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Primary elective total knee arthroplasty rehabilitation during 2010-2021 in Estonia

Põlveliigese esmase plaanilise totaalse endoproteesimise järgne taastusravi Eestis aastatel 2010-2021

Master's thesis

Physiotherapy

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ABBREVIATIONS

CCI	Charlson Comorbidity Index
EU	European Union
ICD-10	International Classification of Diseases, 10th revision
LOS	length of stay
NCSP	Nordic Medico-Statistical Committee's Classification of Surgical Procedures
OA	osteoarthritis
OT	occupational therapy
PT	physical therapy
TKA	total knee arthroplasty

ABSTRACT

Aim: The aim of this thesis was to describe and analyse rehabilitation received in one year after primary elective total knee arthroplasty (TKA) during 2010-2021 in Estonia, with a focus on physical therapy (PT) and occupational therapy (OT) use, its regional differences and temporal trends.

Methods: This population-based retrospective cohort study was based on medical claims data from the Estonian Health Insurance Fund. The study included patients who had undergone primary elective TKA between 1st January 2010 and 31st December 2020.

Results: 10,185 patients' data were analysed; 99.2% (10,107) of patients received rehabilitation within a year after primary elective TKA (median of 6.5 hours). Acute care lasted a median of 7 days; during it, 98.5% (10,034) of patients received PT (median of 2 hours) and 0.4% (38) OT (median of 0.5 hours). During the post-acute phase, 67.5% (6,876) of patients received PT (median of 7 hours), 78.7% (5,410) in inpatient and 44.3% (3,046) in outpatient settings. 15.1% (1,535) of patients received post-acute OT (median of 1 hour), 98.9% (1,518) in inpatient and 1.7% (26) in outpatient settings. Within the first two weeks, PT had ended for 81.9% and OT for 96.2% of patients. There was a 1.01-fold regional difference in the proportion of patients who received PT and 1.8-fold in the median total hours of PT received; as for OT, the differences were, respectively, 5.4-fold and 1.4-fold. During the study period, no temporal changes were seen in PT use, but the proportion of patients who received OT increased by 9.3 percentage points, and the median total hours of OT received decreased by 1.8 hours.

Conclusions: Rehabilitation after primary elective TKA was received primarily in the form of inpatient PT. Rehabilitation showed up to 5.4-fold regional differences and varying temporal trends during the observed 11 years.

Keywords: Total knee arthroplasty, rehabilitation, physical therapy, occupational therapy

LÜHIÜLEVAADE

Eesmärk: Magistritöö eesmärgiks oli kirjeldada ja analüüsida põlveliigese esmase plaanilise totaalse endoproteesimise järgse aasta jooksul saadud taastusravi Eestis aastatel 2010-2021, keskendudes füsio- ja tegevusteraapia kasutamisele ning nende regionaalsetele erinevustele ja ajalistele muutustele.

Metoodika: Antud populatsioonipõhine retrospektiivne kohortuuring põhines Eesti Tervisekassalt saadud andmetel. Uuringusse kaasati patsiendid, kellel viidi läbi põlveliigese esmane plaaniline totaalne endoproteesimine ajavahemikus 1. jaanuar 2010 kuni 31. detsember 2020.

Tulemused: Analüüsiti 10 185 patsiendi andmeid. 99,2% (10 107) patsientidest said taastusravi ühe aasta jooksul pärast põlveliigese esmast plaanilist totaalset endoproteesimist (mediaan 6,5 tundi). Aktiivravi mediaankestuseks oli 7 päeva. Selle jooksul said 98,5% (10 034) patsientidest füsioteraapiat (mediaan 2 tundi) ning 0,4% (38) patsientidest tegevusteraapiat (mediaan 0,5 tundi). Järelravi ajal said füsioteraapiat 67,5% (6876) patsientidest (mediaan 7 tundi), 78,7% (5410) statsionaarselt ja 44,3% (3046) ambulatoorselt, ning tegevusteraapiat 15,1% (1535) patsientidest (mediaan 1 tund), 98,9% (1518) statsionaarselt ja 1,7% (26) ambulatoorselt. Kahe nädala jooksul lõppes füsioteraapia 81,9% ja tegevusteraapia 96,2% patsientide jaoks. Füsioteraapia saajate osakaal erines maakonniti 1,01 korda ning saadud mediaantunnid 1,8 korda, tegevusteraapia puhul olid vastavad erinevused 5,4- ja 1,4-kordsed. Uuringuperioodi jooksul ei esinenud füsioteraapia ajalistes trendides muutusi, kuid tegevusteraapia saajate osakaal suurenes 9,3 protsendipunkti võrra ja saadud mediaantunnid vähenesid 1,8 tunni võrra.

Kokkuvõte: Põlveliigese esmase plaanilise totaalse endoproteesimise järgselt said patsiendid taastusravi valdavalt statsionaarse füsioteraapia näol. Taastusravis esinesid kuni 5,4-kordsed regionaalsed erinevused ning 11-aastase uuringuperioodi jooksul olid taastusravi ajalised trendid varieeruvad.

Märksõnad: Põlveliigese totaalne endoproteesimine, taastusravi, füsioteraapia, tegevusteraapia

1. LITERATURE REVIEW

1.1. Osteoarthritis of the knee

Osteoarthritis (OA) is a chronic degenerative joint disease with increasing prevalence and burden (Charlesworth et al., 2019; Cui et al., 2020; Kiadaliri et al., 2018). It is a complex condition with dynamic pathology and multifactorial aetiology (Charlesworth et al., 2019; The Swedish Arthroplasty Register, 2022). Knee joint is the leading location of site-specific OA by 60.6%, affecting 654.1 million people aged 40 years and older globally (Cui et al., 2020; Long et al., 2022). The prevalence of knee OA worldwide is 16% and in Europe 13.4% (Cui et al., 2020).

OA involves progressive articular cartilage damage, osteophyte formation, subchondral bone sclerosis and subchondral cyst formation (Charlesworth et al., 2019; Lespasio et al., 2017). Pathological changes can occur in cartilage, synovium, subchondral bone, ligament, muscle, adipose tissue and meniscus and affect neurological pathways (Katz et al., 2021). Knee OA can be classified by aetiology as idiopathic or secondary (Lespasio et al., 2017).

Symptoms and signs of knee OA include knee pain, stiffness, reduced range of motion, bony enlargement, muscle weakness, effusion, crepitus, tenderness to palpation (Lespasio et al., 2017; Sharma, 2021) and loss of smooth mechanical movement (Lespasio et al., 2017). Pain and stiffness occur after daytime inactivity and in the morning, lasting under 30 minutes. Pain increases during activity; over time, it gets more severe and frequent and can occur even at night and during rest (Lespasio et al., 2017; Sharma, 2021). In the long term, OA can negatively affect physical activity, sleep, mental health and energy levels (Sharma, 2021), lead to reduced function (OECD, 2021; Sharma, 2021) and quality of life (OECD, 2021), as well as to deconditioning and disability (Sharma, 2021).

A presumptive diagnosis of knee OA can be made by medical history and physical examination (Katz et al., 2021; Sharma, 2021). Laboratory results and radiologic evaluation can support the diagnosis (Lespasio et al., 2017). X-ray of an arthritic knee joint can show joint space narrowing, osteophytes (Lespasio et al., 2017; Sharma, 2021), subchondral sclerosis, cysts and bone attrition (Sharma, 2021).

