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Primary elective total hip arthroplasty rehabilitation during 2010-2020 in Estonia

Puusaliigese esmase plaanilise täieliku endoproteesimise järgne taastusravi Eestis aastatel 2010-2020

Master's thesis

Physiotherapy

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ABBREVIATIONS

AAOS – American Academy of Orthopaedic Surgeons

AOANJRR – Australian Orthopaedic Association National Joint Replacement Registry

CCI – Charlson Comorbidity Index

CI – confidence/credible interval

EHIF – Estonian Health Insurance Fund

LOS – length of stay

NICE – National Institute for Health and Care Excellence

OA - osteoarthritis

PT – physical therapy

SD – standard deviation

THA – total hip arthroplasty

ABSTRACT

Aim: The aim of the study was to describe and analyse primary elective total hip arthroplasty (THA) one-year rehabilitation in Estonia during 2010-2020, focusing on physical therapy (PT) use, its regional differences, and temporal changes.

Methods: This retrospective cohort study used population-wide health claims data acquired from the Estonian Health Insurance Fund, including patients aged ≥18 years with a record of a primary elective THA performed in Estonia between January 2010 and December 2020. The data was further validated using the Nordic Medico-Statistical Committee's Classification of Surgical Procedures codes and operation dates. Rehabilitation related funding codes on health care claims were converted to clinically relevant estimates – received acute and post-acute PT hours.

Results: The study included a total of 12,514 patients. Their median acute length of stay was 7 days. 98.1% (12,278/12,514) of the included patients received PT by a median of 2 hours during the acute phase. Post-acute PT was accessible to 65.2% (8,163/12,514) of patients, and they received a median of 6.5 hours. For half of the population observed, the rehabilitation process had finished 22 days after the end of the acute phase. There were 2.4-fold regional disparities in median received post-acute PT hours. Post-acute PT remained unchanged during these 11 years.

Conclusions: Despite most of the observed population having access to post-acute rehabilitation, the rehabilitation process was relatively short and there existed regional disparities in received PT. Post-acute PT remained unchanged during 2010-2020. These findings highlight the necessity for further evidence-based recommendations regarding post-acute rehabilitation in Estonia.

Keywords: Total hip arthroplasty, rehabilitation, physical therapy, post-acute care

LÜHIÜLEVAADE

Eesmärk: Käesoleva magistritöö eesmärgiks oli kirjeldada ja analüüsida puusaliigese esmase plaanilise täieliku endoproteesimise järgse aasta jooksul saadud taastusravi aastatel 2010-2020 Eestis, keskendudes post-operatiivse füsioteraapia kasutamisele, selle regionaalsetele erinevustele ja ajalistele trendidele.

Metoodika: Retrospektiivsesse kohortuuringusse kaasati patsiendid vanuses ≥18, kellel oli läbi viidud esmane plaaniline täielik puusaliigese endoproteesimine vahemikus jaanuar 2010 – detsember 2020. Andmed valideeriti Põhjamaade Meditsiinistatistika Komitee klassifikatsiooni kirurgiliste protseduuride koodide ja operatsiooni kuupäeva alusel. Eesti Haigekassa tervishoiuteenuste koodid konverteeriti kliinliselt relevantseks näitajaks, summeeritud füsioteraapia tundideks. Füsioteraapia tunde uuriti eraldi aktiiv- ja järelravil.

Tulemused: Uuringusse kaasati 12,514 patsienti. Nende akuutravi mediaankestvuse aeg oli 7 päeva. Kõigist patsientidest 98.1% (12,278/12,514) sai akuutse ravifaasi ajal füsioteraapiat, kokku 2 mediaan tundi. Akuutravi järel sai 65.2% (8,163/12,514) patsientidest füsioteraapiat kogumahus 6.5 mediaan tundi. Pooled uuringus vaadeldud patsientidest ei saanud enam taastusravi peale 22 päeva möödumist akuutse ravifaasi lõpust. Post-akuutses ravifaasis saadud füsioteraapia tundides esines 2.4-kordne regionaalne erinevus. Saadud füsioteraapiatundide arv püsis post-akuutses ravifaasis vaadeldud 11 aasta jooksul muutumatuna.

Kokkuvõte: Kuigi enamiku vaadeldud patsientide jaoks oli post-akuutses ravifaasis füsioteraapia kättesaadav, oli taastusravi protsess võrdlemisi lühike. Füsioteraapia saamises esinesid maakondade vahelised erinevused. Akuutravi järel saadud füsioteraapia ajavahemikus 2010-2020 ei muutunud. Käesoleva uurimustöö tulemus näitlikustab vajadust ravikäsitluse järgi, mis käsitleks post-akuutse ravifaasi taastusravi Eestis.

Märksõnad: Täielik puusa endoproteesimine, taastusravi, füsioteraapia, post-akuutne ravifaas

1. LITERATURE REVIEW

1.1. Hip osteoarthritis

The current pace of population ageing is much faster than in the past. Every country in the world is going through a longevity revolution which means that the proportion of older people as a demographic group is constantly growing (United Nations, 2019). It is estimated that worldwide, by 2030, 1 in 6 people will be aged 60 years and older. By 2050, the number of people aged 60 years and older will have doubled (World Health Organization, 2021).

Osteoarthritis (OA) is a chronic degenerative joint disease presenting with synovitis and pain that significantly affects quality of life (Ferguson et al., 2018). Pathologically, OA is characterised by loss of articular cartilage and accompanying osteophyte formation (Dibonaventura et al., 2011; Robinson et al., 2018). It is the most prevalent joint disease worldwide, affecting approximately 10% of men and 18% of women over 60 years of age (Glyn-Jones et al., 2015). Risk factors for OA include female sex, older age, obesity, genetics, and significant joint trauma (Bennell, 2013). As a result of the proportion of the geriatric population increasing compared to the overall population, the number of people suffering from OA will likely increase (Bennell, 2013; Ferguson et al., 2018). In the United States of America, which has a population of 330 million people, it has been estimated that by the year 2030, there will be approximately 41 million Americans affected by OA (Rees, 2020).

Hip OA is the most prevalent type of OA diagnosed, accounting for up to 43% of cases. Bilateral OA is present in up to 34% of patients with diagnosed hip OA (Eesti Reumatoloogia Selts, 2008). Hip OA is most often diagnosed based on symptoms and is sometimes confirmed by radiography (Bennell, 2013; Ferguson et al., 2018). However, symptoms are not always accurately associable with the degree of structural pathology found in imaging (Kinds et al., 2011). Altman et al. (1991) have established two different clinical sets that are still most commonly used to classify hip OA in a patient. According to the criteria, hip OA is diagnosed if pain coexists with either 1) hip internal rotation over 15 degrees, stiffness of the hip in the morning for less than 60 minutes, and patient age of over 50 years or 2) hip internal rotation under 15 degrees and hip flexion under 115 degrees and patient age of over 50 years (Altman et al., 1991).

Hip OA is a debilitating condition for the individuals affected. Pain is a persistent symptom that gradually worsens over time as the disease progresses. Pain caused by hip OA is usually at its worst at the end of the day and best in the morning, although morning stiffness is common (Courtney & Doherty, 2014). Limitations in all hip ranges of motion have been reported in patients diagnosed with hip OA (Arokoski et al., 2004). Moreover, hip OA leads to lower muscle strength in the hips and lower extremities, especially in the quadriceps and hip abductor muscles (Loureiro et al., 2013). Patients with diagnosed hip OA report difficulty with daily activities such as walking, driving, grocery shopping, gardening, and doing household chores (Bennell, 2013). Work attendance is reduced, and fatigue and sleep problems are common. In addition, people with hip OA usually suffer from various co-morbid diseases that likely increase the probability of poor physical function (Bennell, 2013; Robinson et al., 2018). Hip OA is causing an increasing economic burden, with costs associated with various conservative and surgical treatments and productivity loss. It has been found that individuals with OA-related pain were less likely to be employed (Dibonaventura et al., 2011).

