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Rehabilitation of cerebral palsy during 2010-2022 in Estonia

Tserebraalparalüüsi taastusravi Eestis aastatel 2010-2022

Master's thesis

Physiotherapy

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ABBREVIATIONS

CP – cerebral palsy

ICD-10 – International Classification of Diseases, Tenth Revision

NICE – National Institute for Health and Care Excellence

OT – occupational therapy

PS – psychological therapy

PT – physiotherapy

ST – speech therapy

Abstract

Rehabilitation of cerebral palsy during 2010-2022 in Estonia

Aim: The aim of this study was to investigate the use of rehabilitation services by children with cerebral palsy (CP) within one year of diagnosis, focusing on physiotherapy (PT), speech therapy (ST), psychological therapy (PS) and occupational therapy (OT) use, temporal trends and the cost of treatment.

Methods: This population-based retrospective cohort study used population-wide health data acquired from the Estonian Health Insurance Fund. The study included patients aged 2-6 primarily diagnosed with CP between January 2010 and December 2021.

Results: The study included 573 patients. The median age was 2 (lower-upper quartile: 2-3) years. A total of 79% of patients received rehabilitation by a median of 10 (5-25) hours. The proportion of patients who received different rehabilitative therapies ranged from 28% to 77%. The median hours of therapies received ranged from 5 (5-8) to 10 (5-30) hours. The median start day of therapies ranged from 17th (1-58) to 65th (7-196) day and the median end day of therapies ranged from 202nd (110-273) to 273rd day (194-325) day after the diagnosis. A total of 123 patients (21%) received care in an inpatient and 221 patients (39%) in an outpatient rehabilitation setting. There were temporal changes in the median end day of PT which ended later. Of the total combined cost of treatment for these patients 39.1% was spent on rehabilitation. The median cost of treatment for one patient was 1050.6 (396.2-2973) €. The average cost of treatment per patient increased during the study period.

Conclusions: The study identified shortcomings in the rehabilitation of children with CP in Estonia. There was a considerable proportion of patients who did not receive rehabilitation and the amount of therapies received was relatively low. After the diagnosis rehabilitation started relatively late. There were no temporal changes in the rehabilitation use during the study period, apart from PT which ended later. Compared to other studies the expenditure on medical treatments was lower.

Keywords: cerebral palsy, rehabilitation, physiotherapy, speech therapy, occupational therapy, psychological therapy

Lühiülevaade

Tserebraalparalüüsi taastusravi Eestis aastatel 2010-2022

Eesmärk: Uuringu eesmärk oli analüüsida tserebraalparalüüsiga laste Tervisekassa poolt rahastatud taastusravi teenuste kasutamist ühe aasta jooksul peale tserebraalparalüüsi diagnoosimist, keskendudes füsioteraapia, logopeedi, psühholoogi ja tegevusteraapia teenuste kasutamisele, temporaalsetele trendidele ja ravikulule.

Metoodika: Käesolev populatsioonipõhine retrospektiivne kohortuuring põhines Tervisekassalt saadud andmetel. Uuringusse kaasati patsiendid vanuses 2–6 aastat, kellel diagnoositi tserebraalparalüüs vahemikus jaanuar 2010 kuni detsember 2021.

Tulemused: Uuringusse kaasati 573 patsienti. Patsientide mediaanvanus oli 2 (ülemine-alumine kvartiil: 2–3) aastat. 79% patsientidest sai taastusravi, mediaan 10 (5–25) tundi. Erinevate teenuste saajate osakaal jäi vahemikku 28%–77%. Saadud teraapiate mediaantunnid jäid vahemikku 5 (5–8) kuni 10 (5–30) tundi. Teraapiad algasid mediaan 17. (1.–58.) kuni 65. (7.–196.) päeval ja lõppesid mediaan 202. (110.–273.) kuni 273. (194.–325.) päeval peale diagnoosi saamist. 123 patsienti (21%) sai statsionaarset taastusravi ja 221 patsienti (39%) sai taastusravi ambulatoorselt. Temporalsed muutused toimusid füsioteraapia lõpu osas, mis lõppes hiljem. Ülejäänud teenuste puhul temporaalseid muutusi ei toimunud. Kõikide uuringusse kaasatud patsientide ravikulust moodustasid taastusravi arved 39.1%. Mediaankulu ühe patsiendi kohta oli 1050.6 (396.2–2973) €. Keskmise ravikulu ühe patsiendi kohta suurenes uuringuperioodi jooksul.

Kokkuvõte: Käesolevas uuringus leiti puudujääke tserebraalparalüüsiga laste taastusravis. Arvestatav osakaal patsiente ei saanud taastusravi ja saadud teenuste maht oli võrdlemisi väike. Peale diagnoosi saamist algas taastusravi suhteliselt hilja. Uuringuperioodi jooksul ei toimunud taastusravi kasutamise osas olulisi temporaalseid muutusi, välja arvatud füsioteraapia osas, mis lõppes hiljem. Teiste uuringutega võrreldes olid patsientide ravikulud madalamad.

Märksõnad: tserebraalparalüüs, taastusravi, füsioteraapia, logopeedia, tegevusteraapia, psühholoogia

1. LITERATURE REVIEW

1.1. Cerebral palsy

Cerebral palsy (CP) describes a group of permanent non-progressive disorders of the development of movement and posture, causing activity limitations that are attributed to disturbances occurring in the developing fetal or infant brain (Bax *et al.*, 2005). The motor disturbances that occur with CP are often accompanied by problems with cognition, sensation, communication, perception, behaviour and/or seizure disorder (Bax *et al.*, 2005). CP is the most common physical disability in childhood, which occurs in 2-3 out of 1000 live births (Vitrikas *et al.*, 2020).