Initial treatment for knee OA is nonsurgical, including education, physical therapy (PT) (Katz et al., 2021), exercise, weight loss, non-steroidal anti-inflammatory drugs, intra-articular knee injections (Katz et al., 2021; Lespasio et al., 2017), physical activity modifications, thermotherapy, electrical stimulation and assistive devices (Lespasio et al., 2017). Surgery is considered when the patient's quality of life is remarkably affected, and conservative methods

have been applied for at least three months and have not given favourable outcomes (Lespasio et al., 2017; Rönn et al., 2011). Surgical treatment options for knee OA are as follows: arthroscopy, cartilage repair, osteotomy, unicompartmental knee arthroplasty and total knee arthroplasty (TKA) (Rönn et al., 2011).

1.2. Total knee arthroplasty

Symptomatic end-stage knee OA with constant pain, functional loss and structural damage is the leading indicator for knee arthroplasty (Katz et al., 2021). TKA is proven to be an effective treatment option, especially for the elderly population, since the prostheses' lasting time is limited to 15-20 years (Rönn et al., 2011).

TKA is a standard surgical procedure involving replacing all the femorotibial articulation (AOANJRR, 2021; OECD, 2021) to alleviate pain and reduce disability (OECD, 2021). The articular surface is replaced with a single femoral and a single tibial prosthesis, in some cases combined with a patella resurfacing replacement (AOANJRR, 2021). The method of fixating the components to the bone can be either cemented, cementless or hybrid (AAOS, 2022; AOANJRR, 2021; The Swedish Arthroplasty Register, 2022). Hybrid fixation comprises a cemented and an uncemented part (The Swedish Arthroplasty Register, 2022).

The comorbidity burden of primary elective knee arthroplasty patients has significantly increased in recent years (Penfold et al., 2022). Patients with comorbidities have an increased risk for hospital readmission and revision surgery, higher short-term and long-term mortality (Podmore et al., 2018), complication rate and increased length of stay (LOS) (Tay et al., 2017). Patients with a higher prevalence of comorbidities have worse patient-reported outcomes (Jette et al., 2020).

1.2.1. Postoperative recovery

During the first month after TKA, patients experience a decline in knee range of motion, quadriceps femoris strength and function. Quadriceps femoris strength is highly correlated with functional performance, having a greater impact than knee range of motion and pain level. At one month after TKA, a decline up to 62% in strength can be seen (Mizner et al., 2005). During the second half of the first postoperative year, strength recovers to the preoperative level, and at two years, it reaches a plateau (Paravlic et al., 2022).

Patients who undergo TKA show significant functional recovery from one to six months postoperatively (Mizner et al., 2005; Patterson et al., 2021), with several measurements improving even one year after surgery (Patterson et al., 2021). Patients have reported that they can comfortably do housework and drive around nine weeks postoperatively, walk over one kilometre after three months, use stairs after three and a half months, do gardening after four

and a half months and kneel after six months. Although patients feel satisfied with walking within a few months postsurgery (Barker et al., 2018), studies have shown that gait parameters continue to improve even after one year, reaching the level of healthy individuals at 15 months (Boekesteijn et al., 2022).

1.2.2. Acute management and rehabilitation

Early postoperative rehabilitation, led by a physiotherapist or an occupational therapist, should start within 24 hours after surgery, preferably on the day of the surgery and prior to discharge (Jette et al., 2020; NICE, 2020). Early rehabilitation is associated with improved physical function, decreased pain (Jette et al., 2020) and earlier discharge from acute-care hospital (Chen et al., 2012; Jette et al., 2020).

The acute-care rehabilitation team performs a physical examination and assessment of surgical knee pain and cognitive function (Westby et al., 2018). Acute rehabilitation includes local cryotherapy to handle the early postoperative pain (Jette et al., 2020), knee joint mobilisation (Jette et al., 2020; NICE, 2020; Westby et al., 2018), isometric and isotonic lower limb strengthening, bed mobility, transfer and balance training as well as gait training on even surfaces and stairs (Jette et al., 2020; Westby et al., 2018). Other important factors of rehabilitation are education on the importance and principles of rehabilitation (Jette et al., 2020), guidance on managing activities of daily living (Jette et al., 2020; NICE, 2020; Westby et al., 2018), appropriate progression of physical activity (Jette et al., 2020; Westby et al., 2018) and home exercise programme (NICE, 2020; Westby et al., 2018).

The patient is ready for discharge from the acute-care facility if independence in transfers, basic activities of daily living and home exercise programme has been achieved, and the patient can ambulate safely with an assistive device on level surfaces and stairs (Westby et al., 2018). Patient-related and organisational factors affect LOS after TKA, with the discharge destination being a major predictor. Discharge to a rehabilitation unit is associated with extended hospital stay compared to patients who go home (Roger et al., 2019).

1.2.3. Post-acute management and rehabilitation

Rehabilitation in the post-acute phase can be self-directed (NICE, 2020), home-based (Barker et al., 2020; Mahomed et al., 2008) or received in inpatient (Mahomed et al., 2008; Padgett et al., 2018) or outpatient settings (Barker et al., 2020; NICE, 2020). The decision is made considering patient's safety, mobility, environmental and personal factors (Jette et al., 2020).

The intervention in the post-acute phase consists of pain management, active knee range of motion exercises, resistance training with free weights, bodyweight or machines for lower limb muscles and functional exercises (Jones et al., 2016; Westby et al., 2018). Rehabilitation also

includes static and dynamic balance training, postural and core stability training, gait training, assessment of home exercise programme and education on exercise progression (Westby et al., 2018). Additionally, neuromuscular electrical stimulation can be used to improve quadriceps femoris and hamstring muscles strength and physical performance (Jette et al., 2020).

Although rehabilitation after TKA has proven to be beneficial, there is no consensus about the best practice, including setting, mode, frequency, intensity, duration and monitoring, calling attention to the need for clear evidence-based postoperative rehabilitation protocols (Konnyu et al., 2023; Snell et al., 2018).

1.3. Total knee arthroplasty and rehabilitation in Estonia

Estonia is a country in Northern Europe with a population of slightly over 1.3 million. In Country Health Profile 2021, it was reported that the life expectancy of Estonians increased over seven years between 2000 and 2020, which is more than in any other member country of the European Union (EU). Nevertheless, the disability-free life expectancy of Estonians has not changed remarkably since 2008. In addition, the gender gap in life expectancy is the third largest in the EU, with women living 8.5 years longer than men (OECD & EOHSP, 2021). Since OA is more common in women and elderly (Long et al., 2022; OECD, 2021), it may be presumed that the burden of knee OA is rising in Estonia, as can be seen in Nordic countries (Kiadaliri et al., 2018).

In the Organisation for Economic Co-operation and Development member countries, the knee replacement rate increased by 35% between 2009 and 2019. During the COVID-19 pandemic in 2020, there was a decline due to the postponement of non-urgent elective surgery (OECD, 2021). The first data reports from Organisation for Economic Co-operation and Development concerning knee replacements in Estonia are from 2015 when 94 surgeries per 100 000 population were performed (OECD, 2017). In 2019 the number had risen to 110 (OECD, 2021).

Health care in Estonia is chronically underfinanced (National Audit Office of Estonia, 2006; OECD & EOHSP, 2021). Estonia is spending less than half of the EU average on health in per capita terms and as a share of the gross domestic product (OECD & EOHSP, 2021). In addition to that, the ability to provide rehabilitation services depends on human resources. Although the number of physiotherapists and occupational therapists in Estonia has increased over the years, there continues to be a shortage of professionals to answer the growing demand (National Audit Office of Estonia, 2006; OECD & EOHSP, 2021; Prommik et al., 2022a).