Management of OA can be either non-operative or surgical. Non-operative management is categorised into non-pharmacological or pharmacological, depending on whether specific steroid injection treatments or drugs were used (Eesti Reumatoloogia Selts, 2008; NICE, 2014). Fundamental non-pharmacological measures consist of patient education, weight loss – if the patient is obese or even just overweight, exercise – including aerobic fitness training and resistance training, and reducing unfavourable biomechanical factors (Courtney & Doherty, 2014; NICE, 2014). Patients with persistent symptoms and limitations in terms of participation that are also non-responsive to conservative management should be referred for an examination to determine the necessity of surgical intervention (Courtney & Doherty, 2014).

1.2. Total hip arthroplasty

Since its inception in the 1960s, modern total hip arthroplasty (THA) has completely revolutionised the methodology surrounding the management of the arthritic hip (Knight et al., 2011). The number of successful THA procedures has constantly been increasing, which has led to standardised surgical techniques, and the average age of a person receiving a hip endoprosthesis has reduced (Knight et al., 2011; Madara et al., 2019). Nowadays, THA is a commonplace orthopaedic surgical intervention with successful outcomes in patient quality of life improvement (Ferguson et al., 2018; Karachalios et al., 2018; Knight et al., 2011). More than one million THA

procedures are done worldwide every year (Ferguson et al., 2018). Modern THA can improve patients' self-reported outcome measures more than any other elective surgery (NHS Digital, 2017). Based on data from the British National Joint Registry, approximately 97% of patients who underwent THA reported improvements in pain and function (NHS Digital, 2021). Over 95% of hip endoprostheses survive for longer than ten years, and many do so even for more than three decades (Ferguson et al., 2018). Evans et al. (2019) conducted a study using data collected from the Finnish Arthroplasty Registry and found that 25 years post-surgery, the survivorship was 58%. Furthermore, good clinical outcomes have been reported at 15- to 25- year follow-ups. (Karachalios et al., 2018).

THA is mainly undertaken to improve function and reduce pain in patients with advanced hip OA (Ferguson et al., 2018). Symptomatic OA is the most common reason for primary THA, accounting for 82-92% of surgical procedures undertaken (AOANJRR, 2021; Kärrholm et al., 2019; National Joint Registry, 2021). Acute trauma (hip fracture), avascular necrosis, dysplasia, and inflammatory joint disease account for most of the remaining indications for THA. (Kärrholm et al., 2019; National Joint Registry, 2021). The median age for primary total hip replacement varies between 67-69 years (AOANJRR, 2021; Kärrholm et al., 2019; National Joint Registry, 2021). Kurtz et al. (2009) found that the proportion of younger patients receiving a hip endoprosthesis in the USA has increased, and those younger than 65 years are projected to make up 52% of all THA patients by 2030.

The main clinical indication for THA is late-stage arthritis, with joint pain and stiffness showing little to no improvement regarding conservative treatments (Ferguson et al., 2018). THA should be undertaken solely based on radiographically demonstrated end-stage hip OA after the patient has undergone at least three months of conservative treatment and in the case of high patient distress due to various symptoms connected to the affected hip joint (Günther et al., 2021). It is beneficial for all parties involved when the patient is involved in shared decision-making preoperatively (Berliner et al., 2016; Ferguson et al., 2018). Surgeons need to consider specific patient characteristics, including age, body mass index, and comorbidities, that can affect the outcome of the surgery in terms of limiting the physical improvement and increasing complication rates (Gordon et al., 2013). Best results in terms of functional outcomes have been achieved by operating on patients with better preoperative physical and mental health (Ferguson et al., 2018). It must be noted that undergoing THA while having better preoperative function might lead to

relatively worse results regarding overall functional improvement than those with lower preoperative function due to being in the early phase of the disease (Berliner et al., 2016; Ferguson et al., 2018).

Various techniques and materials are used when undertaking THA depending on the geographical location, patient-specific characteristics, and surgeon preference (Ferguson et al., 2018). Methods of fixation in THA can be categorised into cemented, cementless and hybrid (combined use of cemented and cementless components), and there exists continued debate as to which is the best solution (Ferguson et al., 2018). Cemented fixation has shown excellent long-term survivability rates compared to cementless fixation. (National Joint Registry, 2021). However, cementless fixation might lead to lower revision rates in patients under 65 years of age and is the most often used method in large countries such as the USA and the UK (Ferguson et al., 2018).

1.3. Post-operative rehabilitation

Rehabilitation should start on the day of surgery, if possible, and no more than 24 hours after surgery and should include patient education, exercise guidance and mobilisation training (AAOS, 2022; NICE, 2020). Post-operative patient education usually includes concrete precautions for the next six to eight weeks: patients cannot cross their legs, internal rotation from the hip joint is forbidden, and they are not allowed to flex the operated leg more than 90° from the hip (Matheis & Stöggl, 2018). Post-operative educational sessions based on patients' empowerment have shown benefits for self-efficacy (Colibazzi et al., 2020).

Patients who undertake THA and receive post-operative rehabilitation have lower strength, overall physical function, and worse gait mechanics for up to two years post-surgery compared to normative values from healthy individuals in the same age group (Madara et al., 2019, Monaghan et al., 2017). Many patients only return to activity levels that a physician recommends; nearly 33% of all patients stop participating in their sports and active hobbies altogether (Delasotta et al., 2012; Madara et al., 2019). A group of researchers found that physicians' suggestions regarding activity levels for patients to follow were not based on available scientific evidence (Swanson et al., 2009). Researchers have suggested that fear of returning to activities and lingering impairments might exist due to a lack of a comprehensive, progressive, and individualised rehabilitation plan after THA (Madara et al., 2019).

1.3.1. Early post-operative rehabilitation

The general recommendation after THA is to exercise for at least 20-30 minutes a day, and the exercises should be done two to three times daily during the early post-acute phase of recovery (AAOS, 2022). Early post-acute exercises consist of isometric contractions of the quadriceps and gluteal muscles and active range of motion movements of the ankle, knee, and hip joints (AAOS, 2022; Colibazzi et al., 2020). Umpierres et al. (2014) found that using professional physical therapists compared to only having patient education done by hospital staff yielded significant improvements in pain relief, overall mobility, and muscle strength after two weeks. An enhanced recovery program might reduce the post-operative length of stay (LOS) by more than 30% (Dwyer et al., 2012). Matheis and Stöggl (2018) had patients do an additional 30-min training therapy during their LOS, including different exercises on the cross-walker, weight-shifting and exercises targeting hip abduction and extension. It was observed that patients who underwent this protocol achieved a better hip joint range of motion and 6-minute walking test performance than a control group who performed regular PT (Matheis & Stöggl, 2018).

A study had THA patients do partial body-weight support treadmill training and found that their function had significantly improved after ten days, with positive effects persisting at 3- and 12-month follow-up (Hesse et al., 2003). In addition, gait symmetry, hip abductor muscle strength, and gluteus medius electromyographical activity were better in the treatment group, and these statistically significant differences persisted throughout the follow-up period (Hesse et al., 2003). Another study examined the effects of a resistance training program which only involved the quadriceps muscle. The authors observed notable physical function and impairment benefits and a considerable reduction in the acute hospital LOS period (Suetta et al., 2004).

1.3.2. Late post-operative rehabilitation

Rehabilitation has shown to be very effective even in the later stages of post-surgery (>8 weeks after surgery), with significant improvements in walking speed and overall physical function being achieved with different exercise protocols (Colibazzi et al., 2020; Unlu et al., 2007). The beforementioned interventions were found to be effective even one year after surgery (Unlu et al., 2007). Heiberg et al. (2012) investigated the effect of a 12-session training program which started three months after surgery, consisting of weight-bearing activities, on self-efficacy and physical functioning. Immediate results were observed after completing the training program, with better scores in performance-based measures and self-reported physical function categories compared to

the control group - the most pronounced improvement was walking distance. The differences between groups persisted even 12 months after surgery. The authors note that the supervision and guidance of a physical therapist was an essential part of the program (Heiberg et al., 2012).

