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PÄRT PROMMIK

Hip fracture rehabilitation during 2009–2017 in Estonia

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UNIVERSITY OF TARTU
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Institute of Sport Sciences and Physiotherapy and Department of Traumatology and Orthopaedics, Institute of Clinical Medicine, Faculty of Medicine, University of Tartu, Tartu, Estonia

The dissertation was accepted for the commencement of the degree of Doctor of Philosophy in Exercise and Sport Sciences on 30th August 2021 by the Institute Council of the Institute of Sport Sciences and Physiotherapy, Faculty of Medicine, University of Tartu, Tartu, Estonia.

Supervisors: Associate Professor Helgi Kolk, MD, PhD
Department of Traumatology and Orthopaedics, Institute of Clinical Medicine, University of Tartu, Tartu, Estonia

Professor Aare Märtson, MD, PhD
Department of Traumatology and Orthopaedics, Institute of Clinical Medicine, University of Tartu, Tartu, Estonia

Professor Mati Pääsuke, PhD
Department of Exercise Biology, Institute of Sport Sciences and Physiotherapy, University of Tartu, Tartu, Estonia

Opponent: Professor Morten Tange Kristensen, PT, PhD
Department of Physical and Occupational Therapy, Copenhagen University Hospital, Bispebjerg-Frederiksberg & Department of Clinical Medicine, University of Copenhagen, Denmark

Commencement: 4th November 2021

Publication of this dissertation is granted by the University of Tartu.

This study was supported by the Estonian Research Council and by the European Union through the through the European Regional Development Fund and through the Seventh Framework Programme.

European Union
European Regional
Development Fund

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ISSN 1406-1058
ISBN 978-9949-03-698-1 (print)
ISBN 978-9949-03-699-8 (pdf)

University of Tartu Press
www.tyk.ee

To my family and mentors

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

The thesis is based on the following original publications, and their reference is quoted in the text by the Roman numerals (I–IV):

I Prommik, P., Kolk, H., Sarap, P., Puuorg, E., Harak, E., Kukner, A., Pääsuke, M., & Märtson, A. (2019). Estonian hip fracture data from 2009 to 2017: high rates of non-operative management and high 1-year mortality. *Acta Orthopaedica*, 90(2), 159–164. https://doi.org/10.1080/17453674.2018.1562816

II Prommik, P., Kolk, H., Maiväli, Ü., Pääsuke, M., & Märtson, A. (2020). High variability in hip fracture post-acute care and dementia patients having worse chances of receiving rehabilitation: an analysis of population-based data from Estonia. *European Geriatric Medicine*, 11(4), 581–601. https://doi.org/10.1007/s41999-020-00348-5

III Prommik, P., Maiväli, Ü., Kolk, H., & Märtson, A. (2021). Causal variation modelling identifies large inter- and intra-regional disparities in physical therapy offered to hip fracture patients in Estonia. *Disability and Rehabilitation*. https://doi.org/10.1080/09638288.2021.1918772

IV Prommik, P., Tootsi, K., Saluse, T., Märtson, A., & Kolk, H. (2021). Non-operative hip fracture management practices and patient survival compared to surgical care: an analysis of Estonian population-wide data. *Archives of Osteoporosis*, 16:101. https://doi.org/10.1007/s11657-021-00973-y

Author's contribution:
Papers I–IV: P. Prommik was involved in conceptualising and the study designing, the data acquisition, analysis, interpretation, and writing the papers.

ABBREVIATIONS

CCI	Charlson Comorbidity Index
CI	confidence/credible interval
EHIF	Estonian Health Insurance Fund
h/w	hours per week
HF	hip fracture
LOS	hospital length of stay
ICD-10	International Classification of Diseases, 10th revision
NCSP	Nordic Medico-Statistical Committee's Classification of Surgical Procedures
NOMESCO	Nordic Medico-Statistical Committee
PACS	picture archiving and communication system
PT	physical therapy
PTi	physical therapy intensity

SYNONYMS

Although rehabilitation has a more general meaning than physical therapy, these terms are often used as synonyms when speaking about hip fracture care.

1. INTRODUCTION

The steadily ageing global population is leading to a fragility fracture crisis, deepening the already profound, unmet needs of rehabilitation across the world (The World Health Organization 2017; Dreinhöfer et al. 2018; Kamenov et al. 2019). In order to improve policymaking and clinical practice, high-quality systems-level research targeted at distinct patient groups is needed (Bethge et al. 2014; Gutenbrunner et al. 2014; The World Health Organization 2017; Kamenov et al. 2019). Hip fracture (HF) is the most serious type of fragility fracture, which often leads to severe consequences (Kanis et al. 2013). The severe consequences of HF include death, debility, destitution and limited functional recovery, putting a great burden on the patients, their families, health systems, and society in general (Tajeu et al. 2014; Dyer et al. 2016; Sànchez-Riera and Wilson 2017).

HF management has a critical role in ensuring optimal recovery of this significant injury. It is based on three fundamental care pillars: acute multidisciplinary care, ongoing coordinated post-acute rehabilitation and rapid secondary prevention (Dreinhöfer et al. 2018). The foremost goal of rehabilitation is to regain a patient's independent mobility (Kristensen and Kehlet 2012; Dreinhöfer et al. 2018; Perracini et al. 2018). The recovery of HF is relatively long, taking months of ongoing well-coordinated rehabilitation (Magaziner et al. 2000; Dyer et al. 2016; Dreinhöfer et al. 2018; Perracini et al. 2018). Several interventions are recommended for HF rehabilitation: structured exercise, including high-intensity resistive strength, balance, weight-bearing and functional mobility training; multidisciplinary orthogeriatric program, including physical therapy (PT) and early mobilisation; extended rehabilitation; safe recommendations for maximising physical activity (Chartered Society of Physiotherapy 2018; McDonough et al. 2021). The use of upper-body aerobic training, electrical stimulation for quadriceps strengthening, or pain management may also be considered (McDonough et al. 2021). Although the fundamental role of rehabilitation is well established in HF care, the best strategy for optimal recovery remains unknown. For example, the optimal amount and duration of PT needed for recovery are unclear and scarcely described in the literature, indicating a need for further research (Weinrich et al. 2004; Chudyk et al. 2009; Handoll et al. 2011; The National Institute for Health and Care Excellence 2011; Dyer et al. 2016; McDonough et al. 2021).

In Estonia, around 1300–1500 patients suffer from HF each year, and the societal cost per patient is approximately half of the European average (Jürisson et al. 2015; Laius et al. 2017). Literature on HF outcomes is limited to two studies in the case of Estonia. One of the studies reported one-year mortality as high as 28% (Jürisson et al. 2017a). The second study observed low pre- and post-fracture health-related quality of life estimates for community-dwelling and cognitively intact patients (Jürisson et al. 2016). Jürisson and colleagues (2016, 2017a) speculated that the poor outcomes might be explained by insufficient case management; however, there has been no detailed large-scale investigation of HF care and rehabilitation for Estonia. Furthermore, there is limited published literature on physical rehabilitation in Estonia in general. Two available studies on stroke and traumatic spinal cord injury patients also reported shortfalls in rehabilitation; however, none of them examined PT use or its provision in different care settings or its regional or temporal accessibility (Vibo et al. 2007; Kivisild et al. 2014).

In conclusion, long-term PT use after HF is unknown, and these patients' rehabilitation remains largely unexamined in Estonia. Therefore, the overall aim of this research was to evaluate index HF acute and post-acute management, its regional differences, and temporal trends in Estonia, focusing on rehabilitation in particular. Improved comprehension will enhance our understanding of HF rehabilitation, open new research avenues, update clinical practices and provide inputs for health policy-making in Estonia.

2. LITERATURE REVIEW

2.1. Hip fracture

Human health profile is changing in the world due to a demographic shift; – a steady ageing of the global population is witnessed. The proportion of the world's population over 60 years is expected to double between 2015 and 2050 (The World Health Organization 2018). The health profile change involves an increasing burden of noncommunicable diseases, particularly musculoskeletal conditions (Briggs and Dreinhöfer 2017). As a result, the world is confronted with an augmented number of health problems in the later years of life. A major epidemic problem the world is facing is fragility fractures, incidence of which is expected to grow enormously (Mears and Kates 2015; Dreinhöfer et al. 2018).

Fragility fractures are known as osteoporotic fractures (Sànchez-Riera and Wilson 2017). Osteoporosis is a systemic skeletal disease characterised by low bone mass and microarchitecture deterioration of bone tissue, resulting in increased bone fragility and susceptibility to fracture ("Consensus Development Conference", 1993). Common fragility fractures are hip, vertebral, forearm, proximal humerus, pelvis, rib, distal femur, proximal tibia and clavicle fractures (Schuit et al. 2004; Sànchez-Riera and Wilson 2017).

HF is a type of fragility fracture associated with the highest health burden and severe consequences (Sànchez-Riera and Wilson 2017). HF is anatomically classified in relation to the capsule as intracapsular and extracapsular fractures, covering proximal femur as follows: subcapital to basicervical (femoral neck), from basicervical to lesser trochanter (pertrochanteric, also referred as trochanteric, intertrochanteric or transtrochanteric), and up to 5 centimetres distally from lesser trochanter (subtrochanteric) (Figure 1) (Parker and Johansen 2006; Bhandari and Swiontkowski 2017; Rizkalla et al. 2019).

HF is a common diagnosis in elderly patients. Though an average HF sufferer is frequently around 80 years old with concomitant comorbidities, the patient population is described as relatively heterogeneous (Penrod et al., 2007; Ranhoff et al., 2010). For example, different HF subgroups are: 42% having cognitive impairment, 19% dementia, 22% to 59% being frail, 23% to 31% are long-term care residents, and only 17% are relatively fit and experienced an outdoor fall (Crilly et al. 2010; Ranhoff et al. 2010; Seitz et al. 2011; Hebert-Davies et al. 2012; Kistler et al. 2015; Johansen et al. 2017; Winters et al. 2018; C.-L. Chen et al. 2019; van de Ree et al. 2019). The heterogeneity shows that the patients may have varying needs for care, making HF management more challenging.

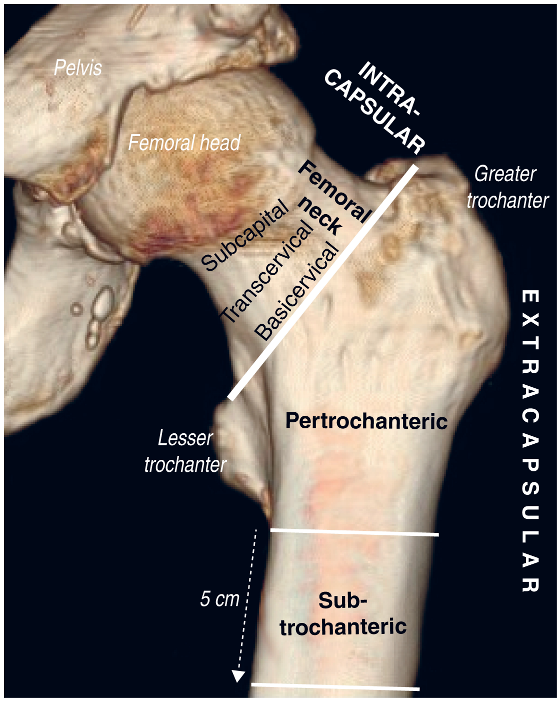


Figure 1. Classification of hip fracture according to anatomical site. The reconstruction of the computed tomography was obtained from the database of the Foundation of Estonian PACS (Picture Archiving and Communication System).

2.2. Hip fracture management

HF management is time-critical; it demands careful planning to avoid adverse consequences in frail patients to ensure a meaningful recovery from this significant injury. HF management consists of three fundamental care pillars: acute multidisciplinary care, ongoing coordinated post-acute care and rapid secondary prevention (Dreinhöfer et al. 2018). A summary of different HF guidelines and standards is given subsequently.

After hospitalisation, a comprehensive screening and assessment are performed, ensuring HF patient's optimisation for early surgery (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; European Society of Trauma and Emergency Surgery 2015; Australian Commission on Safety & Quality in Health Care 2016). Surgical treatment is recommended, and it is also considered for terminal illness patients as part of a palliative care approach. Surgery is performed as soon as possible, on the admission day or the day after (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; The American Academy of Orthopaedic Surgeons 2014; European Society of Trauma and Emergency Surgery 2015; Australian Commission on Safety & Quality in Health Care 2016). A total of 96–99% of HF patients are treated surgically in different countries (Neuman et al. 2010; Cram et al. 2017; Johansen et al. 2017; National Hip Fracture Database 2018); however, lower rates have also been reported (Jain et al. 2003; Amrayev et al. 2017; Lim and Kwek 2018). The guidelines recommend multiple practices for avoiding adverse outcomes, including decubitus prevention, orthogeriatric assessment, rapid optimisation of fitness for surgery, regular pain monitoring and management, minimising the risk of delirium, the prophylaxis of venous thromboembolism, decubitus, monitoring of postoperative hypoxaemia, nutrition, fluid and electrolyte status (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; European Society of Trauma and Emergency Surgery 2015; Australian Commission on Safety & Quality in Health Care 2016; McDonough et al. 2021). Multiple specialists involving doctors, nurses, physiotherapists, occupational therapists, social workers, pharmacists, dietitians, speech pathologists, orthoptist, clinical psychologists and neurophysiologists are engaged in HF care, underlining the importance of multidisciplinary, coordinated co-management (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; European Society of Trauma and Emergency Surgery 2015; McDonough et al. 2021). A multidisciplinary team meets regularly to monitor the patient's care and recovery and review rehabilitation goals if necessary (Australian Commission on Safety & Quality in Health Care 2016).

Rehabilitation has a crucial role in co-management. The foremost goal of rehabilitation is to regain independent mobility of the patient (Kristensen and Kehlet 2012; Dreinhöfer et al. 2018; Perracini et al. 2018). While the majority of recovery takes place within six months, some components of a HF patient's functional status may take over a year to recuperate (Magaziner et al. 2000; Dyer et al. 2016; Perracini et al. 2018). Recuperation times for specific components vary as 4 months for depressive symptoms, cognition and upper extremity function and 11 months for lower extremity function (Magaziner et al. 2000). Consecutively, HF rehabilitation is a lengthy process, covering multiple episodes of care divided by several facilities and specialists. This highlights the importance of careful planning of post-acute pathways to support HF patient's recovery across the whole continuum of care (The American Academy of Orthopaedic Surgeons 2014; European Society of Trauma and Emergency Surgery 2015; McDonough et al. 2021).

Physiotherapy assessment should be carried out before or after surgery, including goal setting to recover mobility, independence and return to pre-fracture residence (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; Chartered Society of Physiotherapy 2018). Rehabilitation should start early, offering mobilisation on the next day of surgery (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; European Society of Trauma and Emergency Surgery 2015; Australian Commission on Safety & Quality in Health Care 2016; Chartered Society of Physiotherapy 2018;

McDonough et al. 2021). Weight-bearing restrictions should be avoided if possible (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; European Society of Trauma and Emergency Surgery 2015; Australian Commission on Safety & Quality in Health Care 2016, 2016). Depend on a patient's clinical condition and the targeted objectives of care, PT should be provided regularly (at least daily) during acute care (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; Australian Commission on Safety & Quality in Health Care 2016; Chartered Society of Physiotherapy 2018; McDonough et al. 2021). A minimum recommended weekly PT amount is only stated in UK standards by the Chartered Society of Physiotherapy. The UK standards state that patients should receive at least two hours of PT per week during acute care and in the subsequent weeks. Before discharge, patient should receive an individualised and collaboratively developed rehabilitation plan, covering her/his ongoing care (Australian Commission on Safety & Quality in Health Care 2016). Clinical care providers and general practioner should receive the patient's rehabilitation plan within 48 hours of discharge (Australian Commission on Safety & Quality in Health Care 2016). Transitions between different care episodes should be smooth to avoid unnecessary delays and to ensure ongoing coordinated post-acute rehabilitation (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014). Inpatient post-acute care should start within two days of referral for the patients, and those moved to a next phase of rehabilitation should be attended by their new provider within 72 hours (Chartered Society of Physiotherapy 2018; McDonough et al. 2021). Finally, there should be a clear communication among different multidisciplinary team members, a consistent documentation of progress during rehabilitation and appropriate clinical handovers between various care episodes (Chartered Society of Physiotherapy 2018; McDonough et al. 2021).

Several rehabilitation interventions have shown potential for improving the recovery of HF patients in various settings and different phases of care. Multidisciplinary interventions improve physical function, mobility, self-care ability, balance confidence, independence in physical activity, lower limb function, gait, number of upright events, activities of daily living, reduce delirium, postoperative complications, nutritional problems, falls, depressive symptoms, hospital length of stay (LOS), hospital readmissions, mortality, and nursing home admissions (Swanson et al. 1998; Marcantonio et al. 2001; Halbert et al. 2007; Stenvall et al. 2007, 2012; Shyu et al. 2008, 2012, 2013; Zidén et al. 2008; Bachmann et al. 2010; Pfeifer and Minne 2010; Singh et al. 2012; Taraldsen et al. 2014, 2015; Watne et al. 2014; Prestmo et al. 2015; Thingstad et al. 2016; Nordström et al. 2018; Lin et al. 2020). Structured exercise enhances mobility, knee extension strength, balance, physical-performance-based tests, the Timed Up & Go Test and improves gait speed (Auais et al. 2012; Diong et al. 2016). Progressive resistance training improves leg extensor power, strength, endurance, mobility, physical function, balance, activities of daily living, self-rated health, performance task outcomes and reduces disability (Mitchell et al. 2001; Hauer et al. 2002; Binder et al. 2004; Pfeifer and Minne 2010; Sylliaas et al. 2011, 2012; Diong et al. 2016; Lee et al. 2017; Stasi et al. 2019; Avola et al. 2020). Balance training improves physical function, quality of life, activities of daily living, performance task scores, lower limb strength, gait, and reduces pain and fall risk (Pfeifer and Minne 2010; Monticone et al. 2018; J. Wu et al. 2019; Lee et al. 2019a; Chen et al. 2020). Another review analysed the effect of extended exercise program on various functional abilities. As per this review, the extended exercise program improved knee extension strength, balance, physical performance-based tests, level of physical activity, the Timed Up & Go Test, gait and increased exercising hours (Resnick et al. 2007; Auais et al. 2012; Turunen et al. 2017; Taraldsen et al. 2019). The benefits of promoting self-efficacy, upper body aerobic training, treadmill training, occupational therapy and home-based rehabilitation also have been reported (Mendelsohn et al. 2008; Chang et al. 2015; van Ooijen et al. 2016; D. Wu et al. 2018; Lee et al. 2019b; Avola et al. 2020; Oh et al. 2020). Finally, recommendations for the interventions mentioned above are also given in different HF guidelines: structured exercise, including high-intensity resistive strength, balance, weight-bearing and functional mobility training; multidisciplinary orthogeriatric program, including PT and early mobilisation; extended rehabilitation; safe recommendations for maximising physical activity (Chartered Society of Physiotherapy 2018; McDonough et al. 2021). The use of upper-body aerobic training, electrical stimulation for quadriceps strengthening or pain management may also be considered (McDonough et al. 2021).