There is little evidence about rehabilitation in Estonia. To the best of this thesis author's knowledge, there is only one report and three studies analysing rehabilitation in-depth (National

Audit Office of Estonia, 2006; Prommik, 2021; Prommik et al., 2022a; Pruunsild, 2022). A report from 2006 concludes that the organisation of rehabilitation is inefficient, and patients' rehabilitation needs are unmet. It was found that after major joint arthroplasty, acute rehabilitation was received only by 20% and post-acute rehabilitation by 18% of the patients (National Audit Office of Estonia, 2006). The same problem is highlighted years later by Prommik et al. (2022a). They concluded that rehabilitation in Estonia is under-prioritised and underfinanced, and the need for PT and occupational therapy (OT) is unmet.

These studies suggest that the rehabilitation system in Estonia has some limitations in terms of ongoing care, but there is insufficient data to assess the extent of problems in different patient populations and provide solutions. Furthermore, there are only a few population-based studies in the world describing rehabilitation after TKA. This master's thesis aims to extend the knowledge by giving an overview of postoperative rehabilitation after primary elective TKA.

2. AIM AND OBJECTIVES

The purpose of the current thesis was to describe and analyse rehabilitation after primary elective TKA in Estonia during 2010-2021, focusing on PT and OT use in the first postoperative year, its regional differences, and temporal trends. Specific objectives of the thesis were:

1. To evaluate acute PT and OT use after primary elective TKA.
2. To evaluate post-acute PT and OT use after primary elective TKA.
3. To analyse regional differences in PT and OT use after primary elective TKA.
4. To examine temporal trends in PT and OT use after primary elective TKA.

3. METHODS

This study is part of a larger project named "Rehabilitation use of different patient populations during 2010-2021 in Estonia", approved by the Research Ethics Committee of the University of Tartu (certificate nr 350/T-5, dated 20.09.2021). The author of this thesis contributed to the writing of the project's ethics committee application and designing the study and was responsible for organising, analysing, and visualising the data and writing the thesis.

3.1. Data sources

This study was based on retrospective data from 11 years received from the Estonian Health Insurance Fund. Estonian Health Insurance Fund covers approximately 95% of Estonia's population (OECD & EOHSP, 2021). Data was received in pseudonymised form. Requested data concerning patients' baseline characteristics included patients' pseudonymised identification number, age at hospitalisation, sex, primary and secondary diagnoses in the form of the International Classification of Diseases (ICD-10) codes and county of residence. Primary and secondary diagnoses were used, respectively, to determine the leading cause of TKA and to assess patient's comorbidity statuses. Comorbidities were identified as diagnoses from hospital or outpatient health care claims during a four-year preoperative period. The county of residence was needed to assess regional differences in the proportion of patients who received rehabilitation and total hours of rehabilitation received. Patients whose information about the county of residence was unavailable were classified as "not registered".

Requested data concerning patients' health care episodes included medical bills of the first postoperative year, operation information in the form of Nordic Medico-Statistical Committee's Classification of Surgical Procedures (NCSP) codes starting with "NGB" (Nordic Medico Statistical Committee, 2001), setting type and used rehabilitation services. NCSP codes were used to validate TKA as surgical management and determine whether the method of fixation was cementless (NGB20), hybrid (NGB30) or cemented (NGB40) (Nordic Medico Statistical Committee, 2001). Setting type codes were used to differentiate inpatient and outpatient services in the post-acute phase. Estonian Health Insurance Fund's funding codes with predefined durations from patients' medical records of the first postoperative year were used to identify and categorise received rehabilitation services (Eesti Haigekassa; Prommik et al., 2022a; Pruunsild, 2022) and to assess the total hours of rehabilitation received.

3.2. Subjects

Patients, who had undergone primary elective TKA (NCSP code NGB20, NGB30 or NGB40) between 1st January 2010 and 31st December 2020, were included in this study. To

increase the homogeneity of the study population, non-elective procedures, partial knee arthroplasties and revision surgeries were excluded, as well as acute fractures as a primary cause of TKA and patients with other extremity TKA performed before 2010. The end date of inclusion allowed complete follow-up for all patients regarding their one-year rehabilitation.

Concerning the primary diagnosis for undergoing TKA, patients were divided into six subgroups (Table 1) based on ICD-10 codes.

Table 1. The classification of primary elective total knee arthroplasty patients' primary diagnoses and corresponding International Classification of Diseases, 10th revision codes.

Primary diagnosis	ICD-10 codes
Implant related complication	T84.0, Z47.0
Inflammatory arthritis	M05.8, M05.9, M06.0, M06.8, M06.9, M07.3, M08.0, M15.8
Malignant tumour	C40.2, C49.2, M80.8
Malunion	M84.1
Osteoarthritis	M17.0, M17.1, M17.2, M17.3, M17.4, M17.5, M17.9, M19.1, M24.5
Osteonecrosis	M87.0, M00.0, M87.8

ICD-10 - International Classification of Diseases, 10th revision

Charlson Comorbidity Index (CCI) was chosen to assess comorbid conditions. CCI is a weighted index that considers the number and seriousness level of comorbidities (Charlson et al., 1987). CCI has proven to predict postoperative complications following TKA (Marya et al., 2016). Lower CCI is associated with greater improvements in activity and functional levels after TKA (Elmallah et al., 2015).

3.3. Statistical analysis

Statistical analyses were performed in R 4.2.0 using packages "comorbidity" for calculating CCI (Gasparini, 2018) and "brms" for Bayesian regression modelling (Bürkner, 2018). The first postoperative year was chosen for postoperative rehabilitation assessment. This timeframe was set considering the length of recovery after TKA (Mizner et al., 2005; Naili et al., 2017; Patterson et al., 2021) and the increasing risk of patients receiving rehabilitation due to other medical reasons.

Data from medical records about received rehabilitation services were used to analyse the proportion of patients who received PT and OT and the total hours of received PT and OT. PT and OT were first described for a whole one-year and then separately for the acute phase

(a period between admission to the acute care hospital and discharge) and the post-acute phase (a period between discharge from the acute care hospital and one year postoperatively). The Kaplan-Meier method was used to estimate the end of PT and OT. End of PT/OT was defined as the last date when patient received PT/OT.

Continuous variables with normal distribution were presented as "mean±standard deviation", and variables with non-normal distribution as "median (25th-75th percentile)". Categorical variables were presented as proportions. CCI was given as categorical counterparts: 0, 1-2, 3-4, and ≥5.

Regression analyses focused on describing regional and temporal one-year PT and OT use. As the primary outcome variables (PT and OT) were zero-inflated and positively skewed, they were analysed in two parts using the strategies described by Prommik et al. (2022b). The first part analysed the proportion of patients who received these therapies using Bernoulli likelihood. The second part examined the median received therapy hours using the lognormal likelihood. Regional analyses were adjusted for age, sex, year and CCI. Countrywide temporal analyses were adjusted for county. In all models, the county variable was specified hierarchically, and default weakly informative priors were used. All point estimates (proportions and median therapy hours) were given with 95% credible or confidence intervals as "[lower; upper]".

4. RESULTS

4.1. Patients' baseline characteristics and operative management

A total of 10,185 patients with a median age of 69.0 years (62.0-75.0) were eligible for this study; 74.3% of them were women (7,565) (Appendix 1). OA was the primary diagnosis for 99.6% of patients (10,141), and the median CCI was 1 (0-2). One-third of patients' (38.2%; 3,890) county of residence was Harju.

The mean number of TKA-s performed in a year during the study period was 925.9±85. Concerning the method of fixation, cemented fixation was used for 97.3% of patients (9,910), followed by hybrid (2.6%; 266) and cementless fixation (0.1%; 9).

