COST COMPARISON OF A FINNISH WEB-BASED NEUROPSYCHOLOGICAL REHABILITATION PROGRAMME AND TRADITIONAL REHABILITATION

- A Case Study

Emilia Lindholm

Supervisor:

Antti Sekki, Principal Lecturer, Laurea University of Applies Sciences

Date: 27.2.2026

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Abstract

Background: The growing economic pressure on healthcare systems makes efficient resource allocation essential, while digital solutions can improve access to services. The Neuropsychological Digital Care Pathway (NP-DCP) is a professional-guided web-based rehabilitation programme for stroke patients with mild-to-moderate cognitive difficulties, aiming to respond to this pressure as an alternative to traditional face-to-face rehabilitation.

Objectives: The aim of this study was to examine the cost structure of the NP-DCP to estimate its cost-efficiency for the health care provider. The second purpose was to assess organizational readiness in data availability, in order to suggest improvements required for rigorous economic evaluations in the future.

Methods: In this mixed-method case study a cost-minimization analysis was the primary component, while qualitative interviews provided contextual understanding. Cost data was obtained retrospectively and complemented with a collected data sample to address missing information.

Results: The estimated cost difference compared to traditional rehabilitation was 230 € per patient, leading to 23 000 € in annual savings with current NP-DCP patient volume. In this case, investment costs remained marginal, whereas the largest cost difference was clinician time per patient. Regarding data availability, suggestions to improve clinician time registering as well as costing model specificity and transparency were presented.

Conclusions: The NP-DCP is a scalable and highly cost-efficient way to treat patients, as the effectiveness of the compared interventions can be considered roughly equivalent. This study lays the groundwork for subsequent research. With improved organizational data availability and robust evidence on clinical outcomes, a full cost-effectiveness analysis would be possible.

Keywords: telerehabilitation, web-based rehabilitation, neuropsychology, cost analysis
JEL classification: I11, O33

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Glossary

NP-DCP = Neuropsychological Digital Care Pathway

CBT = Cognitive behavioural therapy

HUS-iCBT = HUS Helsinki University Hospital internet-delivered CBT

CEA = Cost-effectiveness analysis

CMA = Cost-minimization analysis

Introduction

Cognitive impairment is prevalent in stroke patients even after clinical recovery, often affecting multiple cognitive domains (Jokinen et al., 2015; Kauranen et al., 2014). These impairments are also related to poor functional outcomes later in life. Neuropsychological rehabilitation aims to reduce the impact of cognitive impairments in everyday life and to reach optimal level of well-being (Wilson et al., 2017). Depending on the cognitive profile and patient's needs, rehabilitation methods can vary from cognitive training to more holistic approaches. Patients with mild brain injury usually benefit the most from psychoeducational information and advice (Turner-Stokes et al., 2015), and learning compensatory strategies has a crucial role in managing mild memory deficits (Cicerone et al., 2019). Traditionally neuropsychological rehabilitation has taken place in face-to-face appointments with a neuropsychologist.

The growing economic pressure on healthcare systems makes efficient allocation of resources increasingly essential. Organisations need to find strategies to slow the growth of healthcare costs without compromising accessibility, efficiency or patient safety. Therefore, evidence-based evaluation of alternative interventions is necessary. Recent systematic reviews provide evidence that telerehabilitation is a cost-effective or even cost-saving alternative to traditional face-to-face rehabilitation, while its clinical effectiveness is generally comparable or better (Baffert et al., 2023; Del Pino et al., 2022; Grigorovich et al., 2022).

Neuropsychological Digital Care Pathway (NP-DCP in short; in Finnish Neuropsykologinen nettikuntoutus) is a structured web-based rehabilitation programme for stroke patients with mild-to-moderate cognitive difficulties, developed at the Neurocenter of HUS Helsinki University Hospital during 2018–2019. The NP-DCP is grounded in evidence-based data and clinical practices in neuropsychological rehabilitation, including psychoeducation, skills training, and strategies for compensating cognitive difficulties and managing emotional distress (Cicerone et al., 2019; Crocker et al., 2021; Davies et al., 2024).

The NP-DCP was developed on the *Health Village* platform (www.terveyskyla.fi/en). Health Village is a national public online service collaboratively developed by five Finnish university hospitals (Helsinki, Tampere, Turku, Kuopio, and Oulu) in cooperation with service users. Within Health Village, the *My Path* channel (www.terveyskyla.fi/en/mypath) provides secure digital care pathways for patients who have received a referral, requiring strong

electronic authentication to access. Through this channel, patients log into the NP-DCP and complete the rehabilitation programme independently under the supervision of a neuropsychologist, regardless of time or location.

The NP-DCP consists of eight structured sessions, each including 12–14 interactive tasks, combining text, images, videos, and information links that explain cognitive symptoms and their management. The programme encourages personal goal setting to enhance motivation and uses symptom questionnaires, automated feedback, and self-reflection exercises to promote self-awareness. In addition, case examples depicting fictional neurological patients provide peer support. Patients can communicate with their supervising neuropsychologist via a secure messaging channel. Replies are provided within three business days, and when appropriate, the neuropsychologist gives additional feedback on the patient's progress. A schematic presentation of the structure can be seen in figure 0.1.

