Discussion, Perspective and Summary
The optimization of care for patients with a hip fracture is a current topic in the Dutch health care system.

Over the last few years various developments have occurred in the sphere of action to improve care for the elderly. In 2010 the Royal Dutch Medical Association (KNMG) published the document Care for Vulnerable Elderly Patients (2010) containing recommendations for the 1st and 2nd line. Over the last few years the Health Care Inspectorate (IGZ - Inspectie Gezondheidszorg) has implemented various performance and process indicators for the treatment of patients with a hip fracture. To support clinical decision-making and better care, more transparency and less unwanted practice variation, reviewed Directive proximal femur fracture [1] and Directive multidisciplinary treatment of vulnerable elderly patients regarding surgical procedures were introduced in 2016 [2].

In 2008 the trauma surgeons of Hospital Group Twente (ZGT - Ziekenhuisgroep Twente) anticipated these developments by establishing the Center for Geriatric Traumatology (CvGT - Centrum voor Geriatrische Traumatologie) and implementing the integrated orthogeriatric treatment model. Since the introduction of the treatment model, data registration has occurred for benchmarking, policy problems and scientific research.

Our study into the effectiveness of the integrated orthogeriatric treatment model has been proven to contribute to improved treatment results in the short term and a significant decrease in mortality during the 1st year after a hip fracture. The research described in this study distinguishes itself from previous studies into the effectiveness of integrated orthogeriatric treatment by the size of the study population, the use of verified scoring systems, measuring instruments and definitions, limiting bias and enhancing evidential value (Chapter 8).

To improve the treatment of patients with a hip fracture, it is clinically relevant to be aware of the risk factors affecting the 1-year mortality. The literature frequently describes the male gender, age, health status measured by the ASA and functional restrictions as independent risk factors [3-7]. In addition, we also identified a higher Charlson Comorbidity index, vulnerable due to malnourishment, vulnerable due to physical limitations and a lower Barthel index as independent risk factors for 1-year mortality (Chapter 8). Knowledge of this contributes to the awareness of practitioners that vulnerable elderly patients with a hip fracture run an increased risk of a complicated course and death, and proactively require extra attention by taking preventative measures (Chapter 5).

The international literature deems early preoperative notification of vulnerability increasingly important for surgical procedures [8-12]. This aspect also comes to the fore in recent Directive multidisciplinary treatment of vulnerable elderly patients regarding surgical procedures (2016). Various systems are in use worldwide to score vulnerability. Dutch
hospitals have been using the Safety Management System (VMS - VeiligheidsManagement Systeem) scoring system Vulnerable elderly patients since 2012 [13]. This enables predicting variance in a patient group and not on an individual patient level. In view of the importance of early preoperative notification of patients with an increased risk of complications and death, the risk stratification must be used. After external verification, a prediction model like the Almelo Hip Fracture Score could be helpful for this (Chapter 7).

In the continuous striving to improve the quality of care at the CvGT, data monitoring of treatment results and the treatment process occurs. Evaluation showed that the results of the treatment of vulnerable patients could be improved by putting even more emphasis on preventing delirium, catheter-associated urinary tract infections and pneumonias (Chapter 3 and Chapter 5). Caring for vulnerable elderly patients includes opportunities for the nursing discipline to demonstrate leadership in these three areas of interest [14-21]. The international literature describes favorable effects of these nurse-led quality courses through a decrease in care-related complications [22].

Practitioners’ awareness of early notification of vulnerability and proactive action are key concepts for the integrated orthogeriatric treatment of patients with a hip fracture. However, in view of the different care requirements, in this thesis we also noted that not all patients with a hip fracture required the same extent of integrated orthogeriatric care (Chapters 5 and 7). These patients also received intensive treatment, however without any harmful consequences. In order to contribute to efficient use of orthogeriatric care in hospitals, we believe a prediction model should be developed as a triage instrument in combination with integrated orthogeriatric care (Chapters 7 and 8).

**Perspective and Additional Research**
Evaluating the health care chain is essential for hip fracture care, particularly the role played by the various chains involved in treating the elderly.