Importantly, two frail subgroups of HF population, long-term residential care and cognitive impairment patients, should not be excluded from the rehabilitation (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; Chartered Society of Physiotherapy 2018; McDonough et al. 2021). There is evidence that the rehabilitation of the subgroups was associated with improved outcomes, such as patients' improved function, ambulation, decreased fall risk, delirium, shorter LOS, more likely return to the community, lower risk of long-term care placement and mortality (Goldstein et al. 1997; Huusko et al. 2000; Toussant and Kohia 2005; Muir and Yohannes 2009; Allen et al. 2012; The American Academy of Orthopaedic Surgeons 2014; Resnick et al. 2016; Seitz et al. 2016; Beaupre et al. 2019; Crotty et al. 2019; Smith et al. 2020). The American Physical Therapy Association's guidelines (2021) for HF management also recommended providing rehabilitation to patients with mild to moderate dementia. Despite the evidence, optimal rehabilitation strategies for these HF subgroups need further investigation (Beaupre et al. 2007; Muir and Yohannes 2009; Allen et al. 2012; Buddingh et al. 2013; Resnick et al. 2016; Hall et al. 2017; Smith et al. 2020).

Also, HF patients should be offered rapid secondary prevention to minimise the risk of subsequent fracture, including falls and bone health assessment (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; The American Academy of Orthopaedic

Surgeons 2014; European Society of Trauma and Emergency Surgery 2015; Australian Commission on Safety & Quality in Health Care 2016; McDonough et al. 2021). Multifactorial falls risk assessment should be carried out, including patient's questioning, history of falls, cognition, urinary incontinence, reviewing of footwear, concomitant health problems, medication, gait and balance deficit, syncope syndrome, osteoporosis, possible home hazards, and visual impairment (The National Institute for Health and Care Excellence 2013). Following this, assessment-based management should be administered. Similar to falls assessment, the presence of osteoporosis should be evaluated and managed accordingly. Osteoporosis risk assessment should cover previous fragility fractures, use of glucocorticoids, history of falls, family history of HF, body mass index, smoking and alcohol habits (The National Institute for Health and Care Excellence 2012). Diagnosed osteoporosis should be managed with antiosteoporotic medicines to prevent subsequent fractures.

2.3. Physical therapy use after hip fracture

Despite the fact that PT has a crucial role in HF care, optimal amount and duration of PT needed for recovery are unclear and rarely described in the literature; thus, it imposes a need for further research in this area (Weinrich et al. 2004; Chudyk et al. 2009; Handoll et al. 2011; The National Institute for Health and Care Excellence 2011; Dyer et al. 2016; McDonough et al. 2021). For example, would it be better to offer patients 5 hours, 50 hours or 150 hours of PT while keeping a good balance between recovery gains and cost-efficiency? The literature on total PT use after HF is scant. HF rehabilitation was audited in the United Kingdom in 2017, reporting the amount of PT hours received for the first week in different care setting types (Royal College of Physicians 2017). According to the audit, the received PT amounts were 3.6 hours per week for acute care, 3.5 hours per week for the next step care and 1.8 hours per week for home rehabilitation. A study from the United States of America reported total received PT and occupational therapy hours in a single episode of care in three setting types: 33.3 hours in a skilled nursing facility, 31.6 hours for inpatient rehabilitation facility and 11.9 hours for home health agency (Mallinson et al. 2014). Another study from the United States did not report exact PT hours; however, an approximate estimate can be calculated for inpatient rehabilitation facility using the reported LOS and minimum daily therapy hours (Munin et al. 2005). According to the study, HF patients received at least a total of 38.4 hours of therapy in that setting. A similar calculation was done for a Japanese HF study, wherein the patients treated in a convalescent rehabilitation ward received approximately 48–72 hours of therapy in total (Yoshizawa et al. 2017). An Australian study reported that usual care patients received a total of 115 hours of PT during acute care and inpatient rehabilitation combined (Kimmel et al. 2016). In conclusion, the literature on total PT use after HF is scant. Large-scale studies may help to bridge the literature gap, and ultimately will allow a better understanding of HF long-term management, rehabilitation and PT use.

2.4. Hip fracture outcomes

HF is associated with severe consequences such as disability and death. A systematic review which includes 38 studies, reported a substantial impact on patients' medium- to long-term abilities, function, quality of life and accommodation following HF (Dyer et al. 2016). The authors of the review reported that 40% to 60% of HF patients do not regain their pre-fracture level of mobility and ability to perform instrumental activities of daily living; 30% to 60% do not regain their pre-fracture level of basic activities of daily living; moreover, 10% to 20% HF patients are institutionalised. The recovery of a substantial subgroup of HF patients, long-term care residents, is even poorer. Long-term care residents suffer a loss in pre-fracture function, up to 3 times higher, in six months as compared to those living in the community (Beaupre et al. 2007; Dyer et al. 2016).

HF is also known for its relatively high mortality, which has not been decreased over the three decades (Mundi et al. 2014). A systematic review that has the data of the registries or databases of 36 countries reported mean one-year mortality rates in different continents as, Europe 23%, Asia 18%, Oceania 25%, North America 21%, and South America 27% (Downey et al. 2019). Shorter-term mortality rates range reported as follows: in-hospital 2.3%–14%, one-month 3.3%–17%, three-month 6.4%–20%, six-month 7.1%–23% (Abrahamsen et al. 2009; Medin et al. 2015; Johansen et al. 2017; Downey et al. 2019). HF is associated with excess mortality risk, which is five to eight times higher during the first three months of fracture as compared to age- and sex-matched controls. The excess risk reduces substantially during the first two years; however, it remains higher even up to ten years (Haentjens et al. 2010; Jürisson et al. 2017a).

2.5. Hip fractures in Estonia

Estonia is a Baltic nation with a population of 1.3 million, which is unequally distributed among its fifteen counties (Figure 2) (Statistics Estonia 2020). It has a national, solidarity-based mandatory health insurance system covering 94%-95% of the population and is organised by the Estonian Health Insurance Fund (EHIF) (The World Bank Group 2015; Organisation for Economic Co-operation and Development 2019). The remaining few per cent of the population have a private or no insurance; however, emergency care and ambulance services are guaranteed for all uninsured (The World Bank Group 2015). All retirees have national health insurance. In Estonia, each day, three to four persons aged ≥50 years get an index HF diagnosis and the number is expected to increase due to the ageing of the population (Jürisson et al. 2015; Laius et al. 2017). HF age-standardised incidence rate among women is low and the rate among men is the highest in Europe (Jürisson et al. 2015). Two studies reported poor outcomes of HF in Estonia, including a high one-year mortality rate (28%) and low pre- and post-fracture health-related quality of life estimates among cognitively intact and community-dwelling patients (Jürisson et al. 2016, 2017a). It has been speculated that these poor outcomes may be associated with insufficient case management upon discharge and underutilisation of rehabilitation, nursing care, and social care (Jürisson et al. 2016, 2017a).

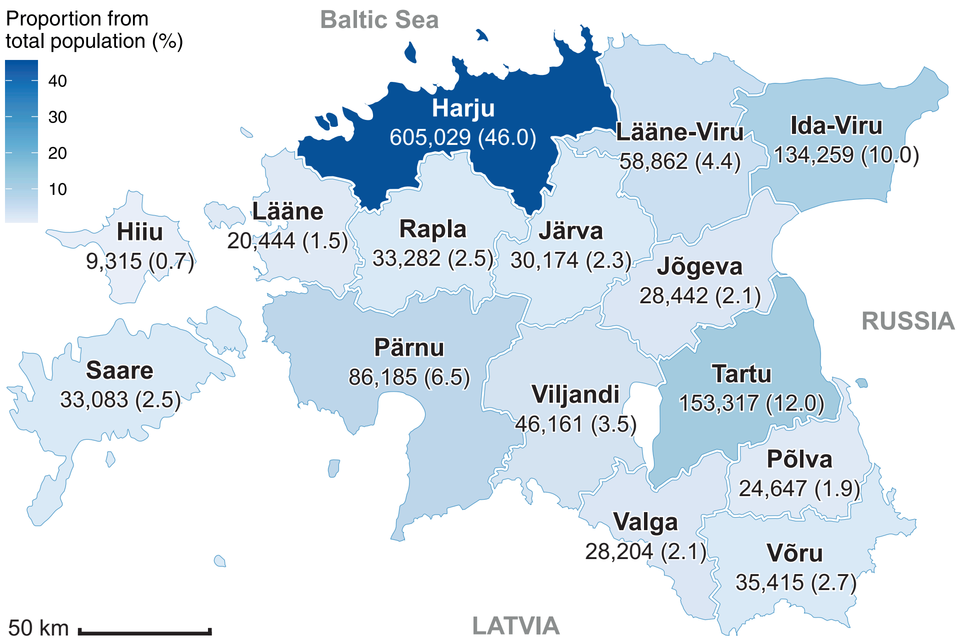


Figure 2. Map of the fifteen counties of Estonia and their populations [shown as n (%)]. The total population is 1,326,819 (the data of year 2020, www.stat.ee/eng).

Nonetheless, there is limited information available on HF clinical management, especially about rehabilitation. One of the available studies reported the use of drugs, different health care settings, care costs; however, it was a modest size, two-hospital based study on cognitively intact and community-dwelling HF patients (Jürisson et al. 2016). The authors reported that the societal cost of HF in Estonia is approximately half of the European average, and there is an underuse of specialised post-acute rehabilitation care. According to the study findings, only 9.3% and 3.5% of HF patients received specialised inpatient and outpatient rehabilitation care, respectively. PT provision in care settings was not investigated in this study. This study also reported the limitations in the last fundamental pillar of HF care, rapid secondary prevention. As per this study, though there is an overall increase in the consumption of antiosteoporotic medicines in Estonia, only 8% of HF patients received bisphosphonates (Jürisson et al. 2016; Laius et al. 2017). Another analysis found that HF patients fail to receive timely ambulatory follow-up care by a family physician or other medical professionals and 33% of HF patients remain hospitalised for more than a 28-day period (The World Bank Group 2015). In summary, the available limited literature on HF management indicated the issues in all fundamental HF care pillars but remains shallow for providing granular input for clinical practice and health policy-making.

Routine HF management in Estonia is given subsequently. There is a national lower limb trauma guideline covering only HF surgical management (Estonian Orthopaedic Society 2010). Multidisciplinary orthogeriatric assessment is available but used non-systematically. Two regional and four central hospitals cover acute care, which is mainly followed by domiciliary post-acute care, dependent on the availability of different health services in a patient's home county. There are multiple options available for post-acute settings, such as inpatient rehabilitation to provide intensive inpatient PT, home PT for patients capable of participating in rehabilitation in their home. Outpatient physiotherapy to provide intensive ambulatory PT. Inpatient nursing care is available for medically stable patients who do not require constant medical attention but need nursing and medical procedures that cannot be delivered at home. On the other side, home nursing care is available for patients who live in the community but need assistance with medical procedures. Occasionally other types of inpatient speciality care (classified here as "other inpatient") are used as a link between different episodes of care or between the acute care phase and the transition to home. Nursing homes do not provide rehabilitation services for the most part in Estonia.

2.6. Summary of the literature

Rehabilitation has a fundamental role in HF management. Despite its key role, the best rehabilitation strategy and programme for optimal recovery are still unclear (Weinrich et al. 2004; Chudyk et al. 2009; Handoll et al. 2011; The National Institute for Health and Care Excellence 2011; Dyer et al. 2016; McDonough et al. 2021). PT amount and duration, ensuring optimal recovery after HF, remain unknown. Descriptions of HF long-term PT use will enhance our understanding of the needs of these patients for rehabilitation.

HF mortality in Estonia is relatively high and indicates the issues in patient management and rehabilitation, which remain largely unexamined. The unexamined topics include HF acute and post-acute management and rehabilitation, their regional differences and temporal trends and the capacity of available post-acute settings to provide PT. The evaluation of the entire HF episode of care is recommended as it provides a complete picture of the aftermath, allowing the identification of ways to improve outcomes like mortality (Bentler et al. 2009). Finally, updates on mortality are also warranted for evaluating its changes in time.

This research will contribute to a deeper understanding of HF post-acute care and PT use. New knowledge helps to open new research avenues, will improve clinical practices and provide inputs for policy-making in Estonia. Furthermore, the significance of this thesis may be even broader, possibly extending to other patient populations seeking rehabilitation in Estonia. Of note, there is minimal literature on physical rehabilitation in Estonia and none of the available studies examined patients' PT use, its provision in different care settings, its regional accessibility or temporal trends (Vibo et al. 2007; Kivisild et al. 2014; Jürisson et al. 2016).

3. OBJECTIVES OF THE STUDY

The overall objective of the study was to evaluate index HF management, its regional differences and temporal trends during 2009–2017 in Estonia, focusing in particular on rehabilitation and its compliance with the international guidelines. Specific objectives of the study are listed as below:

1. To assess acute management and PT use of HF patients (PAPERs I, III);
2. To evaluate post-acute management of HF patients and assess their contemporaneous PT use, its regional differences and temporal trends (PAPERs II, III);
3. To examine the effect of HF patients' characteristics on post-acute PT use (PAPER II);
4. To assess mortality of HF patients in Estonia (PAPER I).

4. SUBJECTS AND METHODS

4.1. Subjects

This study was based on nine-year-spanning retrospective data that was used for publishing four original research papers. These research papers and their objectives are listed in Table 1. The study included patients aged ≥50 years with an index HF diagnosis during from the 1st January 2009 to the 30th September 2017. Index HF diagnosis was based on the International Classification of Diseases, 10^{th} revision (ICD-10) codes: S72.0 – fracture of femoral neck, S72.1 – pertrochanteric fracture and S72.2 – subtrochanteric fracture. HF diagnoses were limited to only primary HFs occurrence ("index HF") in order to increase the homogeneity of the study population (Toth et al. 2020). ICD-10 codes have shown valid for identifying HFs (Lix et al. 2012). Data validation was used for confirming HF diagnosis and its management type. Isolated acetabular, pelvic, periprosthetic, isolated greater and lesser trochanter fractures were excluded. The inclusion/exclusion criteria were chosen in concordance to multiple other studies of the same subject area (Jain et al. 2003; Lix et al. 2012; Diamantopoulos et al. 2013; Jürisson et al. 2015). The study was approved by The Research Ethics Committee of the University of Tartu on 17 June 2013 (reference 227/T-12) and the Estonian Data Protection Inspectorate for the use of personalised data on 1 December 2017 (reference 2.2.-1/17/47).

Albeit the patient data was the same through the study, the published papers had a different number of patients because of implemented data restrictions and ongoing data validation during the study period (Table 1). PAPER I included a total of 11,628 patients as per the inclusion/exclusion criteria (described above) and analysed the HF surgical management and survival. The remaining papers used the same inclusion criteria but had an additional exclusion of some patients. PAPER II included a total of 8,729 patients and compared PT use between index HF patients. This research paper has an additional exclusion of 2,827 patients who died during post-acute care. The additional exclusion criterion allowed to reduce biases in analyses. PAPER III had the inclusion of 11,461 patients, additional exclusion of 30 patients without a registered residency in one of the counties of Estonia and compared regional differences in post-acute PT use. PAPER IV analysed the reasons underpinning nonoperative management, included a total of 11,210 patients and additionally excluded the patients whose nonoperative management decision was unavailable (n = 283). The remaining differences in patient numbers were due to the ongoing data validation that was improved during the study period. The original data was continuously complemented from the medical records in light of new research questions, simultaneously improving the original data quality.

Table 1. Outline of study papers

Objective	Number of included individuals	Used data restrictions	Follow-up time	Main outcome	Primary statistical analyses
PAPER I – To assess treatment methods and mortality rates of HF	11,628	–	One year	All-cause mortality	Descriptive analysis, Kaplan-Meier survival analysis
PAPER II – To map HF post-acute care and compare it between patients with and without a diagnosis of dementia	8,729	Excluded 2,827 patients who did not survive post-acute phase	Six months	The characteristics of post-acute care: LOS, used PT hours and setting types	Descriptive analysis, zero-inflated negative binomial and hurdle lognormal regression.
PAPER III – To evaluate post-acute PT use after HF and analyse its regional differences and temporal trends	11,461	Excluded 30 patients who were without a registered residency in one of the counties of Estonia	Six months	Received PT hours	Descriptive analysis, causal logistic and lognormal regression, and variation modelling
PAPER IV – To identify reasons behind nonoperative management and assess the accuracy of these decisions	11,210	Excluded, 260 patients who had no available nonoperative management reasons; 23 who died before surgery	Three years	All-cause mortality	Descriptive analysis Kaplan-Meier survival analysis and accelerated failure time modelling

HF – hip fracture, LOS – hospital length of stay, PT – physical therapy

As the data quality was improved over time, all the thesis data analyses were based on its most complemented version in order to report the most accurate findings and to reduce the complexity of the thesis methodology. A total of 11,491 patients were included in the analyses of the thesis. A median of 1,294 patients (1,272–1,338) suffered from HF each year during 2009–2016, while there were 997 patients of HF during the first three quarters of 2017.