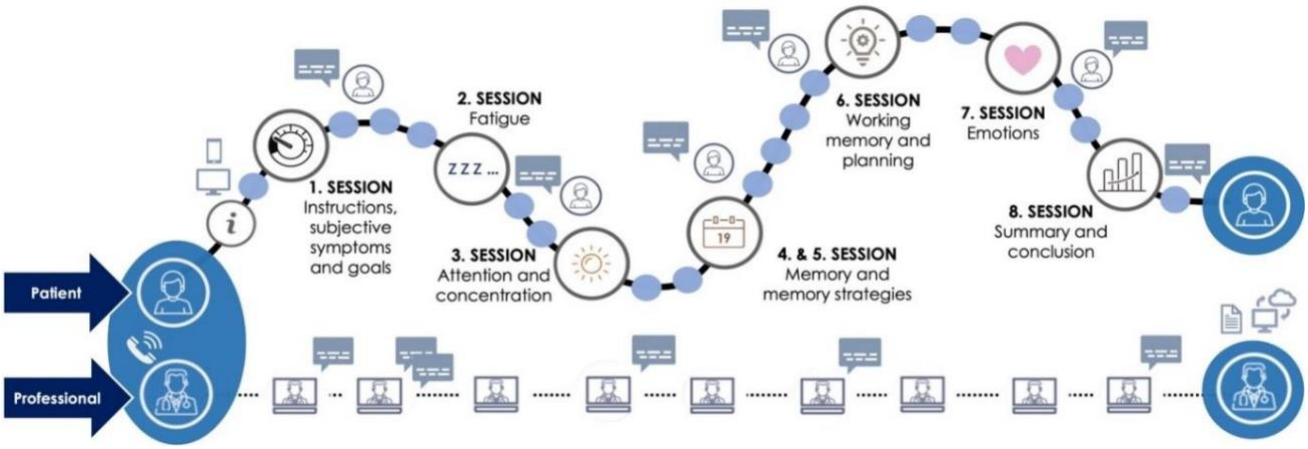


Figure 0.1. A schematic presentation of the NP-DCP. The programme supports communication with neuropsychologists responsible for care via messages. Copyright 2025 by HUS.

Vuori et al. (2025) reported the NP-DCP to be well accepted and usable among stroke patients. Patients found it helpful, providing reliable information on cognitive symptoms, recovery and symptom management. Also, adherence to the NP-DCP was comparable or higher than in other web-based intervention studies, measured by the percentage of non-starters. Completion was highest among patients with mild cognitive symptoms, referred shortly after acute care. Vuori et al. (2025) discussed that clinical neuropsychologists likely spend less time

supporting patients in web-based programmes than in face-to-face rehabilitation but cost analysis comparing these interventions has not yet been conducted.

Economic evaluations play a crucial role in evidence-based practice, helping to allocate the limited healthcare resources efficiently (Brownson et al., 2018). The goal of economic evaluation is to enhance the efficiency of healthcare spending by identifying interventions that achieve comparable or better outcomes at lower costs. The NP-DCP is a web-based psychoeducational programme developed within a public healthcare provider in Finland, with cost-effectiveness as one of its intended advantages. However, this has not yet been empirically demonstrated, either in this context or for similar programmes in other settings.

The first purpose of this study was to demonstrate the cost difference between the NP-DCP and the corresponding traditional face-to-face rehabilitation. By examining the cost structure of the NP-DCP, the aim was to estimate how cost-efficient it is for the health care provider to use this web-based programme for suitable patients in neuropsychological rehabilitation practice. These findings are valuable for provider-level decision making regarding service allocation and scaling. The findings may also be relevant to other healthcare settings where cost savings could be achieved through similar digital solutions by shifting rehabilitation to web-based formats when appropriate.

The study was conducted as a mixed-method case study, in which quantitative cost analysis was the primary component and qualitative information provided contextual understanding of organizational processes and data practices. Quantitative cost data was collected retrospectively from the organization and complemented with primary data to address missing information. In this study costs were analysed solely from the health care provider's perspective. Intervention effectiveness was assumed to be equal based on evidence from similar interventions and clinical practice, enabling a cost-minimisation comparison.

In this organizational context, some of the data was challenging to obtain due to registry limitations, reducing the accuracy of the cost analysis. This leads to the second purpose of the study, which was to assess organizational readiness in terms of data availability and structure, and to present suggestions for development in the clinical, financial and administrative practices. Qualitative data was collected through discussions and interviews with representatives from the organization to better understand the context. This approach enabled

the identification of key development needs required for more rigorous economic evaluations in the future.

AI tools were used in the preparation of this thesis. ChatGPT was used for language correction of the writer's text. NotebookLM was used to find and organize information from the selected articles when writing the literature review.

