>During hospitalization</th>
<th>Discharge - 4 months</th>
<th>4 - 12 months</th>
<th>12 - 36 months</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dementia</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>Cardiovascular</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>15</td>
<td>24</td>
</tr>
<tr>
<td>Cancer</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Cerebrovascular</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Infections</td>
<td>4</td>
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<td>0</td>
<td>2</td>
<td>6</td>
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<tr>
<td>Deep infection</td>
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<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Renal failure</td>
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<tr>
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<td>2</td>
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<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ruptured aortic aneurysm</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Parkinson's disease</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
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<tr>
<td>Pancreatitis</td>
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<tr>
<td>Gangrene</td>
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<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>intestinal infarction</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>pulmonary emboli</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Sum</td>
<td>14</td>
<td>8</td>
<td>12</td>
<td>45</td>
<td>79</td>
</tr>
<tr>
<td>Autopsy</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>15</td>
</tr>
</tbody>
</table>
Paper III

There were no significant differences between the GIHR and control groups in independent walking ability either indoors or outdoors at 3 and 12 months, or in use of walking devices (Table 14). Walking ability deteriorated in both groups. At the 3-month follow-up, 49 (51.6%) participants in GIHR group and 48 (54.5%) participants in the control group had regained or improved their pre-fracture walking ability level (p = 0.800). At 12 months, the totals were 45 (56.3%) and 45 (57.7%) in the GIHR and control groups, respectively (p = 0.982). Two participants in the GIHR group and 1 participant in the control group were not able to walk before the fracture. These numbers increased to 8 (8.4%) versus 3 (3.4%) at 3 months for the GIHR and control groups, respectively, and to 9 (11.3%) versus 8 (10.3%) at 12 months, but there were no significant differences between the groups. The use of a walker indoors did not differ between the groups. Before the fracture, 45.8% of participants in the GIHR group and 43.9% of participants in the control group walked with a walker on wheels indoors, and 12 months after the fracture the proportions were 51.2% and 57.7% for the GIHR and control groups, respectively. Gait speed, both self-chosen and maximum, were almost identical for the groups at the 3- and 12-month follow-up visits (Table 15).

Postoperative LOS was significantly shorter for the GIHR group compared with the control group. LOS from admission to the geriatric ward to discharge was a median (Q1-Q3) of 17 days (12-26) versus 23 days (17-32) for the GIHR and control groups, respectively (p = 0.003). LOS from admission to the geriatric ward to DRD was a median (Q1-Q3) of 15 days (11-22) versus 21.5 days (16-29) for the GIHR and control groups, respectively (p < 0.001). Moreover, when total postoperative LOS after the hip fracture was analyzed, the GIHR group had a significantly shorter LOS, with a median (Q1-Q3) of 22 days (15-34) compared with 26.5 days (19-38) for the control group (p = 0.021). There were no differences between the groups in the 1-year mortality rate. The rates were 19.6% in the GIHR group and 16.3% in the control group (p = 0.666). The GIHR team made an average of 14.2 ± 10.5 visits in the participants’ homes (0-50). Number of days in the GIHR team was a median (Q1-Q3) of 21 days (11.0-35.5). One-third of the participants in the control group were followed-up in primary healthcare or in outpatient rehabilitation during the year after discharge. In the GIHR group, approximately 10% of participants received additional rehabilitation after the intervention ended.
Table 14. Walking ability and use of walking device for the 2 groups before fracture and at the 3- and 12-month follow-up visits in study 2.

<table>
<thead>
<tr>
<th></th>
<th>GIHR* n = 107</th>
<th>Control n = 98</th>
<th>OR†</th>
<th>95% CI‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking independently indoors, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before fracture</td>
<td>95 (88.8)</td>
<td>85 (86.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 3-month follow-up, (n = 95/88)</td>
<td>54 (56.8)</td>
<td>57 (64.8)</td>
<td>0.84</td>
<td>0.39–1.80</td>
</tr>
<tr>
<td>At 12-month follow-up, (n = 80/78)</td>
<td>53 (66.3)</td>
<td>56 (71.8)</td>
<td>0.84</td>
<td>0.35–2.06</td>
</tr>
<tr>
<td>Walking independently outdoors, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before fracture</td>
<td>70 (65.4)</td>
<td>71 (72.4)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 3-month follow-up, (n = 95/88)</td>
<td>41 (43.2)</td>
<td>39 (44.3)</td>
<td>1.76</td>
<td>0.83–3.75</td>
</tr>
<tr>
<td>At 12-month follow-up, (n = 80/78)</td>
<td>39 (48.8)</td>
<td>38 (48.7)</td>
<td>1.50</td>
<td>0.69–3.28</td>
</tr>
<tr>
<td>No walking device indoors, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before fracture</td>
<td>53 (49.5)</td>
<td>47 (48.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 3-month follow-up, (n = 95/88)</td>
<td>15 (15.8)</td>
<td>11 (12.5)</td>
<td>1.91</td>
<td>0.72–5.03</td>
</tr>
<tr>
<td>At 12-month follow-up, (n = 80/78)</td>
<td>24 (30.0)</td>
<td>21 (26.9)</td>
<td>1.41</td>
<td>0.59–3.33</td>
</tr>
<tr>
<td>No walking device outdoors, n (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before fracture</td>
<td>33 (30.8)</td>
<td>34 (34.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 3-month follow-up, (n = 95/88)</td>
<td>3 (3.2)</td>
<td>3 (3.4)</td>
<td>0.80</td>
<td>0.14–4.80</td>
</tr>
<tr>
<td>At 12-month follow-up, (n = 80/78)</td>
<td>8 (10.0)</td>
<td>7 (9.0)</td>
<td>1.20</td>
<td>0.36–4.01</td>
</tr>
</tbody>
</table>

Binary logistic regression analysis adjusted for age, sex, pre-fracture status of the outcome variable, and significant differences between the groups at baseline (antidepressants, analgesics). * GIHR = Geriatric Interdisciplinary Home Rehabilitation † OR = Odds Ratio of being treated in the GIHR group‡ CI = Confidence Interval

Table 15. Self-chosen and maximum gait speed over 2.4 m for the 2 groups at the 3- and 12-month follow-up visits in study 2.