4.2. Methods

4.2.1. Data sources

Multiple administrative nation-wide databases were used for data collection. The initial health insurance claims data were obtained from EHIF. EHIF provided insurance for 93%–96% of Estonia's population during the observation period (Estonian Health Insurance Fund 2012, 2017). EHIF collects patients data simultaneously from multiple sources, including the billings from local hospitals (medical data), through linkage with the Estonian Population Register (demographics) and the Estonian Causes of Death Registry (survival statuses). The billing data covers care in different settings, including inpatient (acute care, nursing care, rehabilitation care), day care and outpatient care (ambulatory specialist care, nursing care rehabilitation care, primary care) (The World Bank Group 2015). Thus, data of EHIF claims virtually contains information about the entirety of health care, including patients' all contacts with health care services. The initial EHIF data were complemented and validated using two other databases: patients' digital images, which were accessed from the Foundation of Estonian PACS (Picture Archiving and Communication System) and the medical records from the Estonian National Health Information System (https://ap.digilugu.ee/arstiportaal). Uploading medical data to both databases is mandatory by law, particularly since 2010 for medical records in EHIF-funded hospitals and since 2014 for digital images. Voluntary uploading took place before the mandatory years. Summary-level data of the general population of Estonia were retrieved from the Statistics Estonia database (http://pub.stat.ee/). Finally, EHIF's expenditures on health care were retrieved from the Health Statistics and Health Research Database (https://statistika.tai.ee/index_en.html).

4.2.2. Collected variables and their use in the study

The initially obtained data included multiple sets of variables, covering different time periods. The obtained datasets and respective observation time periods are shown in Figure 3, and their use is described subsequently. The data included patients' baseline characteristics as pseudonymised identification number, date of index HF, age at hospitalisation, sex, fracture type, county of residence and survival statuses. The index HF diagnosis was defined on the first day of care as shown in a patient's medical claim.

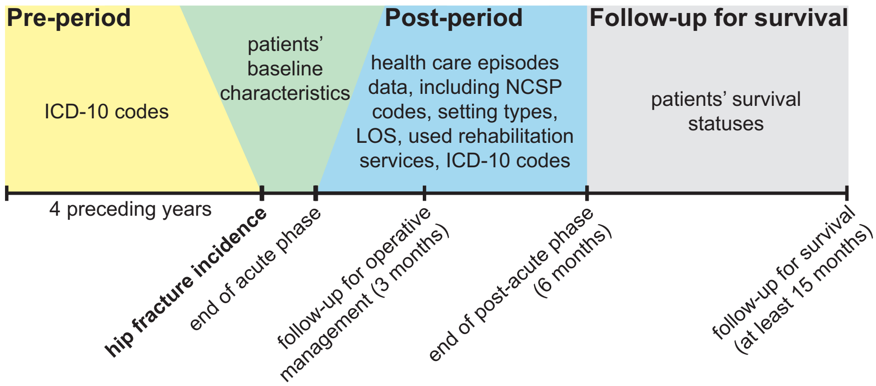


Figure 3. Obtained datasets from the Estonian Health Insurance Fund and their covered time periods. ICD-10 – International Classification of Diseases, 10th revision; LOS – length of stay; NCSP – the Nordic Medico-Statistical Committee's (NOMESCO) Classification of Surgical Procedures.

Comorbidities were defined as diagnoses coded as ICD-10 at any hospital or outpatient health care claims during a four-and-half-year period. Comorbidities were assessed at two time periods. First, baseline comorbidity status was assessed, including ICD-10 codes from the pre-period (at the time of the index HF and during the preceding four years). Second, comorbidity statuses were also assessed at the end of the post-acute phase, including ICD-10 codes from the pre- and post-period (the preceding four years and the succeeding six months after HF incidence) (Figure 3). The four-year preceding period was chosen to avoid under-ascertainment of comorbidities (Jürisson et al. 2017b). The six-month period was chosen according to the length of post-acute phase, where the most of recovery of HF patients takes place (Dyer et al. 2016; Perracini et al. 2018). Finally, a restriction was applied to increase the validity of comorbidity assessment: only ICD-10 codes that appeared at least two times and with a gap of seven days were included (Tosteson et al. 2007; Radley et al. 2008).

Charlson comorbidity index (CCI) was chosen for the comorbidity assessment (Charlson et al. 1987). CCI was chosen as it is a widely used method for case-mix adjustment in health outcome related studies, adapted for usage with ICD-10 codes and validated among HF population (Quan et al. 2005; Radley et al. 2008; Toson et al. 2015). CCI categorises patients' comorbidities and assigns them according to weight based on the adjusted risk of mortality, and the sum of all the weights results in a single score. The revised coding algorithms and the updated weights were chosen to calculate CCI as they slightly outperform earlier versions and may be more appropriate for use with more recent data (Quan et al. 2005, 2011). CCI was preferred over Elixhauser Comorbidity Measure as it discriminates concomitant dementia, which was used in the analyses of the thesis (Quan et al. 2005). The presence of dementia was extracted from the categories of the CCI using ICD-10 codes or their subtypes as follows: F00, F01, F02, F03, F05.1, G30, G31.1 (Quan et al. 2005, 2008). Finally, to note, patient's comorbidity status affects the use of post-acute PT, and baseline CCI may change during the following months from HF incidence. For this reason, we used CCI based on the pre- and post-period ICD-10 codes in all the adjusted analyses, estimating post-acute PT use (Figure 3). This allowed better control of confounding factors.

The data included the Nordic Medico-Statistical Committee's (NOMESCO) Classification of Surgical Procedures codes (NCSP) and operation dates up to three months from the HF incidences. The NCSP codes were used to define operative management type: total hip arthroplasty (NFB20, NFB30, NFB40, NFB99), hemiarthroplasty (NFB00-9; NFB10-9), screws (NFJ70-3), sliding hip screw (NFJ60-3, NFJ80-3) and intramedullary nail (NFJ50-3) (Nordic Medico-Statistical Committee 2001).

The data included variables about patients' health care episodes up to six months from the index hospitalisation. The observed period was limited to six months – until the end of post-acute care, due to multiple reasons. The majority of recovery happens within this time frame. Only 6.0% of the study patients (692) received rehabilitation between 6 and 12 months from HF incidence. This time frame also allowed us to reduce the possibility of receiving PT due to other medical conditions. The data on care episodes allowed analysing about patients' acute and post-acute care, using the variables like LOS, PT hours received and care setting type. Occupational therapy and PT hours were derived from EHIF's funding codes for physical rehabilitation, which, for the most part, had pre-defined lengths (Government of Estonia 2009, 2011, 2014, 2018; Estonian Health Insurance Fund 2014). Three of the used services did not have pre-defined durations; however, their use was negligible: 2 patients received home PT, 72 participated in a pool exercise therapy, and 2 participated in exercise therapy in a cryo-chamber. The pool exercise therapy (code 7017) was later replaced by pool physiotherapy (codes 7056, 7057) with a pre-defined duration. Thus, the duration of the pool exercise therapy session was marked as 0.5 hours. The session duration of home PT and exercise therapy in a cryo-chamber was also marked as 0.5 hours. Occupational therapy hours were included in PT, as occupational therapy was only used by less than one-tenth of the included patients. Finally, the use of day care and home-based rehabilitation settings was excluded from analyses because only 7 and 2 patients were admitted to these settings, respectively. The PT hours provided in day care and home were bundled and showed under another more frequently used post-acute setting type named "other outpatient".

Different parts of the study data were obtained on the following dates: acute and post-acute care data on 26 January 2018, ICD-10 codes on September 2018 and survival statuses were updated several times. The latest update took place on 7 March 2021. Thus, all patients had at least a complete 3-month follow up for fracture management methods and at least 3-year follow up for survival. The patients with a HF diagnosis between 1 July 2017 to 30 September 2017 had a shorter follow up time but at least had a three-month follow-up for post-acute care. Thus, 97.1% (11,158) of the included patients had complete follow-up for six-month PT use; the remaining who had an index HF diagnosis between 1 July 2017 to 30 September 2017 had at least a three-month follow-up period.

4.2.3. Data validation

We used multiple validation steps to improve the administrative data quality as recommended by the previous HF study (Cundall-Curry et al. 2016). Figure 4 shows the data validation steps. First, a logic check was used. A patient's HF diagnosis was confirmed if an available and appropriate NCSP code indicated its operative management type within three months from the index hospitalisation. The three-month period was chosen to limit the use of patients' personalised data needed in the next validation steps. In the absence of NCSP code, digital images and medical records were reviewed to confirm the HF diagnosis and its management type. For the review purpose, EHIF provided the actual personal identification codes of these patients. A radiologist and an orthopaedic surgeon reviewed the digital images and a geriatrician reviewed the medical records. HF diagnoses and their management types were confirmed as follows: the radiologist and report, the orthopaedic surgeon and report, the radiologist and the orthopaedic surgeon (if a report was not available), or the geriatrician (data from medical records). As a result, HFs treated with operative management were confirmed as follows: an appropriate NCSP code, evidence from digital imaging, or a medical record. HFs treated with nonoperative management were confirmed by one of the following ways: evidence from a medical record and digital imaging or a medical record or digital imaging only.

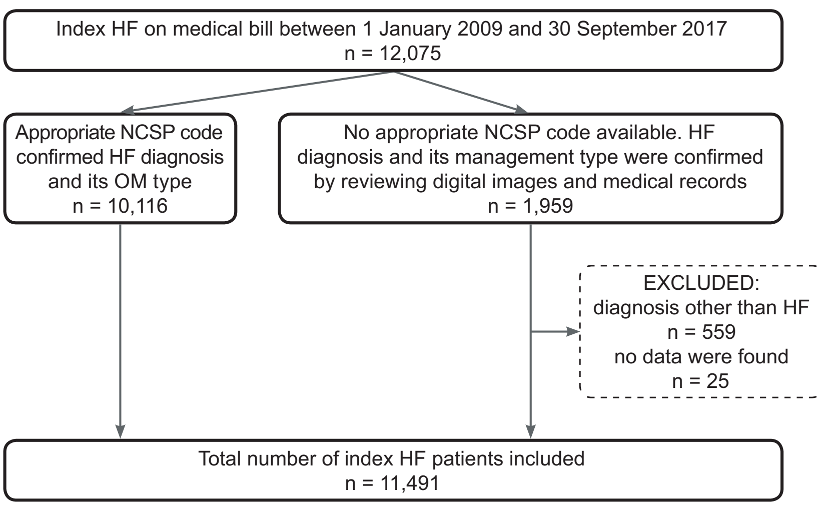


Figure 4. Flowchart showing the validation of HF diagnoses and their management types. HF – hip fracture, NCSP – Nordic-Medico-Statistical Committee's Classification of Surgical Procedures, OM – operative management.

4.2.4. Outcome measures

Six-month PT hours were used to evaluate acute and post-acute rehabilitation. Age, sex, CCI, fracture type, fracture time, county of residence, management method, concomitant dementia status and acute PT use were considered as covariates to control for confounding, depending on the objective of a particular analysis. Patients' survival statuses were used for mortality estimation.

4.3. Statistical analysis

Statistical analyses were performed in R 4.0.4 (R Core Team, 2017), using the following packages: *ggplot* for figures, *DAGitty* (Textor et al. 2016) and *ggdag* for creating a causal diagrams, *comorbidity* for calculating CCI (Gasparini 2018), *survival* and *survminer* for survival analyses and *brms* (Bürkner 2018) for remaining regression modelling. Adobe Illustrator or Adobe InDesign (versions CC, Adobe Systems, San Jose, CA) were additionally used for creating or finalising figures.

Continuous variables were shown as "median (25^{th}–75^{th} percentile)" and categorical as proportions or probabilities. Age was divided into 10-year subgroups. CCI was binned as follows: 0, 1–2, 3–4, and ≥5. Patients' six-month PT use was analysed and reported in two parts: for acute phase and post-acute phase. Overall physical therapy intensity (PTi) was calculated for describing PT provision during inpatient care. PTi was shown as hours per hospitalisation week (h/w).

Crude data analyses were based on Pearson's chi-squared test (proportional comparisons), and on the Kruskal-Wallis test (comparisons of continuous data between the counties). Statistical significance was defined as alpha = 0.05, and all tests were two-sided. Finally, as classical and Bayesian methods were used in this work, reporting was done as follows: only the results of survival analyses were given with 95% confidence intervals (CI), and the remaining regression outcomes were presented with 95% credible intervals (also abbreviated as CI). Both CIs were presented with point estimates as "[lower; upper]". All *brms* models were run with default weakly informative priors, and the 'county' variable was specified as a hierarchical level due to the nested structure of the data.

The distribution of total received post-acute PT hours was zero-inflated and extremely positively skewed. Therefore, relevant analyses were divided into two independent models. Logistic regression was performed using the Bernoulli likelihood to estimate the probability of receiving post-acute PT. A two-part distributional model was opted to co-estimate median and standard deviation, using a custom parametrisation of the log-normal regression (Paul Bürkner 2020). The two-part distributional model included only the patients whose post-acute PT hours were greater than zero. Thereafter, the results of two regression models were presented together as three estimates: (A) the probability of being offered post-acute rehabilitation, (B) the median received PT hours and (C) the standard deviation of received PT hours (Figure 5).

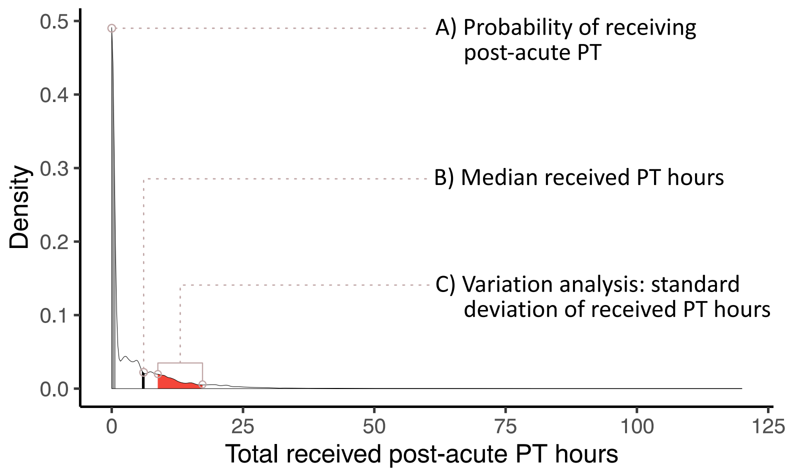


Figure 5. Distribution of post-acute physical therapy (PT) hours. As the variable was zero-inflated and highly positively skewed, it was analysed in three parts: the probability of receiving post-acute PT (A), median received PT hours (B), the standard deviation of received PT hours (C). The analyses B and C included only patients with positive post-acute PT values.

4.3.1. Analyses used for specific objectives

4.3.1.1. Regional differences in post-acute physical therapy use (PAPER III)

We drew a causal diagram to estimate the causal effects of patients' county of residence on the received post-acute PT use. The assumptions of causal pathways are shown on the directed acyclic graph (Figure 6). The directed acyclic graph was used to define minimal sufficient adjustment sets for estimating a direct causal effect. The variable of acute PT hours was marked as "adjusted" in DAGitty since we assumed a correlation between received acute and post-acute PT hours. As a result, the recommended minimal sufficient adjustment set included the following variables: received acute PT hours, age, comorbidity status and sex. Finally, the patients without a registered residency in one of the fifteen counties of Estonia were excluded from the regional analysis due to their small number (n = 30).

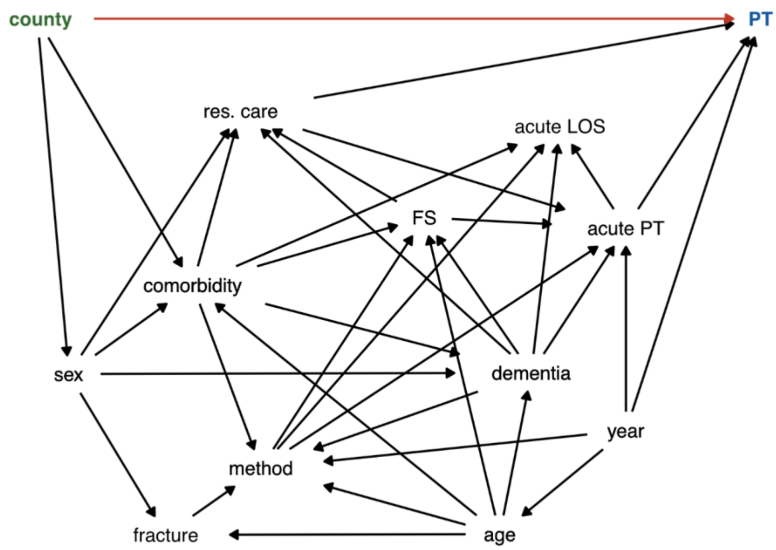


Figure 6. Directed acyclic graph of the association between the county of residence and received post-acute physical therapy after hip fracture. Available variables: county of residence as an exposure (county), post-acute physical therapy as an outcome (PT), age, sex, comorbidity status identified as Charlson Comorbidity Index score, fracture type (fracture), fracture management method (method), received physical therapy during acute care (acute PT), acute length of stay (acute LOS), and study year (year). Unobserved variables were residential care status (res. care) and functional status (FS).

4.3.1.2. Temporal trends in post-acute physical therapy use (PAPER III)

Overall and regional temporal trends were analysed for post-acute PT use. Minimal adjustment set for the temporal analyses included year, county and acute PT hours (Figure 7). As regional temporal trends were also analysed, the patients without a registered residency in one of the fifteen counties of Estonia were excluded from the analysis due to their small number (n = 30).