Risk factors of CP include preterm birth, perinatal infection, intrauterine growth restriction, acidosis, asphyxia etc. that can lead to brain injury. CP can also occur at an older age, often because of head injury or infection (Vitrikas *et al.*, 2020). In approximately 80% of cases the risk factors are not clear and are considered idiopathic (Novak *et al.*, 2017; Vitrikas *et al.*, 2020).

In Estonia CP is defined as an impairment of movement and posture caused by a non-progressive defect or lesion of the brain during ante- or intranatal period that is mainly of hypoxic-ischaemic origin. Although the definition of CP in Estonia is not as broad as international definitions the treatment of CP does not vary based on etiology (Elstein *et al.*, 2007).

CP is a clinical diagnosis which typically occurs between 12 and 24 months and is based on a combination of clinical and neurological signs (Novak *et al.*, 2017). The early signs of CP could be unusual fidgety movements or other abnormalities of movement, including asymmetry of movement, abnormalities of tone (hypotonia, spasticity, dystonia), abnormal motor development and feeding difficulties. The most common delayed motor milestones are not sitting by 8 months, not walking by 18 months (corrected gestational age) and early asymmetry of hand function (NICE, 2017). In addition, children with persistent toe walking should be assessed for CP (NICE, 2017).

The early signs of CP may often be a normal variation of development and usually resolve during the first 1-2 years of life. Therefore, it is difficult to make a specific diagnosis of CP with certainty before that age. In some children who are diagnosed with CP clinical findings that suggest CP may come later in life and may continue to evolve up to 4-5 years of age (Patel *et al.*, 2024). The pathway to being diagnosed with CP can be different depending on whether a child has any risk factors for CP in the neonatal period. If the child has any risk factors, it can lead to earlier screening and developmental surveillance. The diagnosis is made when a child has motor dysfunction and either abnormal neuroimaging or clinical history that suggests the risk (Michael-Asalu *et al.*, 2019).

There are different ways to classify CP. Based on the severity it can be classified as mild, moderate or severe CP. A child with mild CP has a functional impairment which affects daily life to a small extent, whereas a child with severe CP needs help in every area of life (Elstein *et al.*, 2007). The Gross Motor Function Classification System (GMFCS), which was developed to provide information about the real extent of actual motor function, is also widely used (Piscitelli *et al.*, 2021).

GMFCS consists of five levels and is based on self-initiated movement emphasising on sitting and walking. Level I is the mildest form and level V is the most severe. Additionally, it includes four age bands that account for age-related differences in gross motor function (Palisano *et al.*, 1997; Palisano *et al.*, 2008).

Movement disorders associated with CP are spasticity, dyskinesia, ataxia, or mixed/other disorders of which spasticity is the most common (Vitrikas *et al.*, 2020). Spasticity is defined as a velocity-dependent increased resistance to passive muscle stretch and it affects around 2/3 of children with CP (Albright, 2023). Depending on the affected limbs spasticity can be categorised as diplegia, hemiplegia, or quadriplegia. Because of spasticity various complications such as joint contractures, hip subluxations, scoliosis and pain may occur (Vitrikas *et al.*, 2020).

Due to abnormal muscle tone and impaired musculoskeletal control children with CP often have speech impairments and problems with swallowing (Paul *et al.*, 2022). According to meta-analyses around 44% of children with CP have problems with drooling, 50.4% have swallowing problems, and 53.5% feeding problems (Speyer *et al.*, 2019). Approximately half of children with CP have problems with speech or communication (NICE, 2017).

Various behavioral disorders are also prevalent in children with CP such as attention-deficit/hyperactivity disorder, conduct disorders, anxiety, and depression (Paul *et al.*, 2022). Up to 1 in 4 children with CP have behavioral or emotional issues and cognitive impairments may also occur (NICE, 2017; Vitrikas *et al.*, 2020). Mental health problems are also prevalent among the parents of children with CP (Irwin *et al.*, 2019).

Other problems associated with CP are visual problems, hearing deficits, epilepsy and cognitive impairments. Additionally, osteoporosis, pressure ulcers, gastrointestinal problems, urinary incontinence and abnormal sensation and perception may occur (Vitrikas *et al.*, 2020).

1.2. Treatment of cerebral palsy

Treatment of CP varies depending on the specific symptoms that the child has. The goal of the management is not to cure CP but to increase or maintain functionality and independence (Kriger, 2006). The management of CP should focus on optimizing the motor, cognition and communication skills and preventing secondary impairments and complications. Additionally, it should include promoting the parents or caregivers' mental health (Saranti *et al.*, 2024). It is important to set realistic goals and include families in creating a treatment plan which should include a multidisciplinary team and be tailored to the patient's specific needs (NICE, 2017; Vitrikas *et al.*, 2020).

Early diagnosis and treatment are crucial because it helps to provide early intervention during the earliest part of the development (Novak *et al.*, 2017; Paul *et al.*, 2022). Early active movement and intervention are important to prevent developmental delay and maximise neuroplasticity (Novak *et al.*, 2017). Early intervention can include, for example, active hip surveillance, motor training, early standing, constraint induced movement therapy, etc (Novak *et al.*, 2014).