Most elderly people live at home and wish to continue living at home for as long as they can. In his role as director of the elderly persons, the general practitioner will have to know whether his patient is vulnerable and in what area. Information from the district nurse and/or nurse practitioner (NP) is often used for this, at times supported by a vulnerability scoring system. A limiting factor for this is the lack of a uniform definition for vulnerability [13].

Daily practice shows enormous variation in the way a patient with a possible hip fracture is referred from the 1st line to the Emergency Ward (ER). A quality check can be made here. In view of the importance of early notification of high-risk patients, the ER practitioners must be notified of the patient’s vulnerability and points of interest over the phone [23]. Both the physician and nurses are more aware of the patient’s arrival, which is a trigger for anticipatory action.
Triage nurses at doctor’s surgeries, ambulance services and ER wards use the Netherlands Triage System (NTS) to determine the urgency of treating patients [24]. It is striking that elderly patients are often under-triaged in the NTS due to a lack of symptoms despite a serious condition next to the fracture. This results in a low treatment urgency, causing the elderly patient to unwantedly remain at an ER ward for a longer period of time. To improve triage of elderly patients in the future, the NTS must be expanded with an Elderly patient category, so timely proactive treatment is started for high-risk patients. Because not all patients require the same extent of integrated orthogeriatric treatment, for efficient use, any future research must be aimed at developing a risk stratification instrument with a care pathway.

**During hospital admission**
Improving the quality of care for elderly patients with a hip fracture requires the implementation of an orthogeriatric treatment model (Chapter 8). A business plan must be used for a structured approach, whereby medical leadership plays an important part in supporting decision-making. Prior to the implementation, agreements must be made between the specialties of geriatrics and trauma surgery/orthopedics regarding everyone’s role, assignment of tasks and responsibilities. Alignment regarding diagnostics to prevent over- or underdiagnosis, forming a multidisciplinary team, defining evidence-based care pathways and work agreements with various departments regarding the treatment process (e.g. clustering patients) are important. Prior to starting, a description of the current situation with the turnaround times and treatment results of the treatment process is required.

In the often complex treatment of vulnerable elderly patients with a hip fracture, nurse practitioner (NP) or physician assistants (PA) play an increasingly important role. In the integrated treatment model, the NP/PA acts as case manager of the individual patient and as director of the patient flow, striving for made-to-measure care for the patient. They have specific knowledge of orthogeriatric treatment, treatment standards and are a continuous factor in the multidisciplinary team. The NP/PA has strong communicative skills and deliberates with the patient, family and the different disciplines about the treatment goals within the chain of care, demonstrates leadership and supports/conducts practical research, maintains care pathways and training of professionals. In addition the NP/PA monitors quality of care within the treatment process [25, 26].

Admission stops and bed reductions are threats to this vulnerable patient group when admitted to other nursing wards [2]. In order to guarantee qualitative integrated care, it is important for patient clustering to occur due to the specific knowledge and skills of the multidisciplinary team. This requires management support by labeling beds, sufficient expert staff capacity and budget to train professionals. After treating the hip fracture, follow-up care is arranged by the transfer nurse based on the patient’s individual needs.
Follow-up treatment

Evaluation of the health care chain of our patient flows showed insufficient connection to follow-up care was present.

This caused approximately half of the patients to wait for geriatric rehabilitation after hip fracture treatment. In the literature the fact that geriatric rehabilitation beds are not available in time is described as unfavorable for the recovery of vulnerable elderly patients with a hip fracture and results in extra health care costs due to extended hospital stays and more admissions to nursing homes for long-term care [27-28]. In addition, our study results showed that seniors over 80 had significantly lower odds of returning to their original environment (within three months) than younger patients. Aging will cause the proportion of seniors over 80 to increase, meaning this aspect must be taken into account when arranging follow-up care (Chapter 6).