<table>
<thead>
<tr>
<th></th>
<th>GIHR*</th>
<th>Control</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-chosen gait speed, m/s ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 3 months, (n = 80/76)</td>
<td>0.43 ± 0.19</td>
<td>0.43 ± 0.20</td>
<td>0.899</td>
</tr>
<tr>
<td>At 12 months, (n = 68/70)</td>
<td>0.49 ± 0.19</td>
<td>0.48 ± 0.17</td>
<td>0.945</td>
</tr>
<tr>
<td>Maximum gait speed, m/s ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At 3 months, (n = 77/72)</td>
<td>0.70 ± 0.31</td>
<td>0.69 ± 0.29</td>
<td>0.845</td>
</tr>
<tr>
<td>At 12 months, (n = 67/68)</td>
<td>0.74 ± 0.30</td>
<td>0.75 ± 0.27</td>
<td>0.846</td>
</tr>
</tbody>
</table>

* GIHR= Geriatric Interdisciplinary Home Rehabilitation
Paper IV

There were no significant differences between GIHR (n=106) and the control group (n=93) in terms of complications or readmissions after discharge. Between discharge and the 12-month follow-up comparisons between the participants in GIHR and the control group are as follows: 46 (43.4%) vs. 38 (40.9%) fell (p=0.828); 13 (12.3%) vs. 6 (6.5%) suffered an additional fracture (p=0.250); 36 (34.0%) vs. 30 (32.3%) presented with infection (p=0.917); 12 (11.3%) vs. 6 (6.5%) suffered a cardiovascular event (p=0.344); 38 (35.8%) vs. 27 (29.0%) were readmitted to hospital (p=0.383); and the median number of days spent in hospital was 11.5 vs. 11.0 (p=0.353). (Table 16). Fifty-seven (53.8%) participants in the GIHR suffered a complication (including medical and surgical complications) after discharge vs. 44 (47.3%) in control group (p=0.443). After adjustment for age, gender, baseline differences and observation time, the risk of falling during the period from discharge to the 12-month follow-up did not differ between the GIHR and the control groups, 46/106 vs. 38/93, odds ratio 0.99 (95% CI 0.53-1.88). Subgroups analysis revealed no differences in number of complications, readmissions, or days spent in hospital when the intervention and control groups were compared -according to the stratification, type of housing, and type of fracture (data not shown).
Table 16. Complications during hospitalization and at 12-month follow-up.

<table>
<thead>
<tr>
<th>Complications</th>
<th>In hospital</th>
<th></th>
<th>P</th>
<th>Discharge -12 months</th>
<th></th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GIHR (n = 107)</td>
<td>Control (n = 98)</td>
<td></td>
<td>GIHR (n = 106(%))</td>
<td>Control (n = 93(%))</td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Pneumonia/chest infection</td>
<td>13(10.4)</td>
<td>9</td>
<td>0.646</td>
<td>11(10.4)</td>
<td>10(10.8)</td>
<td>1.000</td>
</tr>
<tr>
<td>- Urinary tract infection</td>
<td>38(26.4)</td>
<td>28</td>
<td>0.2613</td>
<td>28(26.4)</td>
<td>23(24.7)</td>
<td>0.913</td>
</tr>
<tr>
<td>- Superficial wound infection</td>
<td>4(3.7)</td>
<td>4</td>
<td>1.000</td>
<td>0</td>
<td>1(1.1)</td>
<td>0.467</td>
</tr>
<tr>
<td>- Deep wound infection</td>
<td>2(1.9)</td>
<td>1</td>
<td>1.000</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Cardiovascular event</td>
<td>10(9.4)</td>
<td>7</td>
<td>0.959</td>
<td>12(11.3)</td>
<td>6(6.5)</td>
<td>0.344</td>
</tr>
<tr>
<td>- Cardiac failure</td>
<td>10(9.4)</td>
<td>7</td>
<td>0.952</td>
<td>10(9.4)</td>
<td>4(4.3)</td>
<td>0.256</td>
</tr>
<tr>
<td>- Myocardial infarction</td>
<td>1(1.1)</td>
<td>1</td>
<td>1.000</td>
<td>3(2.8)</td>
<td>2(2.2)</td>
<td>1.000</td>
</tr>
<tr>
<td>Deep vein thrombosis</td>
<td>0</td>
<td>1</td>
<td>0.478</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Pulmonary emboli</td>
<td>2(2.2)</td>
<td>0</td>
<td>0.499</td>
<td>0</td>
<td>0</td>
<td>1.000</td>
</tr>
<tr>
<td>Stroke</td>
<td>1</td>
<td>1</td>
<td>1.000</td>
<td>4(3.8)</td>
<td>4(4.3)</td>
<td>1.000</td>
</tr>
<tr>
<td>Gastric ulcer</td>
<td>2(1.9)</td>
<td>1</td>
<td>1.000</td>
<td>2(1.9)</td>
<td>1(1.1)</td>
<td>1.000</td>
</tr>
<tr>
<td>Decubital ulcers</td>
<td>27(24.7)</td>
<td>20</td>
<td>0.513</td>
<td>13(14.0)</td>
<td>13(21.3)</td>
<td>0.883</td>
</tr>
<tr>
<td>Falls</td>
<td>24(22.5)</td>
<td>19</td>
<td>0.717</td>
<td>46(43.4)</td>
<td>38(40.9)</td>
<td>0.828</td>
</tr>
<tr>
<td>Falls</td>
<td>33(30)</td>
<td>27</td>
<td>0.662</td>
<td>163</td>
<td>113</td>
<td>0.700</td>
</tr>
<tr>
<td>Additional fracture</td>
<td>1(1.1)</td>
<td>0</td>
<td>1.000</td>
<td>13(12.3)</td>
<td>6(6.5)</td>
<td>0.250</td>
</tr>
<tr>
<td>Luxation</td>
<td>2(2.2)</td>
<td>0</td>
<td>0.499</td>
<td>2(1.9)</td>
<td>0</td>
<td>0.500</td>
</tr>
<tr>
<td>Reoperation</td>
<td>5(1.9)</td>
<td>4</td>
<td>1.000</td>
<td>8(7.5)</td>
<td>5(5.4)</td>
<td>0.741</td>
</tr>
<tr>
<td>Deceased</td>
<td>1(1.1)</td>
<td>2</td>
<td>0.607</td>
<td>20(18.9)</td>
<td>14(15.1)</td>
<td>0.60</td>
</tr>
<tr>
<td>Delirium</td>
<td>84(35.8)</td>
<td>69</td>
<td>0.242</td>
<td>30(35.8)</td>
<td>27(29.0)</td>
<td>0.383</td>
</tr>
<tr>
<td>Days with delirium, median,</td>
<td>3.0(1-7)</td>
<td>3.0(0-7)</td>
<td>0.745</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LOS, median, IQR</td>
<td>17.0</td>
<td>23.0</td>
<td>0.003</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Numbers in parentheses indicate that values are missing. \(P\) = Differences between control and GIHR groups according to Pearson’s chi-square, Student’s t-test, the Mann-Whitney U test or Fisher’s exact test as appropriate. GIHR: Geriatric Interdisciplinary Home Rehabilitation; IQR: Inter quartile Range; LOS: Length of stay
Additional results