Trudelle-Jackson & Smith (2004) examined the effects of a late-phase exercise programme for THA patients who underwent the procedure 4 to 12 months earlier. The intervention lasted for eight weeks and consisted of different strength and postural stability exercises performed in patients' homes. The authors observed statistically significant improvements in self-perceived function and muscle strength for the hip flexors (24%), extensors (48%) and abductors (41%). Furthermore, the experimental group increased knee extensor strength (23%) and postural stability (37%). No significant changes in any parameters were observed in the control group (Trudelle-Jackson & Smith, 2004).

Monaghan et al. (2017) evaluated the effectiveness of a supervised physical therapy (PT) exercise programme conducted between 12- and 18-weeks following THA. Patients in the exercise group attended a physical therapist-supervised functional exercise class twice per week, while the control group proceeded with regular care protocol. The authors observed significant improvements in walking speed and overall physical function for patients who underwent the programme compared to patients receiving usual care (Monaghan et al., 2017). Consistent and longer-lasting PT sessions improve patient satisfaction and beliefs regarding how effective the rehabilitation is for them (Westby & Backman, 2010).

It is already known that late-stage post-operative rehabilitation has a beneficial effect on patients (Heiberg et al., 2012; Monaghan et al., 2017; Trudelle-Jackson & Smith, 2004; Unlu et al., 2007). However, there is still little to no evidence regarding the optimal dosage for PT hours received, especially for the post-acute phases of rehabilitation. A recent systematic review found a need for additional studies regarding post-operative rehabilitation of THA because of existing uncertainties about the dosage and duration necessary for optimal recovery (Colibazzi et al., 2020). This study hopes to fill in some of the gaps in scientific literature and give an overview of primary elective THA post-operative rehabilitation in Estonia.

2. AIM AND OBJECTIVES

The study's main objective was to describe and analyse primary elective THA rehabilitation in Estonia during 2010-2020, focusing specifically on one-year PT use and its regional differences and temporal trends. The specific objectives of the study are stated as follows:

1. To evaluate acute and post-acute PT use after primary elective THA in Estonia.
2. To analyse regional differences in post-acute PT use after primary elective THA in Estonia.
3. To examine temporal trends in post-acute PT use after primary elective THA during 2010-2020 in Estonia.

3. METHODS

This master's thesis was conducted as 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 (reference: 357/M-18). The timeframe of this thesis was from October 2021 to May 2022.

3.1. Data collection

This study was based on eleven-year-spanning retrospective data. The health care system in Estonia makes obtaining such extensive health data possible. The country has a national, mandatory, solidarity-based, centralised health insurance system covering 95% of the population (EHIF, 2021; OECD, 2021). The health care system in Estonia has a single health insurance fund – the Estonian Health Insurance Fund (EHIF). The EHIF provided pseudonymised data, enabling data analysis without the researcher knowing the patient's identities. The asked data included the Nordic Medico-Statistical Committee's (NOMESCO) Classification of Surgical Procedures (NCSP) codes and operation dates. The codes starting with "NFB" were requested to establish the operative management type as hip endoprosthesis (NOMESCO, 2001). The data also included general information about the patient - age, sex, location, and diagnoses (primary and secondary) - necessary for establishing patients' baseline characteristics and analysis. Primary and secondary diagnoses received from the EHIF were in accordance with the International Classification of Diseases, 10^{th} revision (ICD-10) codes. Furthermore, details about the surgical procedure and hospital stay – location, date of operation, acute care start, and end date were obtained to analyse acute care, using variables such as LOS and overall PT received. Regional information was requested to examine temporal trends and inter-regional differences in the counties of Estonia in terms of rehabilitation of primary elective THA patients. In addition, patients' health care episodes up to one year post-operatively, which included PT use and setting type (inpatient and outpatient service providers), were acquired to analyse post-operative rehabilitation. PT hours that the patients received were obtained from the EHIF's service codes. Only codes pertaining to rehabilitation were used in the analysis. By the EHIF's latest redaction, all of the codes received included pre-established duration, with timeframes of 0.5 hours and 1 hour, depending on the service (Government of Estonia, 2022).

3.2. Subjects

The study included patients aged ≥18 years with a primary elective THA performed in Estonia from 1st January 2010 to 31st December 2020. Only primary elective THA procedures were obtained to increase the homogeneity of the population. THA as the chosen surgical management was validated with NCSP codes received from the EHIF, with NFB20, NFB30 and NFB40 being the corresponding codes used for THA. In addition, the beforementioned codes were also used to establish the surgical management type, which was then categorised into either cementless (NFB20), hybrid (NFB30) or cemented (NFB40). All acute fractures were excluded from the data request to maintain the population's homogeneity since the study focuses solely on primary elective THA. ICD-10 codes for primary diagnoses were used to validate the population and subgroup patients into seven categories based on the medical reason for undertaking THA as an elective surgery (Table 1).

Table 1. Primary diagnoses classification and the respective ICD-10 codes used

Diagnosis	ICD-10 codes
Osteoarthritis	M15 (polyarthrosis), M16.0-9 (coxarthrosis)
Osteonecrosis	M00.0-9 (pyogenic arthritis), M87.0-9 (osteonecrosis), M90.5 (osteonecrosis based on other diseases)
Implant related complication	T79 (certain early complications of trauma), T84 (complications of internal orthopaedic prosthetic devices, implants, and grafts)
Malunion	M84 (disorders of continuity of bone), T93 (sequelae of injuries of lower limb)
Inflammatory arthritis	M05-M13 (inflammatory polyarthropathies)
Malign tumour	C40-C41 (malignant neoplasms of bone and articular cartilage)
Benign tumour	D16 (benign neoplasm of bone and articular cartilage)

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

Diagnoses acquired from health care claims were used to calculate the Charlson Comorbidity Index (CCI). Comorbidities were defined as primary or secondary diagnoses coded as ICD-10 on medical claims at any hospital or outpatient service provider up to four years before surgery. CCI was chosen since it has been widely used since 1987 for different health outcome related studies,

is adapted for usage with ICD-10 codes and has been recently validated for THA patients (Mannion et al., 2020). The final inclusion consisted of 12,514 patients who met all the criteria.

3.3. Analysis of physical therapy received post-operatively

PT hours received by primary THA patients during various health care episodes were used to evaluate post-operative rehabilitation. A couple of service codes that represent occupational therapy from medical records (7042, 7053, 7054, 7061, 7068, 7069) were also categorised as PT hours received. These codes attributed to merely ~7,6% of all the PT hours registered. To accurately analyse acute physical therapy received, only the period which coincided with the patients' LOS was included. Post-operative acute medical claims were matched with corresponding patients' IDs to validate the data. The difference between acute care start and end dates was calculated to establish the LOS. No setting analysis was done regarding acute care because the acute care period in Estonia is prevalently spent in inpatient care.

For the post-acute phase of PT, a one-year duration from the end of acute care was chosen to analyse rehabilitation. The beforementioned period was selected because most recovery from undergoing THA happens within this time frame. Analysing this period also reduced the possibility of a THA patient receiving PT due to another medical condition. The medical records also contained information about the setting used by the patient receiving PT. The different types of locations used for PT were obtained in a coded format. There were five different settings included in the analysis: Other outpatient (code: 1), other inpatient (code: 2), inpatient rehabilitation (code: 15), outpatient rehabilitation (code: 16) and inpatient nursing care (code: 18). A setting was excluded from the analysis of rehabilitation, ambulatory surgery and care (code: 19), because there were only seven total medical bills containing PT hours throughout the study's timeframe. The proportion of each setting was calculated for the post-acute period of rehabilitation. In addition, it was also analysed whether a patient received PT in different types of settings during the post-acute period.

Health care claims from the EHIF were used to calculate the probability of receiving post-operative PT and the median hours of rehabilitation acquired. This data was used to analyse regional differences and the temporal trends in post-acute rehabilitation.