This provides opportunities to improve the performance of the health care chain. In order to optimize the turnaround times and outflow issues in both the hospital and nursing homes, the collaboration between the partners of the chain must be intensified, as well as the roll-out of the multidisciplinary care pathway within the nursing homes [29]. By continuing protocolled evidence-based standards of care, the recovery in both the physical and psychological areas are supported during rehabilitation. The use of a care pathway also contributes to optimizing the inflow and flow-through of patients coupled with a decrease in health care costs [30-32]. This is important since the costs of geriatric rehabilitation amount to half of the total cost of hip fracture treatment [33]. By optimizing the health care chain, a contribution is made to qualitative care on the one hand and the manageability of health care costs in the Dutch health care system on the other.

The extent of functional recovery during the entire health care chain process is the next aspect we would like to focus on at the CvGT. Monitoring, where possible supported by technology, is essential in gaining more insight into the duration, intensity and effect of geriatric rehabilitation at discharge to the original environment for the various patient groups. Home rehabilitation could possibly be an alternative for certain patient groups. Home rehabilitation is applied in different countries [34-36]. From a patient’s perspective this is also an important aspect. However, in 2014 the Social Planning Agency (SPB - Sociaal Plan Bureau) reported that one in five elderly persons does not have a social network to offer support [37]. The government is counting on the ability to live independently. Research is required to check if this is feasible for this vulnerable patient group. Hereby the fact that the moral appeal made by the government and organizations on the use of informal care can also interfere with valuable relationships. From a social viewpoint everyone should think about how each person regards his life when he becomes more vulnerable and older and is even co-responsible for his care [38].
In the continuous striving to improve quality of care, the CvGT can be considered a learning health care system. The use of data registration and monitoring contributes to continuous evaluation of the quality of care provided to its patients. Quality registration systems have been used abroad for some time, not only on an organizational level, but also on a national level [39-42]. Now that more results of integrated orthogeriatric care are becoming available, national follow-up is important. An instrument for this is the recently started audit system called the “Dutch Hip Fracture Audit” [43]. It provides short-term opportunities to conduct benchmarking into various aspects of hip fracture (follow-up) treatment within the Dutch health care system, with a purpose to further improve the quality of care for patients with a hip fracture, both on an organizational and a national level in the health care chain.
Summary

Introduction
Chapter 1 describes the epidemiology of hip fractures.

The treatment of this patient group is complex because approximately three-quarters of them have an unfavorable profile, meaning they are more vulnerable than patients without a hip fracture [11, 44-46]. The consequences for the patient’s quality of life are discussed, as well as the social and economic consequences.

The last few decades have shown an increasing amount of interest in evidence-based treatment strategies to improve the outcome of treating patients with a hip fracture. Mundi et al (2014) concluded that so far its implementation has not resulted in a significant decrease in mortality for patients with hip fractures.

The history of geriatric co-treatment with surgeons/orthopedists and the development of orthogeriatric treatment models is discussed. The literature distinguishes between three groups of models; Model 1: the geriatric liaison model: geriatric consultation at a surgical ward, Model 2: postoperative transfer to a geriatric ward with rehabilitation option, and Model 3: the integrated (shared or co-managed care) model, where both specialties (geriatrician and surgeon) share responsibility for the treatment.

To improve the treatment and logistics of the treatment process for elderly patients with a hip fracture, the Center for Geriatric Traumatology was established in Hospital Group Twente (ZGT). From the day of admission, the integrated orthogeriatric treatment model is used, with intensive geriatric co-treatment in a multidisciplinary team by applying clinical pathways (Model 3).

The international literature on the effectiveness of the various treatment models compared to standard care on the treatment results after a hip fracture are presented. The majority of the studies show a favorable effect of the application of orthogeriatric treatment models for both patient, health care institution and health care system. It is striking that Model 1 is the most (n=9) studied for effectiveness on 1-year mortality and Model 3 the least (n=3).

The purpose of this thesis is to conduct research into the effectiveness of the integrated orthogeriatric treatment model of the CvGT on 1-year mortality after a hip fracture within a Dutch health care system.