1. Literature review

1.1. The state of health care

All social and health care processes should aim to promote individuals' ability to manage everyday life. There are six operational goals: accessibility, quality, equity, effectiveness, safety, and cost-effectiveness of care (Malmivaara, 2022). Growing economic pressure on healthcare systems makes efficient allocation of resources increasingly essential. Organisations need strategies to slow the growth of healthcare costs without compromising accessibility, efficiency, or patient safety. In public healthcare, funding is often a "zero-sum game," where total available resources are unlikely to increase significantly from year to year (Brownson et al., 2018). Therefore, evidence-based evaluation of alternative interventions is necessary. If less efficient interventions are implemented in a resource-constrained environment, society faces a high opportunity cost.

Economic evaluation plays a crucial role in evidence-based practice, as its primary purpose is to help allocate limited healthcare resources efficiently (Brownson et al., 2018; Malmivaara, 2020). Economic evaluation provides systematic information on the costs and benefits of alternative therapeutic or preventive interventions, thereby supporting informed decision-making (Baffert et al., 2023). The goal of economic evaluation is to improve the efficiency of health care spending and to demonstrate value for money. By identifying interventions that achieve comparable or better outcomes with lower costs, such analyses help ensure that limited healthcare resources are used in the most effective way possible.

1.2. Digital health interventions offer a solution

Knowledge regarding the costs and effectiveness of digital tools in health care is still limited. However, a systematic review reveals growing evidence that digital health interventions tend to produce beneficial results, showing advantages in both cost efficiency and patient outcomes (Gentili et al., 2022). The review included a broad spectrum of intervention types, such as new digital technologies and video-conferencing systems, but also mobile phone-based applications and self-guided programmes comparable to the NP-DCP.

Telemedicine refers to all healthcare practices delivered through remote communication technologies, and it is considered an innovative service model compared with traditional face-

to-face care (Paleari et al., 2022). The goal is to overcome geographical barriers and promote equity in access to healthcare by using information and communication technologies.

Telerehabilitation is a subfield of telemedicine that focuses on supporting patients in recovering their cognitive and physical performance status (Paleari et al., 2022). It has been developed to address challenges in modern healthcare by improving patients' access to rehabilitation services from home, reducing hospital stays, and lowering costs for both patients and healthcare providers (Peretti et al., 2017).

1.3. Cost-effectiveness of telerehabilitation

Telerehabilitation specifically offers promising solutions for optimising the use of healthcare resources, and economic analyses help to reveal its value. Recent systematic reviews provide evidence that telerehabilitation is a cost-effective or even cost-saving alternative to traditional face-to-face rehabilitation, while its clinical effectiveness is generally comparable or better (Baffert et al., 2023; Del Pino et al., 2022; Grigorovich et al., 2022). In their systematic review, Baffert et al. (2023) reported that most studies identified telerehabilitation as more effective and less costly than traditional care. The review covered different types of telerehabilitation interventions for somatic conditions, such as home-based monitoring of rehabilitation or rehabilitation programme with exercise and an educational intervention at home. The included studies were all randomised clinical trials and used health-related quality of life instruments to describe patients' health states. Overall, telerehabilitation was recognised as a cost-effective approach for large populations across various clinical conditions.

A cost analysis of remote cognitive remediation therapy has identified mainly societal-level cost savings (Cella et al., 2024). Cognitive remediation therapy shares similar aspects with neuropsychological rehabilitation, focusing often on both cognitive training and learning compensatory strategies through psychoeducation. Cella et al. (2024) studied the feasibility and estimated costs of remote cognitive remediation therapy as an alternative to traditional face-to-face therapy in people with psychosis. A software was used to practice a range of cognitive tasks. However, sessions were supported by the therapist via a remote communication platform Microsoft Teams. This means the therapist time was not significantly reduced, leading to similar costs than in face-to-face therapy using the same therapy modality. Only societal costs were reduced in remote therapy due to participants' savings in travel and productivity. In web-

based interventions supporting independent learning, also the clinician's time per patient is reduced, leading to better expectations of cost saving compared to Cella et al. (2024).

A study of virtual reality–based telerehabilitation for balance recovery after stroke found a home-based intervention to be less costly than an equivalent clinic-based one (Lloréns et al., 2015). Here therapists time, patients travel costs and equipment expenses were considered. Therapist hours per patient were reduced, but the home-based programme required hardware for the VR-system, which was a significant expenditure for the clinic. A rehabilitation programme built to be web-based, could be more cost-beneficial, as it does not require hardware in addition to patient's own existing devices.

To conclude, a web-based psychoeducational intervention differs from many other remote therapies by potentially requiring less therapist time and relying more on patients independent but supported learning. It also does not depend on synchronous therapist involvement or additional hardware, which minimizes personnel and logistical expenditures while maintaining accessibility and scalability. Therefore web-based programmes can be expected to achieve even greater savings in health care costs.