3.4. Statistical analysis

Statistical analyses were performed in R 4.0.4 (R Core Team, 2017) using the following packages: *comorbidity* for CCI (Gasparini, 2018); *brms* for Bayesian regression modelling (Bürkner, 2018). Continuous variables are presented as a 'median (25th-75th percentile)' or as a mean (SD), and categorical variables as proportions or probabilities. CCI was grouped into categorical counterparts: 0, 1-2, 3-4, and ≥5.

Continuous variables were compared using the Kruskal Wallis test, and the Pearson chi-squared test was used for proportional comparisons. A Kaplan–Meier analysis was conducted for the start and end of post-acute rehabilitation. Statistical significance was defined as $p < 0.05$, and all tests were two-sided.

Regression analyses focused on post-acute PT use. As an outcome variable, post-acute PT use was zero-inflated and positively skewed, meaning that all analyses consisted of two parts. The first part analysed the probability of receiving post-acute PT using Bernoulli's likelihood. The second part analysed the median received PT hours using the lognormal likelihood. Regional analyses were adjusted for age, sex, primary diagnosis, year, CCI, surgical method, acute PT hours and county (specified hierarchically). Country-wide temporal analyses were adjusted for acute PT hours and year. Regional temporal analyses were adjusted for acute PT hours, year and county using free slope (year) and free intercept (county) specification. All models were run with default weakly informative priors, and point estimates [probabilities and median PT hours] were given with 95% credible intervals (CI) as '[lower; upper].'

4. RESULTS

4.1. Patients

The median patient age who underwent primary THA as an elective surgery was 67 years, their median CCI was 1 and 61% were female. Osteoarthritis was the main primary diagnosis (Table 2).

Table 2. Baseline characteristics of primary elective THA patients during 2010-2020 in Estonia

	Total n = 12,514
Age	67.0 (59-75)
Sex	
F	7,624 (60.9)
Primary diagnosis	
Osteoarthritis	12,137 (97.0)
Osteonecrosis	181 (1.4)
Implant related complication	88 (0.7)
Malunion	66 (0.5)
Inflammatory arthritis	18 (0.1)
Malign tumour	17 (0.1)
Benign tumour	7 (0.1)
CCI score	
0	5,977 (47.8)
1-2	5,153 (41.2)
3-4	1,205 (9.6)
≥ 5	179 (1.4)
Comorbidities	
Myocardial infarction	602 (4.8)
Congestive heart failure	3,247 (26.0)
Peripheral vascular disease	593 (4.7)
Cerebrovascular disease	858 (6.9)
Dementia	42 (0.3)
Chronic obstructive pulmonary disease	1,294 (10.3)
Rheumatoid disease	658 (5.3)
Peptic ulcer disease	674 (5.4)
Mild liver disease	366 (2.9)
Diabetes without complication	1,504 (12.0)
Diabetes with complication	373 (3.0)
Hemiplegia or paraplegia	238 (1.9)
Renal disease	483 (3.9)
Cancer (any malignancy)	893 (7.1)
Moderate or severe liver disease	25 (0.2)
Metastatic solid tumour	14 (0.1)
AIDS/HIV	9 (0.1)

Categorical variables are represented as "n (%)" and continuous variables as "median (25^{th}-75^{th} percentile)". CCI – Charlson Comorbidity Index, THA – total hip arthroplasty

The county of residency and proportions are shown in Table 3. The regional variations are listed as the minimum and maximum values of the following properties. Comparing all the counties of Estonia, the median age ranged from 65-69 years ($p < 0.01$). Osteoarthritis was the prevailing primary diagnosis for THA, ranging between 95.2%-99.1% ($p < 0.001$). The median CCI score among the counties ranged from 0-1 ($p < 0.001$).

Table 3. Primary elective THA patients by county in Estonia during the years 2010-2020

	Total n = 12,514
Residency by county	
Harju	4,935 (39.4)
Hiiu	114 (0.9)
Ida-Viru	1,153 (9.2)
Jõgeva	340 (2.7)
Järva	294 (2.3)
Lääne	306 (2.4)
Lääne-Viru	615 (4.9)
Põlva	250 (2.0)
Pärnu	1,141 (9.1)
Rapla	431 (3.4)
Saare	499 (4.0)
Tartu	1,277 (10.2)
Valga	283 (2.3)
Viljandi	538 (4.3)
Võru	293 (2.3)
Residency not available	45 (0.4)

Categorical variables are represented as "n (%)".

4.2. Acute management and physical therapy use

On average, 1,137 ± 60.1 (SD) primary elective THA procedures were done yearly during 2010-2020 in Estonia. The amount of primary elective THA procedures done per year ranged from a minimum of 1,054 to a maximum of 1,226 per year, with the highest amount of primary elective THA procedures done in the last year of this study's timeframe.

The most common endoprosthesis type used was cemented, and it was the chosen method for 48.5% of patients, followed by 39.5% cementless and 12.0% hybrid. The use of cemented THA decreased by 28 percentage points, and the use of cementless THA increased by 26 percentage points from 2010 to 2020 ($p < 0.001$) (Figure 1).

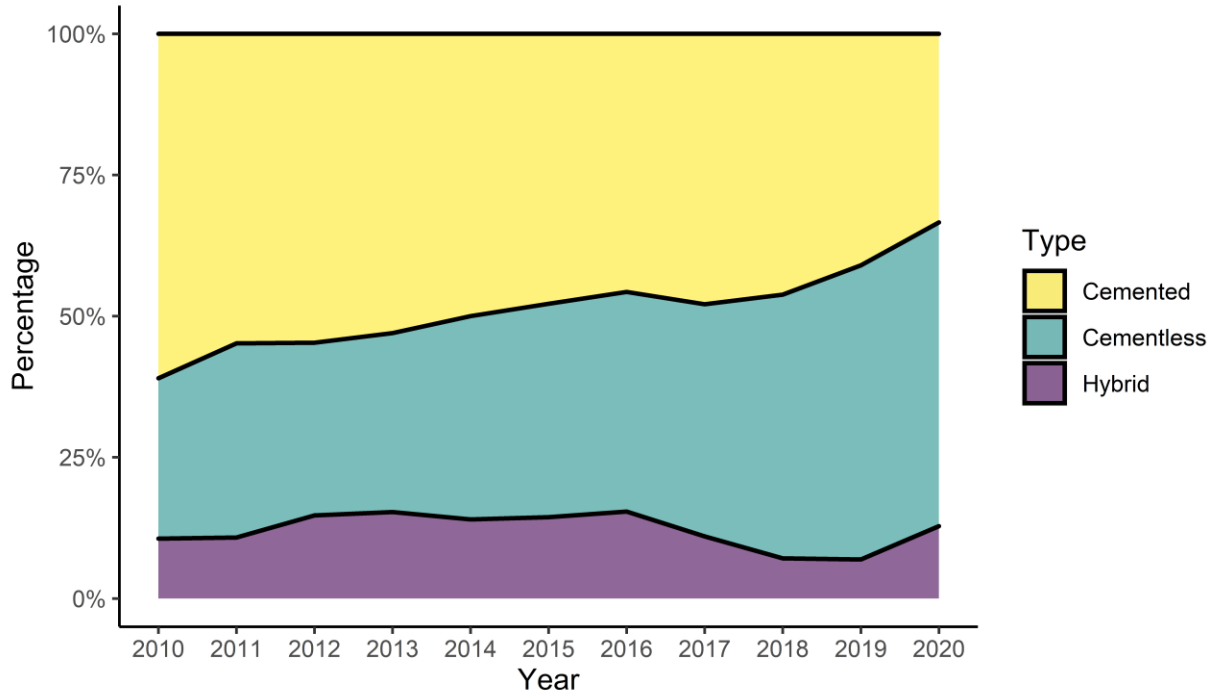

Figure 1. Endoprosthesis types used for primary elective total hip arthroplasty procedures during 2010-2020.