In study 2, no significant differences between the GIHR and control groups were found when comparing mortality and readmission at 30 days following discharge from hospital. Four individuals died in the GIHR group vs. 1 in the control group (p=0.374) and 10 individuals were readmitted to hospital in the GIHR group vs. 6 in the control group (p=0.610). No significant differences between the GIHR and control groups were found when comparing mortality and readmission at 30 days following admission to hospital. No one person died in the GIHR group vs. 1 in the control group (p=0.467) and 3 individuals from the GIHR group and one from the control group were readmitted (p=0.624).

Among those who had a LOS of 10 days or less, 10 in the GIHR group vs. 2 in the control group, none were readmitted or died within 30 days of admission, nor within 30 days of discharge.

In study 1 83/185 (45%) and in study 2 84/199 (42%) fell between discharge and 12-month follow-up and 92/160 (57%) vs. 90/158 (57%) regained the same level of walking ability as before the fracture. The rate of readmissions was 62/185 (34%) in study 1 and 65/199 (33%) in study 2 within one year after fracture.
DISCUSSION

The results in this thesis reveal that an in-hospital orthogeriatric care model using CGA, which reduced in-hospital falls and complications, had no significant effect on falls after discharge. Old individuals who sustain hip fracture have many co-morbidities and suffer from numerous complications. Co-morbidities at baseline and complications during hospitalization are both associated with mortality. The regaining of walking ability is similar for individuals that participated in GIHR, who have a significantly shorter LOS in hospital, and those who received conventional geriatric care. No significant differences were seen regarding complications, readmissions and total days spent in hospital after discharge, between participants in GIHR and those receiving conventional geriatric care.

Falls and fractures

Although falls are one of the most hazardous complications, few studies investigating orthogeriatric care models have included falls as an outcome measure, either in-hospital or during follow-up. Falls after discharge were reported in one study of orthogeriatric care by Shyu et al.\textsuperscript{114,129} The risk of falling after discharge in the intervention group in study 1 was lower than in the control group, but not significant. A power calculation showed that a larger sample size would have been required to detect significant differences in fall rates. In contrast to our results Shyu et al. reports a significant risk reduction of subsequently falling between intervention and control groups after 12 months and up to 2 years after discharge.\textsuperscript{114} One explanation for the inconsistency with the results from study 1 might be that individuals with severe cognitive impairment and those with weak muscle power were excluded, resulting in a population more responsive to fall-prevention interventions.\textsuperscript{59} Furthermore, the participants in their intervention group received home visits from a nurse and a PT after discharge, whereas no home visits were made in study 1.

In study 2, the in-hospital orthogeriatric care model in study 1 was combined with a GIHR team, trained in CGA. In GIHR fall prevention was given special priority, but despite this there was no significant reduction in number of falls compared to the control group. On the contrary, there was a tendency for the intervention group to have more falls and fractures, but the difference was not significant. One can only speculate that the intervention group may have been more fall-prone, perhaps related to more prescribing of antidepressants and Parkinson medications at baseline.
Two previous team-based HR studies report falls after discharge,\textsuperscript{147,148} neither showing significant differences between intervention and control groups. However, differences in lengths of follow-up and in methodology used for data analysis make comparison with our results difficult. In another team-based HR study by Ziden et al., the reported number of falls during the period from discharge to the 12-month follow-up is similar to that in study 2, although individuals with severe cognitive impairment and those living in care facilities were not included and the intervention was shorter.\textsuperscript{145} These findings are surprising since we expected to have a higher fall rate than in their population. However, they did not report any complications after discharge. It is known that complications might lead to falls,\textsuperscript{50} and since we do not know whether the rate of complications in their study was higher than in ours, this might provide an explanation for the lack of difference. Another team-based HR study reports fall rates of 26-33\% between assessments; even though their intervention lasted for one year no difference in fall rates between intervention and control groups was seen.\textsuperscript{150}

The proportion of fallers after discharge up to the 1-year follow-up in study 1 (83/185, 45\%) and study 2 (84/199, 42\%) was high compared to the expected fall rate among individuals in the community,\textsuperscript{34,35} although not compared to those in residential care facilities.\textsuperscript{175,176} This was not unexpected since the participants were a mix of those living in residential care facilities and ordinary housing before fracture, and individuals with hip fracture are at high risk of falling again.\textsuperscript{39,40}

The results regarding fallers and number of falls after discharge in studies 1 and 2 were similar, although the study populations differed. Study 2 included individuals with trochanteric fractures, which study 1 did not, and there was also a larger proportion of individuals with cognitive impairment and with ≥3 comorbidities in study 2. These findings might indicate that the participants in the second study were frailer individuals, but even so the number of falls were not higher.