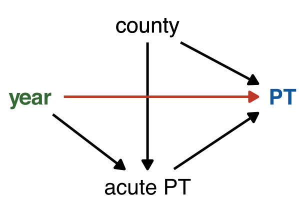


Figure 7. Directed acyclic graph of the association between study year and received post-acute physical therapy after hip fracture. Variables are: study year as an exposure (year), post-acute physical therapy as an outcome (PT), county of residence (county), and received physical therapy during acute care (acute PT).

4.3.1.3. Effect of patients' characteristics on post-acute physical therapy use (PAPER II)

To investigate the effects of different patient's characteristics on received post-acute PT hours, we used the two-part modelling described above. The model was adjusted to acute PT hours, age, sex, modified CCI, dementia status, fracture type/management method and the county of residence. A modified CCI was used in statistical modelling to avoid the overlap with another confounder – dementia. Dementia was therefore extracted from the total CCI score and was included separately in the analyses. Variables 'fracture type' and 'management method' were examined in separate models since certain fractures are treated with specific operation methods. Finally, the patients who died during the acute or post-acute care were excluded from the analysis. This is because the utilisation of post-acute health care services presupposes a patient's survival. Their exclusion allowed to reduce a bias from the analysis since the mortality of patients with different baseline characteristics varies and affects post-acute PT use.

4.3.1.4. Mortality analysis (PAPER I)

Kaplan-Meier unadjusted cumulative all-cause mortality analyses were conducted at the end of acute hospitalisation (termed as 'in-hospital') and at 1, 3, 6 and 12 months.

5. RESULTS

5.1. Patients' baseline characteristics (PAPERs I, III, IV)

The median patient age was 81 years (73–87); half of the included patients, 51.2% (5,883), had a femoral neck fracture (Table 2). The proportion of men was 28.2% (3,246), and they had a median age of 74 years (64–82); the men were 9 years younger than women, who had a median age of 83 years (76–87). The men's proportion was higher in the two youngest age subgroups: 64.5% (510) in 50–59 years age subgroup, 53.2% (748) in 60–69 years age subgroup, 31.1% (914) in 70–79 years age subgroup, 18.3% (892) in 80–89 years age subgroup and 12.2% (182) in 90 years and over age subgroup. The median baseline CCI was 2 (0–2). The baseline CCI increased by 0.4 units [0.3; 0.4] by the end of the post-acute phase, resulting in a median of 2 (0–3). According to the categories of the baseline CCI, 9.6% (1,106) of patients had a concomitant diagnosis of dementia. Patients' baseline characteristics differed among the counties, including age and the distributions of CCI, sex and fracture type (Table 3).

Table 2. Baseline characteristics of index hip fracture patients during the years 2009–2017.

	Total n = 11,491
Age	81 (73–87)
Age subgroups	
50–59	791 (6.9)
60–69	1,406 (12.2)
70–79	2,943 (25.6)
80–89	4,865 (42.3)
≥90	1,486 (12.9)
Woman	8,245 (71.8)
Baseline CCI score	
0	4,495 (39.1)
1–2	4,127 (35.9)
3–4	2,258 (19.7)
≥5	611 (5.3)
Fracture type	
Femoral neck	5,883 (51.2)
Pertrochanteric	4,953 (43.1)
Subtrochanteric	655 (5.7)
Has national health insurance at the time of hip fracture	11,427 (99.4)
Comorbidities	
Myocardial infarction	796 (6.9)
Congestive heart failure	5,025 (43.7)
Peripheral vascular disease	1,197 (10.4)

	Total n = 11,491
Cerebrovascular disease	2,477 (21.6)
Dementia	1,106 (9.6)
Chronic pulmonary disease	1,243 (10.8)
Rheumatic disease	383 (3.3)
Peptic ulcer disease	542 (4.7)
Mild liver disease	174 (1.5)
Diabetes without chronic complication	1,242 (10.8)
Diabetes with chronic complication	678 (5.9)
Hemi- or paraplegia	530 (4.6)
Renal disease moderate/severe	465 (4.0)
Any malignancy	1,179 (10.3)
Moderate/severe liver disease	36 (0.3)
Metastatic solid tumor	42 (0.4)
AIDS/HIV	1 (0.009)
County of residence	
Harju	4,369 (38.0)
Hiiu	77 (0.7)
Ida-Viru	1,440 (12.5)
Järva	309 (2.7)
Jõgeva	320 (2.8)
Lääne	289 (2.5)
Lääne-Viru	541 (4.7)
Pärnu	732 (6.4)
Põlva	302 (2.6)
Rapla	305 (2.7)
Saare	320 (2.8)
Tartu	1,218 (10.6)
Valga	336 (2.9)
Viljandi	478 (4.2)
Võru	425 (3.7)
Registered residency not available	30 (0.3)

Continuous variables are shown as “median (25th–75th percentile)” and categorical as “n (%)”. CCI – Charlson Comorbidity Index.

Table 3. Baseline characteristics of index hip fracture patients during the years 2009–2017 by county.

	Harju Total n = 4,369	Hiiu Total n = 77	Ida-Viru Total n = 1,440	Järva Total n = 309	Jõgeva Total n = 320	Lääne Total n = 289	Laane-Viru Total n = 541	Pärnu Total n = 732	Põlva Total n = 302	Rapla Total n = 305	Saare Total n = 320	Tartu Total n = 1,218	Valga Total n = 336	Viljandi Total n = 478	Võru Total n = 425	p-value
Age	81 (73–87)	80 (72–86)	80 (73–86)	80 (70–87)	81 (73–86)	80 (71–86)	81 (71–86)	80 (72–86)	81 (72–87)	79 (69–86)	81 (74–87)	81 (74–87)	81 (73–86)	81 (71–87)	82 (74–87)	<0.001
Age subgroups																0.003
50–59	278 (6.4)	5 (6.5)	122 (8.5)	26 (8.4)	21 (6.6)	16 (5.5)	45 (8.3)	49 (6.7)	18 (6.0)	24 (7.9)	25 (7.8)	72 (5.9)	28 (8.3)	26 (5.4)	29 (6.8)	
60–69	511 (11.7)	10 (13.0)	173 (12.0)	48 (15.5)	35 (10.9)	39 (13.5)	66 (12.2)	110 (15.0)	41 (13.6)	55 (18.0)	38 (11.9)	128 (10.5)	36 (10.7)	61 (12.8)	46 (10.8)	
70–79	1,101 (25.2)	22 (28.6)	384 (26.7)	68 (22.0)	89 (27.8)	88 (30.4)	143 (26.4)	190 (26.0)	77 (25.5)	80 (26.2)	84 (26.2)	325 (26.7)	72 (21.4)	125 (26.2)	91 (21.4)	
80–89	1,867 (42.7)	33 (42.9)	630 (43.8)	132 (42.7)	134 (41.9)	112 (38.8)	216 (39.9)	292 (39.9)	128 (42.4)	108 (35.4)	133 (41.6)	523 (42.9)	161 (47.9)	200 (41.8)	188 (44.2)	
≥90	612 (14.0)	7 (9.1)	131 (9.1)	35 (11.3)	41 (12.8)	34 (11.8)	71 (13.1)	91 (12.4)	38 (12.6)	38 (12.5)	40 (12.5)	170 (14.0)	39 (11.6)	66 (13.8)	71 (16.7)	
Woman	3,217 (73.6)	46 (59.7)	1,045 (72.6)	217 (70.2)	223 (69.7)	212 (73.4)	381 (70.4)	516 (70.5)	209 (69.2)	203 (66.6)	225 (70.3)	855 (70.2)	245 (72.9)	343 (71.8)	292 (68.7)	0.03
Baseline CCI score																<0.001
0	1,770 (40.5)	32 (41.6)	463 (32.2)	150 (48.5)	105 (32.8)	129 (44.6)	252 (46.6)	303 (41.4)	75 (24.8)	134 (43.9)	164 (51.2)	440 (36.1)	126 (37.5)	193 (40.4)	141 (33.2)	
1–2	1,515 (34.7)	28 (36.4)	520 (36.1)	93 (30.1)	118 (36.9)	93 (32.2)	186 (34.4)	264 (36.1)	135 (44.7)	98 (32.1)	105 (32.8)	496 (40.7)	131 (39.0)	178 (37.2)	160 (37.6)	
3–4	854 (19.5)	14 (18.2)	339 (23.5)	52 (16.8)	77 (24.1)	51 (17.6)	82 (15.2)	139 (19.0)	66 (21.9)	56 (18.4)	41 (12.8)	236 (19.4)	62 (18.5)	80 (16.7)	104 (24.5)	
≥5	230 (5.3)	3 (3.9)	118 (8.2)	14 (4.5)	20 (6.2)	16 (5.5)	21 (3.9)	26 (3.6)	26 (8.6)	17 (5.6)	10 (3.1)	46 (3.8)	17 (5.1)	27 (5.6)	20 (4.7)	
Dementia	409 (9.4)	5 (6.5)	165 (11.5)	29 (9.4)	41 (12.8)	31 (10.7)	51 (9.4)	53 (7.2)	36 (11.9)	25 (8.2)	30 (9.4)	110 (9.0)	32 (9.5)	44 (9.2)	42 (9.9)	0.2
Fracture type																<0.001
Femoral neck	2,281 (52.2)	43 (55.8)	702 (48.8)	140 (45.3)	163 (50.9)	146 (50.5)	289 (53.4)	356 (48.6)	175 (57.9)	170 (55.7)	176 (55.0)	590 (48.4)	176 (52.4)	245 (51.3)	219 (51.5)	
Pertrochanteric	1,866 (42.7)	31 (40.3)	646 (44.9)	143 (46.3)	141 (44.1)	133 (46.0)	213 (39.4)	321 (43.9)	115 (38.1)	119 (39.0)	117 (36.6)	570 (46.8)	146 (43.5)	193 (40.4)	183 (43.1)	
Subtrochanteric	222 (5.1)	3 (3.9)	92 (6.4)	26 (8.4)	16 (5.0)	10 (3.5)	39 (7.2)	55 (7.5)	12 (4.0)	16 (5.2)	27 (8.4)	58 (4.8)	14 (4.2)	40 (8.4)	23 (5.4)	

Continuous variables are presented as “median (25^{th}–75^{th} percentile)” and categorical as “n (%)”. CCI – Charlson Comorbidity Index.

Table 4. Characteristics of index hip fracture acute care during the years 2009–2017 by county.

	Harju Total n = 4,369	Hiiu Total n = 77	Ida-Viru Total n = 1,440	Järva Total n = 309	Jõgeva Total n = 320	Lääne Total n = 289	Laane-Viru Total n = 541	Pärnu Total n = 732	Põlva Total n = 302	Rapla Total n = 305	Saare Total n = 320	Tartu Total n = 1,218	Valga Total n = 336	Viljandi Total n = 478	Võru Total n = 425	p-value
LOS, days	8.0 (5.0–11.0)	5.0 (4.0–7.0)	7.0 (6.0–11.0)	8.0 (6.0–12.0)	7.0 (5.0–10.0)	7.0 (5.0–9.0)	8.0 (5.0–12.0)	7.0 (5.0–10.0)	7.0 (5.0–10.0)	8.0 (6.0–11.0)	11.0 (8.0–14.0)	8.0 (6.0–11.0)	7.0 (4.8–9.0)	8.0 (5.0–14.0)	7.0 (4.0–11.0)	<0.001
Management method																<0.001
Intramedullary nail	1,199 (27.4)	18 (23.4)	329 (22.8)	112 (36.2)	67 (20.9)	94 (32.5)	142 (26.2)	290 (39.6)	57 (18.9)	87 (28.5)	108 (33.8)	292 (24.0)	74 (22.0)	79 (16.5)	132 (31.1)	
Hemiarthroplasty	1,240 (28.4)	21 (27.3)	313 (21.7)	84 (27.2)	86 (26.9)	63 (21.8)	154 (28.5)	138 (18.9)	89 (29.5)	93 (30.5)	69 (21.6)	311 (25.5)	75 (22.3)	95 (19.9)	118 (27.8)	
Sliding hip screw	1,063 (24.3)	23 (29.9)	508 (35.3)	65 (21.0)	80 (25.0)	61 (21.1)	123 (22.7)	114 (15.6)	77 (25.5)	65 (21.3)	24 (7.5)	328 (26.9)	80 (23.8)	157 (32.8)	79 (18.6)	
Total hip arthroplasty	275 (6.3)	6 (7.8)	127 (8.8)	20 (6.5)	33 (10.3)	8 (2.8)	43 (7.9)	38 (5.2)	34 (11.3)	12 (3.9)	7 (2.2)	127 (10.4)	42 (12.5)	46 (9.6)	39 (9.2)	
Screws	285 (6.5)	7 (9.1)	95 (6.6)	10 (3.2)	6 (1.9)	26 (9.0)	12 (2.2)	72 (9.8)	4 (1.3)	30 (9.8)	38 (11.9)	48 (3.9)	9 (2.7)	28 (5.9)	11 (2.6)	
Nonoperative	307 (7.0)	2 (2.6)	68 (4.7)	18 (5.8)	48 (15.0)	37 (12.8)	67 (12.4)	80 (10.9)	41 (13.6)	18 (5.9)	74 (23.1)	112 (9.2)	56 (16.7)	73 (15.3)	46 (10.8)	
Received acute rehabilitation	3,460 (79.2)	68 (88.3)	1,012 (70.3)	240 (77.7)	245 (76.6)	185 (64.0)	409 (75.6)	478 (65.3)	211 (69.9)	227 (74.4)	211 (65.9)	986 (81.0)	259 (77.1)	368 (77.0)	322 (75.8)	<0.001
Their received PTi, h/w	1.8 (1.3–2.3)	1.8 (1.4–2.3)	2.2 (1.8–2.6)	1.8 (1.2–2.1)	2.0 (1.3–2.8)	1.8 (1.4–2.3)	2.1 (1.5–2.9)	2.2 (1.8–2.5)	2.1 (1.4–2.8)	1.8 (1.3–2.2)	1.6 (1.3–2.0)	2.1 (1.5–2.6)	2.1 (1.5–2.7)	2.1 (1.6–2.4)	2.0 (1.4–2.7)	<0.001

Continuous variables are presented as “median (25th–75th percentile)” and categorical as “n (%)”. LOS – length of stay, #surgery within the first two days of hospitalisation, PTi – received physical therapy intensity of those included in acute rehabilitation, h/w – hours per week.

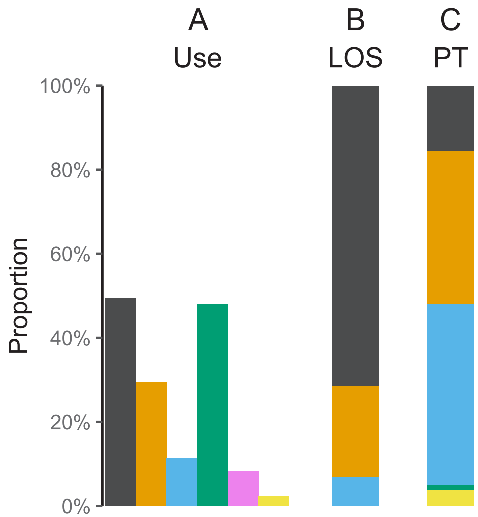
5.2. Acute management and physical therapy use (PAPERs I, III)

The median acute LOS was 8 days (5–11). A total of 90.9% of patients (10,442) received operative management, and in 99.4% cases (10,376/10,442), the date of surgery was available. Among the patients treated with operative management, 71.5% (7,461/10,376) were operated within the first two days of hospitalisation. Surgical methods distributed as follows: 26.9% (3,091) intramedullary nail, 25.7% (2,952) hemiarthroplasty, 24.9% (2,856) sliding hip screw, 7.5% (861) total hip arthroplasty and 5.9% screws. Although most of the patients underwent surgery, a considerable proportion of the patients [9.1% (1,049)] received nonoperative management. A total of 8,701 patients (75.7%) were offered PT during acute care, and the included patients received a median PTi of 2.0 h/w (1.4–2.5). Finally, acute management varied among the counties. Its regional variabilities are presented as a range of minimum and maximum values of the counties: median LOS – 5–11 days, proportion treated nonoperatively – 2.6%–23.1%, received acute rehabilitation – 64.0%–88.3%, and median received PTi of patients included in acute rehabilitation – 1.6 h/w to 2.2 h/w (Table 4).

5.3. Post-acute management (PAPER III)

A total of 1,649 patients (14.4%) received no post-acute care. The rest of the patients were admitted into different setting types, which were either used separately [39.8% (4,572)] or in combination [45.9% (5,270)]. The use of different setting types and the relevant LOS, PT and descriptions are shown in Figure 8. The proportion of patients receiving post-acute hospital care was 67.8% (7,795), and their median overall LOS was 25 days (14–40). The median overall post-acute LOS ranged considerably, from 18 to 35 days, among the counties.

The majority of post-acute PT (95.0%) was received in inpatient settings, followed by outpatient physiotherapy (3.9%) and other outpatient care (1.1%) (Figure 8C). All the patients received PT in specialised rehabilitation settings, inpatient rehabilitation and outpatient physiotherapy care, which were accessible to only 13.3% of the patients (1,526). However, the provision of PT varied regionally and was inconsistent for other inpatient and inpatient nursing care (Figure 9), which together covered 93.0% of the total number of days spent in hospital care (Figure 8B). Finally, post-acute rehabilitation was seldom received in other outpatient care: only 1.9% of the admitted patients (107/5,509) received PT.



Setting type	Use	LOS	PTi/PT
Inpatient nursing care	5,677 (49.4)	25 (16-38)	0.0 (0.0-0.0)
Other inpatient	3,393 (29.5)	11 (8-18)	2.0 (1.2-2.6)
Inpatient rehabilitation	1,307 (11.4)	11 (10-14)	6.6 (5.6-8.5)
Other outpatient	5,509 (47.9)	-	0.0 (0.0-0.0)
Home nursing	969 (8.4)	-	-
Outpatient physiotherapy	271 (2.4)	-	5.0 (3.0-7.8)

Figure 8. Use and descriptions of post-acute setting types. (A) The proportions of patients using different setting types (total n = 11,491). Any patient may receive care in multiple settings. (B) Total post-acute hospitalisation days partitioned by setting type (total = 239,360 days). (C) Total provided physical therapy hours partitioned by setting type (total = 40,400 hours). Descriptions of setting types include the number of patients admitted and their proportion; LOS – median overall length of stay in days; PTi – median overall physical therapy intensity in hours per week (used for inpatient settings); PT – median overall received physical therapy hours (used for outpatient settings).