4.2. Rehabilitation

A total of 10,107 patients (99.2%) received rehabilitation after TKA, for a median of 6.5 hours (3-12). PT was received by 99.2% of patients (10,106) and OT by 15.4% (1,569). All the patients who accessed OT, except one, received it in combination with PT (15.4%; 1,568).

Rehabilitation had ended within two weeks after undergoing TKA for 81.9% of patients [81.2-82.7] who received PT postoperatively. The percentages for weeks six and ten were respectively 93.2 [92.7-93.7] and 97.7 [97.4-98.0]. By week 43, PT had ended for all the patients (Figure 1).

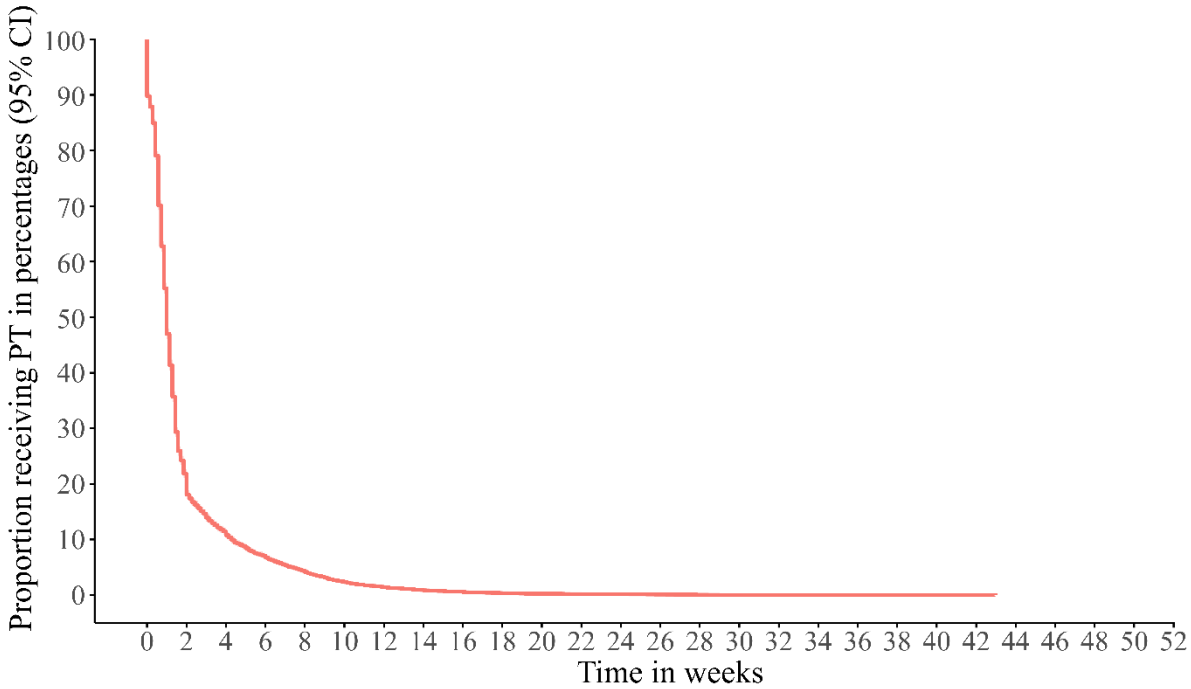

Figure 1. The proportion of patients receiving physical therapy in Estonia during the first postoperative year after primary elective total knee arthroplasty. CI – confidence interval, PT – physical therapy.

Two weeks after TKA, OT had ended for 96.2% [95.1-97.0], after six weeks for 99.4% [98.8-99.7] and after ten weeks for 99.6% [99.1-99.8] of patients who accessed OT. After 33 weeks, there were no patients receiving OT (Figure 2).

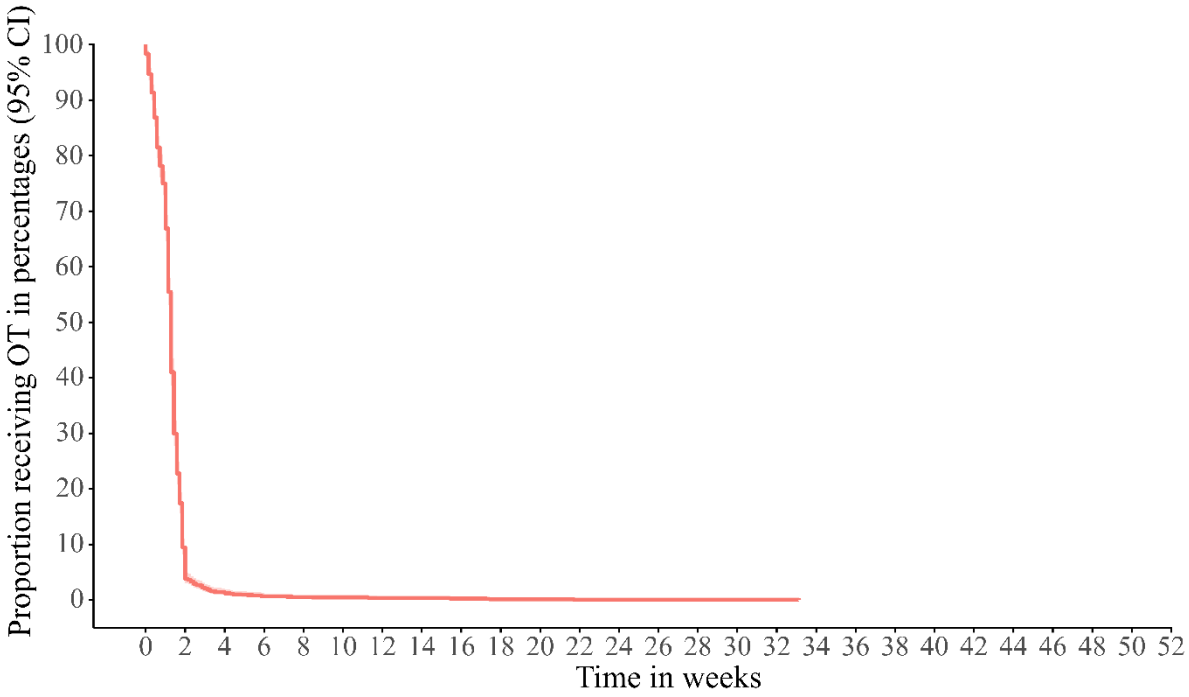

Figure 2. The proportion of patients receiving occupational therapy in Estonia during the first postoperative year after primary elective total knee arthroplasty. CI – confidence interval, OT – occupational therapy.

4.2.1. Acute management and rehabilitation

The median acute LOS after TKA was 7 days (6-8). During acute care, 98.5% of patients (10,034) received PT for a median of 2 hours (2-3) and 0.4% of patients (38) OT for a median of 0.5 hours (0.5-1). OT and PT were received simultaneously by 0.3% of patients (33).

4.2.2. Post-acute management and rehabilitation

A total of 6,104 patients (59.9%) received inpatient post-acute care with a median LOS of 10 days (7-16). The use of different inpatient post-acute care settings was following: other inpatient care 59.7% (3,643), inpatient rehabilitation 58.5% (3,570) and inpatient nursing care 8.5% (516).