Short-term effect of integrated orthogeriatric treatment
Chapter 2 describes the study results of two studies regarding the short-term results after implementation of the integrated orthogeriatric treatment model at Hospital Group Twente (ZGT). A retrospective comparison is made of two groups of patients, where one group is treated according to the new, integrated treatment model (intervention group), and the historical control group where treatment occurs using the regular method.
The first study showed the median duration of hospital stay was one day longer than with the implementation of the new treatment model. The patients from the intervention group developed less complications, the hospital mortality decreased and less consultations with other specialties per patient were required compared to patients from the regular health care group. Delirium was diagnosed significantly more often in the intervention group. Significantly more patients rehabilitated in the nursing home compared to the period before the implementation. In the intervention group the number of readmissions within 30 days decreased significantly compared to the control group. The second study differed from the first due to larger study populations. After the integrated orthogeriatric treatment, a favorable effect was noted on the duration of admission, whereby in the intervention group this was shortened by one day (median) compared to the period before implementation.

In conclusion, it appears that integrated orthogeriatric treatment leads to better short-term results for elderly patients with a hip fracture.

**Geriatric co-treatment**

Chapter 3 displays the results of the descriptive study (prospective) regarding the recommendations and interventions during geriatric co-treatment in the integrated treatment model. It included 106 patients, 85 of which had a hip fracture and 21 a vertebral fracture. It investigated patient characteristics, Charlson Comorbidity Index (CCI), time of the first consultation, geriatric recommendations and interventions, as well as the number of complications, deaths and the number of readmissions within 30 days. 94% of patients had one or more chronic disorders with a median CCI score of 3 at the time of admission. In over three-quarters of patients the first consultation occurred on the day of admission, 92% of which preoperatively. 431 recommendations were made, 59% of which medication-related. The other recommendations and interventions related to additional diagnostics, treatment and consultation requests. 57% of the patients had an uncomplicated course. Four patients died (4%) during admission and one patient (1%) was readmitted within 30 days.

Due to the lack of specific knowledge from trauma surgery/orthopedic practitioners regarding the influence of comorbidity, polypharmacy, vulnerability and their mutual connection to the treatment, we concluded that geriatric co-treatment has added value.

**Conservative treatment of thoracolumbar vertebral fracture**

Chapter 4 presents the study results of the prospective study at the CvGT into the effect of conservative treatment of patients with a thoracolumbar vertebral fracture on the functional recovery. 106 patients with 143 diagnosed vertebral fractures were included. Evaluation of 61 patients occurred after three months.

Fifty three percent (53%) of patients had a vertebral fracture involving the anterior and central column. In over half of the patients, the prescribed bed rest resulted in a complication,
which is why mobilization was started early. It was striking that patients prescribed early mobilization, developed no new complications or neurological damage.

Three months after admission, the majority of patients had recovered and were able to perform all activities from before the fracture. “Aged under 80” was identified as an independent predictor for good functional recovery within six weeks after admission. In addition, the level of functioning within six weeks was an independent predictor for the level of functioning after three months. No differences were noted in functional recovery between patients who were mobilized early and patients treated with bed rest.

We concluded that in the future, performing both CT diagnostics and the treatment strategy for elderly patients with a thoracolumbar vertebral fracture of the anterior and central column should possibly be reconsidered, whereby bed rest could be replaced with early mobilization.

Complications during hospitalization and risk factors.

Evaluation of the quality of care by means of continuously monitoring treatment results is a standard part of the process at the Center for Geriatric Traumatology. Insight into recovery offers opportunities for further optimization. The results of the prospective study on 452 patients with a hip fracture are presented in Chapter 5. Based on the ASA score, the study population was divided into high risk (HR, ASA ≥3, n=341) and low risk (LR, ASA 1-2, n=111) and compared on their recovery.

49.6% (n=224) of patients experienced a complicated course and the in-hospital mortality was 3.8% (n=17). 57.5% (n=196) of HR patients experienced a complicated course, and the same was true for 25.2% (n=28) of the LR group. The most frequent complications in both groups were delirium (HR 25.8% vs. LR 8.1%, p=<0.001), anemia (HR 19.4% vs. LR 6.3%, p=0.001), catheter-associated urinary tract infections (HR 10.6% vs. LR 7.2%, p=0.301) and pneumonia (HR 10.9% vs. LR 5.4%, p=0.089). Independent risk factors for a complicated course included age (OR (odds ratio) 1.04, 95% CI (confidence interval) 1.01-1.07, p=0.023), delirium VMS Frailty score (OR 1.57, 95% CI 1.04-2.37, p=0.031) and ASA score ≥3 (OR 3.62, 95% CI 2.22-5.91, p=<0.001).