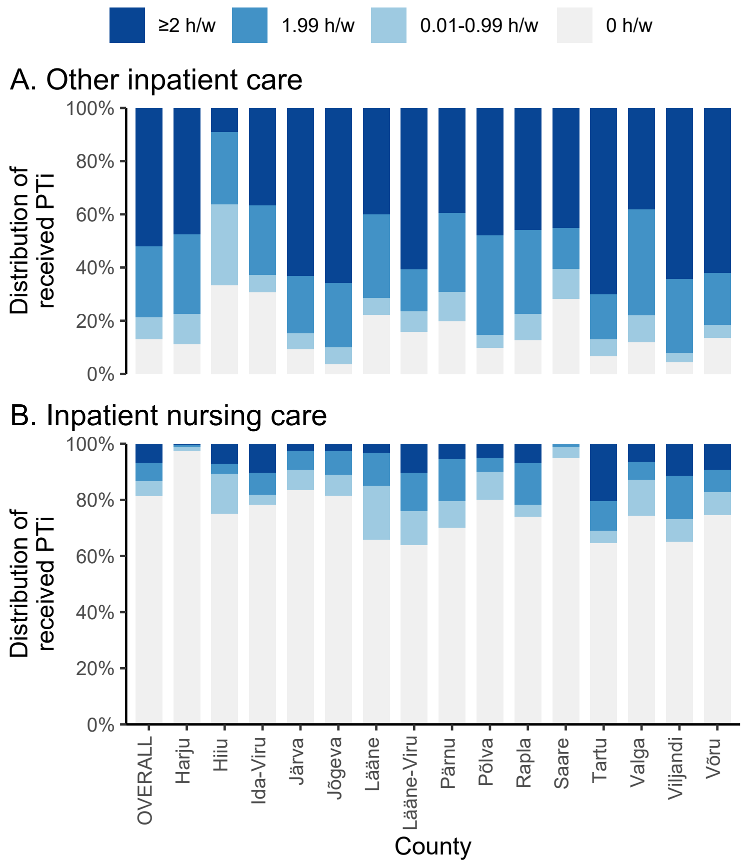


Figure 9. Distributions of received physical therapy intensity in other inpatient (A) and inpatient nursing care (B) by county. The frequencies of physical therapy intensity distributions differed between the counties for both settings ($p < 0.001$). PTi – physical therapy intensity, h/w – hours per week.

5.3.1. Post-acute physical therapy use (PAPERs II, III)

As a result of the frequent use of post-acute settings with inconsistent PT provision, only 40.2% (4,621) of patients received post-acute PT by a median of 6.0 hours (3.0–11.0). Exclusion from post-acute rehabilitation was also prevalent among the patients admitted to hospital care. Only 56.7% of them (4,416/7,795) received PT; their median received PTi was 1.1 h/w (0.6–1.9). Only 14.1% of the hospitalised patients (1,100/7,795) received a PTi of ≥2 h/w, and their proportion decreased rapidly from the second hospitalisation week onwards (Figure 10). Finally, post-acute rehabilitation was also not accessible for most of the patients, who were not admitted to post-acute hospital care (3,696) as only 4.3% of them received PT (159/3,696).

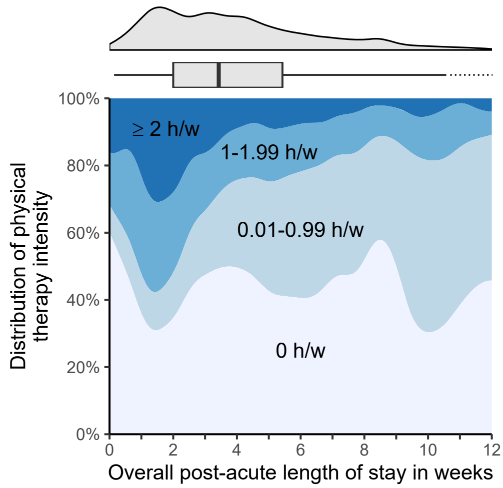


Figure 10. Distribution of received post-acute physical therapy intensity by overall post-acute hospital length of stay. Analysis includes only those patients who were admitted to post-acute hospital care, n = 7,795. The marginal distribution of the included patients by the total post-acute length of stay is shown as a density and a box-plot above the main figure. h/w – hours per week.

5.3.2. Regional differences in post-acute physical therapy use (PAPER III)

Adjusted analyses showed multi-fold inter-regional differences in post-acute rehabilitation; additionally, intra-regional disparities were also detected. The probability of receiving post-acute rehabilitation ranged from 29.5% to 73.0%, resulting in a 2.5-fold difference among the counties (Figure 11A). The total received PT of patients undergoing post-acute rehabilitation ranged from 2.9 to 7.5 hours, resulting in a 2.6-fold difference among the counties (Figure 11B). In addition to the inter-regional differences, variation modelling identified intra-regional disparities in HF post-acute rehabilitation that otherwise would have remained undetectable with analyses based on the measures of central tendency. For example, the patients from Harju and Ida-Viru had a relatively similar probability for receiving an equal amount of post-acute rehabilitation; however, the standard deviation of received PT hours was 1.5 times higher for the patients from Harju county (Figure 11C). Higher variation means that the values of total post-acute PT hours are spread out over a wider range, i.e. a higher proportion of patients are receiving little, or much, PT. In other words, extreme post-acute PT values were more common in Harju as compared to Ida-Viru county. Thus, the variation modelling complemented the analyses based on measures of central tendency by additionally detecting intra-regional disparities, showing an inequality in the allocation of local rehabilitation resources.

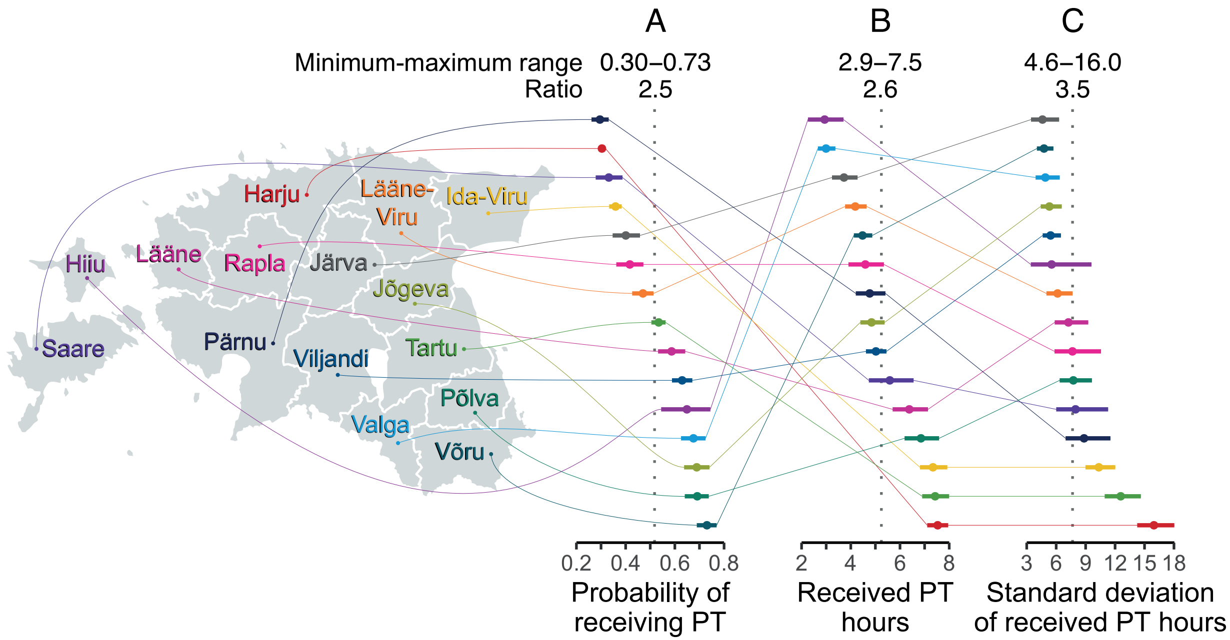


Figure 11. Adjusted inter- (A, B) and intra-regional (C) comparisons of the total received post-acute physical therapy hours. (A) Mean probability for receiving post-acute physical therapy. (B) Median total received post-acute physical therapy hours. (C) The standard deviation of received physical therapy hours. Point estimates are given with 95% credible intervals. Dotted lines represent the respective estimates for the whole country. CI – credible interval, PT – physical therapy

5.3.3. Overall temporal trends in post-acute physical therapy use (PAPERs II, III)

There were positive temporal changes in the probability of receiving post-acute PT only; it increased by 28.2 percentage points [17.0; 39.9] (Figure 12A). The median total received post-acute PT showed no temporal trend with a marginal rise by 0.9 hours only [-0.7; 2.7]; however, the standard deviation of received PT increased by 4.5 hours [1.9; 7.1] during the study period (Figure 12B–C). Consequently, more HF patients started to receive post-acute rehabilitation, but the division of provided PT resources became less equal among its receivers. Despite the increased probability of receiving post-acute rehabilitation, in the year 2017, crude analyses showed that 50.6% of the patients (504/997) received no post-acute PT, and only 19.6% of hospital care patients (136/997) received a PTi of ≥2 h/w.

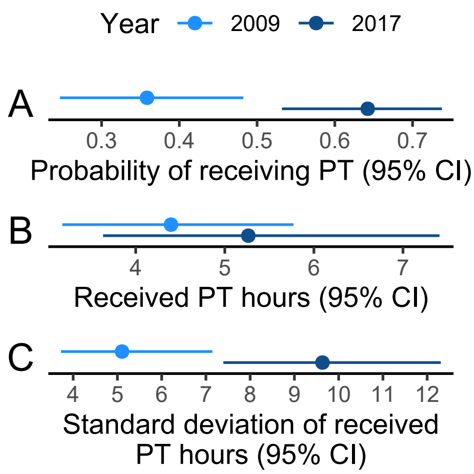


Figure 12. Adjusted temporal trends in the total received post-acute physical therapy hours. (A) Mean probability for receiving post-acute physical therapy. (B) Median total received post-acute physical therapy hours. (C) The standard deviation of received physical therapy hours. Point estimates are given with 95% credible intervals. CI – credible interval, PT – physical therapy.

5.3.4. Regional temporal trends in post-acute physical therapy use (PAPER III)

The probability of receiving post-acute rehabilitation changed the most during the nine-year study period. The probability increased by 9.1 to 52.1 percentage points in 12 counties, excluding Hiiu, Lääne-Viru and Võru. Despite the change, there remained a 2.4-fold difference in the probability of receiving post-acute rehabilitation among the counties in the last year of the study (Figure 13A).

In contrast, the total received post-acute PT changed in only four counties – Ida-Viru, Tartu, Viljandi and Võru. Patients from these four counties started to receive from 1.1 to 5.4 hours more post-acute PT. The temporal change in the received PT increased intra-regional differences from 2.4-fold in 2009 to 4.4-fold in 2017 (Figure 13B).

The standard deviation of received PT hours changed in seven counties, namely, Ida-Viru, Jõgeva, Lääne, Tartu, Valga, Viljandi and Võru with an increase from 3.6 to 10.6 hours (Figure 13C). Variation modelling revealed that the increase in post-acute PT hours was not entirely a positive change in HF rehabilitation since the added local health resources may not be divided equally among the patients. For example, all the four counties with increased PT hours simultaneously showed a temporally increased variation and indicated a rising inequality in local rehabilitation resource allocation.

In summary, 2.4- to 4.4-fold inter-regional disparities persisted in HF rehabilitation at the end of the study period (Figure 13A–B). Variation modelling revealed that the division of local rehabilitation resources remained dissimilar for the patients from different counties, resulting in 3-fold intra-regional disparities in 2017 (Figure 13C).

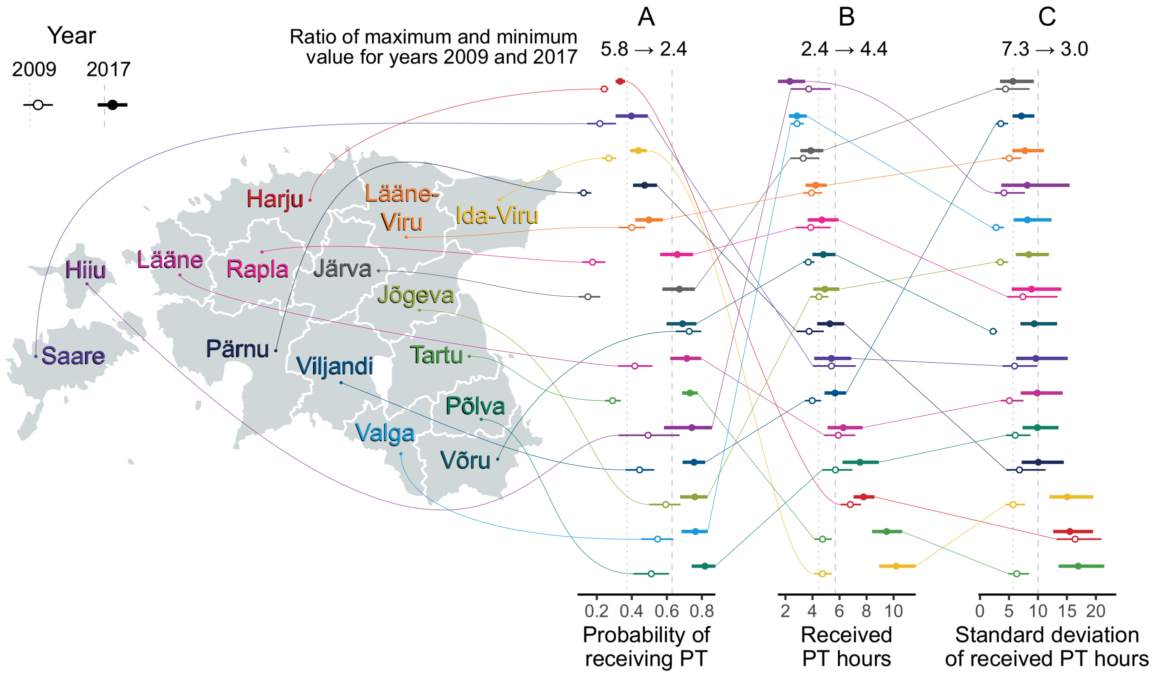


Figure 13. Adjusted inter- (A, B) and intra-regional (C) temporal trends in the total received post-acute physical therapy hours. (A) Mean probability for receiving post-acute physical therapy. (B) Median total received post-acute physical therapy hours. (C) The standard deviation of received physical therapy hours. Point estimates are given with 95% credible intervals. Dotted lines represent the respective estimates for the whole country. CI – credible interval, PT – physical therapy.

5.4. Effect of patients' characteristics on post-acute physical therapy use (PAPER II)

The patients' age showed no significant effect on the probability of being included in post-acute rehabilitation or on the received PT hours. In contrast, post-acute rehabilitation differed between the sexes. The women had 5.5 percentage points [2.9; 8.1] higher probability of receiving post-acute rehabilitation, and they received a median of 0.6 hours [0.2; 0.9] more PT than the men. The patients with more comorbidities received more PT. The probability of receiving post-acute rehabilitation increased by 3.4 percentage points [2.6; 4.1] for every one unit increase in CCI. The patients undergoing post-acute rehabilitation received a median of 0.4 hours [0.3; 0.5] more PT for every one unit increase in CCI.

The patients with a dementia diagnosis had 10.2 percentage points [3.9; 17.4] lower probability for receiving post-acute rehabilitation. However, there was no difference in the amount of received post-acute rehabilitation, because dementia patients received a median of 0.7 hours [-0.4; 1.7] less PT. Fracture type showed almost no effect on post-acute rehabilitation, excluding femoral neck fracture. The difference showed that femoral neck fracture patients had 3.0 percentage points [0.7; 5.3] higher probability of receiving post-acute rehabilitation than those with a pertrochanteric fracture.

Finally, the received post-acute PT hours were relatively similar among the patients treated with different HF management methods; however, there were considerable differences in the probability of being included in post-acute rehabilitation. Nonoperatively treated patients had 39.0 percentage points [33.7; 44.1] lower probability of receiving post-acute PT than those treated with operative management methods in general. Total hip arthroplasty patients had the highest probability of receiving post-acute rehabilitation. They had 15.5 percentage points [11.9; 19.5] higher chance of receiving post-acute PT than those who were treated with the remaining surgical methods (Figure 14).

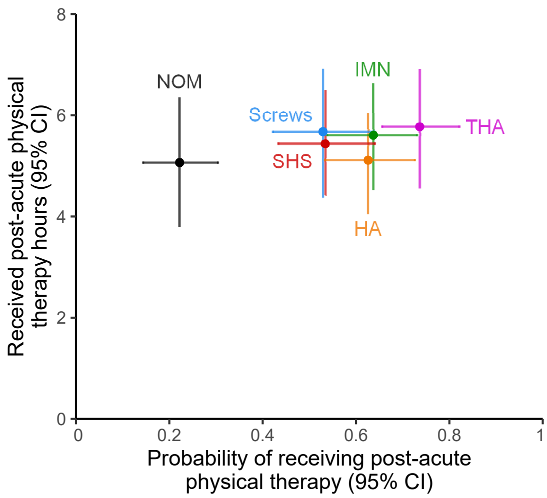


Figure 14. Post-acute physical therapy use among hip fracture patients treated with different management methods. CI – credible interval, HA – hemiarthroplasty, IMN – intramedullary nail, NOM – nonoperative management, SHS – sliding hip screw, THA – total hip arthroplasty.