1.4. Cost savings on web-based programmes

Studies including cost evaluations on web-based psychoeducational programmes for managing cognitive difficulties have not yet been conducted. Vuori et al. (2023) identified four studies meeting the criteria in a systematic review aiming to summarize knowledge on interventions like the NP-DCP. None of these studies analysed costs. Some evidence on cost-savings, however, can be found on web- or mobile-based interventions developed for different purposes.

Kumar et al. (2018) compared the cost-effectiveness of mobile cognitive behavioural therapy (CBT) to traditional therapy. The mobile CBT programme for generalized anxiety disorder led to both improved health outcomes and lower costs than traditional CBT. The mobile CBT was cost-saving primarily due to a better clinical response rate and lower programme costs compared with traditional therapy. The programme is comparable to the NP-DCP as it also consists of eight self-guided modules combining education and practice, with individualized support from a coach via asynchronous messages.

Mobile app self-care must sometimes reach a certain level of usage before it becomes less expensive than in-office treatment. On a stress reduction mobile app this threshold was found to be approximately 1600 users in a cost-minimization analysis (Luxton et al., 2014). The intervention did not require a doctor's referral, which makes it harder to analyse the user population and cost-efficiency.

Cost-effectiveness of a psychoeducational web-based programme for first-time mothers in the postpartum period has been examined in Singapore (Zheng et al., 2022). The study was a randomized controlled trial comparing three groups: routine hospital care alone, a home-based intervention delivered by a professional added to routine hospital care, and a web-based programme added to routine hospital care. The interventions were designed to support mothers during the early postpartum phase. Although the web-based programme required a relatively high initial investment, it was scalable and reduced subsequent health care utilization and costs among mothers compared to the other two groups. As a result, despite being delivered in addition to routine care, the web-based intervention proved to be most cost-effective overall.

Regarding HUS Helsinki University Hospital internet-delivered CBTs (HUS-iCBTs) for psychiatric disorders, using the same Digital Care Pathway platform as the NP-DCP, the cost saving is thought to result mainly from the markedly lower amount of therapist time required per patient. At HUS, the recommended therapist time per patient is 77 minutes in total for the seven weekly sessions of the iCBT programme, whereas a comparable traditional face-to-face intervention takes on average 840 minutes (Rosenström et al., 2025). Given that the clinical effectiveness of the interventions is similar, therapist-supported iCBT has been interpreted as a cost-effective and scalable solution for meeting high service demand (Rosenström et al., 2025). However, the cost differences underlying this interpretation have not been analysed in more detail.

1.5. Limitations in digital interventions and cost studies

The generalisability of results on health care interventions and economic evaluations is often limited. In addition to commonly reported weaknesses in methodological quality, many studies fail to describe the intervention in sufficient detail to allow replication or practical clinical application. This limitation has also been noted among web-based psychoeducational interventions (Vuori et al., 2023). Economic evaluation studies frequently lack detailed

descriptions of unit-costs, data sources, and cost calculations, and their generalisability is often limited by dependence on local contextual factors (Hilty et al., 2023; Sanyal et al., 2018). Baffert et al. (2023) also note that the generalizability of available evidence to other countries is limited, resulting to a need to conduct evaluations within specific contexts and countries.

It is important not to be blinded by the calculations of direct cost-savings. Digital health interventions do not always lead to the expected cost savings within health care systems, as they may even increase costs in the short or medium term, creating additional expenses for patients and society (Snoswell et al., 2020, 2021). These additional costs may arise from the need for new technical investments and equipment, staff training or system maintenance. If telerehabilitation is used as additive to traditional appointments, ongoing costs may increase due to a higher frequency of patient–clinician contact. When digital services improve accessibility, they may increase overall service utilisation, which can also offset potential cost reductions. On the other hand, a common misconception is that telehealth brings direct cost savings mainly for healthcare providers, but savings often occur at the patient or societal level - for example, through reduced travel expenses or time savings: When the costs of telehealth using video communication were analysed only from the healthcare provider's perspective, the proportion of studies reporting cost savings decreased by half compared with analyses adopting a broader societal perspective (Jacobs & Barnett, 2017).

Merely reducing the development time and costs of digital therapeutics is not advantageous. Their effectiveness and safety must be demonstrated in clinical trials, just as medicines or medical devices are required to do (Kim, 2020). Certain assumptions must be met before implementation of telerehabilitation to everyday practice. Sustainable implementation of digital interventions requires several capabilities from the organisation. Sufficient readiness must be in place, including leadership commitment, appropriately trained and resourced staff, established best practices and policies, systematic evaluation mechanisms, and a culture of continuous process improvement (Hilty et al., 2023). A lack of digital literacy among service users has also been identified as a key barrier that must be addressed to ensure successful implementation of telerehabilitation (Cella et al., 2024).