The orthogeriatric care model described in this thesis, using CGA and a systematic prevention, detection, and treatment of complications, reduced in-hospital falls and complications,\textsuperscript{111,126} such as delirium, urinary tract infection and decubital ulcers. Considering that no effect was seen on these outcomes after discharge, not even when GIHR was added, there is a need for reflection. Delirium was the main focus during hospitalization, since it is strongly associated with falls.\textsuperscript{40} The effect on falls in hospital might have been due primarily to a reduction in delirium. Moreover, urinary tract infections were common among people with hip fracture, during hospital stay and after discharge, in both studies in this thesis. Since urinary tract infection is an important fall risk factor,\textsuperscript{177} its reduction during hospitalization probably contributed to the decreased
in-hospital fall rate. Furthermore, the interdisciplinary team work, performed by specially trained personnel working around the clock on the geriatric ward as an important part of fall prevention, was not maintained after discharge. Knowing that falls are associated with several risk factors, it is possible to speculate that since the close focus on fall-risk factors during hospitalization was not continued after discharge, partly due to less supervision, there was less prospect of preventing falls. Consequently, in studies 1 and 2 the prevention of falls and complications was not as comprehensive and systematic after discharge as during the hospital stay.

Furthermore, the intermediate groups regarding cognitive function and ADL functions have a high risk of becoming fallers, thus those who can rise from a chair but need help when walking and have less insight into their abilities have a high risk of falling. Our results show that 32% vs. 50% of the population in studies 1 and 2 had dementia, and only 57% (92/160) vs. 57% (90/158) regained the same level of walking ability as before the fracture. These findings might imply that a large proportion of participants in studies 1 and 2 were “at risk of falling”, which could have had an impact on the results. In addition, a hypothesis was put forward by Cameron et al. in a Cochrane report where they suggest that exercise programs might increase falls in frail residents and reduce falls in less frail residents. Since fall prevention among people with dementia has not been successful so far, according to a clinical practice guideline, better supervision might be needed for these individuals.

Considering other aspects of fall prevention, Boonen et al. report in a review that vitamin D significantly improved body sway and lower extremity strength, reducing the risk of falling. When vitamin D is prescribed together with calcium the risk of fracture is somewhat reduced among old people. However, in Sweden the recommendation today is to only prescribe vitamin D for those who have a diagnosed deficiency. According to two Cochrane reports, prescription of vitamin D reduces the number of falls in care facilities, probably because residents have low vitamin D levels, and it might also have an effect among individuals living in the community who have low levels prior to treatment. In study 1 vitamin D and calcium seem to have had no effect on reducing falls, even though the prescription rate in the intervention group was higher (66% vs. 22%). However, no vitamin D concentrations were measured.

The prescription of bisphosphonates was not reported in studies 1 and 2. There is under-treatment in this respect according to the Swedish National Board of Health and Welfare even though bisphosphonate treatment is recommended. The use of Bisphosphonates is supported by Nordström et al. who reports an association with reduced risk of hip
fracture, with comparable effects in people aged >80 years.\textsuperscript{184} Antidepressants were also associated with falls in a study by Kallin et al.\textsuperscript{52} However, there was no significant difference in the number of falls between intervention and control groups in either study 1 or 2, even though there was a significant difference in prescriptions of antidepressants.

In conclusion, this thesis confirms that older individuals run a high risk of falling after hip fracture, since almost half of the population in studies 1 and 2 fell again during the period from discharge to the 12-month follow-up and the participants in study 1 suffered 464 falls and 56 new fractures during 3 years of follow-up. Previous research reports that multifactorial interventions can reduce falls,\textsuperscript{55,56} thus better adherence to national recommendations, including osteoporosis treatment, individualized fall prevention and supported physical training, is urgently needed to prevent falls.\textsuperscript{183} There is also a crucial need for much greater effort from society, since fall accidents are the most costly accidents even though they are the lowest funded compared to other accidents, such as car accidents.\textsuperscript{44} Considering that 95\% of hip fractures are caused by a fall,\textsuperscript{37} primary and secondary fall and fracture prevention need to become a part of the routine care for older individuals.

Complications, readmissions and mortality

Complications

The two studies in this thesis highlight the situation that old individuals with hip fracture suffer from numerous complications after discharge from hospital. In study 2, 101/199 (51\%) had ≥1 complication (medical and surgical) after discharge up to 1 year after surgery. Despite the importance of complications, several orthogeriatric studies,\textsuperscript{113,118,121} and cohort studies\textsuperscript{64-66} including old people with hip fractures, register only medical and surgical complications during acute hospital stays. Among team-based HR studies complications are also only sparsely reported after the initial hospital stay.

Furthermore, in the published literature complications have a range of definitions and the time points for reporting differ, making comparison difficult. A review by Goldhahn et al. concludes that there is a lack of homogeneity among orthopedic clinical trials when complications are reported. They suggest that complications should be defined prior to start of any study, assessment should be blinded, the complications monitored by an independent data review board and the observation time should be standardized.\textsuperscript{68} Complications in studies 1 and 2 were predefined, but assessment of complications was not blinded and there was no independent monitoring. More recently, a recommendation on how to
report orthogeriatric care models has been published, covering definitions of complications, which to include and time points of assessment. All the complications recommended in this report, apart from renal failure and adverse drug reactions, were included in studies 1 and 2, although the definitions of complications and the time point for assessment did not comply with the recommendations in all aspects.

Infections, cardiovascular events and decubital ulcers were the most common complications, after discharge up to the 1-year follow-up, found in studies 1 and 2, when medical and surgical complications were included. A cohort study by Hansson et al. reports general complications up to 6 months after fracture, describing new falls, pneumonia and new fractures as being the most common. Another cohort study by Flikweert et al. reports that 75% of patients suffered ≥1 complication up to 6 months after fracture, and describes delirium, pneumonia and heart failure as the most frequent complications. Both of these studies include complications during hospital stay and the reporting of complications is inconsistent.

One team-based HR study by Tinetti et al. reports pain related to exercising during the 6 months of follow-up, though no significant differences between intervention and control groups was seen. Pain was not reported as a complication in our study, even though it is common among people who have suffered a hip fracture. The intervention group in study 2 had a tendency towards more complications, but it was not significant. The low power concerning complications in study 2 means that the results must be interpreted with caution.

As a result of increasing healthcare costs and changes in healthcare payment systems complications have attracted increasing interest in the United States and the United Kingdom. Large cohort studies report complication rates up to 30 days after surgery of between 19-25%. Complications 30 days after surgery were not analyzed in studies 1 and 2. The findings in this thesis, and the reported association with both functional outcome and mortality, might imply that medical complications beyond the recommended 30 days after admission should be reported.