The median length of stay (LOS) during acute care after THA was 7 (5-8) days. Of all the patients included in this study, 1.9% (236) received no PT during acute care, and the median amount of PT received was 2 (1.5-3) hours.

4.3. Post-acute management and physical therapy use

Most of the PT received during post-acute rehabilitation occurred in various inpatient settings, with the following rates of usage: other inpatient care (52.3%), inpatient rehabilitation (44.6%) and inpatient nursing care (4.7%). Outpatient rehabilitation was used by 33.3%, and other outpatient services with 10.6% comprised the outpatient category. In terms of total PT hours received, 69.4% occurred in inpatient settings. Of all the patients who received post-acute PT, the proportion who logged PT hours in at least two different setting types was 36.8% (3,004/8,163). The median LOS for post-acute rehabilitation in inpatient settings was 8 (6-10) days.

The proportion of patients who received post-acute PT during one year post-operatively was 65.2%, and their median amount of PT received was 6.5 hours (3-12). The post-acute rehabilitation process had started for 38.8% of the observed population one month after the end of acute care (Figure 2). Regarding the length of rehabilitation, for 50% of the observed population, the rehabilitation process had ended 22 days after being discharged from acute care (Figure 3).

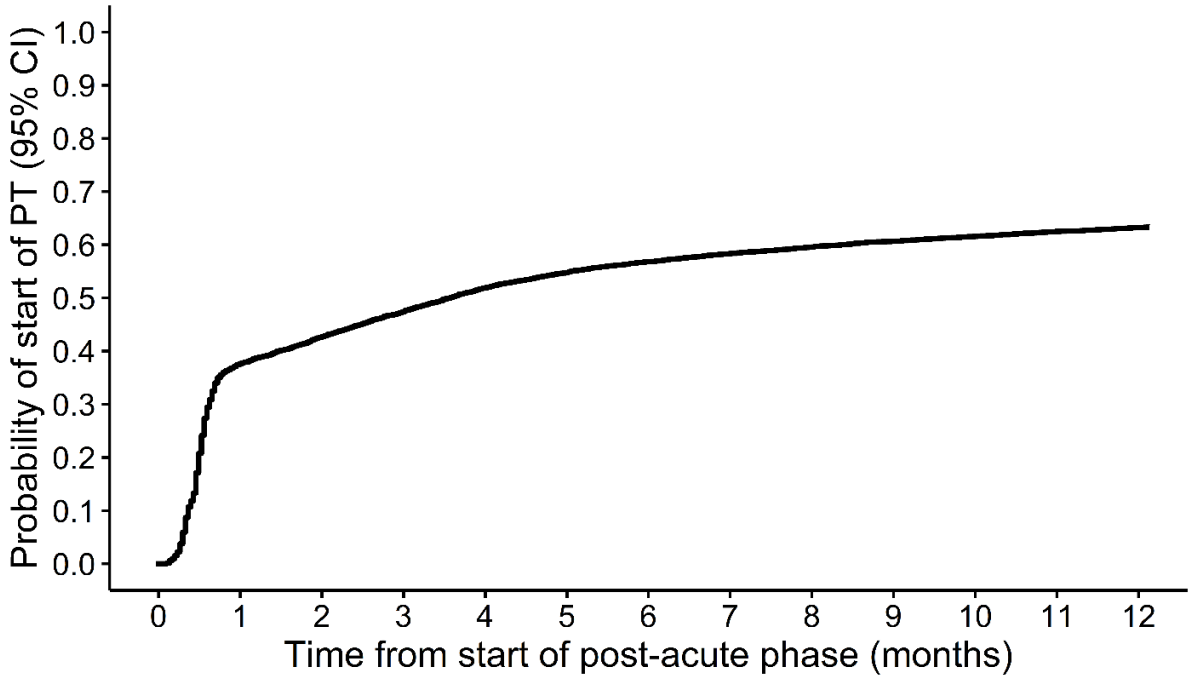

Figure 2. Probability of start of post-acute PT after a certain period. The starting point for rehabilitation was established using the start date of the first healthcare episode underwent. CI- confidence interval, PT – physical therapy

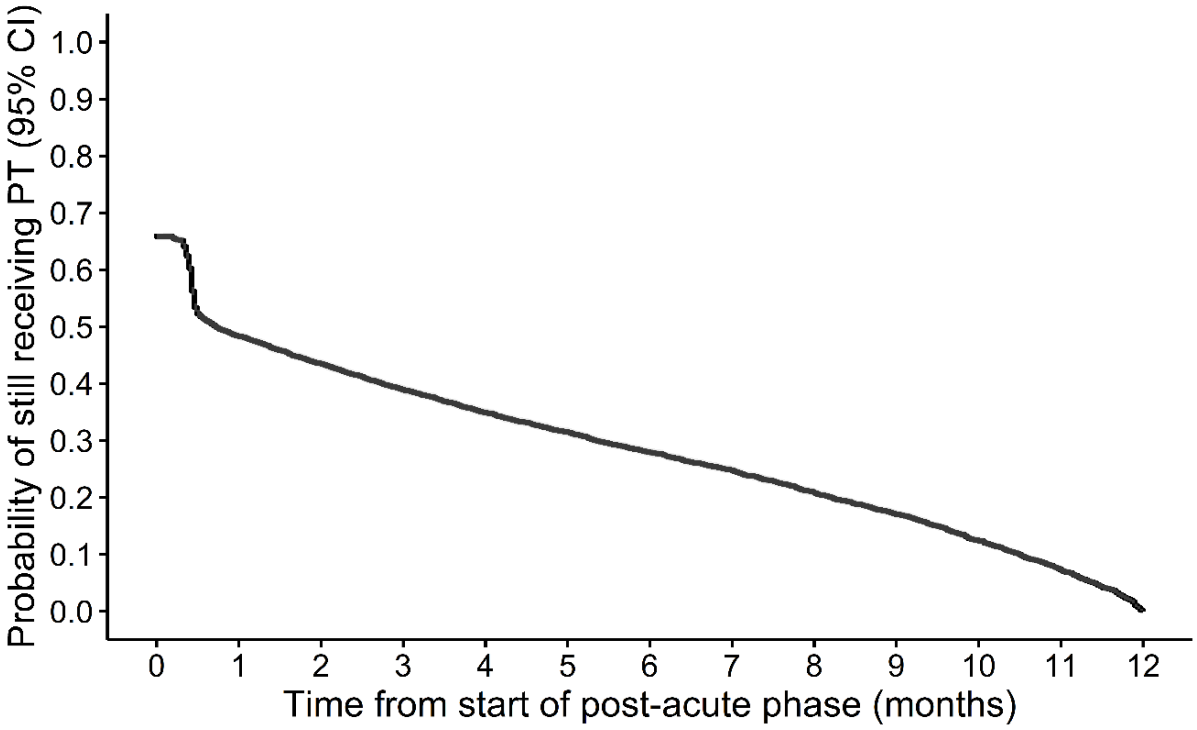

Figure 3. Probability of receiving post-acute PT after a certain period. The endpoint for rehabilitation was established using the end date of the last healthcare episode underwent. CI- confidence interval, PT – physical therapy

4.4. Differences among the counties in post-acute physical therapy use

There were regional differences found in post-acute PT use. The probability of receiving post-acute PT varied among the counties, with the lowest chance being in Järva (64.1%) and the highest in Saare (80.0%). There existed a 1.3-fold inter-regional difference between the counties regarding the probability of receiving PT during the post-acute phase. The total median PT hours received regionally exhibited variation ranging from 4.5 to 11 hours, which resulted in a 2.4-fold difference among the counties (Figure 4).