It is important to ensure that the children with CP have access to a local integrated multidisciplinary team. The team should be able to meet the child's individual needs and provide following expertise through a local network of care: paediatric or adult medicine, nursing care, physiotherapy, occupational therapy, speech and language therapy, dietetics, psychology (NICE, 2017). Outcomes will be better if a combination of interventions is used (Novak *et al.*, 2020).

Physiotherapy (PT) and occupational therapy (OT) are important components of treatment for motor and balance impairments in patients with CP (Vitrikas *et al.*, 2020). These interventions help to improve independence and participation in daily activities and to minimize secondary musculoskeletal deformities such as contractures (Noritz *et al.*, 2022). Physiotherapists and occupational therapists also recommend various (mobility)aids and help to adjust everyday environment to the child's specific needs (Elstein *et al.*, 2007).

PT addresses strength, endurance and gross motor skills such as sitting (Houtrow & Murphy, 2019; Inamdar *et al.*, 2020). In addition, PT can help to prevent and reduce contractures through maintaining the joint range of motion. PT uses different techniques like stretching, strengthening, range of motion exercises, balance training, neurodevelopmental treatment, etc. (Paul *et al.*, 2022).

OT focuses on developing the skills that are necessary to do everyday tasks and self-care activities such as dressing and various fine motor skills (Novak & Honan, 2019; Steultjens *et al.*, 2004). According to Novak *et al.* (2020) to improve motor functions, it is recommended to practice daily activities and use self-generated active movements and the child should be actively participating in therapy. Since motivation is an important modulator of neuroplasticity, task-specific training should be enjoyable to children, whereas passive motor interventions are less effective (Novak *et al.*, 2020).

Speech therapy (ST) addresses problems with communication and cognition. Furthermore, speech therapists identify and treat dysphagia in children with CP (Houtrow & Murphy, 2019). ST helps to improve oral motor skills, disarticulation problems and communication (Paul *et al.*, 2022). If a child is nonverbal or has little functional speech and has poor prognosis for speech development, speech therapists may introduce them to augmentative and alternative communication systems (Clarke *et al.*, 2016).

Given the high prevalence of mental health problems among patients with CP (NICE, 2017), psychological therapy (PS) is an important part of the treatment. It is recommended to evaluate children with CP for mental health conditions (Bjorgaas *et al.*, 2012). A psychologist can also evaluate child's development and emotional, behavioural and cognitive functions (Elstein *et al.*, 2007). Additionally, a psychologist can assist the child and the parents to cope with the stress caused by the disability (Elstein *et al.*, 2007; Vitrikas *et al.*, 2020).

For the treatment of spasticity, botulinum toxin injections and baclofen are used (Kriger, 2006). Usually, these are used in combination with rehabilitative treatments such as PT. In the

treatment of CP various surgical treatments are also used. Common orthopedic surgical procedures are, for example, osteotomy and muscle or tendon lengthening. Another surgical option is selective dorsal rhizotomy which has the potential to reduce spasticity but is not recommended for most of the patients (Colver *et al.*, 2014). Following surgical treatment rehabilitation is also important. In the combination with PT and OT botulinum toxin, baclofen and surgeries, orthoses are often used to prevent inappropriate joint movements and deformities (Kriger, 2006).

1.3. Cost of treatment

Treatment of CP requires significant medical costs. A study conducted in Denmark evaluated the lifetime costs of people diagnosed with CP including health care costs, productivity costs and social costs. Lifetime costs of CP were approximately 860 000 € for men and 800 000 € for women. Total lifetime healthcare costs were 66 155 € for men and 65 258 € for women (Kruse *et al.*, 2009). Prommik *et al.* (2022) found that rehabilitation in Estonia is underfunded and to improve the situation the funding of the health care system should be increased (Prommik *et al.*, 2022).

1.4. Rehabilitation in Estonia

There is little known about rehabilitation in Estonia. There are few studies that have analysed rehabilitation. In 2006 there was a report that stated that only 19% of adults who needed rehabilitation received it and only half of them got it at the right time (National Audit Office of Estonia, 2006). Prommik *et al.* (2022) found that in Estonia the need for PT and OT is greater than the people are receiving (Prommik *et al.*, 2022). To the author's knowledge rehabilitation of CP and children's rehabilitation in general have not been studied in Estonia before. Therefore, it is important to study the rehabilitation of children with CP as the knowledge can help improve the health care system. This study aims to evaluate the rehabilitation of children with CP in Estonia during 2010-2022.

2. AIM AND OBJECTIVES

The aim of this study is to investigate the use of rehabilitation services by children with CP within one year of diagnosis in Estonia, focusing on PT, ST, PS and OT use, temporal trends and the cost of treatment. The specific objectives were:

1. To evaluate PT, ST, PS and OT use during one year after being diagnosed with CP.
2. To analyse temporal trends in PT, ST, PS and OT use.
3. To evaluate the cost of treatment during one year after being diagnosed with CP.

3. METHODS

This is a population-based retrospective cohort study which is a part of a bigger project named "Rehabilitation use of different patient populations during 2010–2030 in Estonia", approved by the Research Ethics Committee of the University of Tartu (396/M-19).