Readmissions

Study 1 confirms a high rate of readmissions among old people with hip fracture. During the 3-year follow-up 96 participants had 234 hospital admissions, a total of 3984 days were spent in hospital. The rate of readmissions was 62/185 (34%) in study 1 and 65/199 (33%) in study 2 within one year after fracture. This is comparable to a cohort study by Merchant et al. who present a readmission rate of 31.7%. There was a
higher proportion of readmissions in the GIHR than in the control group, 35.8% vs. 29.0%, but it did not reach significance. One explanation could be that those in the intervention group were frailer and suffered more complications leading to hospitalization.

Two previous team-based HR studies for older people with hip fracture evaluated readmissions after discharge. Crotty et al. report means of admissions, and Tinetti et al. have an admission rate of 11% vs. 13% in an intervention and a control group in a 6-month follow-up. However, people with cognitive impairment and those living in residential care facilities were not included in these studies, and the inconsistency in methods of reporting makes comparison difficult.

Early readmission within 30 days of discharge has become a measure of performance for hip fracture care. The 30-day readmission rate in study 2 was 16/199 (8%), similar to a recent review by Ali et al. who report a median all-cause 30-day readmission rate after hip fracture of 10.1% (range = 4.5–23.1%). These reported rates include both 30 days following the first admission, and 30 days following discharge to readmission. Ali et al. also describe patient-related risks factors for readmission, such as age, ASA grade, co-morbidities and functional status, as stronger risk factors than hospital-related factors. The majority of readmissions after hip fracture are for medical reasons. According to Ali et al., pneumonia, cardio-vascular disease, renal dysfunction and gastrointestinal disorder were the most common reasons for readmission, and the most common surgical reasons were infection, dislocation and fixation failure. Risk factors and reasons for readmissions have not been analyzed in studies 1 and 2.

Mortality

The high mortality after hip fracture is confirmed in study 1, which shows that 79/199 (40%) had died by the 3-year follow-up. The in-hospital mortality in study 1 was 7% (14/199), which is higher than reported in the Swedish national hip register. However, these data were retrieved from orthopedic wards with a much shorter mean LOS. The 30-day mortality rate in study 1 was 6% (13/199), similar to that in earlier orthogeriatric models reporting mortality 30 days after fracture. Adunsky et al. report a mortality rate of 1.9 at 30 days. We found a 1-year mortality rate of 17% (34/199) in study 1, which is comparable to previously published reports, but lower and higher rates are also reported (9.7%-29%). Compared to the results in study 2, one-year mortality is lower in earlier team-based HR studies for older people with hip fracture.
The inconsistency in mortality rates might be due to differences in LOS and in inclusion criteria for participation. The populations in studies 1 and 2 are presumably less healthy, with a poorer prognosis than those in studies which exclude people who have dementia/cognitive impairment or live in residential care facilities. Historically the LOS has decreased which might have resulted in lower in-hospital mortality rates in more recent studies due to a shorter observation time. In addition, differences between healthcare systems and the ability to transfer a person to end of life care in the community may also affect LOS and mortality rates. Therefore, a comparison of 30-day mortality is probably more relevant.\textsuperscript{185}

The causes of excess death have been the subject of debate. Vestergard et al. suggest that the increased mortality is associated with postoperative complications,\textsuperscript{85} while others ascribe it to prefracture co-morbidities together with postoperative complications\textsuperscript{65,78} and yet others suggest that the co-morbidities are the underlying cause.\textsuperscript{190} Previous research reports several risk factors associated with death, although differences in methodology have probably contributed to the deviating results. We found that both comorbidities and post-operative complications were of significance, a finding that is in line with a recent review using data from a National Trauma Data Bank in USA.\textsuperscript{64} A cohort study by Roche et al. reports that male gender, cancer, chest infection, cardiac failure and stroke are the strongest predictors for 1-year mortality, although they do not report dementia or functional levels.\textsuperscript{65} Dementia was included in our model, since it is common among old individuals with hip fracture.\textsuperscript{12} In another prospective database cohort study, Pugely et al. find that the risk factors for mortality are age, male gender, reduced functional status, an ASA class >3, and cancer.\textsuperscript{191} These findings are only partly consistent with our findings. However, they included only baseline characteristics in their multivariate model and not complications as we did.

In a recent study that examines post-mortem reports in people with hip fracture, respiratory infections and cardiovascular disease, are the main causes of death within 30 days after admission.\textsuperscript{88} These results are in line with earlier studies,\textsuperscript{85,86} and support the results of study 1, as 46 % (6/13) of early deaths were due to a cardiovascular event. Cardiovascular disease was the most common comorbidity and also a strong predictor of post-operative cardiac failure among people with hip fracture in a study by Roche et al.\textsuperscript{65} A large cohort study by Castronuovo et al.\textsuperscript{84} also cites heart disease as a risk factor for 30-day mortality. All participants in study 1 who died due to cardiovascular events during hospitalization, had a pre-fracture cardiovascular disease. This indicates that a hip fracture can destabilize an old individual with several co-morbidities thereby causing death. A prospective observational study by Juliebo et al. reports that treatment of cardiovascular disease among people with hip fracture is not
in accordance with current guidelines, thus, there might be room for improvement.\(^83\)

During follow-up cardiovascular events, dementia and cancer were the most common causes of death in study 1, which is partly consistent with earlier studies.\(^86,87,90\) The difference in the prevalence of infection as a cause of death might be due to how the causes of death were determined in study 1, (see method section). There might also be an under diagnosis of dementia among many old people,\(^192\) which could affect the assessment of the cause of death. Participants in study 1 were tested for cognitive impairment during hospitalization and at 4, 12 and 36 months, thus increasing diagnostic validity.

**Walking ability and LOS**

**Walking ability**

Participants in the GIHR and control groups regained walking ability in both the short and long term in a similar way. Furthermore, no significant differences in walking ability, use of walking devices and gait speed were found when comparing participants in the intervention and control groups at follow-ups in study 2. In contrast, significant effects on walking ability are reported in three previous team-based HR studies for older people with hip fractures.\(^145,149,151\) However, the populations differed as mentioned previously, that is, individuals living in residential care facilities and those with severe co-morbidities were not included, individuals living alone\(^151\) and those with severe,\(^145\) and moderate\(^149\) cognitive impairment were also excluded.