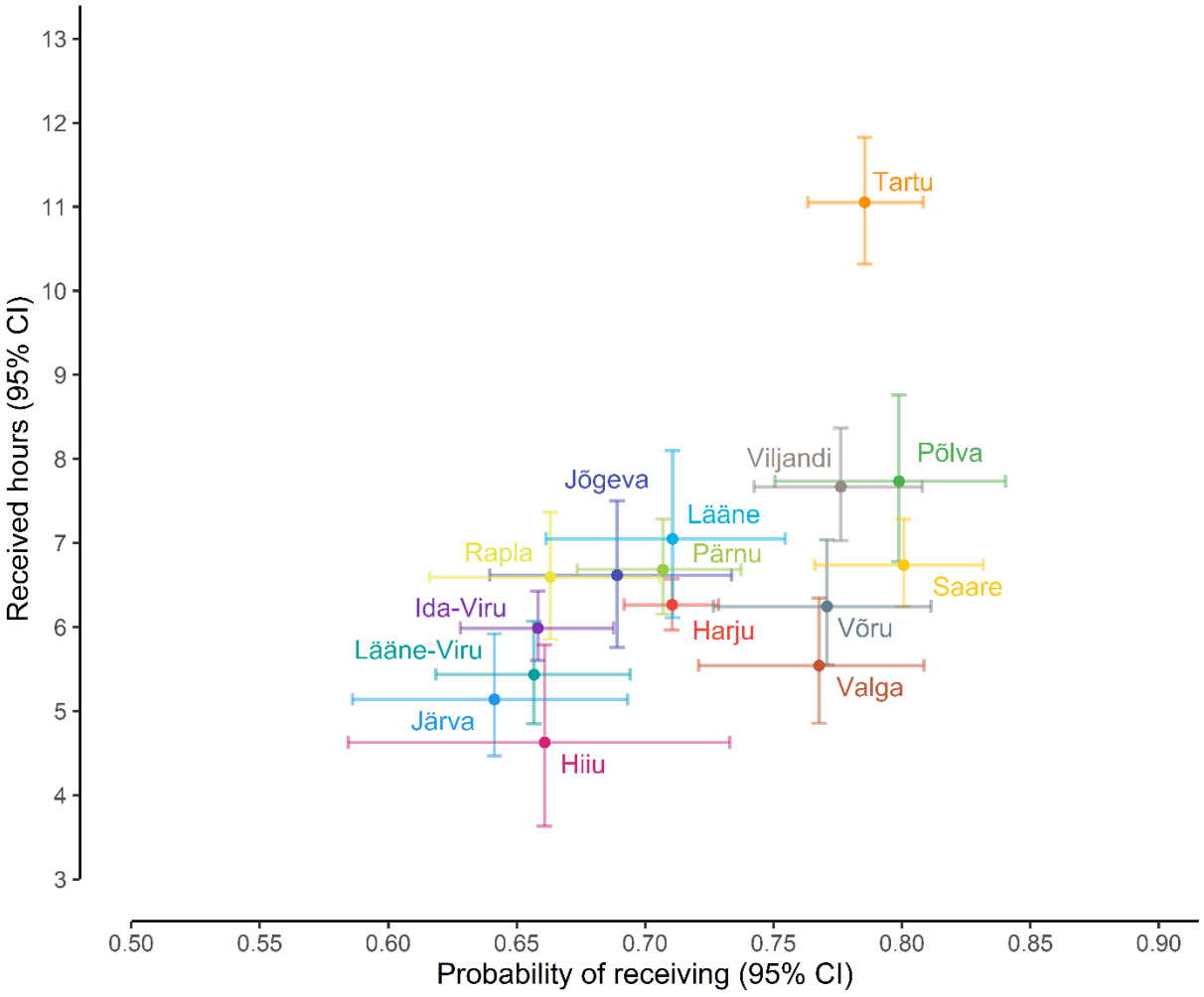

Figure 4. Median total physical therapy hours received and the probability of receiving physical therapy based on the patient's county in Estonia 2010-2020. CI – credible interval

4.5. Time-related trends in post-acute physical therapy use

No significant temporal changes were observed in the overall median amount of PT hours received and the probability of receiving PT. The probability of receiving post-acute PT increased by 2.5 percentage points [-0.3; 5.2] (Figure 5A), and the median amount of post-acute PT hours received decreased by 0.5 hours [-0.9; 0] (Figure 5B).

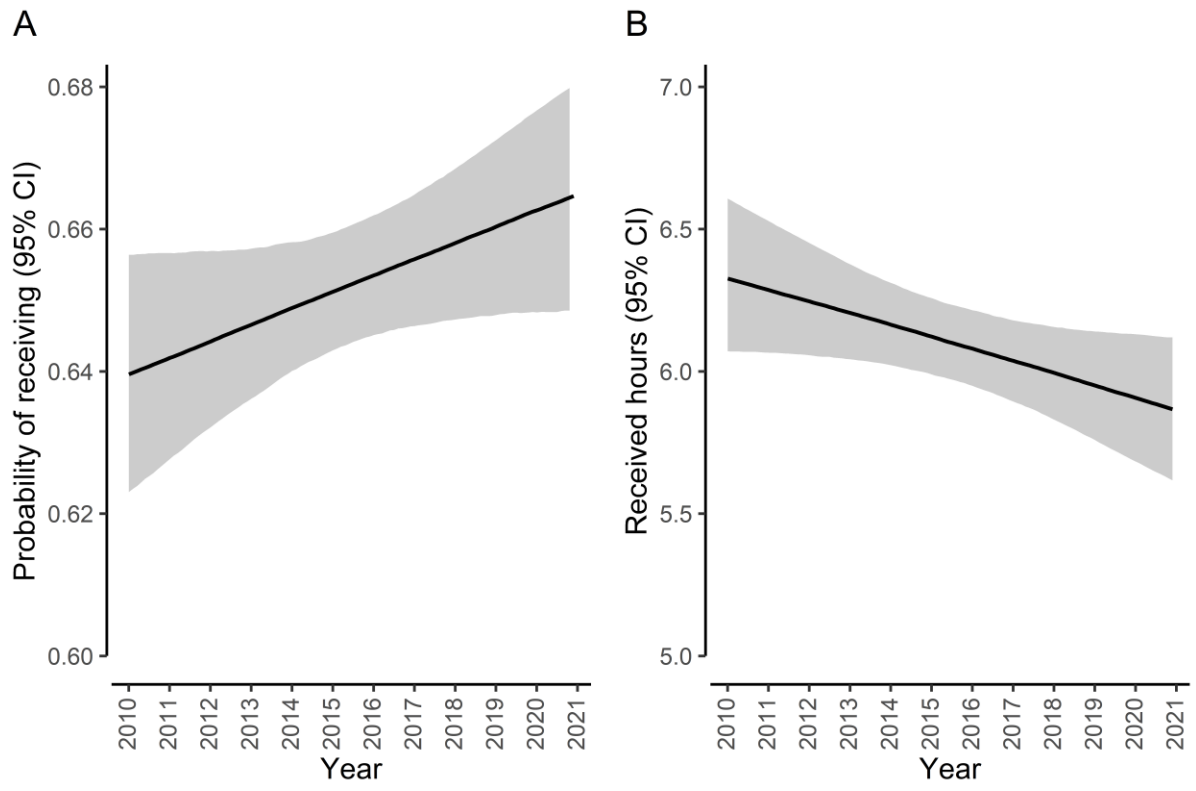

Figure 5. Temporal trends in post-acute physical therapy use in Estonia during 2010-2020. (A) Average probability of receiving post-acute physical therapy. (B) Median overall post-acute physical therapy hours received. CI – credible interval

There were no significant changes observed in temporal parameters when comparing 2010 to 2020 regarding overall post-acute PT hours received and the probability of receiving PT in the counties of Estonia. The overall post-acute PT hours received changed in six counties – Harju, Lääne-Viru, Pärnu, Saare, Tartu and Viljandi. Only two counties showed an increase in the total amount of PT hours received - Viljandi by 1.6 hours and Tartu by 2.1 hours. The rest of the beforementioned counties underwent a decrease in total PT hours received by 0.8 to 1.7 hours

(Figure 6). The regional disparities for PT hours received remained unchanged, showing a 2.4-fold difference when comparing the study period's beginning and end.