5.5. Mortality

In-hospital, 1-, 3-, 6- and 12-month unadjusted all-cause mortality rates were 3.3% (378), 8.6% (986), 18.5% (2,125), 24.4% (2,803) and 30.8% (3,534), respectively. The respective mortality rates for surgically treated patients were 2.2% (234/10,442), 6.6% (690/10,442), 15.8% (1,646/10,442), 21.4% (2,236/10,442), and 27.6% (2,880/10,442). Despite higher mortality in nonoperatively treated patients, a considerable proportion of the them survived for one year [37.7% (395/1,049)] (Figure 15).

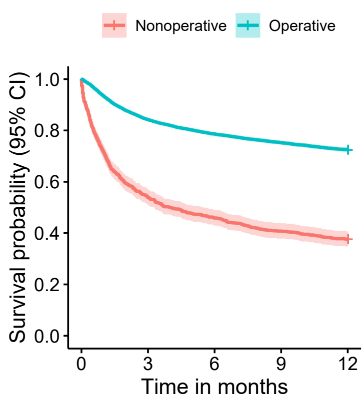


Figure 15. One-year survival probability of nonoperatively and operatively treated hip fracture patients. CI – confidence interval.

6. DISCUSSION

6.1. Patients

Most of the patients' baseline characteristics were in line with the findings of the other HF databases (Johansen et al. 2017). However, there were discrepancies in men's age and the prevalence of baseline dementia compared to other studies. The median age of men at the time of HF was relatively low. Other studies reported a similar median age for HF women, but with a smaller age difference between the sexes (Kannegaard et al. 2010; Kurtinaitis et al. 2012; Diamantopoulos et al. 2013; Klop et al. 2014). Estonian HF population has 5 percentage points more patients below 80 years of age than the Austrian study by Brozek and colleagues (2014). Also, there was a difference in the proportion of sexes in age subgroups. In Estonia, men were highly prevalent in each of the two youngest age subgroups, whereas in the Austrian study, the proportion of men was 10 percentage points lower in the 50–59 and 60–69 age subgroups (Brozek et al. 2014). Jürisson and colleagues (2015) proposed that high HF incidence among Estonian men aged 50–69 years can be explained by relatively high alcohol consumption rates that consequently leads to a greater risk of alcohol-related falls and injuries. Second, the prevalence of baseline concomitant dementia diagnosis rate in this study was two to three times lower as compared to other studies (Seitz et al. 2011; Hebert-Davies et al. 2012). The low prevalence of dementia can be explained by the systematically unused geriatric assessment and its ICD-10-based identification method (Quan et al. 2008).

6.2. Acute management and rehabilitation

The surgical care of HF patients showed similarities with the available literature, including the distribution of operative management methods and the proportion receiving surgery within the first two days from hospitalisation (Gjertsen et al. 2017; Johansen et al. 2017). In contrast, the nonoperative management rate was unexpectedly high, being 1.6–10 times higher than reported by other studies (Neuman et al. 2010; Cram et al. 2017; Johansen et al. 2017; National Hip Fracture Database 2018). Similar or higher nonoperative management rates have been reported for Canada, Singapore and Kazakhstan (Jain et al. 2003; Amrayev et al. 2017; Lim and Kwek 2018). The nonoperative rate in Estonia is comparable to that reported for nursing home residents (Berry et al. 2009; Neuman et al. 2014). The nonoperative management rate also showed significant variability among the counties, leaving up to a quarter of patients without surgery in Saare county.

Multiple factors are generally associated with nonoperative management: older age, male sex, more comorbidities, residence in a rural area, femoral neck fractures, baseline residence at long-term care, lower income and black race (Neuman et al. 2010; Cram et al. 2017). The relatively high nonoperative management rate in Estonia could also be attributed to country-specific factors like traditions and limited knowledge of patients and their relatives about the urgency of the fall-injury event. Also, there could be a higher proportion of very frail HF patients in Estonia, i.e. bed-bound nursing home residents or those with severe dementia, who are less often considered as candidates for surgery. Although our data did not allow assessing the patients' functional statuses and dementia severities, this conjecture is supported by the findings of nursing home facilities inspection by the officials of the Chancellor of Justice office of Estonia. The inspection revealed several shortcomings in the nursing homes: locking residents in a room without their approval, negligence in implementing the nursing care plans, limited staff, inappropriate handling of medicines, lack of safe room settings, unavailability of suitable walking aids and exclusion of severely disabled candidates from activities (Estonian Chancellor of Justice 2017). These limitations are likely to aggravate nursing home residents physical and cognitive deconditioning. Finally, the high nonoperative management rate could be partly an adaption to limited rehabilitation possibilities discussed under the discussion section of post-acute management. Frail HF patients may more likely receive nonoperative management as clinicians infrequently see their recovery with surgery in Estonia.

The eight-day-long HF acute care is relatively short in Estonia, while compared to the findings from other countries, leaving more of a patient's rehabilitation for post-acute care (Johansen et al. 2017; Royal College of Physicians 2017). The majority of patients included in acute rehabilitation received the recommended PTi of 2 h/w by the Chartered Society of Physiotherapy, UK (Chartered Society of Physiotherapy 2018). However, one-quarter of the patients received no rehabilitation during their acute care. The high rate of nonoperative management may partly explain the exclusion of these patients from acute rehabilitation due to the poor prognosis and untreated fracture, albeit studies reported benefits of their mobilisation (Jain et al. 2003; Lim and Kwek 2018).

The relatively high and geographically varying rates of nonoperative management and the proportion of patients excluded from acute rehabilitation showed limitations of patient management, likely leading to poorer outcomes (Neuman et al. 2014). These limitations may be due to missing national or non-use of international guidelines, depriving patients from receiving necessary and recommended care. International guidelines recommend considering surgery even for terminal illness patients and offering daily rehabilitation (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; Australian Commission on Safety & Quality in Health Care 2016; Chartered Society of Physiotherapy 2018; McDonough et al. 2021). These findings also suggest a lack of co-management due to insufficient geriatric expertise and services that lead to inadequate management of these frail patients. This conjecture is supported by the fact that 38% of nonoperatively managed HF patients survived one year, indicating shortcomings in clinical decision making as poor prognoses did not transfer to mortality.

6.3. Post-acute management and rehabilitation

The relatively shorter HF acute care was followed by the post-acute phase, where rehabilitation provision was limited. The shortcomings of the post-acute rehabilitation included inaccessible PT or its limited provision, largescale inter- and intra-regional differences, high use of suboptimal care and non-need-based PT allocation.

Access to post-acute rehabilitation after HF is low in Estonia. While guidelines recommend a continuous rehabilitation after acute care, 60% of HF patients received no post-acute PT during the observed period (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; Australian Commission on Safety & Quality in Health Care 2016; Chartered Society of Physiotherapy 2018; McDonough et al. 2021). The non-receivers rate is 24-48 percentage points higher than the rates reported in the studies from Israel and Italy (Zucker et al. 2013; Tedesco et al. 2018). The rate is 20 percentage points higher than the Canadian study on HF patients with concomitant dementia (Seitz et al. 2016). The exclusion from continued rehabilitation was also prevalent among the patients admitted to post-acute hospital care. Almost half of those patients (43%) received no PT during their post-acute hospital care with a median length of 25 days. These findings showed that post-acute care did not support continuous recovery after HF in Estonia. This is especially concerning for hospital care patients as a prolonged bed rest with inadequate rehabilitation leads to hospital-associated deconditioning and the depletion of functional reserves (Falvey et al. 2015).

HF post-acute rehabilitation was not only inaccessible for the majority of patients but also was relatively limited for the patients receiving PT. Although there are not many reports, which studied the received PT after HF, the available studies reported higher PT amounts. The total median received post-acute PT was 6 hours in Estonia, which was over 5-times less than the patients received in a single episode of skilled nursing or inpatient rehabilitation facility in the United States (Mallinson et al. 2014). When total combined acute and post-acute PT hours were compared, Estonian HF patients received 14 times less rehabilitation than usual care patients in Australia (Kimmel et al. 2016). The PTi of patients who received post-acute hospital care was also low. The Chartered Society of Physiotherapy, UK recommended a minimum of two hours of rehabilitation per week; however, only 14% of hospitalised patients received the recommended PTi. The median PTi of hospitalised patients was 1.1 h/w, which was 1.1–19 times less than intensities reported for different settings in the literature (Munin et al. 2005; Mallinson et al. 2014; Royal College of Physicians 2017; Yoshizawa et al. 2017).

HF patients receiving post-acute hospital care in Estonia should have received 1.8 times more PT in total to cover their total post-acute LOS as per the recommended PTi of 2 h/w (Chartered Society of Physiotherapy 2018). The need for additional rehabilitation resources could be even higher. The LOS-based estimation of the total needed PT hours possibly led to an underestimation since the median post-acute hospitalisation was less than a month; however, HF recovery often takes more than six months, including care in different care settings (Dyer et al. 2016). Secondly, a total of 32% of patients were not hospitalised after acute care; however, the proportion of receiving any outpatient PT (4.3%) was 4.4 times lower than reported in the study from Israel (Zucker et al. 2013). In part, this can be explained by the negligible use of home-based rehabilitation despite its implementation since 2016 in Estonia. Multiple studies showed positive outcomes associated with home PT use after HF (Mehta and Roy 2011; Mallinson and Leland 2014; Berggren et al. 2018; D. Wu et al. 2018). In summary, considering that the majority of patients received no post-acute PT and the remaining would probably have needed multiple times more, there is a multi-fold unmet rehabilitation need for optimal HF management.

We also found large inter- and intra-regional disparities in PT use after HF that remained persistent during the nine-year study period. The analyses based on central tendency measures detected inter-regional disparities in the probability of receiving post-acute rehabilitation and in received PT hours. The respective differences were 2.5 to 2.6-fold among the counties. Two-fold regional differences were also found in post-acute LOS. Other studies that used different outcome measures also reported regional differences in HF rehabilitation (Kane et al. 2002; Sund et al. 2011; Zucker et al. 2013; Pitzul et al. 2016; Teppala et al. 2017). Varying local accessibility of rehabilitation services may explain the regional differences. The Israeli HF study partly attributed regional variability to rehabilitation beds' availability (Zucker et al. 2013). Additionally, the variation analysis detected intra-regional disparities, showing that the received PT hours were more affected by extreme values in counties like Harju, Ida-Viru and Tartu. Therefore, local rehabilitation resources were divided less equally in these three counties. These intra-regional disparities show that HF rehabilitation depends not only on local rehabilitation resources but also on the regional policy used for their division among patients.

The analysis of the effect of patients' characteristics on post-acute PT showed that the patients with more comorbidities received better rehabilitation. This was expected due to their higher care needs as compared to their healthier counterparts. In contrast, three results of the analysis indicated further patient-level inequalities in HF rehabilitation; however, these should be interpreted with caution due to some limitations. First, adjusting to pre-fracture functional status and residence was not possible, possibly leading to some uncontrolled confounding. Second, the prevalence of dementia was underestimated as described earlier.

Patients with diagnosed dementia had a lower probability of receiving post-acute rehabilitation. While multiple studies reported benefits of rehabilitation in dementia patients (Goldstein et al. 1997; Huusko et al. 2000; Toussant and Kohia 2005; Muir and Yohannes 2009; Allen et al. 2012; The American Academy of Orthopaedic Surgeons 2014; Resnick et al. 2016; Seitz et al. 2016; Beaupre et al. 2019; Smith et al. 2020), other research reports also reported the exclusion of HF patients with dementia from rehabilitation (Beaupre et al. 2007;

Bellelli et al. 2007; Seitz et al. 2016; Sheehan et al. 2018). There could be multiple reasons for excluding them from rehabilitation: labelling dementia patients as having no rehabilitation potential, inadequately equipped healthcare staff for providing care to people with cognitive impairment, and limited guidelines for their rehabilitation (The National Institute for Health and Care Excellence 2011; Allen et al. 2012; The American Academy of Orthopaedic Surgeons 2014; Australian Commission on Safety & Quality in Health Care 2016; Hall et al. 2017; Gill et al. 2017, 2017; Chartered Society of Physiotherapy 2018; Hall et al. 2019; McDonough et al. 2021). Therefore, it is crucial to educate healthcare staff accordingly and develop evidence-based PT strategies to improve rehabilitation of dementia patients. These findings showed an additional inequality in HF rehabilitation in Estonia since a vulnerable subgroup of patients less often received post-acute PT.

Differences in post-acute PT use among the patients treated with various management methods also suggest inequality in HF rehabilitation. In practice, the choice of a management method depends on fracture's morphology and different patient characteristics. Patient's characteristics are particularly considered while treating femoral neck fractures, where cancellous screws, sliding hip screw, hemiarthroplasty and total hip arthroplasty are available as treatment options. Total hip arthroplasty is recommended for healthier, cognitively and functionally more capable patients compared to hemiarthroplasty (The National Institute for Health and Care Excellence 2011; Bhandari and Swiontkowski 2017). In the present study, paradoxically, patients treated with total hip arthroplasty had the highest probability of receiving post-acute rehabilitation. Non-operatively managed patients had the worst chances for receiving post-acute rehabilitation, which was possibly due to their poor prognosis and untreated fracture, albeit the studies reported benefits of their mobilisation (Jain et al. 2003; Lim and Kwek 2018). Age showed no effect on received post-acute PT. However, it can be assumed that a need-based rehabilitation would show an association, as younger HF patients need less PT for recovery. These findings further suggested that rehabilitation resources were not divided according to HF patients needs in Estonia.

This study was unable to identify another critical and vulnerable subgroup of HF patients – nursing home residents. Nursing home residents are often left out from rehabilitation, which is not in agreement with the current guidelines since they also benefit from it (Crotty et al. 2000; The National Institute for Health and Care Excellence 2011; Sheehan et al. 2018; Beaupre et al. 2019). The data retrieved from EHIF could not distinguish nursing home residents from community-dwelling patients and hence did not allow to analyse their post-acute rehabilitation. As a considerable proportion of the study patients (30%) did not receive post-acute hospital care or ambulatory PT, the exclusion of nursing home residents may be another issue in HF rehabilitation in Estonia.

The above findings showed significant shortcomings of HF post-acute rehabilitation in Estonia: the overall limited access and provision of PT, inter- and intra-regional disparities in PT use, and its non-need-based allocation among the patients. The shortcomings especially contrast in light of the relatively short acute care, covering less HF patients' recovery. Numerous reasons can explain the shortcomings of HF rehabilitation in Estonia. The reasons can be grouped into two major categories: insufficient rehabilitation resources and their allocation among the patients. The two categories are unfolded subsequently.

Estonian rehabilitation system may not likely have enough resources to ensure adequate post-acute management for HF patients: post-acute rehabilitation was inaccessible for the majority; patients undergoing post-acute rehabilitation received a relatively small amount of PT; post-acute rehabilitation showed large regional differences; high use of suboptimal inpatient care. While 95% of HF post-acute rehabilitation was hospital-based in Estonia, only one-tenth of patients had access to inpatient rehabilitation care. This favoured the use of alternative inpatient settings where PT provision was inconsistent or unavailable for the majority of patients (Figure 9). Insufficient resources might have especially limited HF rehabilitation in counties like Järva, where a small proportion of patients received a relatively small amount of PT. Insufficiency of rehabilitation resources in the health care system was supported by three earlier study reports. These reports pointed to similar issues in rehabilitation, including insufficient health care spending, a low number of occupational and physiotherapists and heavy workloads (National Audit Office of Estonia 2006; The World Bank Group 2015; Organisation for Economic Co-operation and Development 2019). Limited rehabilitation was also reported by the other studies on stroke, traumatic spinal cord injury and HF patients (Vibo et al. 2007; Kivisild et al. 2014; Jürisson et al. 2016). Thus, it is apparent that limited rehabilitation is not restricted to HF care, but it is a system-wide problem.

While sufficient resources are a presumption for optimal rehabilitation planning, their unlimited increase would not be cost-efficient and does not guarantee equal allocation among patients. Multiple results of this work showed unequal PT allocation: the identified intra-regional disparities, increased inequality in the division of PT resources among its receivers during the study period, the patient-level inequalities that left more vulnerable patients without post-acute rehabilitation. This observation particularly refers to the counties like Harju and Ida-Viru, where a small proportion of patients received a relatively high amount of PT, resulting in an unequal allocation of local rehabilitation resources. This showed limitations in HF management, including a lack of coordinated multidisciplinary approach, non-use of rehabilitation programmes covering all episodes of care, unplanned care pathways and the absence of appropriate clinical handovers. These missing practices are in disagreement with the recommended whole-pathway approach, which aims to ensure uninterrupted post-acute rehabilitation for HF patients (The National Institute for Health and Care Excellence 2011; Australian & New Zealand Hip Fracture Registry 2014; The American Academy of Orthopaedic Surgeons 2014; European Society of Trauma and Emergency Surgery 2015; Australian Commission on Safety & Quality in Health Care 2016; Chartered Society of Physiotherapy 2018; McDonough et al. 2021). As a result, existing post-acute care pathways seem fragmented and coincidental, not supporting continual recovery after HF. Similar issues were reported for the Estonian rehabilitation system, including inefficient division of resources among patients, lack of updated guidelines in line with international standards, weakly coordinated post-acute care, poor information flow between care settings, lack of clarity in responsibilities, inadequate continuity of primary care, weak monitoring and reporting of quality of care (National Audit Office of Estonia 2006; The World Bank Group 2015; Organisation for Economic Co-operation and Development 2019). Other factors may also contribute to the issues of HF management, including untrained health care professionals or their poor attitudes against the vulnerable HF subgroups, non-provision of PT on weekends and limited multidisciplinary geriatric expertise.