Despite the positive effects on walking ability reported, Kuisma et al.\(^151\) conclude that neither of the groups reached prefracture level and Ziden et al. report that only 29% vs. 9% in the groups thought that they had fully recovered.\(^145\) The decline in walking ability after hip fracture is confirmed in study 1 and 2, as only 57% regained or improved their walking ability by the 12-month follow-up compared to their prefracture status, according to S-COVs. This is consistent with previous studies.\(^22,23\)

One reason why the effect on walking ability was similar in the GIHR and control groups might be that both groups received a multifactorial, multidisciplinary intervention program while in hospital. Compared to standard care, this intervention was successful in reducing postoperative complications, reducing LOS, and improving mobility and performance of ADL, both in the short and long term.\(^111,137\) In addition, the program was particularly successful in people with dementia.\(^193\) Other explanations for the lack of differences might be that the control group seems to have had
more PT and OT interventions than the GIHR group during the year after discharge/end of GIHR. The intervention may not have been comprehensive enough or the time period long enough to have an effect on walking ability.194

The duration, frequency and intensity of exercise are important to achieve improvements in physical function according to Liu et al.195 A previous HR study had a number of home visits similar to that in study 2.148 In a study by Ziden et al. there was only one third as many home visits, yet they report significant improvements in independence, balance confidence, and physical activity in the HR group. One possible explanation might be that these participants had the ability to exercise on their own.145 Our clinical experience is that cognitively impaired individuals and those living in residential care facilities have limited ability to exercise without supervision. Another important aspect to consider is the effect of complications on functional outcome. Hansson et al. report that general complications during the 6 months after fracture correlate to loss of function.70 A trend towards more complications, falls and fractures in the intervention group in study 2 could have affected walking ability. The numerous complications after discharge might also explain the low rate of regained walking ability among people with hip fracture.

LOS

The participants in GIHR had a significantly shorter postoperative LOS. In contrast, the earlier team-based HR studies described in this thesis show no reduction in the LOS in hospital, apart from Crotty et al. who report a mean LOS of 7.8 days vs. 14.3 days in a control group.148 Different settings and concepts in the team-based HR studies included might explain this discrepancy. Reduced LOS may reflect improved clinical outcome, however, during the last few decades LOS has become shorter, mostly due to lack of hospital beds and shrinking resources.11 As a result, the concept of using intermediate forms of care such as community facilities, skilled nursing homes and home-based rehabilitation have evolved. Furthermore, previous level of function, in-hospital complications,66 as well as the local healthcare organization can also affect the LOS.196

A shorter LOS might not be beneficial for older individuals with hip fracture. A recent study presents an association between a LOS shorter than 10 days and increased mortality among those discharged to short-term nursing homes.197 However, a post-hoc analysis in study 2 shows no significant differences in 30-day or 1-year mortality, when comparing individuals living in residential care facilities to those in ordinary housing. There were only 12 individuals with a LOS shorter than 10 days in study 2, and none of them died during follow-up.
Ethical considerations

Medical research involving old individuals requires careful ethical consideration of whether the benefits outweigh the risks and burdens. A majority of the population sustaining hip fracture are old individuals with multiple comorbidities and many suffer from cognitive impairment. This group of people is less likely to receive rehabilitation following hip fracture, and their rehabilitation is shorter than that for older adults without dementia, although research indicates that they benefit from team rehabilitation. However, it is important to aim for evidence-based care for these individuals and they have been underrepresented in previous research. We considered it important to include these individuals, particularly as excluding them would also limit the external validity. GIHR can offer a task-specific training and individual support in the home environment, to help participants resume their pre-fracture activities. This might be especially valuable for people with dementia, e.g. Alzheimer’s disease because their ability to transfer skills is impaired and activities should be practiced in an environment that is similar to the one in which the skill will be used.

People with cognitive impairment have a higher risk of falling than those without cognitive impairment, and this was an ethical consideration when aiming at early discharge for participants in GIHR group. This could mean putting people with cognitive impairment at a higher risk of falling because they had less supervision? Another aspect to consider was whether an early discharge would put an extra burden on the next of kin. These issues were taken into consideration when planning for discharge, which included planning for care required at home.

Another ethical consideration in study 2 concerns the randomization; participants with cervical fractures were randomized before they had consented to participate for logistical reasons. However, the process of giving information and asking for consent was the same for all participants and it was emphasized that they could withdraw at any time without prejudice. Furthermore, all participants in the two intervention studies in this thesis were given oral and written information, and in those cases where the participants could not provide consent the next of kin were asked. All participants were informed that they could withdraw from the study at any time or stop an assessment. The assessors were experienced in assessing old people with cognitive impairment and were also sensitive to signs of discomfort or fatigue. Detection of medical issues during data collection in control groups was also an ethical consideration, however, all participants with medical problems were recommended to contact the appropriate healthcare service. Furthermore, the control group in study 2 did not receive rehabilitation at the geriatric out-patient clinic until 3 months after the fracture. This was done to minimize the
confounding effects at the 3-month follow-up. The second study in this thesis was registered at Current Controlled Trials to improve transparency in conduct and reporting, and to reduce the risk of bias.

Methodological considerations

The major strength of studies 1 and 2 is the design, a randomized controlled study including a sealed randomization and an intention-to-treat analysis. Furthermore, only a small proportion of those eligible declined to participate in the studies. Incorporating people living in nursing homes and individuals with cognitive impairment/dementia in both study 1 and 2 improved the generalization of results. Another strength of our studies is that all complications were systematically analyzed. A protocol with definitions of each variable was drawn up prior to the chart review. The detailed medical information retrieved and the systematic analysis of the causes of death were another strength. In addition, all assessors in study 2 were blinded to group allocation. The fall definition used in this thesis is consistent with the recommended definition by The Prevention of Falls Network Europe Consensus.203

This study has some limitations, assessors were not blinded as to group allocation in the first study, or in hospital or during home visits. In order to reduce assessor bias the assessments in the intervention group were made by a nurse from the orthopedic unit and the assessments in control group were carried out by a nurse from the geriatric unit. The geriatricians working on the ward in the second study were occasionally responsible for both the intervention and control groups and, since they are responsible for discharges, this might unintentionally have influenced the LOS. One specialist in geriatric medicine who was not blinded to allocation, assessed all complication data retrospectively in both studies, which could have led to bias and also to a limited ability to ensure the accuracy of some of the diagnoses. For logistic reasons a selection bias became unavoidable in the second study, leading to the selection of individuals with pertrochanteric fractures needing a longer period of rehabilitation, presumably they were frailer. This reduces the external validity among the population of pertrochanteric fractures.