3.1. Data collection

This study was based on retrospective data from 2010-2022 received from the Estonian Health Insurance Fund. In Estonia there is one public health insurance fund which provides health care to all insured people (Tervisekassa, 2024). Data was received in pseudonymised form enabling data analysis without knowing the patients' identities. Data included patients' pseudonymised identification number, age at diagnosis, primary and secondary diagnoses, sex, the start and end date on medical bills, the treatment costs and county of residence. Estonian Health Insurance Fund's funding codes from the medical records were used to identify received rehabilitation services and to analyse the total hours of different rehabilitation services received. Estonian Health Insurance fund's codes used to identify: PT (7011, 7022, 7031, 7050, 7052, 7056, 7057, 7058, 7059, 7060, 7065, 7067, 7075, 7076, 7077), OT (7053, 7054, 7061, 7068, 7069, 7078), ST (3014, 3016, 7611, 7614, 7619, 7620, 7621, 7622, 7623, 7624, 7625, 7628, 7629) and PS (3007, 7601, 7602, 7603, 7607, 7615, 7616, 7630, 7631, 7632, 7633, 7634, 7635, 7636, 7637, 7638, 7639, 7640, 7609, 7604, 7617, 7626, 7627). To differentiate between inpatient and outpatient services setting type codes were used.

3.2. Subjects

The study included patients aged 2-6 primarily diagnosed with cerebral palsy (ICD-10 (International Classification of Diseases, Tenth Revision) code G80) between 1. January 2010 and 31. December 2021. To be included in the study, patients had to get a rediagnosis of CP or be diagnosed with a functional impairment (ICD-10 codes G81, G82, G83, R47, R13) within two years from the index diagnosis.

3.3. Statistical analysis

Statistical analyses were performed in R 4.3.3 (R Core Team, 2017). Continuous variables were shown as "median (lower-upper quartile)" and categorical as proportions. Temporal comparisons based on the Chi-Squared test for categorical variables and the Kruskal-Wallis test for continuous variables. Statistical significance was defined as $\alpha = 0.05$, and all tests were two-sided. Temporal cost analyses based on a Bayesian regression model using lognormal likelihood. The modelling results were presented with 95% credible intervals (CI).

4. RESULTS

4.1. Patients

The study included a total of 573 patients, of which 346 (60.4%) were male (Table 1). The patients were aged 2-6 years, and the median age was 2 (lower-upper quartile: 2-3) years.

Table 1. Baseline characteristics of the patients included in the study.

Variable	Total n=573
Age	2 (2-3)
Age group	
2-4	503 (87.8)
5-6	70 (12.2)
Male	346 (60.4)
Female	227 (22.8)
County of residence	
Harju	139 (24.5)
Ida-Viru	129 (22.8)
Järva	18 (3.2)
Jõgeva	19 (3.4)
Lääne	8 (1.4)
Lääne-Viru	15 (2.6)
Pärnu	29 (5.1)
Põlva	12 (2.1)
Rapla	9 (1.6)
Saare	2 (0.4)
Tartu	117 (20.6)
Valga	23 (4.1)
Viljandi	31 (5.5)
Võru	16 (2.8)

Continuous variables are shown as "median (lower-upper quartile)" and categorical as "n (%)".

4.2. Rehabilitation

A total of 79% of patients received rehabilitative therapies within one year after the diagnosis of CP by a median of 10 (5-25) hours. The proportion of patients who received different rehabilitative therapies ranged from 28% to 77% (Figure 1). The median hours of therapies received ranged from

by a median of 5 (5-8) to 10 (5-30) hours. The median duration for PT was 228 days, for ST 206, for PS 137 and for OT 246 days. The median start day of therapies ranged from the 17th (1-58) to 65th (7-196) day and the median end day of therapies ranged from the 202nd (110-273) to 273rd day (194-325) day after the diagnosis.

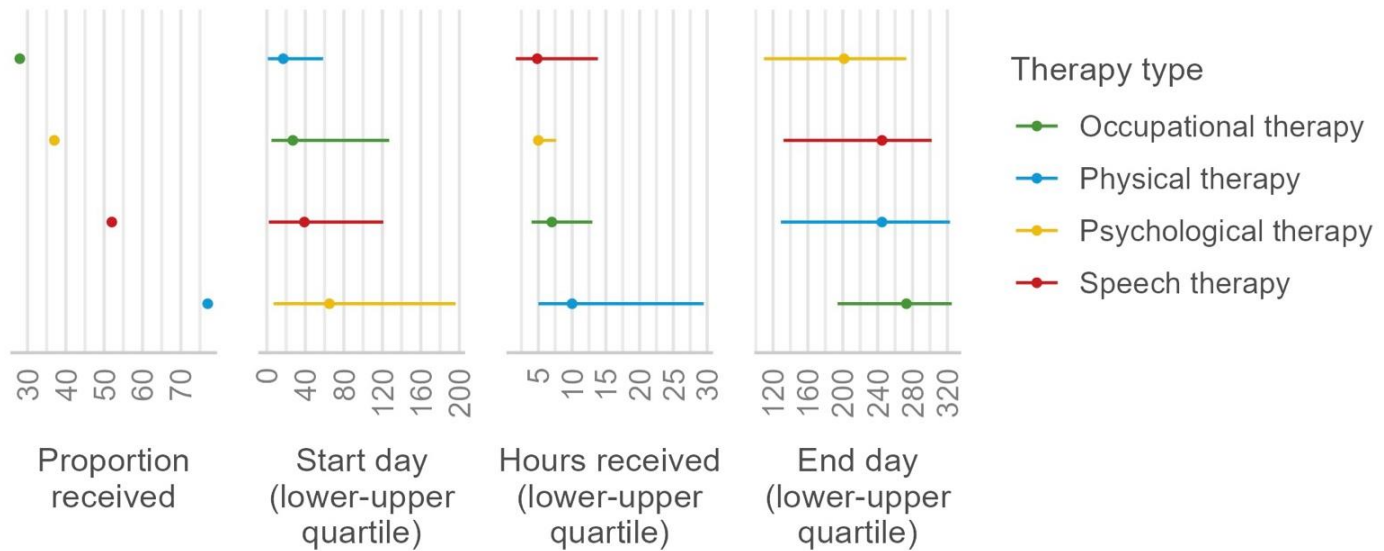


Figure 1. The proportion of patients who received rehabilitative therapies, the median hours of therapies received and the median start and end day of therapies.