During the first postoperative year, 67.5% of patients (6,876) received post-acute PT for a median of 7 hours (3.5-12). 78.7% of them (5,410) accessed PT in inpatient and 44.3% (3,046) in outpatient settings. 15.1% of patients (1,535) received post-acute OT for a median of 1 hour (0.5-2). 98.9% of them (1,518) accessed OT in inpatient and 1.7% (26) in outpatient settings. The percentage of patients who received both PT and OT was 15.0 (1,532). Three patients (0.03%) received home-based rehabilitation for a median of 5 hours (4-5.5).

4.2.3. Regional differences in rehabilitation

After adjusting to age, sex, year and CCI score, there were regional differences found in rehabilitation (Figure 3 and Figure 4). There was a minor (1.01-fold) difference among counties in the proportion of patients who received PT, the proportion varying from 98.5% (Hiiu) to 99.9% (Tartu). Concerning the median total hours of PT received, there existed a 1.8-fold difference among counties. Received median hours varied regionally from 4.8 (Hiiu) to 8.6 (Tartu).

There was a 5.4-fold difference among counties in the proportion of patients who received OT, the proportion varying regionally from 4.7% (Põlva) to 25.7% (Harju), and a 1.4-fold difference in the median total hours OT received, hours varying from 1.1 (Pärnu) to 1.5 (Võru).

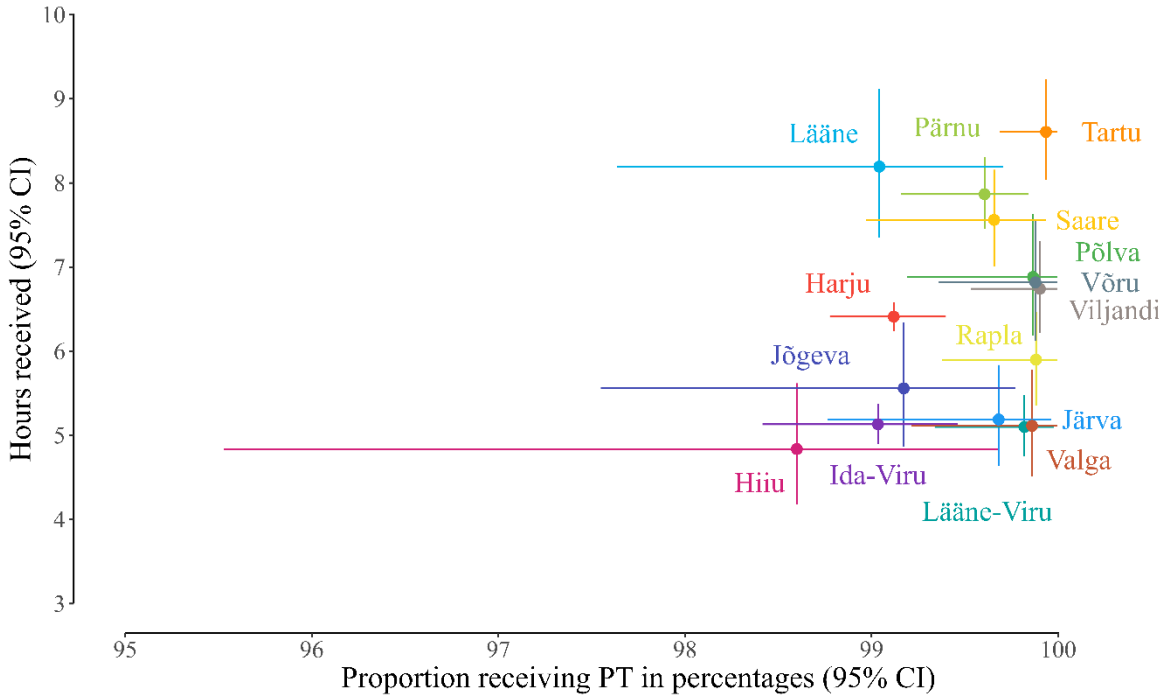

Figure 3. The proportion of patients who received physical therapy and the median total physical therapy hours received based on the patient's county of residence after primary elective total knee arthroplasty during 2010-2021 in Estonia. Reported estimates were adjusted for age, sex, year and Charlson Comorbidity Index score. CI – credible interval, PT – physical therapy.

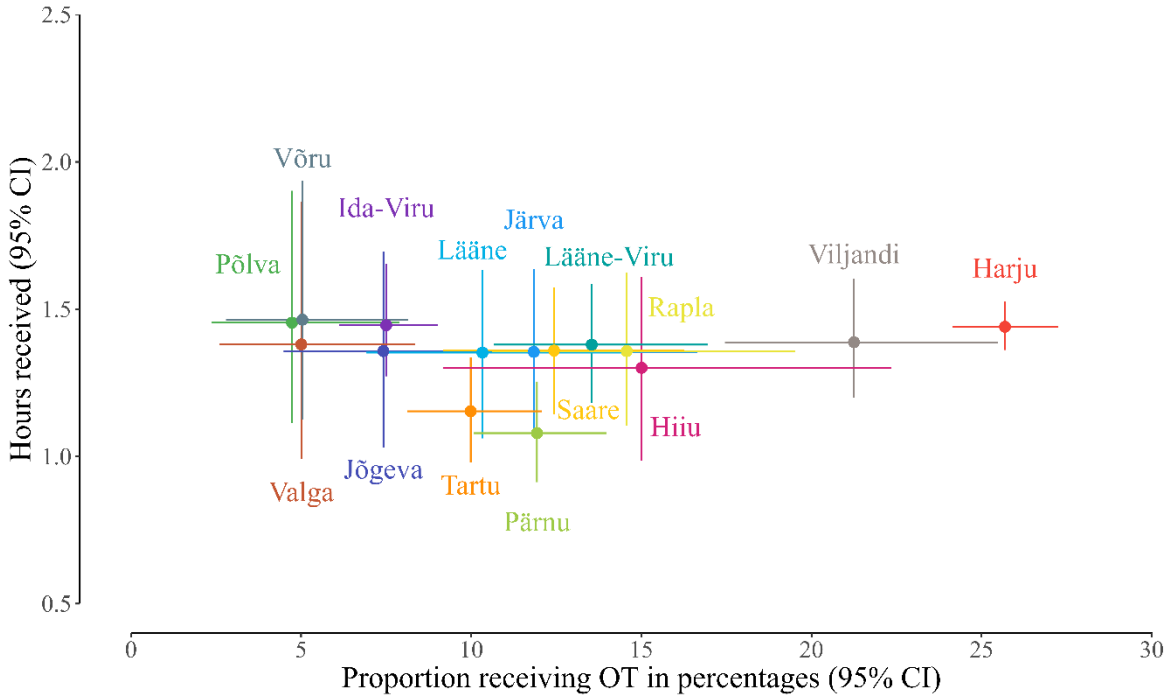

Figure 4. The proportion of patients who received occupational therapy and the median total occupational therapy hours received based on the patient's county of residence after primary elective total knee arthroplasty during 2010-2021 in Estonia. Reported estimates were adjusted for age, sex, year and Charlson Comorbidity Index score. CI – credible interval, OT – occupational therapy.

4.2.4. Temporal trends in rehabilitation

Temporal trends were analysed during the 11-year study period for PT use (Figure 5) and OT use (Figure 6). After adjusting to county, there were no changes in the proportion of patients who received PT nor in the median total hours of PT received. The respective effect sizes between the last and the first study year were 0.2 [-1.3; 0.3] and 0.1 [-0.3; 0.4].

However, in OT use, both positive and negative changes were seen. The proportion of patients who received OT increased by 9.3 [3.3; 18.5] percentage points, but the median total hours of OT received decreased by 1.8 [-2.3; -1.3] hours.