As HF continued care is limited due to numerous factors, there will be no single easy fix; system-wide improvements are needed for ensuring ongoing coordinated post-acute rehabilitation. HF rehabilitation's self-fixing should not be expected as nine-year temporal changes were marginal or showed an increasing inequality. First, sufficient resources should be guaranteed, allowing to plan optimal HF rehabilitation pathways: increasing health care spending on rehabilitation, increasing the provision of rehabilitation services, improving the accessibility of home rehabilitation and inpatient rehabilitation care, ensuring regionally equal opportunities, and possibly the training of more occupational and physiotherapists and geriatricians. Second, the allocation of PT resources should be optimised to ensure cost-efficient and need-based ongoing rehabilitation for all HF patients. This includes confirming HF care to international guidelines and standards, implementing the multidisciplinary approach, taking HF rehabilitation programmes into use, coordinating patients care across different care settings, ensuring clinical information flow between different stages of care, decreasing the use of suboptimal care and increasing the corresponding expertise of healthcare staff. One possible causal relationship between the above factors is given as a schematic presentation in Figure 16. The causal scheme may help to put the information into practice, as it underlines the topics, which need improvement and further provides a possible sequence for required actions.

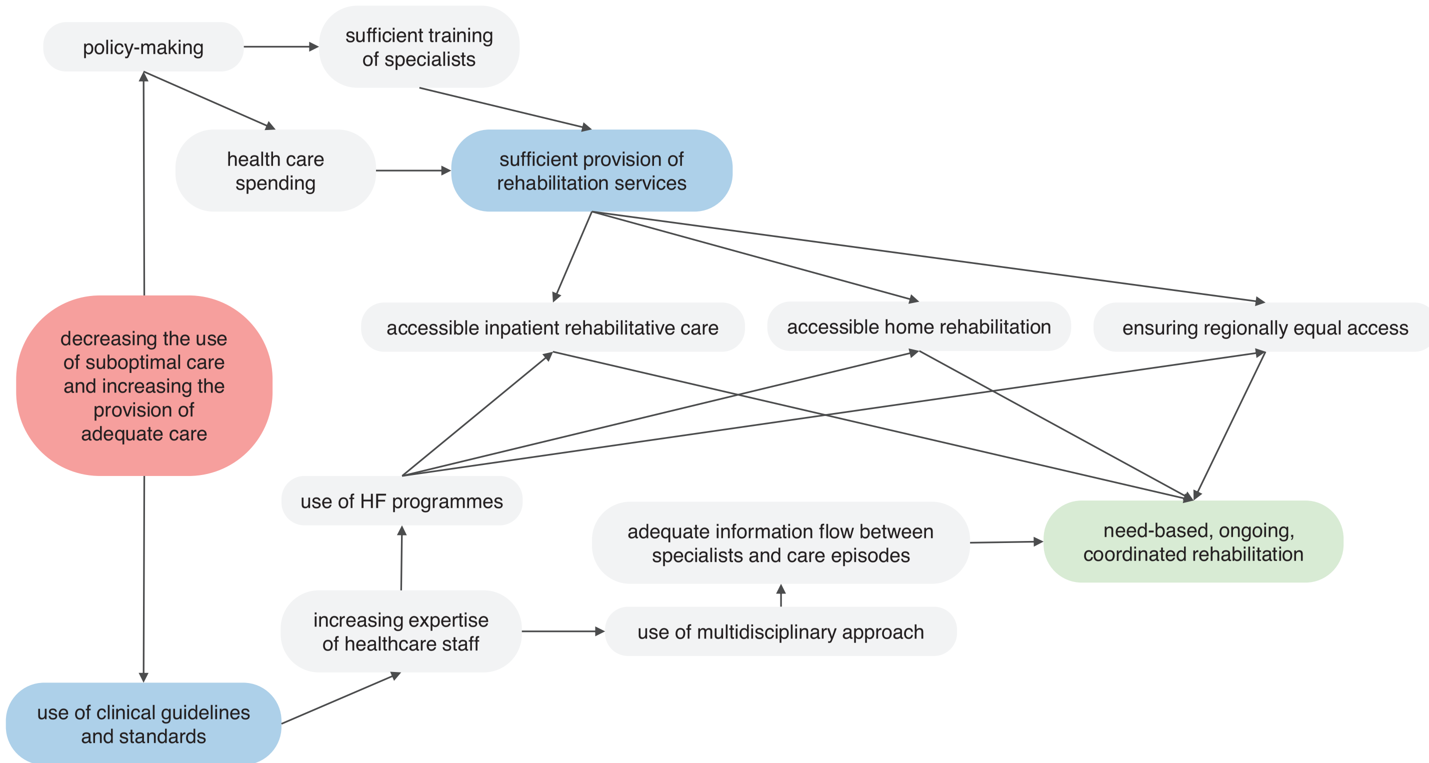


Figure 16. Schematic presentation showing a possible causal pathways between the underpinning reasons of limited hip fracture rehabilitation in Estonia. Fill colours are used as follow: red marks the issue, blue identifies the categories that need improvement and green shows the goal.

Ultimately, HF management is lacking a fundamental care pillar in Estonia – ongoing coordinated post-acute care, leaving these patients without essential rehabilitation. Relatively similar issues were detected in 2004 in the rehabilitation of cardiologic, neurologic and orthopaedic patients; however, actions taken for improving the system were insufficient (National Audit Office of Estonia 2006). This could be due to a continuous under-prioritisation of rehabilitation, seeing it as an optional extra rather than an essential component of integrated health care services (The World Health Organization 2017). While receiving only a part of emergency care or trauma surgery would not be considered acceptable, this is apparently possible with rehabilitation. Rehabilitation is often spread over many months, dividing responsibility for its provision among numerous specialists and facilities. The under-prioritisation is supported by the fact that the proportion of EHIF's expenditure on rehabilitation did not change notably during the years 2003–2019, being constantly around 1% in total (Figure 17). The proportion of the expenditure spent on day rehabilitation was marginal during these years; it was always below 0.04%. The proportion spent on home-based rehabilitation was zero during these years. Such trends are concerning as an alarming input for policy-making was already available in the audit published in 2006: rehabilitation was available only for one-fifth of the observed patients, participated health care specialists estimated that health care spending on rehabilitation should be 3 to 6 times higher, and poor rehabilitation was associated with adverse outcomes and increased expenditures (National Audit Office of Estonia 2006). Adding new rehabilitation resources could increase the cost-effectivity of HF care. Improved functional status after HF could lead to quicker hospital discharge, reduce re-hospitalisations and expenditures (Ponten et al. 2015).

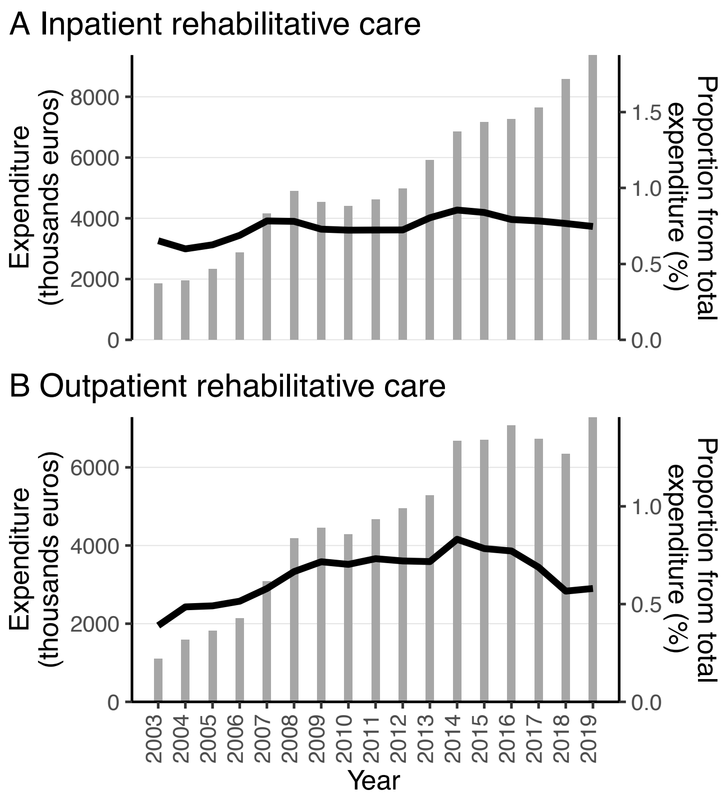


Figure 17. The Estonian Health Insurance Fund's expenditure on inpatient (A) and outpatient (B) rehabilitation during the years 2003-2019. Lines show the proportion of the total expenditure on the secondary y-axis. The total expenditure on health care ranged from 284,686.2 euros in 2003 to 1,255,915.2 euros in 2019. Source: the Health Statistics and Health Research Database (https://statistika.tai.ee/).

6.4. Mortality

Mortality rates for in-hospital and at one month were consistent with earlier studies (Medin et al. 2015; Johansen et al. 2017). However, mortality rates at three, six and twelve months were higher. For example, the Estonian three-month mortality rate was comparable to the highest reported rates of a systematic review of 63 studies (Abrahamsen et al. 2009). Multiple studies, including a systematic review, reported lower mortality rates at twelve months than the Estonian rate at six months (Kurtinaitis et al. 2012; Diamantopoulos et al. 2013; Brozek et al. 2014; Klop et al. 2014; Mundi et al. 2014, 2014; Poenaru et al. 2014). However, relatively similar twelve-month mortality rates were reported in Denmark, Hungary, and Scotland (Medin et al. 2015; Jantzen et al. 2018).

Importantly, the one-year HF mortality rate in Estonia did not decrease. Jürisson and colleagues (2017a) analysed population-wide data from years 2004–2013 and reported 3 percentage points lower (28%) one-year mortality rate. The discrepancy with our findings can be explained by the multi-step data validation strategy that we used. The strategy minimised the considerable amount of flawed data by excluding a relatively high proportion of unsuitable cases (4.8%) who had no actual HF diagnosis. This agrees with the recommendation that clinical data should not be drawn from administrative databases without validation (Cundall-Curry et al. 2016). The flawed data rate also indicated that future studies using EHIF's database should consider various validation strategies for improving study data. The validation strategies may include logic checking and reviewal of patients clinical information from other data sources.

The relatively high mortality rates from the third month onwards may be partly attributed to high rates of nonoperative management. However, the mortality rate of surgically treated patients was also relatively high as compared to the other studies (28%), indicating other contributing factors. Studies reported various pre-operative indicators to be associated with increased HF mortality risk: advanced age, male sex, pre-fracture functional status, residence in an institutional care home, intra-capsular fracture, cognitive impairment, depression, and more comorbidities (Hu et al. 2012; Liu et al. 2018). While most of these indicators were reported in this work too, three of them – pre-fracture residence, cognitive impairment and depression – could not be assessed. The high mortality from the third month onwards may also be related to the shortcomings in acute and post-acute management since in-hospital and one-month mortality rates were comparable to other studies. This observation is also supported by a study that compared the Estonian HF group to a non-fracture control group using age and comorbidity adjusted relative risk ratios (Jürisson et al. 2017a). The relative risk ratios were higher, especially for HF women at 3 and 12 months in Estonia as compared to findings of a systematic review (Haentjens et al. 2010; Jürisson et al. 2017a). The same estimates for men were near the upper confidence limits reported in the review article (Haentjens et al. 2010; Jürisson et al. 2017a). Similar speculation was done in two other Estonian studies on stroke and HF patients, wherein patient death was attributed to insufficient rehabilitation possibilities (Vibo et al. 2007; Jürisson et al. 2017a).

Ultimately, the common use of suboptimal post-acute care may explain the high HF mortality from the third month onwards. Prolonged bed rest with inadequate rehabilitation leads to hospital-associated deconditioning and the depletion of functional reserves, which are associated with higher mortality risk (Baztán et al. 2009; Falvey et al. 2015). Further research should be therefore undertaken to investigate the effect of rehabilitation on mortality in Estonia.

6.5. Strengths and limitations of the thesis

This thesis extends our understanding of long-term PT use after HF, simultaneously providing a granular and actionable input for clinical practice and policy-making in Estonia. Here, we described the provision of rehabilitation in different care settings, phases, counties and years. Extrapolation of our results is increased by a complete analysis of post-acute care, which was based on a large, validated, whole population and nine-year-spanning data collected in a standardised way. Also, the thesis provides a methodological framework for analysing an essential measure of rehabilitation – used PT hours. The zero-inflated and extremely positively skewed outcome variable was analysed without its transformation, using two-part analysis and reporting all the results in easily interpretable scales (hours, probabilities). Directed acyclic graphs were used to optimise adjustment sets for modelling explicitly. Variation modelling allowed separating true positive temporal changes from an increasing inequality and enabled us in detecting intra-regional disparities, which would have remained undetected otherwise in analyses based on the measures of central tendency, i.e. mean or median. Finally, this work provides a methodology for using EHIF's funding codes to estimate PT use in different patients' groups, paving the way for subsequent large-scale rehabilitation studies in Estonia.

Nonetheless, the following limitations should be considered when interpreting the results of this thesis. The obtained EHIF data was limited to the variables used in the study. Second, there are numerous other quality indicators used for making generalisations about HF management. Some of the other quality indicators are orthogeriatric management use, time to mobilisation, future fracture prevention assessment, systemic assessment of pain, assessment of malnutrition and pressure ulcer prevention (Voeten et al. 2018). Third, outcome measurement was limited to mortality. Other outcome measures as functional status, complications rate, readmissions, return to the place of residence and quality of life would have allowed investigating HF management's effects in more detail (Voeten et al. 2018). EHIF's funding codes only allowed to examine the amount of used rehabilitation. Thus, the type, quality and exact provision date of specific physiotherapeutic interventions used in HF rehabilitation could not be assessed. Finally, the study data did not provide information on multiple analytically relevant variables like patients' residence, functional status and lifestyle factors. The availability of these variables would have enabled us for a better control of confounding and informed some of the issues raised in the discussion.

Limitations are not restricted to the data. The use of CCI is associated with two limitations. Studies have shown that Elixhauser Comorbidity Measure can outperform CCI (Lix et al. 2011; Ondeck et al. 2018); however, the differences in performance may be marginal (Metcalfe et al. 2019). In the present work, CCI was preferred as it discriminates the presence of concomitant dementia separately, which is an essential descriptive characteristic of HF population (Quan et al. 2005). Nevertheless, the prevalence of dementia was underestimated in this study due to the solely ICD-10 based identification method (Quan et al. 2008; Seitz et al. 2011; Hebert-Davies et al. 2012). Consequently, the differences in post-acute PT use may be underestimated, as the non-dementia group also included patients with cognitive deficit. Also, CCI does not allow risk stratification based on disease severity, leaving some confounding unmeasured in the conducted analyses (Hindmarsh et al. 2014). Second, the conclusions of this thesis are restricted to index HF patients as the patients with secondary fracture were excluded. It should be considered that secondary HF is rather prevalent because 11% of men and 15% of women are likely to have it within ten years from the first occurrence (Omsland et al. 2013). There is still a possibility that some secondary HF patients were included, as EHIF's database dates back only to 2004. Third, only publicly financed rehabilitation services were analysed in this work, leading to a possible underestimation of PT hours. However, the author considers that the proportion of HF patients receiving non-publicly funded PT is negligible in Estonia. The private rehabilitation sector is just in the developing stage, and available providers mainly focus on outpatient musculoskeletal physiotherapy. Another factor that may lead to a possible underestimation of used PT hours is the inclusion of patients without health insurance; however, they were only 0.6% proportion of the study population. Only emergency care is guaranteed for the uninjured in Estonia, meaning that their post-acute rehabilitation is not publicly funded by EHIF (The World Bank Group 2015). Finally, the proportion of patients receiving surgery within two days may be overestimated, as the index HF event was defined from the start of acute hospitalisation.

7. CONCLUSIONS

1. During 2009–2017, acute care of index HF patients was regionally varying, and its length was relatively short in Estonia. Although the acute phase of HF care was better covered by rehabilitation, a quarter of patients were offered no PT.
2. During the study period, post-acute care was highly varying among index HF patients in Estonia, contrasting from ‘no care’ to ‘extensive hospitalisation’ and was mainly covered by settings, where PT provision was inconsistent and geographically varying. Consequently, most of the patients were offered no post-acute rehabilitation, and the remainder received a relatively small amount of PT, a median of 6 hours.
3. The post-acute rehabilitation of index HF patients showed large multi-level regional disparities in received PT. First, there were approximately two-and-a-half-fold inter-regional differences in the probability of receiving post-acute rehabilitation and received PT hours. Second, there were intra-regional disparities, showing unequal allocation of local rehabilitation resources within the counties of Estonia.
4. Temporally, the probability of receiving post-acute PT increased. Despite the positive trend, only half of index HF patients received post-acute PT in the final year of the study; the inequality in the division of PT resources increased among its receivers, and large inter-regional and intra-regional disparities remained persistent or even increased.
5. The findings of this work suggested unequal and non-need-based allocation of post-acute PT among index HF patients in Estonia. Post-acute PT chances were better for total hip arthroplasty patients as compared to those treated with other surgical methods and worse for those who were treated nonoperatively or who had concomitant dementia. Lastly, age showed no association with used PT.
6. Up to one-month mortality rates of Estonian index HF patients agreed with the findings from the other similar studies. However, the mortality rates from the third month onwards were relatively higher, possibly due to the shortcomings detected in post-acute management and rehabilitation.