A total of 123 patients (21%) received care in an inpatient rehabilitation setting and 221 patients (39%) received care in an outpatient rehabilitation setting.

4.3. Temporal trends in rehabilitation

When comparing the first and the last five years of the study period there were no significant changes in the proportion of patient who received PT, ST, PS and OT (Figure 2). There were changes in the median end day of PT which ended a median of 24 days later ($p=0.04$) during the last five years of the study period. Apart from that, there were no significant changes in the median hours, the start and the end day of PT, ST, PS and OT.

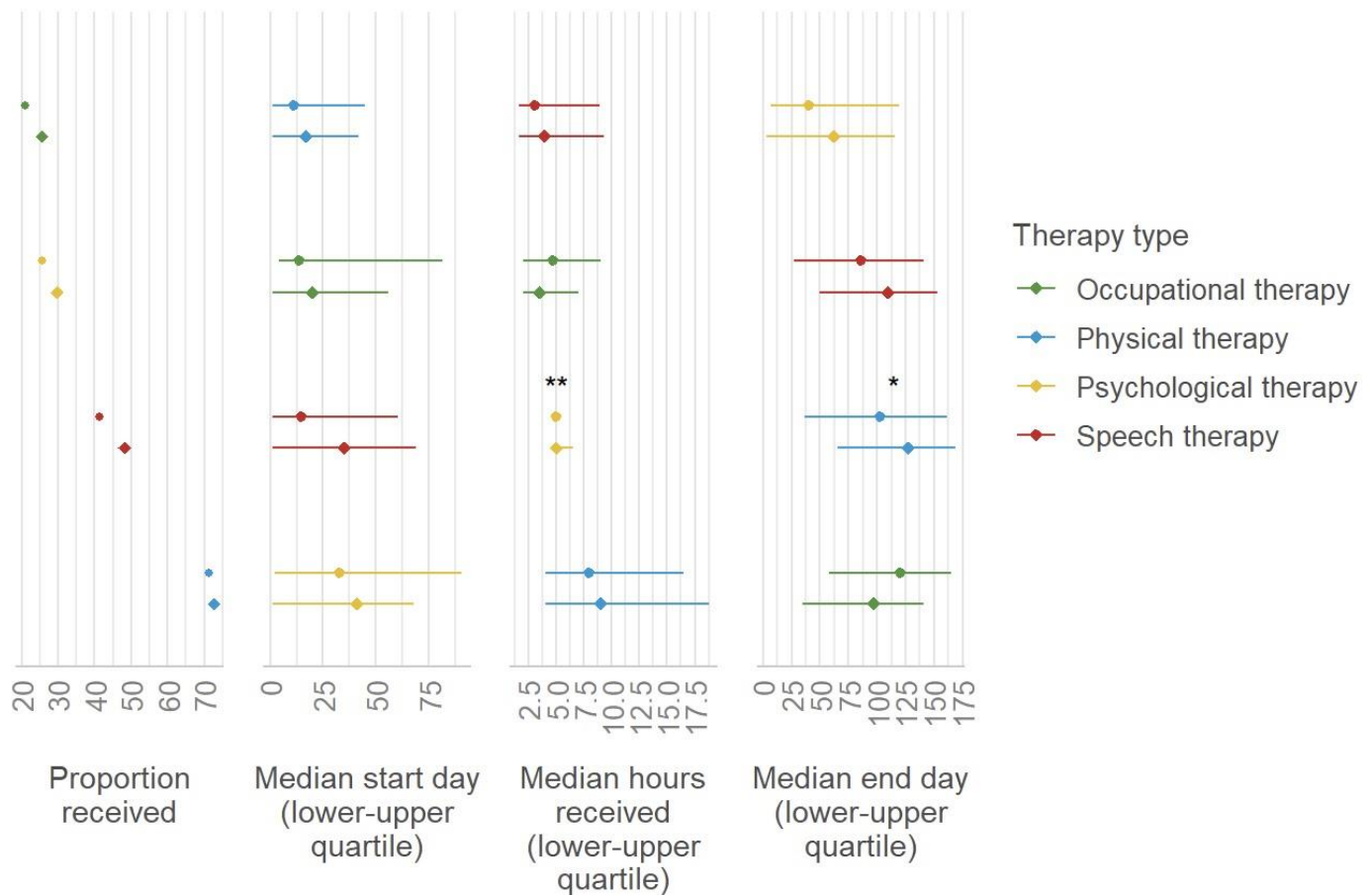


Figure 2. Temporal changes in the proportion of patients receiving rehabilitative therapies, the median hours of therapies received and the median start and end day of therapies when comparing the first (circle) and the last (rectangle) five years of the study period.

* $p < 0.05$

4.4. Cost of treatment

The total combined cost of treatment for these patients during one year after the diagnosis was 1 401 077 €. The outpatient and inpatient rehabilitation medical bills accounted for 39.1% (548 013.9 €) of the total cost. The median cost of treatment for one patient was 1050.6 (396.2-2973) €. During the study period the expenditure on one patient increased on average by 2074.6 € [95% CI: 655.5; 3785.4] (Figure 3).