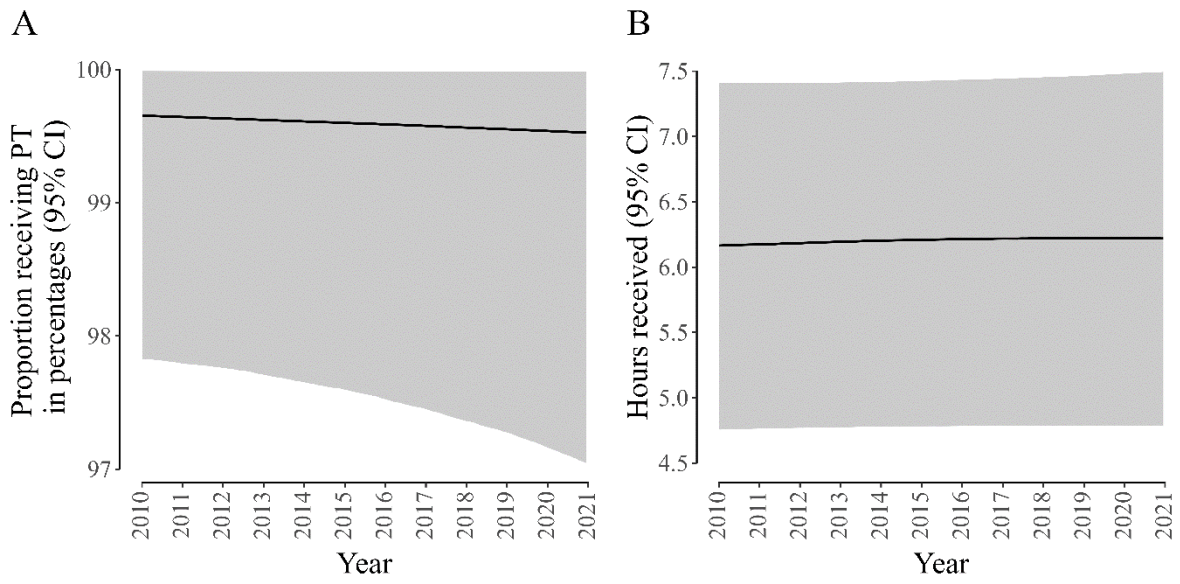

Figure 5. Temporal trends in the proportion of patients who received physical therapy (A) and the median total physical therapy hours received (B) within a year after primary elective total knee arthroplasty during 2010-2021 in Estonia. Reported estimates were adjusted for county. CI – credible interval, PT – physical therapy.

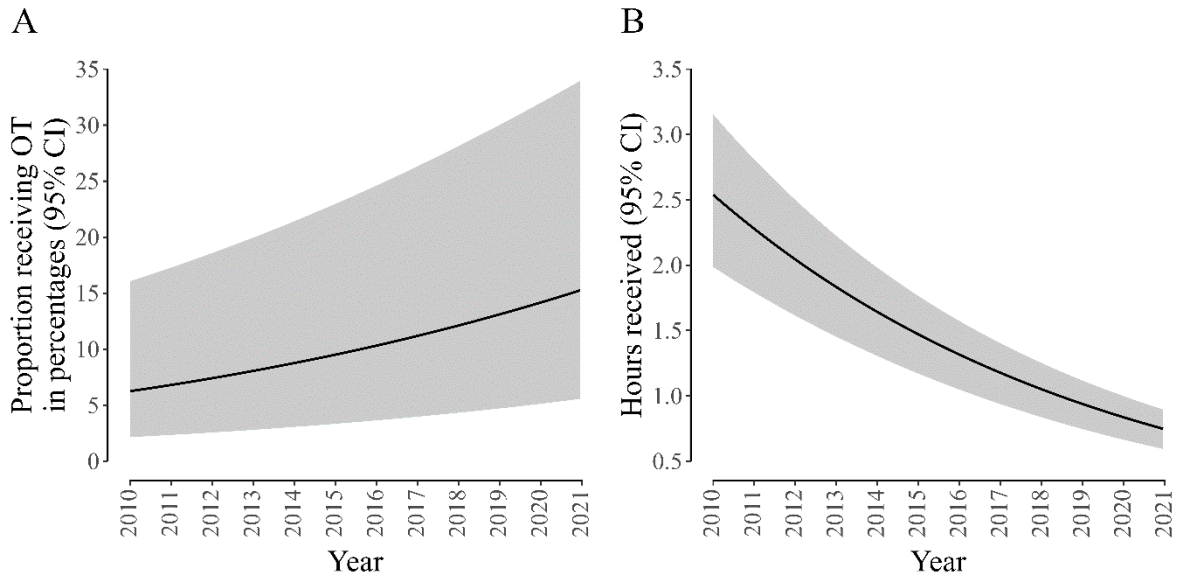

Figure 6. Temporal trends in the proportion of patients who received occupational therapy (A) and the median total occupational therapy hours received (B) within a year after primary elective total knee arthroplasty during 2010-2021 in Estonia. Reported estimates were adjusted for county. CI – credible interval, OT – occupational therapy.

5. DISCUSSION

5.1. Patients' baseline characteristics and operative management

Overall, the patients' main baseline characteristics are similar to the data from different studies and national joint registries except for a higher proportion of females (AAOS, 2022; AOANJRR, 2021; Groot et al., 2022; Irmola et al., 2022; LROI, 2022; Papalia et al., 2022; Roger et al., 2019; Snell et al., 2020; The Swedish Arthroplasty Register, 2022) and patients with a primary diagnosis of OA (LROI, 2022; The Swedish Arthroplasty Register, 2022) in this thesis. The latter difference can be explained by this thesis's inclusion criteria, excluding non-elective procedures and patients with acute trauma as a primary diagnosis.

Nearly half of the adults in Estonia have at least one chronic condition, compared to the 36% of the EU average (OECD & EOHSP, 2021). Papalia et al. (2022) research, including 1,256 adult patients undergoing TKA in Italy, represented the same median CCI score as in this thesis. CCI score over one is associated with longer LOS (Papalia et al., 2022) and CCI of three and more with increased risk for complications (Tay et al., 2017). Furthermore, each additional comorbidity causes a 1-3% increase in health care charges (Ponnusamy et al., 2017). In this study, over half of the patients had a CCI score of one or higher and over one-fifth of patients three or higher, which could affect the cost-effectiveness of TKA.

Studies conducted in Estonia about patients undergoing total hip arthroplasty and patients with hip fractures are in accordance with this thesis's results concerning the most common comorbidity. Respectively, it was reported that 26.0% and 43.7% of the patients had congestive heart failure as the most prevalent comorbidity (Prommik, 2021; Pruunsild, 2022).

The most used method of fixation for TKA is cemented, varying 67-98% among countries (AAOS, 2022; AOANJRR, 2021; Irmola et al., 2022; LROI, 2022; The Swedish Arthroplasty Register, 2022) and the findings of this thesis support it. Similar to Estonia, high usage of cemented fixation can be seen in Finland and Sweden, respectively, 98% and 96%, although their proportion of cementless fixation is higher and hybrid fixation lower than in Estonia (Irmola et al., 2022).

5.2. Rehabilitation

Studies conducted in New Zealand and the Netherlands showed that 90.7-98.0% (Groot et al., 2022; Snell et al., 2020) of patients received any rehabilitation after TKA, which is 1.2-8.5 percentage points less than in Estonia. These results suggest that PT and OT are more accessible for patients in Estonia or the need for rehabilitation might be higher. Although, it needs to be taken into account that both studies had multiple times smaller sample sizes, only surveyed the

period of six months postsurgery, data about rehabilitation were collected via questionnaires, and the study carried out in the Netherlands did not include OT (Groot et al., 2022; Snell et al., 2020).