1.6. Effectiveness of Digital Care Pathways compared to face-to-face appointments

The literature on effectiveness of web-based psychoeducational programmes specifically for managing cognitive difficulties in patients with conditions affecting cognition is extremely limited. A systematic review found four studies examining programmes comparable to the NP-DCP that met the inclusion criteria, yet the studies were quite heterogenous in terms of the interventions and populations (Vuori et al., 2023). This scarce evidence indicated that web-based interventions are feasible and support subjective cognitive functioning. None of the studies, however, included a comparison between a web-based programme alone and a traditional treatment.

Corresponding internet-delivered cognitive behavioural therapies (iCBTs) are already used as evidence-based practice for many psychiatric and somatic disorders, as the literature widely demonstrates they are not only acceptable and practical health care, but effective in reducing symptoms (Andrews et al., 2018; Käll et al., 2024). An updated systematic review and meta-analysis of 31 randomized controlled trials states that therapist-guided iCBT produces clinical outcomes equivalent to face-to-face CBT, providing convincing evidence that iCBT is an effective alternative to traditional therapy (Hedman-Lagerlöf et al., 2023). In iCBT programmes, patients access materials through a secure digital platform. The educational content is delivered through written modules, videos, and audio recordings, accompanied by structured exercises to facilitate behavioural change. Therapist support is typically provided via asynchronous text-based communication, through which clinicians offer feedback on assignments, encouragement, and support. For depressive disorders, similar effectiveness between iCBT and face-to-face CBT has been demonstrated widely in RCTs, naturalistic studies, and quasi-experimental research (Rosenström et al., 2025).

HUS-iCBTs use the same Digital Care Pathway platform as the NP-DCP and served as a model for the NP-DCP during its development. The programmes use similar ways to deliver educational information and provide therapist support. The effectiveness of HUS-iCBT programmes has already been plausibly demonstrated, providing also an indication of the assumed effectiveness of the NP-DCP. Ritola et al. (2022) reported that 54.4% of patients with generalized anxiety disorder treated with the HUS-iCBT programme achieved recovery. This was an outcome comparable to previously published recovery rates for face-to-face CBT in

similar populations (51.4%). Rosenström et al. (2025) used large-scale registry data, enabling post hoc balancing of intervention groups and thereby approximating an RCT design under real-world conditions. Their findings indicate that short first-line therapist-supported HUS-iCBT programmes for depression are at least as effective and efficacious as traditional face-to-face CBT. Evidence from the therapist-guided HUS-iCBT for insomnia also aligns with prior RCT findings, showing comparable effect sizes in patient-reported improvements in insomnia symptoms (Stenberg et al., 2022). Despite differences in delivery methods between iCBT and face-to-face CBT, the non-specific factors that drive therapeutic change seem to have similar effects in both modalities, supporting the assumption on comparable effectiveness. A meta-analysis found that treatment expectations predict clinical outcomes to the same extent in therapist guided online therapy and face-to-face therapy, suggesting that iCBT is equally susceptible also to expectancy effects (Pontén et al., 2024).

2. Theoretical framework

An *economic evaluation* can be defined as "the comparative analysis of alternative courses of action in terms of both their costs and consequences" (Drummond et al., 2015). The costs and consequences of health care interventions must be first identified and then measured, valued and compared. This way an economic evaluation provides a systematic way to make decision making more transparent and accountable by comparing alternative actions and the evidence of their expected effects (Drummond et al., 2015). Health care cannot automatically lean to the least-cost interventions; hence the consequences must be weighted. When costs are related to a single effect that may differ in magnitude between alternative interventions, the evaluation is usually referred to as a *cost-effectiveness analysis* (CEA) (Drummond et al., 2015). These effects can be measured for example in life-years gained per unit of cost.

Sometimes the relative effectiveness of the interventions is not a contentious issue, and studies compare interventions by considering costs only, which can be called a *cost analysis* (Drummond et al., 2015). If the consequences of two interventions are broadly equivalent based on previous research or professional opinion, the difference between them reduces to a comparison of costs. This is referred in the literature as a *cost-minimization analysis* (CMA) which, however, cannot be viewed as a form of full economic evaluation and should be applied with caution, as the assumption of equivalent outcomes may be questionable (Dakin & Wordsworth, 2013; Drummond et al., 2015). When choosing CMA over CEA there is a risk of either overestimating or underestimating the impact of uncertainty (Dakin & Wordsworth, 2013).

Dakin & Wordsworth (2013) discuss that conducting a CEA is more costly and requires more resources than a CMA. However, trial-based economic evaluations are often conducted alongside clinical trials where clinical data on consequences is already collected. In these cases, the additional resources required to conduct a full economic evaluation are minimal and a CEA should therefore be chosen. In comparison, a CMA may have a role in model-based evaluations, when decisions must be made with limited resources. CMA may also be appropriate if the cost difference is so marked that no plausible difference in efficacy could change the conclusions, or if the differences in consequences are sufficiently small compared to expected costs so that the bias in uncertainty estimates is acceptable (Dakin & Wordsworth, 2013).