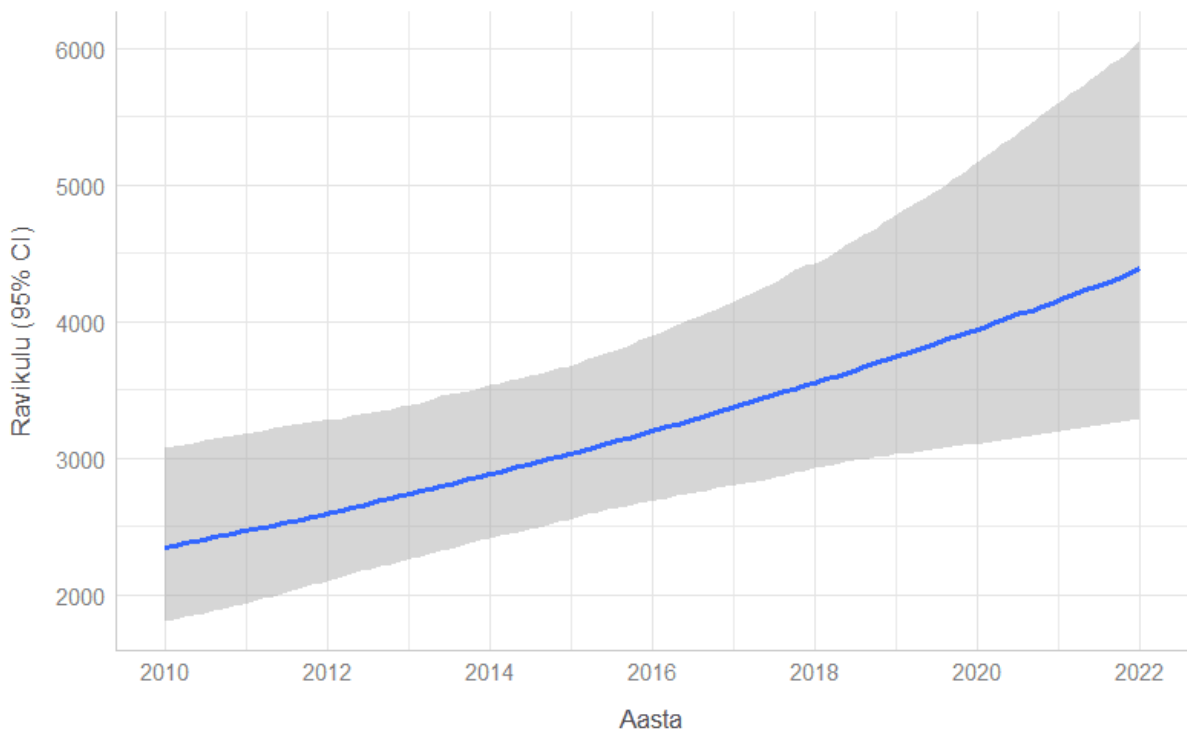


Figure 3. The average expenditure on one patient during the study period. CI – credible interval

5. DISCUSSION

The aim of this study was to analyse rehabilitation use of children with CP during 2010-2022 in Estonia, focusing on PT, ST, PS and OT use during one year after the diagnosis of CP and temporal trends in rehabilitation use. Furthermore, this study examined the cost of treatment and compared the expenditure on rehabilitation and other medical treatments. To the author's knowledge this is the first study to analyse the rehabilitation of CP in Estonia.

5.1. Rehabilitation

A few studies have evaluated the proportion of patients with CP who have received PT, ST and OT. To the author's knowledge there are no published papers that have analysed the proportion of patients with CP who have received PS. A study conducted in the United States and Canada showed that 94% of the children aged two to six included in the study received PT and 85% received OT, which is considerably higher than the proportion of patients who received these services in Estonia. However, these numbers consider both medical and education setting (Palisano *et al.*, 2012). There was a study conducted in Australia that examined therapy service use among children and adolescents with CP. In addition to PT and OT this study examined ST use. Out of all the children involved in the study 88% had received PT, 83% OT and 60% ST. 5-year olds, who are closest to the age of children in the current study, received therapy most frequently and 90% were receiving PT, OT or ST (Meehan *et al.*, 2015). In both of the studies the proportion of children who received rehabilitative therapies was considerably higher than in the current study, especially the proportion of patients who received OT. However, both studies included services received in an educational setting of which in this study we do not have the information. Additionally, health care systems in the United States, Canada and Australia are different than in Estonia.

This study showed that 79% of children with CP received rehabilitative therapies. In the current study 77% of children received PT within one year after the diagnosis of CP. All children with CP have problems with motor function and posture. To manage these problems PT is an important part of the treatment and all children with CP should be assessed by a physiotherapist. A physiotherapist can give advice on positioning and handling to improve muscle tone and help to develop different movement skills. Additionally, they can give advice about orthotics and mobility aids that many children with CP need (Elstein *et al.*, 2007; Vitrikas *et al.*, 2020). Therefore, there was a considerable amount of patients in this study who did not receive PT but probably needed it.

This study showed that 52% of children received ST within one year after the diagnosis of CP. Around half of the children with CP have problems with communication, feeding, drooling or swallowing (NICE, 2017; Speyer *et al.*, 2019) indicating that the proportion of patients who received ST in this study may be in line. According to some sources up to 60% to 80% of children with CP have some problems with communication and 25% are nonverbal (Noritz *et al.*, 2022). This means

that even more children with CP might need ST than the proportion of patients who received it in this study.