It has been suggested that PT after TKA should last at least six weeks (Westby et al., 2018). However, in Estonia, PT ended within two weeks for four-fifths of the patients who received it postoperatively. Groot et al. (2022) reported that after TKA, 66% of patients received PT for 12 weeks or more. Snell et al. (2020) found that the average duration of postoperative rehabilitation was 9.6 weeks, although the total hours of rehabilitation received in their study were similar to the results of this thesis.

The findings of previously mentioned studies suggest that more patients in Estonia access rehabilitation after TKA than in New Zealand and the Netherlands; however, the median duration of rehabilitation is multiple times shorter than recommended (Westby et al., 2018) and seen in those countries (Groot et al., 2022; Snell et al., 2020). Most patients in Estonia lose contact for support with their therapist in the early postoperative stage, although functional recovery lasts for over a year (Patterson et al., 2021). It raises concerns because a notable decline in functional performance occurs early after surgery (Mizner et al., 2005), and it has been suggested that therapeutic attention and progress monitoring are important for better outcomes (Snell et al., 2018). As a consequence, patients unable to meet their rehabilitation goals might be left unnoticed, and therefore the desired outcomes might not be achieved.

5.2.1. Acute management and rehabilitation

The LOS of TKA patients in this study is two to four days higher than the researchers in France (Roger et al., 2019) and Italy have found (Papalia et al., 2022), similar to data from Australia (Naylor et al., 2017) and lower than reported in Germany (den Hertog et al., 2012). Compared to the data about rehabilitation after major joint arthroplasties from the 2006 report (National Audit Office of Estonia, 2006), nearly five times more patients received acute rehabilitation in this study, indicating that acute care rehabilitation provision has improved in Estonia.

Although there is no consensus about optimal intensity, frequency, and duration of rehabilitation after TKA (Snell et al., 2018), Westby et al. (2018) proposed that patients should be mobilised on the first postoperative day and receive supervised rehabilitation at least once a day from then on. In Germany, the standard rehabilitation protocol suggests first mobilisation on the second postoperative day and one hour of individual PT per day; however, it has been suggested that mobilisation on the same day and two hours of PT per day leads to enhanced recovery, including reduced LOS (den Hertog et al., 2012). In contrast to these

recommendations, patients in Estonia receive two hours of PT during their entire seven-day acute care stay.

Given the state of Estonia's health care system the suggested one to two hours of rehabilitation per day would likely be unachievable due to the under-prioritisation (Prommik et al., 2022a) and under-funding of rehabilitation and the unmet need for physio- (National Audit Office of Estonia, 2006; OECD & EOHSP, 2021; Prommik et al., 2022a) and occupational therapists (National Audit Office of Estonia, 2006; Prommik et al., 2022a). In Alberta, the acute rehabilitation teams in rural settings with up to 45 beds include one physiotherapist, one or two PT assistants and one occupational therapist. The physiotherapist visits patients one or two times per day and PT assistants two or three times per day (Jones et al., 2016). However, it is uncommon in Estonia to have PT assistants and occupational therapists in an acute care unit. Financially, during a timeframe from 2003 to 2019, the spending on rehabilitation remained around 1% of the total health expenditure (Prommik et al., 2022a), even though already in 2006, the need to raise it to 3-8% was highlighted by specialists (National Audit Office of Estonia, 2006).

One possible way to save hospitals' financial resources would be to decrease LOS (Chen et al., 2012). It has been found that the first postoperative rehabilitation session on the day of the surgery and the higher amount of rehabilitation received per day are associated with earlier discharge (Chen et al., 2012; den Hertog et al., 2012). Meaning that if patients in Estonia could get more rehabilitation per day starting from the day of the surgery, they could achieve the rehabilitation goals needed for discharge sooner.

5.2.2. Post-acute management and rehabilitation

The author of this thesis found only one study by Smith et al. (2020) with a large generalisable sample of 20,260 individuals to represent rehabilitation at a national level. Similar to this study, the first postoperative year was examined, but the data about received PT sessions were collected via questionnaire. They found that during the first postoperative year, 79% of the patients received at least one PT session after discharge from acute-care hospital. In comparison, the accessibility to post-acute PT in this thesis is over ten percentage points lower. However, when comparing the data of this thesis with the data about rehabilitation after major joint arthroplasties from the report of The National Audit Office of Estonia (2006), nearly four times more patients receive it, indicating that the availability of post-acute rehabilitation in Estonia has improved.

In France, 28.4% of patients are discharged from acute-care hospital to a rehabilitation unit and 71.6% to home (Roger et al., 2019). In the USA, 59% of the patients go home with or

without home health care, 31% go to extended-care facilities, and 10% to inpatient rehabilitation (Ponnusamy et al., 2017). In Estonia, discharge to different inpatient post-acute care settings is more common.

Two studies have compared rehabilitation in different types of inpatient post-acute care facilities. DeJong et al. (2009) analysed the amount of rehabilitation received after knee arthroplasty in patients 21 and older, and Mallinson et al. (2011) did a similar study on TKA and total hip replacement patients aged 65 years and older, including revisions. In these studies, patients received 6.7-12.0 hours of PT and 6.3-9.8 hours of OT during their stay in skilled nursing or inpatient rehabilitation facilities (DeJong et al., 2009; Mallinson et al., 2011). A total of 13.0-18.4 hours of rehabilitation was received during the mean 10.4 day LOS (DeJong et al., 2009). In addition, most patients from these inpatient facilities were discharged with additional post-acute care services like home and outpatient rehabilitation (Mallinson et al., 2011), meaning that the total amount of rehabilitation received during the post-acute phase was even higher for the majority of patients. These studies illustrate that a relatively high amount of rehabilitation was received within one to two weeks (DeJong et al., 2009; Mallinson et al., 2011). Therefore, it can be assumed that the sudden decrease in rehabilitation receivers in this thesis, seen around the end of the second postoperative week, marks at least to some extent the end of inpatient rehabilitation.

It has been found that admission to inpatient rehabilitation is determined mainly by the hospital where TKA was performed, not by patient-related factors, suggesting low-value care (Schilling et al., 2018). As was found in 2006, inpatient rehabilitation, compared to outpatient rehabilitation in Estonia, was more available to patients and less dependent on their residences. Since outpatient rehabilitation was less accessible in rural areas, inpatient rehabilitation was prescribed to patients without immediate need, affecting rehabilitation's cost-effectiveness (National Audit Office of Estonia, 2006). The results of this thesis show that patients mainly receive post-acute rehabilitation in inpatient settings, suggesting that the same trend continues to this day.

Padgett et al. (2018) found that patients discharged to inpatient rehabilitation settings had no significant difference in the complication rates at six months nor in functional and patient-reported outcomes at two years compared with patients discharged directly home. Naylor et al. (2017) highlighted that besides the fact that inpatient rehabilitation is more expensive than rehabilitation received in other settings, patients discharged from inpatient rehabilitation facilities need more PT visits afterwards than those discharged directly home, raising the healthcare cost even higher. Therefore, discharging patients without the direct need for inpatient

rehabilitation to home makes possible to reduce healthcare system costs without adverse effects on patient outcomes (Naylor et al., 2017; Padgett et al., 2018; Schilling et al., 2018).