We concluded that at admission, practitioners were aware of the high risk of a complicated course in this vulnerable patient group. The treatment results can be optimized by putting more emphasis on preventive measures to prevent delirium and care-related infections, such as catheter-associated infections and pneumonia.

Patients with a hip fracture returning to their own environment after geriatric rehabilitation

Retrospective research into the recovery of 95 patients with a hip fracture occurred in cooperation with three nursing homes in our health care district. We examined which patients could be discharged to their original environment within three months after geriatric rehabilitation and which predictive factors played a role in this (Chapter 6).
During the rehabilitation period, 44% of patients had a complicated course and 7% died. Within three months, 63% of patients had recovered sufficiently to be discharged to their original environment.

“Aged 80 and over” turned out to be an independent negative predictor. The odds of returning to the living situation from before incurring the fracture decreased 6.8 times compared to the group of patients under the age of 80. On the other hand, a positive relation was noted for “Living independently without assistance”.

**Prediction model early mortality: the Almelo Hip Fracture Score**

Chapter 7 describes how the preoperative identification of patients with a hip fracture and an increased risk of 30-day mortality could be improved by using a simple prediction model. The literature shows that the Nottingham Hip Fracture Score (NHFS) is the most suitable for that.

A cohort study was performed over a period of 5.5 years on 850 patients. The NHFS was amended by replacing the “Abbreviated Mental Test Score” (AMTS) with “Presence of cognitive disorders” (NHFS-a). The patients, who died within 30 days after a hip fracture, were compared to the survivors. A higher NHFS-a and American Society of Anesthesiologists (ASA) score and a Parker Mobility Score of 5 or lower were identified as independent risk factors for 30-day mortality. This was used to develop a new prediction model for vulnerable elderly patients; the Almelo Hip Fracture Score (AHFS). Both scores were applied and compared for accuracy and discriminatory power.

Thirty days after the hip fracture, 7.5% of the patients had died. The AHFS predicted the 30-day mortality significantly better than the NHFS-a. By using cut-off points of the AHFS (≤9 and ≥13), patients were classified in a low, moderate and high-risk group at 30-day mortality. The area under the curve (AUC) improved when using the AHFS (AHFS 0.82 vs. NHFS-a 0.72). Based on our findings, the conclusion that the AHFS accurately identifies preoperatively vulnerable elderly patients with a high risk of 30-day mortality after a hip fracture seems justified.

**Effect integrated orthogeriatric treatment model on recovery up to one year after hip fracture**

Chapter 8 shows the results of the study into the effectiveness of the integrated orthogeriatric treatment model vs. regular care at 1-year mortality after having a hip fracture. As of April 2008 through October 2013, 850 patients (CvGT group) were included. The treatment results were compared to a historic control group of 535 patients after regular care (October 2002 through April 2008).

During admission CvGT patients developed significantly less complications (53.4% vs. 66.9%), the in-hospital mortality (4.4% vs. 6.2%) and 30-day mortality (7.5% vs. 10.3%)
decreased after integrated orthogeriatric treatment compared to the regular care group.
The incidence rate of 1-year mortality in the CvGT group was 23.1% vs. 35.1% in the regular care group.

Male gender, a higher American Society of Anesthesiologists (ASA) score and Charlson Comorbidity Index (CCI), vulnerable due to malnourishment, vulnerable due to physical restrictions in daily activities and a preoperatively lower Barthel Index were identified as independent risk factors for death within one year after a hip fracture.

We concluded that after integrated orthogeriatric treatment, there was a link between better treatment results in the short and longer term for elderly patients with a hip fracture.
Discussion, Perspective and Summary

Literature

42. http://rikshof.se.
44. https://www.dica.nl/dhfa/home.
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