The proportion of children who received OT (28%) in this study is worrisome because upper limb involvement is common in CP. Up to 60-80% of children with CP have upper limb involvement and would benefit from OT (Lloyd *et al.*, 2024). Furthermore, the goal of OT is to help patients gain more independence in everyday activities and to recommend various aids and orthoses (Elstein *et al.*, 2007). This indicates that a significantly higher proportion of patients included in this study probably needed OT.

Various mental health disorders are common among children with CP such as attention-deficit/hyperactivity disorder, anxiety and depression. To manage these conditions cognitive behavior therapy and mental health screenings can be beneficial (Paul *et al.*, 2022). Emotional and behavioural difficulties can occur in up to 1 in 4 children with CP. In case of these difficulties a child should be referred to a specialist for psychological and behavioral assessment and management (NICE, 2017; Novak *et al.*, 2012). This indicates that the proportion of patients who received PS (37%) in this study may be in line. A study conducted in Iceland found that 40% to 50% of preschool children with CP had behavioural or emotional difficulties when assessed by parents and 60% to 65% had these problems when assessed by teachers (Sigurdardottir *et al.*, 2010). Additionally, the parents of children with CP might also need psychological support, as mental health problems related to caregiving are common among the parents of children with disabilities (Irwin *et al.*, 2019; Parkes *et al.*, 2011; Sawyer *et al.*, 2011). Therefore, even higher proportion of patients in this study could have benefited from PS.

The reason why a considerable number of patients did not receive certain rehabilitative treatments could be that there are not enough specialists to meet the rehabilitation needs of all patients in Estonia. Prommik *et al.* (2022) found that there is an unmet need for PT and OT in Estonia. The reason for that could be that there are not enough physiotherapists and occupational therapists to provide PT and OT for everyone who needs it (Prommik *et al.*, 2022). This could explain, for example, the low proportion of patients who received OT in this study.

A few studies have looked at the amount of PT, ST and OT received. There are no studies that have examined the amount of PS that children with CP have received. McCoy *et al.* (2019) explored the relationship between rehabilitation therapies and development of children with CP. In the study they also looked at the median number of sessions received during a 12 month period using a questionnaire for parents. For PT the median number of sessions varied from 2-52, for OT it varied from 2-30 and for ST from 0-30. Children with higher GMFCS level, indicating more severe form of CP received generally more therapies. However, the duration of one therapy session is not reported (McCoy *et al.*, 2019).

Palisano *et al.* (2012) examined the amount of PT and OT children with CP received in the United States and Canada. They looked at therapy received in both clinic and education setting. Children who received therapies in a clinic setting received a mean of 120 minutes of PT and 120 minutes OT per month. Children who received therapies in both settings received a mean of 420 minutes of PT and 360 minutes of OT per month (Palisano *et al.*, 2012). If children received that amount of therapies every month, it was more than the patients received in this study where children received a median of 10 hours of PT and 7 hours of OT during one year. However, it is possible that the children included in the current study also received some therapy in other settings, for example via Social rehabilitation. However, the proportion of social rehabilitation could probably not have been too high, because applying for disability and preparing a rehabilitation plan take time, and children often do not access the service within the first year after receiving a diagnosis.

There is no consensus regarding the optimal dose and frequency of different rehabilitative therapies. Jackman *et al.* (2021) wrote that the optimal dose varies and depends highly on the individual and the type of intervention. They pointed out that to receive a specific functional goal 15 to 25 hours of practice is needed, of which a half can be done at home. Practicing at home is also important as children can practice various skills in everyday setting (Jackman *et al.*, 2021). Even then, however, there should be regular therapy sessions to train the parents to deliver home programs and to track children's progress (Beckers, *et al.*, 2020; Lord *et al.*, 2018). If the goal is to improve motor ability more generally, over 40 hours of practice is needed. This is applicable to PT and OT, for example (Jackman *et al.*, 2021). Patients in the current study often did not receive enough hours of PT and OT to learn a specific goal or to improve general motor ability.

According to Houtrow & Murphy (2019) if a child demonstrates continuous progress towards goals, PT and OT should take place 1-2 times a week or every other week. Children who are functionally stable and have reached most of their developmental milestones may only need periodic therapy services. However, the age group in this study needs continuous therapy services to maximise neuroplasticity and improve different functions (Houtrow & Murphy, 2019). Therefore, for the age group included in this study PT and OT should take place regularly 1-2 times a week or every other week. It is not known how often children in this study participated in PT and OT. However, looking at the median hours of these therapies received, the therapy period probably did not last long or there was quite a long time between therapy sessions.

When using task-focused active-use therapy (for example constraint-induced movement therapy), it is recommended to use intensive programme over a short time period, for example 4 to 8 weeks (NICE, 2016). According to Korkalainen *et al.* (2023) high frequency therapy is also optimal for motor learning to improve speech in patients with CP. It has been suggested that high-intensity therapy consists of minimum 12 sessions over 3 weeks (Korkalainen *et al.*, 2023) which is probably higher than the median of 5 hours of ST received in this study.