According to the principles described by Drummond et al. (2015) and Husereau et al. (2022), a cost analysis requires a transparent and systematic identification of all relevant resource inputs. Costs are commonly organised into investment, fixed and variable costs to clarify different types of resource commitments. *Investment costs* refer to one-time expenditures such as development work or major equipment, *fixed costs* remain mainly unchanged regardless of the number of patients, and *variable costs* increase or decrease with service utilisation. In an economic evaluation, these cost categories are quantified by assigning unit-costs to each identified resource and multiplying them by the observed or estimated quantities of use. These components are then compiled to produce total costs for each alternative. This structured approach helps ensure that the analysis reflects the true resource usage of an intervention and supports valid comparison between interventions.

Costs that are identical across alternatives can usually be excluded, as they do not influence the comparison. Similarly, very small cost components may be omitted if they are unlikely to affect the results, provided that the rationale for their exclusion is clearly justified. Nonetheless, all cost categories should at least be identified, even if detailed estimation is not undertaken. (Drummond et al., 2015)

Sensitivity analysis is a way to evaluate the uncertainty related to the assumptions a cost analysis includes (Jain et al., 2011). It demonstrates whether findings remain stable and cost-effective when key variables, such as unit-costs or resource use, are varied. It shows how uncertainty influences the results and can highlight areas where better data is needed.

3. Methodology

3.1. Research design

Research was conducted as a case study examining cost structure of the NP-DCP and its cost-efficiency compared with the corresponding face-to-face intervention, while also assessing organisational readiness for cost evaluation. The study design was shaped by practical and methodological constraints, where conducting a rigorous cost-analysis was not possible with the available data. A case study approach is suitable when the phenomenon requires examining in its real-life setting, in this case the organizational context (Yin, 2018). It allows the use of both quantitative and qualitative data. This study adopts a mixed-evidence method, in which quantitative cost analysis is the primary component, but qualitative information adds contextual understanding. In applied health services research, a case study approach is commonly used to combine complementary evidence types to strengthen the credibility and usefulness of findings for practice (Crowe et al., 2011).

The first purpose of the study was to demonstrate cost difference of the NP-DCP compared with traditional face-to-face appointments. Quantitative data, as numerical information, enables calculation and comparison (Yin, 2018). Secondary data was obtained retrospectively on the available costs, and some missing information was collected as a primary data sample. The costs were viewed solely from the health care provider's perspective, while patient costs and broader societal costs were outside the scope. Here, the effectiveness of the two interventions was assumed to be equal based on the clinicians' experience and research on similar interventions (Pontén et al., 2024; Ritola et al., 2022; Rosenström et al., 2025; Stenberg et al., 2022). The aim was to categorize costs into investment, fixed and variable costs for each intervention to estimate annual cost savings. Some of the required data was challenging to obtain, which decreased the quality of the analysis. The effect of changes in key variables on cost-efficiency was examined using a sensitivity analysis.

The second purpose of the study was to assess organizational readiness in terms of data availability and structure, in order to present suggestions for development in organizational practices. The aim was to be able to reach readiness for real-time cost monitoring, enabling more precise and intervention-specific cost analyses in the future. Qualitative data was collected to understand the organizational and financial practices in the context where the intervention of interest is implemented. Qualitative data is non-numerical, meaning-focused information,

helping to describe processes and contextual factors (Yin, 2018). Information was gathered during the process through discussions and interviews with representatives from the organization. In addition, the writer's professional experience working as a neuropsychologist in the clinical unit informed the discussion.

3.1.1. Research questions

The research questions are

1. What is the estimated cost difference between the NP-DCP and corresponding number of face-to-face appointments per patient?
2. What is the estimated annual cost saving for the health care provider?
3. How do changes in patient numbers, fixed costs and the number of corresponding appointments affect cost-efficiency?
4. What improvements in organizational practices are needed to achieve readiness to provide real time data for cost evaluations?

3.2. Data collection methods

The cost data was obtained as secondary data from the organization. Information on the costs of development work and IT-support were obtained from product managers via email. The organization's PowerBi system provided data of patient numbers and completion rates on the NP-DCP. The clinician fixed salaries were obtained from the intranet available for all employees.

Primary data was collected as a sample of clinician time used per patient for each intervention, as this data was not registered routinely in clinicians' daily practice. Neuropsychologists in the clinical unit were asked to report their time use on an excel-sheet with five-minute precision. Data on face-to-face rehabilitation was collected in 2025 by the author over a one-week period. The sample consisted of 12 single appointments reported by four different clinicians. Data on the NP-DCP was collected between 2023 and 2025 as part of ongoing IRENE-project studying the effectiveness of the NP-DCP using a sample size of 7 patients who had completed the digital care pathway. The average time was calculated in minutes for both samples.