The probability of receiving post-acute PT increased in only three counties – Ida-Viru, Lääne-Viru and Tartu, by 10.3 to 11.9 percentage points – and decreased in one county – Pärnu, by 10.4 percentage points (Figure 6). The regional disparity between the counties marginally reduced from a 1.3-fold difference in 2010 to a 1.23-fold difference in 2020.

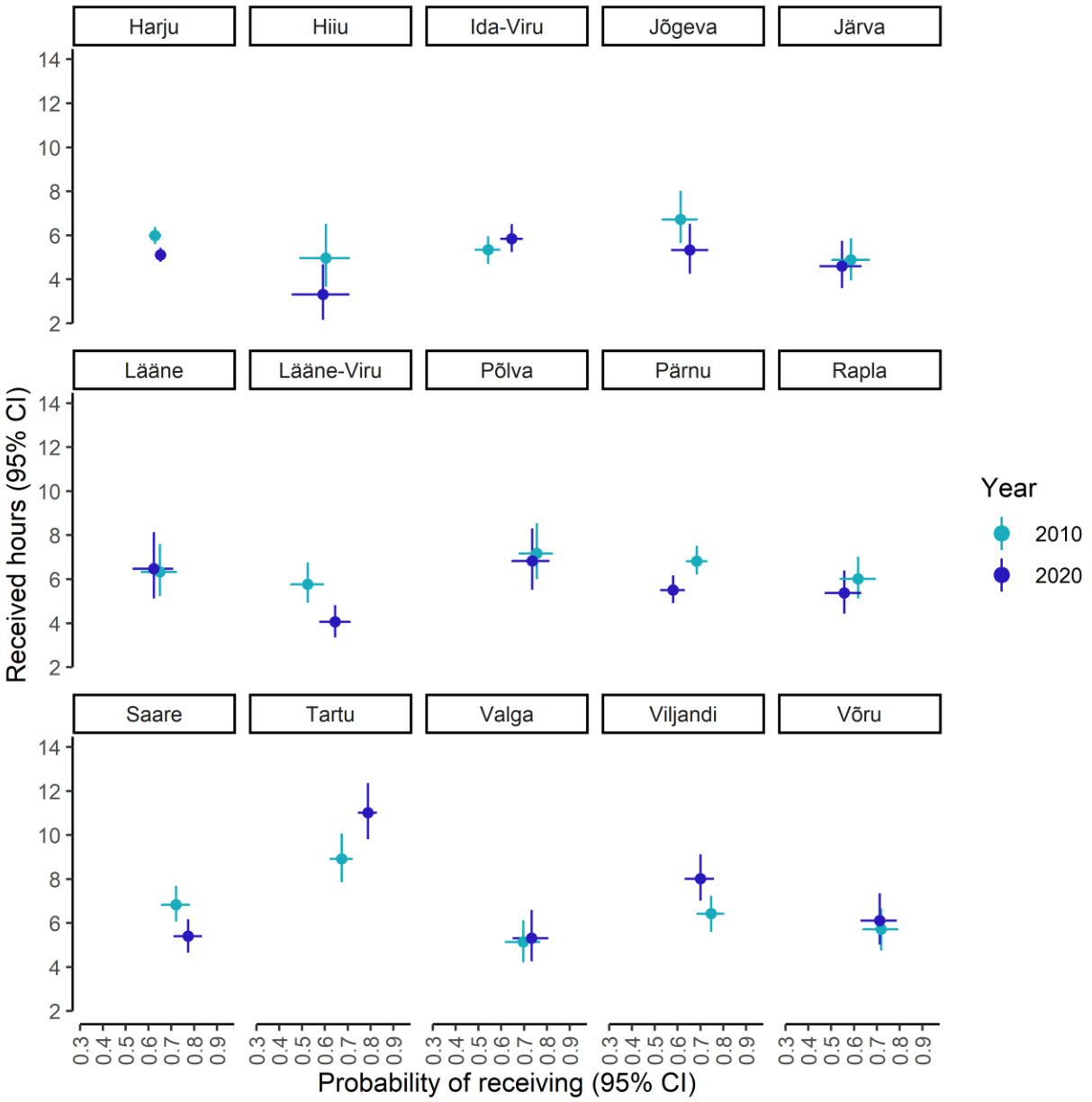

Figure 6. Temporal changes in post-acute total median physical therapy hours received and the probability of receiving physical therapy in counties of Estonia from 2010 to 2020. CI – credible interval

5. DISCUSSION

This study's focus was to analyse acute and post-acute PT regarding the amount of PT hours received by primary elective THA patients and the regional and temporal changes in rehabilitation during the years 2010-2020 in Estonia. Acute care PT for primary elective THA patients was relatively well covered in Estonia. Regarding the post-acute phase, most of the patients received PT, with disparities shown in the counties regarding rehabilitation.

5.1. Patient's characteristics

This study's patient characteristics were similar to the data reported in large national joint registries - the overall median age and proportions of men and women observed in this study were in line with the reports from national primary THA databases (AOANJRR, 2021; Kärrholm et al., 2019; National Joint Registry, 2021).

The proportion of patients who underwent primary THA and had OA as a primary diagnosis was higher than the data reported from national databases - a difference between 5-15% depending on the database was noted (AOANJRR, 2021; Kärrholm et al., 2019; National Joint Registry, 2021). The observed disparity can be mainly explained by the exclusion of patients with a primary diagnosis of acute trauma from the data requested from the EHIF, which can account for up to 5-10% of all primary THA procedures done. Proportions for other primary diagnoses were in line with primary THA database findings (AOANJRR, 2021; Kärrholm et al., 2019; National Joint Registry, 2021).

The usage of cemented or non-cemented surgical fixation for THA procedures is an ongoing debate, with significant geographical differences prevalent worldwide (Ferguson et al., 2018). For the last 20 years, national join registry data have shown a constant reduction in cemented THA procedures and a significant increase in cementless THA procedures (AOANJRR, 2021; Kärrholm et al., 2019; National Joint Registry, 2021). This thesis's findings were in line with the data presented in primary THA databases, showing a constant decrease in cemented THA and an increase in cementless THA procedures in Estonia during the thesis's timeframe (Figure 1).

5.2. Acute physical therapy use and management

The median amount of PT hours received by primary elective THA patients during acute care was in accordance with the national guidelines concerning rehabilitation in terms of the amount of

PT received (AAOS, 2022). PT hours remained constant throughout the whole timeframe of the study. The data analysed in this study showed that a non-negligible number of patients received no PT service during their acute care phase. There might be a few reasons why a patient didn't receive acute care PT: a patient might decline PT, the condition of a patient was unstable during acute care, so PT was not possible, or the lack of a physical therapist in the department. In 2013 there existed a significant, 5.6-fold difference in the amount of practising physical therapists when comparing Estonia to the Nordic countries' average (European Health Information Gateway, 2016). The availability of a physical therapist is essential in the early post-operative phases, with many national guidelines suggesting that rehabilitation should be started as soon as possible (AAOS, 2022; NICE, 2020). Studies have also highlighted the need for a skilled physical therapist for the acute care phase of post-surgery (Umpierres et al., 2014). This suggestion is followed chiefly in Estonia, where post-operative rehabilitation after a primary elective THA is usually started within 24 hours from the surgery under the guidance of a licensed physical therapist.

Early post-operative rehabilitation has shown good results for THA patients in reducing the acute care LOS (Dwyer et al., 2012; Suetta et al., 2004; Wainwright et al., 2020). The median LOS found by analysing data in this thesis was higher than in most other studies examining the LOS after primary THA. Researchers in the USA and the UK have shown a median LOS in the range of 4.2 to 5.4 days following primary THA and suggest that early rehabilitation might lead to quicker discharges from acute care (Bristol, 2021; Burn et al., 2018). The longer the LOS, the fewer resources available to new patients regarding vacant hospital beds and medical personnel. There should be considerations to undertake new strategies to optimise the acute care phase of primary elective THA patients to achieve better outcomes and further reduce the LOS.