In studies 1 and 2, the ASA risk score was used to assess the participants’ general health before surgery. This tool is simple, easy, inexpensive, and used routinely in our hospital, although it includes subjective variables. In study 1 only three assessments were performed after discharge, during the 3-year follow-up, which undoubtedly led to complications being missed, even though the participants’ medical charts were thoroughly reviewed. In addition, the fall outcome in Papers I, II and IV was only registered at follow-ups and when reviewing the medical charts. Some falls might have been missed, though presumably none that resulted in a fracture which
would have called for a medical assessment. Even so, the number of vertebral and rib fractures was probably underestimated as people with such fractures do not always seek medical care. Today, the use of prospective daily calendars with monthly reporting is the recommended method for recording falls.\textsuperscript{203} This was not done in the studies in this thesis.

The number of outpatient rehabilitation periods were similar between the groups in study 1, however, more participants in the intervention group in study 1 were assigned to geriatric daytime rehabilitation care after discharge. The only data available in study 2 were the proportion of participants receiving an intervention from a PT or an OT after discharge from hospital/the end of GIHR. All fall-preventive interventions during follow-up might have affected the outcomes.

Causes of death were obtained from death certificates. A comparison of cause-of-death data over time and across countries should be undertaken with caution. Although the intention of the International Classification of Diseases is to provide a standard means of recording underlying causes of death, the rules for selecting the underlying cause of death have been re-evaluated and sometimes changed. Incorrect or incomplete death certificates, misinterpretations of the rules of the International Classification of Diseases for selection of the underlying cause, and variations in the use of coding categories for unknown and ill-defined causes might all occur, according to WHO. Another limitation is that no gait speed tests were carried out at baseline because the in-hospital assessments took place soon after the participants had fractured their hips. Moreover, gait speed tests were performed with the participant’s usual walking device, which may limit the ability to detect initial gait and mobility deficiencies and changes over time.\textsuperscript{204}

The sample size in study 1 was based on reduction of delirium, whereas in Paper I the power calculation was estimated retrospectively, based on fall assumptions. In study 2 the power calculation was based on assumed length of stay. The studies were not sufficiently powered to detect differences in low-incidence events, which increased the risk of making a Type 2 error, i.e. that there is a true difference that we cannot detect due to the smallness of the sample size. This must be considered when interpreting the results. Considering the age and morbidity of the participants, losses before follow-up were to be expected, which also resulted in missing values. No imputations were made in the statistical analyses. In Paper I, the Poisson regression model (Nbrfg) was used for fall analysis since it takes into account observation time and frequent fallers, and the selection of adjusting variables in the analysis was based on known associations to falls. The multivariate analysis in Paper II should be interpreted with caution as only one person had pulmonary
emboli and died soon after the fracture. The studies included in this thesis were single-center trials, which should be considered when generalizing the results.

It is not known what constitutes the optimal team-based HR model. The finding that there were no significant effects on outcomes, apart from a shorter LOS, in study 2, this calls for consideration. Perhaps the orthogeriatric care model in our study is of a higher quality than the average "usual care", reducing the possibility of finding any further benefit from GIHR. Another possible explanation lies in the study design; a longer and more comprehensive intervention might have yielded a better effect. A review by Littbrand et al. reported that, to have an effect on walking, exercise interventions among people with dementia should last for at least a few months, be task-specific and challenge an individual’s physical capacity.\textsuperscript{205}

The home-based team and the in-hospital orthogeriatric care model had different preconditions. A dedicated personnel on a ward, focusing on the care of older people, can precipitate learning and the development of skills and expertise according to Ellis et al.\textsuperscript{106} Furthermore, working closely together facilitates more efficient interdisciplinary team work and team building. A mobile team, in contrast, often faces difficulties when trying to modify the behavior of other health professionals involved in the care of the individual.\textsuperscript{106} In a study of the effectiveness of a geriatric consultation team, Allen et al. report that compliance with the recommendations made by the team is sometimes minimal.\textsuperscript{206} In line with this Ellis et al. report that the positive effects of CGA were seen in dedicated wards and not in mobile teams in hospital.\textsuperscript{106}

**Clinical implications**

Since an orthogeriatric care model based on CGA can reduce falls and complications during hospital stay,\textsuperscript{111,126} compared to usual care, it should be offered to all older people suffering a hip fracture. In line with current recommendations, it should become a part of standard care. Furthermore, this model of care focusing on preventing, identifying and treating complications could, with some modifications, probably be used in all departments treating the old and vulnerable.

It seems that GIHR is a complement to geriatric care and rehabilitation. Individuals with comorbidities, cognitive impairment and those living alone could participate in GIHR. The time spent in hospital could be reduced without any ensuing disadvantages, and walking ability could be regained to an extent comparable to those who received conventional care. Nevertheless, due to the low power of the study and a tendency for there to be more complications in the GIHR group, the results must be
interpreted with caution. In clinical practice, the GIHR team did not include participants from residential care facilities after the study ended. This decision is based on difficulties in interacting with staff leading to a lack of compliance with interventions recommended by the team.

Earlier research reports positive effects on fall prevention by using multifactorial interventions both in residential care facilities and in the community. However, the research into how to prevent falls among people with dementia/cognitive impairment is inadequate. In contrast, the in-hospital orthogeriatric care model presented in this thesis reduced falls among those with dementia by using CGA and a systematic prevention, detection and treatment of complications. Specific attention needs to be focused on precipitating factors, such as acute illness, urinary tract infections, acute drug side effects, and delirium, as well as on optimizing predisposing factors such as gait and balance; chronic diseases and a poor nutritional status should be heeded.

A large proportion of people with hip fractures are cognitively impaired, 32-50% in our studies, and they have a low threshold for developing delirium. Delirium can develop within a short period of time and can fluctuate over the course of the day. Probably the most successful approach to preventing falls among these frail individuals is a sound understanding of delirium, the use of hip protectors where suitable and adequate supervision.