Employees from the organization were involved to gather qualitative information. Eventually cost information was not obtained from the financial department, but representatives

responsible for the clinical unit's finances provided valuable insight into the organizational practices. Financial representatives were consulted through two semi-structured interviews of approximately 30 minutes held via Microsoft Teams. The first interview was conducted during the data collection planning phase to map available data sources and possibilities for the research. The second interview was carried out after the analysis phase to gather insights specifically to support the development of improvement suggestions related to data availability and cost monitoring. Here the interview topics focused on the representatives' views on (1) how lack in time registration affects cost calculations and reporting in the clinical unit, (2) the potential benefits of more accurate time registering and how the information could be used, and (3) what would be required to improve the accuracy and accessibility of unit-cost estimates. The interview topics were sent to the representatives beforehand via email, to allow time to prepare. Semi-structured method allowed the researcher to present follow-up questions on themes of interest, to also allow space for more free-flowing discussion.

Additionally, qualitative information on clinical workflows and the intervention types in case were collected through unstructured discussions with the manager neuropsychologist responsible for the digital care pathway, as well as with colleagues involved in routine clinical practice, complemented by the author's own professional experience in the setting.

3.3. Data analysis

The obtained cost data was categorized into cost types and compared between face-to-face rehabilitation and the NP-DCP through a cost-minimization analysis. The totals of fixed and variable costs were summed for each intervention to get a comparable cost per patient. The monetary difference was multiplied by the amount of patients who completed the digital care pathway in 2024 to estimate the annual cost difference between the interventions.

Sensitivity analysis involved recalculating the annual cost difference across a range of plausible patient volumes. Results were then compared to determine how the cost difference increases with patient volume and what is the threshold volume at which the NP-DCP becomes cost-favourable. Results are described and presented in demonstrative figures.

The qualitative information from interviews and email discussions was analysed descriptively. Notes from the discussions were reviewed during the analysis stage and used to

identify recurring issues related to data availability and organizational practices. These observations were then synthesised into a set of development suggestions, aiming to reflect the perspectives raised across different organisational roles.

4. Research findings

4.1. Cost analysis

4.1.1. Investment costs

From the health care provider's perspective, investment costs typically include everything needed to develop and implement the programme, and to integrate it into routine care (Khan et al., 2024). When starting from scratch, first costs come from planning and designing the concept and product. This includes developing content such as text, images, videos and narratives, but also the user experience from start to finish. Software development comes into question if there is no existing platform, often requiring also to build a prototype and test it. Sometimes third-party services are needed, generating costs for software, licenses or consultation. Implementing a new digital system also brings one-time costs, such as software installation and configuration, integration with existing electronic health record systems, and required data migration. Even with existing systems, additional costs may arise from aligning the new digital process with current workflows and routine care. In web-based programmes, hardware and other equipment rarely become a major cost, since both clinicians and patients typically use existing devices. The development work is, however, a cost through paid workhours, including content creation, software development, prototype testing and administrative work. In some cases, staff training to use the digital intervention can be a substantial investment. Ignoring labour costs could bias the result of the analysis, making them as important to include as any other costs.

The digital care pathways are developed internally by health care professionals and IT-support, which minimizes the expenditure on additional investments and third-party services. The Health Village platform is a national public online service collaboratively developed with other Finnish university hospitals. The platform for digital care pathways already existed before development of the NP-DCP, as it had previously been widely used for pioneering care pathways, like the HUS-iCBTs for psychiatric disorders. The Health Village platform already includes several hundred digital care pathways used in Finland, in addition to other services, meaning that integration with other systems was already in place. In the case of the NP-DCP, the marginal system development and integration costs for this specific pathway are difficult to separate and are not considered significant enough to routinely calculate in such a large-scale non-profit organization.

The content of the NP-DCP was developed and implemented on the existing platform in the Neurocenter clinical unit by clinical neuropsychologists. A total of approximately two months of full-time neuropsychologist work time was used for content development during 2019–2020 (approximately 11 162 € based on average salary).

Technical support during development was provided internally by the IT- department. The cost of this service was included in an annual payment made by the clinical unit to the IT-department, which covers the continuous maintenance and investments relate to IT-development for all digital care pathways within the clinical unit. For this reason, IT-related development work is not routinely recorded as a separate investment-type cost in the financial department and therefore could not be obtained. In this analysis, the continuous annual IT-support payment was included in the fixed costs.

The traditional face-to-face rehabilitation included no investment costs. The investment costs related to the NP-DCP were marginal and therefore challenging to fully capture. The only one-time cost fell under NP-DCP content development. The two-month neuropsychologist salary for content development can be considered to have been offset already during the first year of use, as it is lower than the estimated annual cost saving. Therefore, investment-type costs were described separately in table 4.1. and were not included in the annual cost estimates.

4.1.2. Fixed costs

Fixed costs typically include costs that do not change with patient numbers in the short term. In digital interventions, this can include ongoing development of the product and its content, as well as costs related to digital infrastructure and hardware maintenance (Khan et al., 2024). In some cases, also ongoing third-party licences and workforce is required. Additionally, resources may need to be allocated to change management throughout the intervention's lifespan, including developing and updating guidelines, or organizing staff training.