Concerning PS there is no consensus on the optimal amount of therapies needed as it depends highly on the individual. Generally, various psychological treatments should take place regularly, for example weekly, and multiple sessions are required to see the improvement (Robinson *et al.*, 2019). Previous studies that have examined interventions for psychological problems in children with CP have also used intervention protocols consisting of multiple (e.g. 6-24) treatment sessions (Silberg *et al.*, 2023; Whittingham *et al.*, 2014). Therefore, the median of 5 hours of PS received in this study might be sufficient for some patients, however, others may need more sessions to improve psychological functions.

There is not a specific time pointed out in the literature when different rehabilitative therapies should begin after being diagnosed with CP. However, when a child is diagnosed, they should be quickly referred to specific interventions (NICE, 2017). Children with spasticity should be assessed by a physiotherapist and when necessary, an occupational therapist. Since spasticity is very common among children with CP they should be referred to PT or OT as soon as possible (NICE, 2016). Early intervention is crucial because a huge proportion of motor learning happens in early childhood. It has been stated that children with CP reach 90% of their motor potential by the age of 5 (Noritz *et al.*, 2022). Therefore, early intervention is important for the age group included in this study and the interventions should start as soon as possible (NICE, 2017; NICE 2016).

In this study rehabilitative therapies started relatively late, some even 1-2 months after being diagnosed. Children would have benefited from the earlier start of therapies as therapists can give parents recommendations to improve their child's development, participation and quality of life (Houtrow & Murphy, 2019). In this thesis the majority of rehabilitative therapies ended around a median of 100 days before the end of the year which means that there was some time during the year after being diagnosed where children did not receive PT, ST, PS or OT. Children with CP, however, should get rehabilitative therapies that they need regularly (Houtrow & Murphy, 2019).

In the current study more children received rehabilitation in an outpatient than in an inpatient rehabilitation setting. Similarly to current thesis Kim *et al.* (2019) found that in South Korea more children received rehabilitation therapy (PT, OT and hydrotherapy) in an outpatient setting (Kim *et al.*, 2019). Heathcock *et al.* (2021) found that regarding PT both high-intensity schedule of therapy and outpatient weekly therapy can be effective if the total number of hours of the therapy received remains the same (Heathcock *et al.*, 2021). In this study inpatient rehabilitation could be classified as high-intensity therapy where children receive rehabilitation services every day for a few weeks. Therefore, both options can be beneficial for children with CP (Heathcock *et al.*, 2021).

5.2. Temporal trends in rehabilitation

Temporal changes were seen in the median end day of PT. Otherwise, there were no temporal changes in the rehabilitation use. The results indicate that there has not been a significant positive change in the rehabilitation use among children with CP.

A few studies have analysed temporal trends in PT use in Estonia. Pruunsild (2022) and Leppik (2023) found no significant temporal changes in PT use after primary elective total hip and knee arthroplasty (Leppik, 2023; Pruunsild, 2022). Prommik (2021) also found no changes in the median hours of PT received after hip fracture. Luks (2024) found that the proportion of patients receiving PT after stroke increased. Other aspects, however, remained the same (Luks, 2024). One study has investigated OT use and found that the proportion of patients who received OT after total knee arthroplasty increased, however, the total median hours decreased (Leppik, 2023). To the author's knowledge this is the first study in Estonia that has examined temporal trends in ST and PS use.

5.3. Cost of treatment

According to the results of this study less money was spent on rehabilitation than other treatments when looking at the total cost of treatment for all patients in this study. A Dutch study found that the mean annual societal costs of CP were 40 265 € of which therapy and rehabilitation was 3262 € and expenditure on other medical care was 1573 € (Hoving *et al.*, 2007). It differs from the current study as expenditure on rehabilitation and medical care was higher.

Other studies have also shown the increase in medial costs over several years. Kim *et al.* (2018) found that the expenditure on rehabilitation therapies increased. The authors attributed the increase in the cost to the increase in the amount of rehabilitative treatments patients received (Kim *et al.*, 2018). Since there were no significant changes in the amount of rehabilitation received in Estonia the increase of the expenditure on medical treatments is probably caused by other reasons.

A study conducted by Kim *et al.* (2019) analysed the cost of rehabilitation treatment of children with CP in South Korea using information from The National Health Insurance Database. Health care costs for CP patients was higher than the general population. They found that while almost all patients with CP should have received rehabilitation there was a proportion of patients who did not receive it. Therefore, to properly treat CP higher treatment costs are required (Kim *et al.*, 2018). The results of this study also indicate that if all children would have got rehabilitation in the necessary amount, the expenses on rehabilitation would have been higher.

5.4. Strengths and limitations of this thesis

This thesis has multiple strengths. Firstly, this is one of the few population-based studies to analyse the use of rehabilitation. Secondly, this is the first study in Estonia to evaluate the rehabilitation of CP and children's rehabilitation. Thirdly, the study period was 12 years which allowed us to assess temporal trends. Lastly, it is one of the first studies to evaluate the expenditure on rehabilitation in Estonia.

This thesis has some limitations which need to be considered when interpreting the results. This study did not account for the rehabilitation services which were not financed by The Estonian Health Insurance Fund.

6. CONCLUSIONS

1. There was a considerable proportion of patients with cerebral palsy who did not receive rehabilitative therapies and who may have needed it.
2. The amount of physiotherapy, speech therapy, psychological therapy and occupational therapy received was relatively low.
3. After the diagnosis of cerebral palsy rehabilitative therapies started relatively late.
4. There were temporal changes in the median end day of physiotherapy which ended later. Apart from that, however, there were no significant changes in the rehabilitation use during the study period.
5. Compared to other studies the expenditure on medical treatments was lower.

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