8. IMPLICATIONS FOR PRACTICE

This thesis provides granular evidence-based inputs for clinical practice and health policy-making in Estonia. Currently, HF management is lacking one of its fundamental care pillars – ongoing coordinated post-acute care that prevents these patients from availing essential rehabilitation. As numerous reasons underpin the limited rehabilitation, there is a need for system-wide improvements. The primary goal of these improvements should be ensuring a need-based ongoing coordinated HF rehabilitation. First, sufficient resources should be guaranteed, allowing the planning of optimal HF rehabilitation pathways such as increasing health care expenditure on rehabilitation, expanding the provision of rehabilitation services, improving the accessibility of home rehabilitation and inpatient rehabilitation care, ensuring equal opportunities in all regions, and possibly the training of more occupational and physiotherapists and geriatricians. Insufficient resources may especially limit HF rehabilitation in counties like Hiiu, Järva, Lääne-Viru, Rapla and Valga. Second, the allocation of PT resources should be standardised for providing cost-efficient need-based rehabilitation for all HF patients. This includes conforming HF care in accordance with international guidelines and standards, improving decision making on HF operative and nonoperative management, implementing the multidisciplinary approach, coordinating patients care across different care settings, putting HF rehabilitation programmes into use, ensuring clinical information flow between different stages of care and increasing the corresponding expertise of healthcare staff. Simultaneously, the strategies mentioned above will decrease the use of suboptimal care. The available rehabilitation resources allocation strategies should be particularly reviewed in Harju, Ida-Viru, Pärnu and Tartu county. Finally, EHIF should consider quality-based funding to ensure ongoing coordinated rehabilitation in every step of HF care. For instance, all health care providers treating HF patients should follow specific clinical standards and use predetermined outcome measures. This would guarantee the continuity of adequate management and allow simultaneous outcome monitoring.

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SUMMARY IN ESTONIAN

Reieluu proksimaalse osa murru diagnoosiga patsientide taastusravi Eestis aastatel 2009–2017

Rehabilitatsiooni vajadus on maailmas olulisel määral katmata, jättes haiged vajaliku taastusravita (Kamenov et al. 2019). Veelgi süvendab probleemi maailma vananev rahvastik, sest lisaks eakate osakaalu suurenemisele ennustatakse haprusmurdude arvu hüppelist kasvu (The World Health Organization 2017; Dreinhöfer et al. 2018). Probleemi lahendamiseks on vaja tõenduspõhiseid andmeid, mis aitaksid suunata tervishoiupoliitikat ja parandada erinevate haigete kliinilist käsitlust (Bethge et al. 2014; Gutenbrunner et al. 2014; The World Health Organization 2017; Kamenov et al. 2019).

Reieluu proksimaalse osa murd on üks tõsisemaid traumasid eakatel, olles haprusmurdudest raskeim (Kanis et al. 2013). Sellise murru diagnoosiga haige prognoos on tõsine. Tagajärjeks võib olla kehalise võimekuse langemine, iseseisva hakkamasaamise kadumine või isegi surm. Tõsisest prognoosist tulenevalt on sellel haigusel suur koormus nii patsiendile, tema lähedastele, tervishoiule kui ka ühiskonnale tervikuna (Tajeu et al. 2014; Dyer et al. 2016; Sànchez-Riera ja Wilson 2017). Reieluu proksimaalse osa murru diagnoosist taastumine saab õigeaegse ja vajaduspõhise ravi puhul olla siiski edukas.

Reieluu proksimaalse osa murru diagnoosiga haigete ravikäsitlus põhineb kolmel sambal: multidistsiplinaarne aktiivravi, järjepidev koordineeritud taastusravi ja varajane teisese murru ennetus (Dreinhöfer et al. 2018). Järjepidev hästi koordineeritud taastusravi on oluline, sest haigusest taastumine on tihti kuudepikkune (Magaziner et al. 2000; Dyer et al. 2016; Dreinhöfer et al. 2018; Perracini et al. 2018; McDonough et al. 2021). Taastusravi peamine eesmärk on taastada patsiendi iseseisev liikumisvõime (Kristensen ja Kehlet 2012; Dreinhöfer et al. 2018). Ravijuhised soovitavad erinevaid sekkumisi nende patsientide taastusraviks. Täpsemalt on soovitatud on kasutada struktureeritud harjutusprogrammi, multidistsiplinaarset ortogeriaatrilist käsitlust koos füsioteraapia ja patsiendi varajase mobiliseerimisega, taastusravi pakkumist pikema-ajalisel perioodil ja ohutut kehalise aktiivsuse maksimeerimist (Chartered Society of Physiotherapy 2018; McDonough et al. 2021). Lisaks eelnevale soovitatakse ülakeha aeroobset treeningut, nelipealihase elektristimulatsiooni ja valuravi (McDonough et al. 2021). Olenemata taastusravi olulisest rollist reieluu proksimaalse osa murru diagnoosiga haigete käsitluses, pole teada, millised strateegiad on taastumiseks parimad (Weinrich et al. 2004; Chudyk et al. 2009; Handoll et al. 2011; The National Institute for Health and Care Excellence 2011; Dyer et al. 2016). Näiteks pole teada optimaalse taastusravi kestus ega maht.

Eestis saab igal aastal 1300–1500 inimest reieluu proksimaalse osa murru diagnoosi ja nende kogu ravikulu on umbes poole väiksem Euroopa keskmisest (Jürisson et al. 2015; Jürisson et al. 2016; Laius et al. 2017). Nende haigete ravitulemuste kohta on Eestis tehtud kaks uuringut. Esimene näitas kõrget, 28%-list ühe-aasta suremust (Jürisson et al. 2017a). Teine tõi valitud haigetel välja murrueelse ja -järgse suhteliselt madala elukvaliteedi (Jürisson et al. 2016). Jürisson ja tema kolleegid (2015, 2017a) spekuleerisid, et kasinad ravitulemused võivad olla tingitud puudulikust ravikäsitlusest. Ravikäsitlus on aga põhjalikult uurimata, puuduvad detailsed mahukad uuringud nende haigete taastusravist. Lisaks eelnevale on taastusravi üleüldse Eestis vähe uuritud. Avaldatud on kaks uuringut, esimene uuris insuldi ja teine seljaajutrauma diagnoosiga haigeid. Mõlemad leidsid küll taastusravis puudusi, aga kummaski ei uuritud kasutatud füsioteraapia mahtu ega selle kättesaadavust erinevates ravitüüpides, ravi faasides, maakondades ega aastatel (Vibo et al. 2007; Kivisild et al. 2014).

Kokkuvõttes on reieluu proksimaalse murru järgse taastusravi kasutamine suuresti uurimata nii maailmas kui ka Eestis. Käesoleva uurimustöö eesmärk oli uurida reieluu proksimaalse murru diagnoosiga haigete ravikäsitlust, täpsemalt taastusravi, selle regionaalseid erinevusi ja ajalisi trende. Paremad teadmised reieluu proksimaalse murru järgsest taastusravist aitavad mõista nende haigete vajadusi taastumiseks, annavad sisendi edasiseks teadustööks ning loovad teaduspõhise baasi ravikäsitluse ja tervishoiukorralduse parandamiseks Eestis.

Uurimustöö eesmärgid

Uurimustöö eesmärk oli hinnata reieluu esmase proksimaalse murru järgset ravikäsitlust Eestis aastatel 2009–2017. Täpsemalt keskenduti nende haigete taastusravile ning taastusravi regionaalsete erinevuste ja ajaliste trendide uurimisele ning vastavusele rahvusvaheliste ravijuhiste soovistustega. Uurimustöös püstitati järgmised eesmärgid:

1. Hinnata reieluu proksimaalse osa murru diagnoosiga haigete aktiivravi ja selle osana osutatud füsioteraapia mahtu.
2. Hinnata reieluu proksimaalse osa murru diagnoosiga haigete järelravi ja selles osutatud füsioteraapia mahtu, selle maakondlikke erinevusi ja ajalisi trende.
3. Hinnata reieluu proksimaalse osa murru diagnoosiga haigete üldnäitajate mõju järelravi ajal saadud füsioteraapia mahule.
4. Hinnata reieluu proksimaalse osa murru diagnoosiga haigete suremust Eestis.

Kasutatud meetodid

Retrospektiivses kohortuuringus kasutati Eesti Haigekassa valideeritud rahvastikupõhiseid andmeid. Uuringusse kaasati 50-aastased ja vanemad patsiendid, kellel oli diagnoositud reieluu proksimaalse osa esmane murd (rahvusvahelise haiguste klassifikatsiooni koodid S72.0–2) ajavahemikul 1. jaanuar 2009 kuni 30. november 2017. Luumurru diagnoosi ja selle kirurgilise ravi meetodi valideerimiseks kasutati NOMESCO (Põhjamaade Meditsiinistatistika Komitee) kirurgiliste protseduuride koode (Nordic Medico-Statistical Committee 2001). Koodi puudumisel vaadati läbi patsiendi kuvauuringud ja haiguslood. Komorbiidsuse hindamiseks kasutati ajakohastatud kaaludega Charlsoni indeksit (Quan et al. 2011). Uuritavad tunnused olid järgmised järelravi näitajad: kasutatud füsioteraapia teenused, erinevate ravitüüpide kasutamine ning ravikestus. Uuringu kiitsid heaks Tartu Ülikooli inimuuringute eetika komitee ja Andmekaitse Inspektsioon.

Järeldused

1. Esmase reieluu proksimaalse murru diagnoosiga haigete aktiivravi varieerub maakonniti ja selle kestus on võrdlemisi lühike, kattes nende patsientide taastumisest väiksema osa. Olenemata sellest, et aktiivravi on järelravist füsioteraapiaga paremini kaetud, ei osutatud neljandikule haigetest esmase hospitaliseerimise ajal füsioteraapiat.
2. Reieluu proksimaalse osa murruga haigete järelravi varieerus suurel määral: nullravist kuni pikaajalise haiglaravini. Haigete järelravi oli peamiselt kaetud ravitüüpidega, kus füsioteraapia kättesaadavus oli puudulik ja regionaalselt varieeruv. Eelnevast tulenevalt ei saanud enamik patsientidest peale aktiivravi füsioteraapiat ning ülejäänud said seda võrdlemisi väikeses koguses (mediaan 6 tundi).
3. Regionaalne analüüs tuvastas märkimisväärse mitme-tasandilise ebavõrdsuse aktiivravi järgselt saadud taastusravis. Täpsemalt leiti maakonniti 2,5-kordne erinevus tõenäosuses saada aktiivravi järgselt füsioteraapiat. Füsioteraapiat saanud patsientide teraapiatundide mahus ilmnes maakonniti 2,6-kordne erinevus. Lisaks eelnevale leiti maakonniti olulised erinevused saadud füsioteraapiatundide varieeruvuses, mis näitab maakondade sisest ebavõrdsust. Maakondade sisene ebavõrdsus näitab erinevust kohalike taastusravi ressursside jagamises sealsete haigete vahel.
4. Vaadeldud perioodil suurenes aktiivravi järgse füsioteraapia saamise tõenäosus. Positiivsest muutustest hoolimata ei saanud pooled haigetest uuringu viimasel aastal aktiivravi järel füsioteraapiat, teraapiatundide jagunemine muutus patsientide vahel ebaühtlasemaks ning maakondade vaheline ja sisene ebavõrdsus säilis või hoopiski suurenes.
5. Uurimustöö tulemused viitavad ebavõrdsusele ja mittevajaduspõhisusele esmase reieluu proksimaalse osa murru diagnoosiga haigete aktiivravile järgnevas taastusravis. Aktiivravijärgse füsioteraapia saamise tõenäosus oli parim totaalartroplastika patsientidel võrreldes teiste kirurgiliselt ravitud haigetega. Samas hapramad haiged, näiteks mitteopereeritud ja need, kellel oli kaasuvalt dementsus, jäid sagedamini aktiivravi järel füsioteraapiata. Lisaks eelnevale ei näidanud vanuse tunnus mingit seost aktiivravi järel saadud füsioteraapiaga.
6. Esmase reieluu proksimaalse osa murru diagnoosiga haigete suremus on esimesel kuul pärast murru saamist võrdlemisi sarnane teiste riikide uuringute tulemustega. See-eest on Eestis võrdlemisi kõrge suremus alates kolmandast kuust edasi. Kõrgem hiline suremus võib olla tingitud leitud puudustest nende haigete järelravis.

Praktilised soovitused

Käesolev doktoritöö annab tõenduspõhise sisendi kliinilise praktika ja tervishoiupoliitika parandamiseks Eestis. Reieluu proksimaalse osa murru ravi ühes alussambas, taastusravis, esinevad Eestis olulised puudujäägid. Puuduliku taastusravi taga on mitmed põhjused, mis näitavad vajadust süsteemi ulatuslikult korrastada. Korrastamise peamine eesmärk peaks olema vajaduspõhise järjepideva koordineeritud taastusravi tagamine reieluu proksimaalse osa murru diagnoosiga haigetele. Esiteks on oluline tagada piisavalt ressursse, mis võimaldaks planeerida optimaalseid raviteekondi, suurendada taastusravi rahastust, suurendada taastusravi kättesaadavust, parandada kodus osutatava füsioteraapia ja statsionaarse taastusravi kättesaadavust ja lõpetuseks tagada regionaalselt võrdne taastusravi kättesaadavus. Lisaks tuleb tagada piisav füsio- ja tegevusterapeutide ning geriaatrite ettevalmistus, kes tagaksid nende teenuste osutamise. Ressursside puudus võib olla aktiivravi järgse taastusravi peamine limiteeriv põhjus järgnevates maakondades: Hiiumaa, Järvamaa, Lääne-Virumaa, Raplamaa ja Valgamaa. Teiseks tuleb tagada taastusravi ressursside kuluefektiivne ja vajaduspõhine kasutamine. Selleks on vaja võtta kasutusele rahvusvahelised ravijuhendid, vaadata üle mitteoperatiivse ravi kriteeriumid, rakendada multidistsiplinaarset ravikäsitlust, planeerida taastusravi teekonnad ja neid koordineerida ning tagada info liikumise erinevate ravietappide vahel, vähendada suboptimaalse ravi kasutamist ja koolitada olemasolevaid spetsialiste. Taastusravi olemasolevate ressursside kasutamine tuleb eelkõige üle vaadata Harjumaal, Ida-Virumaal, Pärnumaal ja Tartumaal. Lisaks eelnevale võiks Eesti Haigekassa kaaluda tulemuspõhise rahastamise kasutuselevõtmist, et tagada järjepidev koordineeritud taastusravi igas ravietapis, näiteks nõuda tervishoiuteenuste osutajatelt teatud kliiniliste standardite ja tulemuslikkuse mõõdikute täitmist. Viimane garanteeriks standardiseeritud patsiendikäsitluse ja lubaks ühtlasi jälgida ravi tulemuslikkust.

ACKNOWLEDGMENTS

This study was supported by Institutional Research Funding (Nos. IUT20-46 and IUT20-58) and Personal Institutional Research Funding (PRG335) from the Estonian Research Council, and by the European Union through the European Regional Development Fund (No. MMVCM16293I) through the Seventh Framework Programme (No. 602398).

It is a genuine pleasure to express my sincere gratitude and appreciations to people supporting me during the studies:

- Professor Aare Märtson for inspiring positive attitude, overall support, and extremely valuable mentoring not only on research and orthopaedics but on life in general;
- Associate Professor Helgi Kolk for initiating me into the studies, her constant support and coaching throughout the studies, significant help with the data validation, and introducing the world of geriatrics;
- Professor Mati Pääsuke for all the valuable advice, continuous assistance and teaching throughout the process;
- Associate Professor Ülo Maiväli for basically making a supervisor-level contribution by providing me extensive personal and professional guidance on data analysis and on research in general, co-authoring the papers, and paving the way to Bayesian statistics;
- Dr Andres Kukner, Dr Egon Puuorg, Dr Toomas Saluse, Dr Pirja Sarap, Dr Eiki Strauss, Dr Kaspar Tootsi and Dr Karin Veske for their help with co-authoring and/or data validation.
- Reviewer Professor Priit Kaasik for his careful reading and valuable advice for my dissertation;
- Opponent Professor Morten Tange Kristensen for objective criticism of my dissertation;
- Professor Krista Fischer for all the help she provided with statistics, especially with the survival analyses;
- Ms Marion Kalju for preparing the data for validation;
- Mr Rait Käpp for helping to prepare digital imaging data for reviewing;
- Mrs Kaire Kallas for superior secretarial assistance;
- Mr Priit Koovit for helping to get the Estonian Data Protection Inspectorate's approval for the study.

Finally, and above all, I would like to thank my family – my loving wife Karin and my sons Robert and Hendrik – for their patience and unceasing backing.

PUBLICATIONS

CURRICULUM VITAE

Name: Pärt Prommik
Date of birth: November 20, 1984
Citizenship: Estonian
Telephone: +372 731 8225
E-mail: part.prommik@ut.ee

Education

2013– University of Tartu, Faculty of Medicine, PhD studies
2008–2010 University of Tartu, Faculty of Exercise and Sport Sciences, MSc in Physiotherapy
2005–2008 University of Tartu, Faculty of Exercise and Sport Sciences, BSc in Physiotherapy
2002–2004 Tartu Tamme Gymnasium

Professional employment

2013– University of Tartu, Department of Traumatology and Orthopaedics, lecturer
2011– Tartu University Hospital, Traumatology and Orthopaedics Clinic, physiotherapist
2009–2011 Tartu University Hospital, transplant coordinator

Membership

Estonian Association of Physiotherapists

Publications

Prommik, P., Tootsi, K., Saluse, T., Märtson, A., & Kolk, H. (2021). Nonoperative hip fracture management practices and patient survival compared to surgical care: an analysis of Estonian population-wide data. *Archives of Osteoporosis*, 16:101. https://doi.org/10.1007/s11657-021-00973-y

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ELULOOKIRJELDUS

Nimi: Pärt Prommik
Sünniaeg: 20. november 1984
Kodakondsus: Eesti
Telefon: +372 731 8225
E-post: part.prommik@ut.ee

Haridus

2013–	Tartu Ülikool, Meditsiiniteaduste valdkond, doktoriõpe
2008–2010	Tartu Ülikool, Kehakultuuriteaduskond, MSc füsioteraapia erialal
2005–2008	Tartu Ülikool, Kehakultuuriteaduskond, BSc füsioteraapia erialal
2002–2004	Tartu Tamme Gümnaasium

Töökogemus

2013–	Tartu Ülikool, Traumatoloogia ja ortopeedia kliinik, lektor
2011–	Tartu Ülikooli Kliinikum, Traumatoloogia ja ortopeedia kliinik, füsioterapeut
2009–2011	Tartu Ülikooli Kliinikum, transplantatsiooni koordinaator

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