Although home-based rehabilitation has proven to be as effective as inpatient (Mahomed et al., 2008) and outpatient rehabilitation (Barker et al., 2020) while having a lower cost (Barker et al., 2020; Mahomed et al., 2008), only a few patients received home-based rehabilitation during the 11-year study period in Estonia. Therefore, increasing the availability of home rehabilitation services might be one way to raise the cost-effectiveness of rehabilitation and ensure that more patients, regardless of their residence, access rehabilitation services.

In the UK, Hamilton et al. (2019) conducted a study where routine post-discharge outpatient PT after TKA was not provided. Patients received a home exercise program and could access additional outpatient PT if they needed assistance with their recovery. With this setting, 48.2% of patients after TKA turned to outpatient PT. They found that patients who accessed PT reported greater physical dysfunction in the early postoperative phase, were younger and more likely to live in less deprived areas. In comparison, less than half of the patients who received PT in Estonia accessed it in outpatient settings. When analysing the proportion of patients who received PT in outpatient settings from all patients who underwent TKA, it was notably lower than seen in the UK. Although in the previous study, they did not specify the usage of post-discharge inpatient PT. Therefore, it remains unknown if and how many patients received inpatient PT and in what amount.

Hamilton et al. (2019) concluded that for cost-effectiveness (health economics, service delivery), outpatient PT should be available for those who need extra assistance. However, it raises the question of how to adequately assess the need for additional PT since they found that it cannot be reliably predicted on preoperative data. It is essential to keep in mind that if patients with a need for rehabilitation do not access it, serious health problems and, therefore, greater costs to the health system follow (National Audit Office of Estonia, 2006). Since the long-term sustainability of the Estonian health system has been continuously worrisome (OECD & EOHSP, 2021), the cost-effectiveness of rehabilitation could be increased by a comprehensive assessment of patient's needs before discharge and during first postoperative months to find out who would benefit from additional rehabilitation and in which setting, as well as making outpatient rehabilitation and home-based rehabilitation more accessible.

5.2.3. Regional differences in rehabilitation

In 2006, it was found that access to rehabilitation in Estonia is significantly better in big cities than in municipalities (National Audit Office of Estonia, 2006). This thesis showed that the proportion of patients who accessed PT was relatively high and rather equal among counties,

although the amount of PT received varied significantly. In OT, regional disparities in both aspects were high.

Other studies conducted in Estonia on total hip arthroplasty and hip fracture patients have also found multifold regional differences concerning the probability and amount of rehabilitation received (Prommik et al., 2022b; Pruunsild, 2022). However, in addition to the different patient populations, they did not analyse regional differences in OT and PT use separately. In this thesis, regional differences between PT and OT use showed considerable variations, indicating that it is informative to assess them separately.

One national-level study conducted in England and a smaller study in Alberta on rehabilitation after TKA also found geographical variability in PT provision after TKA (Jones et al., 2016; Smith et al., 2020) and the latter study in the amount of PT received as well (Jones et al., 2016). In contrast, no association between geographical location and accessibility to rehabilitation was found in New Zealand (Snell et al., 2020).

5.2.4. Temporal trends in rehabilitation

In this thesis, temporal changes were seen in OT use but not in PT use. Two studies in Estonia have also analysed temporal trends in rehabilitation. A study about rehabilitation after primary elective total hip arthroplasty showed no significant temporal changes (Pruunsild, 2022). Another study with hip fracture patients found significant positive temporal changes in the probability of receiving rehabilitation but not in the median total hours of rehabilitation received (Prommik, 2021).

To the best of this thesis author's knowledge, this is the first study analysing temporal changes separately in PT and OT use in Estonia. Although there was an increase in the proportion of patients who received OT, the relatively wide range of credible interval may suggest varying intra-county temporal changes. On the other hand, the decline in the median total hours of OT received means that patients received more than three times less OT in the study's last year compared to the first. These results show that towards the end of the study period, OT was available for more patients, but the amount of OT per person decreased significantly.

5.3. Strengths and limitations of the thesis

This thesis has multiple strengths. First, this is one of the few population-based studies in the world and the first study in Estonia that describes rehabilitation after TKA. Second, both in the acute and post-acute phase PT and OT use was assessed separately to give more detailed information about rehabilitation. Third, regional differences were analysed to highlight the inequalities patients might encounter based on their county of residence. Fourth, the 11-year

study period allowed to assess temporal trends and therefore expand the knowledge of long-term rehabilitation use.

This study also has some limitations that need to be considered while interpreting the results. First, only the data from publicly financed rehabilitation was analysed; however, only 5% of people in Estonia are not covered by it (OECD & EOHSP, 2021). Second, it was not possible to determine if patients received PT and OT during the post-acute phase due to TKA or other medical reasons; although the first postoperative year was chosen for assessment to decrease the possibility of the latter.

Future studies are needed to assess the relationship between the amount of rehabilitation received, functional outcomes, revision surgeries and mortality of primary elective TKA patients in Estonia and to clarify the optimal duration and amount of rehabilitation needed in acute and post-acute phase after TKA.

6. CONCLUSIONS

The following conclusions were made based on this thesis.

1. During a week-long acute care, after primary elective TKA, rehabilitation was accessible for almost all patients, primarily in the form of PT. Only a fraction of patients received OT, mainly in combination with PT.
2. During post-acute phase, two-thirds of primary elective TKA patients received post-acute rehabilitation, primarily in the form of inpatient PT; however, its duration was relatively short-lived.
3. There were up to 5.4-fold regional differences in one-year PT and OT use.
4. During 11 years, there were omnidirectional trends in OT use, but no changes in the PT use after primary elective TKA.

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APPENDIX 1. Baseline characteristics of primary elective total knee arthroplasty patients during 2010-2021 in Estonia

Variable	Total n=10,185
Age	69.0 (62.0 - 75.0)
Women	7,565 (74.3)
Primary diagnosis	
Implant related complication	7 (0.1)
Inflammatory arthritis	29 (0.3)
Malignant tumour	1 (0.01)
Malunion	1 (0.01)
Osteoarthritis	10,141 (99.6)
Osteonecrosis	6 (0.1)
Charlson Comorbidity Index	
0	4,386 (43.1)
1-2	3,697 (36.3)
3-4	1,698 (16.7)
≥ 5	404 (4.0)
Comorbidities	
Myocardial infarction	457 (4.5)
Congestive heart failure	3,595 (35.3)
Peripheral vascular disease	656 (6.4)
Cerebrovascular disease	1,183 (11.6)
Dementia	58 (0.6)
Chronic pulmonary disease	1,690 (16.6)
Rheumatic disease	960 (9.4)
Peptic ulcer disease	823 (8.1)
Mild liver disease	446 (4.4)
Diabetes without chronic complication	1,345 (13.2)
Diabetes with chronic complication	522 (5.1)
Hemiplegia or paraplegia	222 (2.2)
Renal disease	367 (3.6)
Any malignancy	864 (8.5)
Moderate or severe liver disease	24 (0.2)

Variable	Total n=10,185
Metastatic solid tumour	13 (0.1)
AIDS/HIV	2 (0.02)
County of residence	
Harju	3,890 (38.2)
Hiiu	105 (1.0)
Ida-Viru	1,229 (12.1)
Jõgeva	218 (2.1)
Järva	213 (2.1)
Lääne	256 (2.5)
Lääne-Viru	486 (4.8)
Not registered	36 (0.4)
Põlva	205 (2.0)
Pärnu	1,112 (10.9)
Rapla	260 (2.6)
Saare	390 (3.8)
Tartu	924 (9.1)
Valga	194 (1.9)
Viljandi	408 (4.0)
Võru	259 (2.5)

Continuous variables are shown as "median (25th–75th percentile)" and categorical as "n (%)".

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Kaie Leppik

20.05.2023