Furthermore, considering that there is an under-treatment of osteoporosis, all clinicians meeting old individuals should be given further education regarding the risk factors for fractures. Looking to the future, the expected increase in the population of frail, old individuals, the reduction in the number of hospital beds and the limiting of access to residential care facilities, are bound to increase the incidence of falls and fractures. This situation can only be counteracted by putting in place interventions that adhere to guidelines and recommendations and by the provision of skilful personnel in care facilities and in social home services.

**Implications for future research**

The studies reported in this thesis confirm the high risk of falling after hip fracture among older individuals, and also the occurrence of numerous complications after discharge. Considering that common complications, such as delirium, infections and aggravations of chronic diseases, such as cardiac failure, can cause falls and fractures, these should be the focus of future research. Fall prevention has to become a part of everyday care for frail, old individuals for it to be effective over time, and all personnel and next of kin living or working close to these individuals need to be
educated and informed about fall prevention. As many individuals with hip fracture need assistance in their daily life, future interventions among relatives, staff in social services working in the individual’s home and in residential care facilities, might be relevant. High quality methodological studies are needed in future research, including a representative hip fracture population, in order to find fall-preventive strategies that are effective over time. In addition, fragility fracture services need to be developed and evaluated in future research.

In the future, the role of the geriatric team might be to collaborate with a variety of specialists, since old individuals with several comorbidities and highly complex circumstances will form a majority in the hospitals. They will need a geriatric assessment to optimize care and outcome. The co-managed care model is unlikely to cause harm to anyone and might become a standard concept in the care of frail, old individuals. This also calls for more clinical research.

In the literature, the designs of orthogeriatric care models differ; they vary with respect to concepts of co-management, inclusion criteria, outcome variables, time points for evaluation and methods of assessment. The descriptions of the interventions are not always clear, and it may be unrealistic to provide explicit protocols. In more recent years, a standard set of outcome parameters has been identified, based on international guidelines and recommendations from an international expert group. Adherence to the recommendations will be important for future research as it will allow comparisons to be made between studies and results to be summarized.

Moreover, large RCTs with interdisciplinary HR, including the entire group of people with hip fracture, are needed to help clinicians to determine which subgroup benefits the most from GIHR. In a world with limited resources economic analyses should accorded high priority. Furthermore, investigating the participants’ quality of life and experiences of GIHR would also be of value.
GENERAL CONCLUSIONS

The orthogeriatric care model in this thesis successfully reduced in-hospital falls and complications, although it did not have a long-lasting effect on falls among older people with hip fracture, including people with cognitive impairment/dementia. Old people with femoral neck fracture have multiple comorbidities, suffer numerous falls and complications, and are frequently readmitted to hospital. Comorbidities at baseline and complications during hospitalization were associated with 3-year mortality.

For older people with hip fractures, GIHR seems to complement conventional geriatric care and rehabilitation. Individuals with serious medical conditions, cognitive impairment and those living alone could receive GIHR. Participants in GIHR and those receiving conventional geriatric care regained their walking ability in the short- and long-term to a similar extent. The proportion of complications after discharge was no higher for those in GIHR, even though the initial time they spent in hospital was shorter. The results confirm that there is a deterioration in walking ability after hip fracture. It seems that the prevention of falls and complications has to be a part of everyday life in older people. This thesis suggests that primary and secondary prevention of falls and fractures needs to become a part of routine care.
ACKNOWLEDGEMENTS

I am finally here! I wish to take the opportunity to extend my gratitude to all who has contributed to this thesis in various ways. Thanks to you all it was possible for me to complete this work.

This work was carried out at the Department of Community Medicine and Rehabilitation, Geriatric Medicine, Umeå University.

My special gratitude goes to:

Yngve Gustafson, my supervisor, for valuable advice and unfailing support, for not giving up on me! Your passion for research into old people are inspirational. Thank you for giving me the opportunity to carry through my studies these years.

Michael Stenvall, my co-supervisor, for your support and advice, always listening and patient, pointing in the right direction, for discussions about life and being a friend.

Birgitta Olofsson, my co-supervisor, for excellent support and advice, encouragement to reach the final and being a friend.

Åsa Karlsson, my co-author, for support and advice, always a smile, and for being a friend.

Nina Lindelöf and Peter Nordström, my co-authors, for superb advice and guidance.

Undis Englund, my friend and co-author, for encouragement and support, thank you for believing in me, and for providing excellent working conditions.

Maria Lundström, for cooperation and useful opinions.

Henrik Holmberg, Annika Toots and Bodil Wiedung, for a great support and help in statistical analysis.

Chatarina Carlen, for assistance and support with practical matters.

Karina Sjögren and Elisabeth Johansson, for valuable advice and help with references.
All the participants and staff at the Orthopedic and Geriatric departments at the University Hospital in Umeå for their cooperation and participation. All the wonderful personal at the Ward 4, who took part in development, implementation and the ongoing work with the orthogeriatric care model and the Geriatric interdisciplinary home rehabilitation team. Börje Hermansson, for inspiring me to become a Geriatrician. Anita Persson, for support and engagement.

My colleagues and friends at the Department of Geriatric Medicine and at Geriatric Centre in Umeå, for valuable seminars, a pleasant working atmosphere and support in my work.

Patricia Shrimpton, for excellent language revision.

Larry Fredriksson, for fantastic computer support.

My family and friends, for making the world brighter.

Per, you are the love of my life, thank you for just being you! Andre, Caroline and Sandra, you are the best!

This work was supported by the the Vårdal Foundation, the Joint Committee of the Northern Health Region of Sweden (Visare Norr), the JC Kempe Memorial Foundation, the Foundation of the Medical Faculty, the Borgerskapet of Umeå Research Foundation, the Arneska Foundation, University of Umeå and the County Council of Västerbotten (“Dagmar”, “FoU”, and “Äldre Centrum Västerbotten”), the Swedish Research Council, Grant 2005/D1255-V and grant K 2014-99X-22610-01-6, the Strategic Research Programme in Care Sciences, Sweden, the Umeå University Foundations for Medical Research; Umeå University (ALF) and The Swedish Dementia Foundation.
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PAPERS I-IV