5.3. Post-acute physical therapy use and management

There is little data concerning larger populations of primary elective THA patients and the volume and extent of PT used in the post-acute rehabilitation phase. A study conducted in Germany observing the post-acute rehabilitation of THA patients reported a participation rate of 82.6%, a higher rate than the data presented in this thesis (Ritter et al., 2017). Snell et al. (2020) analysed long term outcomes for primary THA procedures in terms of rehabilitation received in the post-acute phase and found that the average amount of PT received was 6.2 hours, and the proportion of patients who received post-acute rehabilitation was 63.3%. The beforementioned study falls in

line with the data reported in this thesis, although the sample size for primary THAs was relatively small, with only 219 patients included in the final population (Snell et al., 2020).

No concrete recommendations exist in national guidelines in terms of long-term care concerning rehabilitation and the optimal dosage of PT hours that primary elective THA patients should acquire (AAOS, 2022; NICE, 2020). A panel of experts weren't able to establish a scientific consensus on the appropriate rehabilitation dose in terms of duration, frequency, and the number of treatment sessions for optimal outcomes concerning THA patients (Westby et al., 2014). Due to limited available information, it is currently difficult to pinpoint the optimal amount of post-acute PT hours necessary to fully recover after undergoing primary elective THA, which indicates the need for further research.

Naylor et al. (2019) analysed primary THA patients and their use of post-acute rehabilitation. The researchers found that 61.1% of the observed population received PT in a home-based setting, whilst outpatient settings accounted for 32.6% of all PT received, followed by 22.8% in inpatient settings. Compared to data analysed in this thesis, there is a three-fold difference between the proportional use of inpatient settings in post-acute rehabilitation compared to observations made by Naylor et al. (2019). The significant difference in the usage of inpatient settings could be partially attributed to the minimal use of home-based PT in Estonia. It must be noted that the data examined in this thesis could not describe home-based settings since this category hadn't gotten any use during this timeframe in medical databases received from EHIF. Home-based physical therapy is still a novel concept in Estonia, with Tartu University Hospital starting a programme to provide home PT as recently as 2020 (Tartu University Hospital, 2020). Comparing the data from this thesis to other research showed some similarities in settings used during the post-acute rehabilitation phase (Snell et al., 2020; Vina et al., 2017).

Monaghan et al. (2017) stated that post-acute PT is considered progressively more unnecessary for this patient group, which shows a gap in the current knowledge and availability of scientifically proven studies on the effectiveness of post-acute PT for primary elective THA patients. Multiple studies have confirmed the effectiveness of post-acute PT, with starting dates for rehabilitation ranging from 8 weeks up to 11 months post-operatively (Colibazzi et al., 2020; Heiberg et al., 2011; Monaghan et al., 2017; Trudelle-Jakcson & Smith, 2004). The interventions being supervised by a professional physical therapist were crucial for optimal rehabilitation outcomes

(Heiberg, 2011; Monaghan et al., 2017, Umpierres et al., 2014). Notably, the interventions seem to have long-lasting benefits for THA patients who undergo them during the later post-acute rehabilitation phase, with good results being shown even one year after surgery (Heiberg et al., 2011; Trudelle-Jackson & Smith, 2004). The data analysed in this thesis indicates that half of primary elective THA patients had stopped receiving PT before even one month had passed from the start of the post-acute phase. Post-acute rehabilitation might be relatively short in Estonia for primary elective THA patients in light of the findings in this thesis.

5.4. Inter-regional differences in post-acute rehabilitation

Regional disparities regarding rehabilitation received during post-acute care in Estonia have been recently demonstrated in hip fracture patients (Prommik et al., 2021). The data analysed by the current thesis suggests that more than two-fold inter-regional differences exist in post-acute median PT hours received. These findings aligned with the data examined by Prommik et al. (2021), where the authors reported 2.5 to 2.6-fold inter-regional differences in post-acute median PT hours received. Although many differences exist, hip fracture and primary elective THA patient groups share similarities – patients of older age and a higher proportion of women. The authors highlight shortcomings in the rehabilitation system of Estonia, which include inaccessibility to resources and significant disparities when comparing the counties (Prommik et al., 2021). The data presented in this thesis suggests that the same issues are prevalent for more than one group of patient populations in Estonia, which could indicate a nationwide disparity in the rehabilitation system.

The inter-regional variations for rehabilitation in counties of Estonia showed similarities when compared to data reported by other authors researching hip fractures in Estonia, with Hiiu being the county with the least amount of post-acute median PT hours received in both primary elective THA patients (Figure 4) and hip fracture patients (Prommik et al., 2021). In terms of all the counties of Estonia, Tartu stood out as the county where the median hours of post-acute PT were remarkably higher. Furthermore, Tartu was highly ranked regarding the probability of receiving post-acute PT. This disparity could be explained by the fact that Tartu has a large general hospital and a lot of medical personnel, thus being a city with excellent resources in terms of rehabilitation accessibility. Viljandi and Põlva also showed significantly better than average results in probability and median hours of PT received (Figure 4). These results could be explained by these counties having better infrastructure and medical resources explicitly directed to patient rehabilitation. The

data presented in Figure 4 could give an overview of how many resources are available to primary elective THA patients in the post-acute phase of rehabilitation in the different counties of Estonia.

5.5 Temporal trends in post-acute rehabilitation

The current thesis found no significant changes for primary elective THA patients regarding the median amount of PT hours received and the probability of receiving rehabilitation in the post-acute phase during the observed timeframe. Even though this study found no significant changes in terms of post-acute median PT hours received, this could also be considered a worrying trend that there has been little progress in rehabilitation during the timeframe of data analysed by this thesis.

The regional disparity regarding the probability of receiving rehabilitation decreased by a non-significant margin during the period observed in this thesis. A lower regional difference could mean that the accessibility of rehabilitation has increased in Estonia, being less dependent on the geographical location. Three counties showed an improvement in the likelihood of receiving post-acute PT, whilst in Pärnu, there was a significant decrease in the probability of receiving post-acute PT.

5.6. Strengths and limitations of this thesis

This thesis has multiple strengths in terms of the methodology used and data quality. Data collected from the EHIF was standardised and contained unbiased information on various medical procedures done in Estonia. High-quality data that included the entire population of primary elective THA patients was used to synthesise the results, with numerous processes undertaken to ensure the validity of the data presented. In addition, the timeframe observed in this current thesis was long (11 years), which enabled the analysis of temporal trends. All the beforementioned factors allowed for remarkable generalisation of the data analysed in this thesis.

However, some limitations must be noted. The EHIFs databases contained no data concerning the patients who pay for post-acute rehabilitation out of their own pocket, which meant that this segment of patients was not included in this thesis. However, since most of the people in Estonia are medically insured by the EHIF, including a certain amount of rehabilitation post-operatively, private-pay patients would likely amount to a small proportion of the overall population observed in this thesis. Secondly, there were no details regarding what was done during the PT sessions analysed in this study – the data only contained information about the amount of PT received.

Furthermore, there was no good way to differentiate whether a post-acute phase rehabilitation session was for the primary elective THA or due to another medical condition. The issue of overlapping rehabilitation timelines was reduced by keeping the post-acute period of analysis to one year post-operatively.

6. CONCLUSIONS

1. Acute care was somewhat prolonged regarding LOS whilst relatively well covered with PT for primary elective THA patients in Estonia from 2010-2020.
2. The majority of all primary elective THA patients received post-acute PT during this thesis' data timeframe. For most of the population observed in this study, the rehabilitation process was relatively short.
3. The post-acute rehabilitation of primary elective THA patients manifested notable regional disparities in received median PT hours.
4. Primary elective THA post-acute rehabilitation remained unchanged during the study period; however, there existed varying county-level trends regarding the median amount of PT hours received and the probability of receiving PT.

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