In this analysis, most of the fixed costs like administrative costs, facility rents and equipment such as computers, were considered to be the same for each intervention. Neuropsychologists manage NP-DCP patients as part of their regular working day at the hospital. These costs were therefore assumed to offset each other and were not included in the calculation. In fact, the specific costs on a single intervention would not have been easily separable from the costing model used in the financial department.

The NP-DCP had additional fixed costs compared with face-to-face rehabilitation. The first of the additional costs was the ongoing 15 % share of the product manager neuropsychologist's work time dedicated to continuous development and management of the NP-DCP (904 €, salary including paid social insurance contributions). This includes updating the content based on collected patient feedback, but also developing guidelines for the clinician team.

The second additional cost consisted of an annual payment from the clinical unit to the IT-department covering continuous maintenance and development of all digital care pathways used in the clinical unit. This annual cost was divided by the current number of digital care pathways to estimate the NP-DCP's share (approximately 3243 € in 2025). The annual payments are allocated to clinical units based on the total number of digital care pathways and their utilization rate, in a way that units with a larger number of actively used digital care pathways benefit, while units with only a few pathways and limited number of patients pay higher average costs. A more detailed allocation formula for this could not be obtained. This annual payment may vary slightly, but was seen as relatively stable from year to year given the proportion of a single digital care pathway.

These two costs in total (904 + 3243 = 4147 €) were divided by the number of patients who completed the NP-DCP in 2024 (n = 100). Therefore, an additional fixed-cost estimate of 41 € per patient for the NP-DCP, compared with face-to-face rehabilitation is presented in table 4.1.

4.1.3. Variable costs

Variable costs change with patient numbers, one example being personnel costs arising from clinician involvement. This category can also include partially variable costs like maintenance, implementation and technical support, which may increase stepwise as the patient volume grows (Khan et al., 2024).

In this analysis, the variable costs included the clinician time spent per patient by a neuropsychologist. In face-to-face rehabilitation, time spent on preparation, the appointment itself and documentation was included. On average, clinicians used 88 minutes per appointment in total, ranging from 70 to 120 minutes. Time use varied depending on the nature of the appointment, as for example first meetings with the patient were reported to take more time due to familiarisation with patient information and planning of the rehabilitation. Based on the

product manager neuropsychologist's clinical estimate, the content of the NP-DCP corresponds to an average of six face-to-face appointments. The corresponding face-to-face rehabilitation would therefore be 528 minutes per patient in average.

In the NP-DCP, clinician time consists of monitoring and commenting on the patient's progress, answering their possible questions and documentation to the patient records at start and end of the pathway. On average, clinicians used 50 minutes per patient in total from start to finish, ranging from 25 to 110 minutes. Time use depended mostly on how active the patient was in messaging and asking questions.

The cost per hour was calculated based on the current average neuropsychologist salary (4651 € per month) and social insurance contributions paid in 2025 (an additional 20 % of salary). This results in an hourly clinician cost of 34 €. When comparing the two interventions, 528 minutes per patient in face-to-face rehabilitation corresponds to 299 € in clinician time, while 50 minutes per patient in the NP-DCP corresponds to 28 €, resulting to a cost difference of 271 € per patient. This comparison is presented in table 4.1.

4.1.4. Cost estimates per patient

Table 4.1. Breakdown of estimated costs per patient.

Costs per patient (when n=100, based on treated NP-DCP patients in 2024)	**NP-DCP**	**Traditional face-to-face rehabilitation**
Investment costs		
Content development, 2 months of work time	112 €	none
Other investment costs	marginal	none
Fixed costs		
Product manager, 15 % of work time	9 €	none
Annual IT-payment	32 €	none
Other fixed costs (offset each other)		
Variable costs		
Clinician time, 34 € / hour	28 € (50 min)	299 € (528 min, 6 appointm.)
Total cost on 1. year when including development costs	**181 €**	**299 €**
Total continuous cost	**69 €**	**299 €**

All estimated costs per patient, divided into cost-types, are presented in Table 4.1. Costs are calculated assuming 100 patients treated per year, which was the number of patients treated through the NP-DCP in 2024. The number of appointments used for the face-to-face intervention is based on clinicians' estimate that six appointments correspond to the content of the digital care pathway. Total costs per patient are presented both with and without investment costs, as the relatively small development cost can be assumed to be offset in one year. The total continuous cost difference per patient when comparing the NP-DCP and six face-to-face appointments is 230 € (299 € - 69 €).

The correspondence to six face-to-face appointments in average is a clinical estimate. The number of appointments may vary in clinical practice based on patient needs. In cases of mild cognitive symptoms and fast recovery, the guidance needed may be delivered in fewer appointments. The effect of reducing the number of face-to-face appointments in the comparison is presented in figure 4.1. One appointment cost 50 € in clinician time (88 minutes). Therefore, even two face-to-face appointments per patient would exceed the average total cost of the NP-DCP (100 € - 69 € = 31 €).

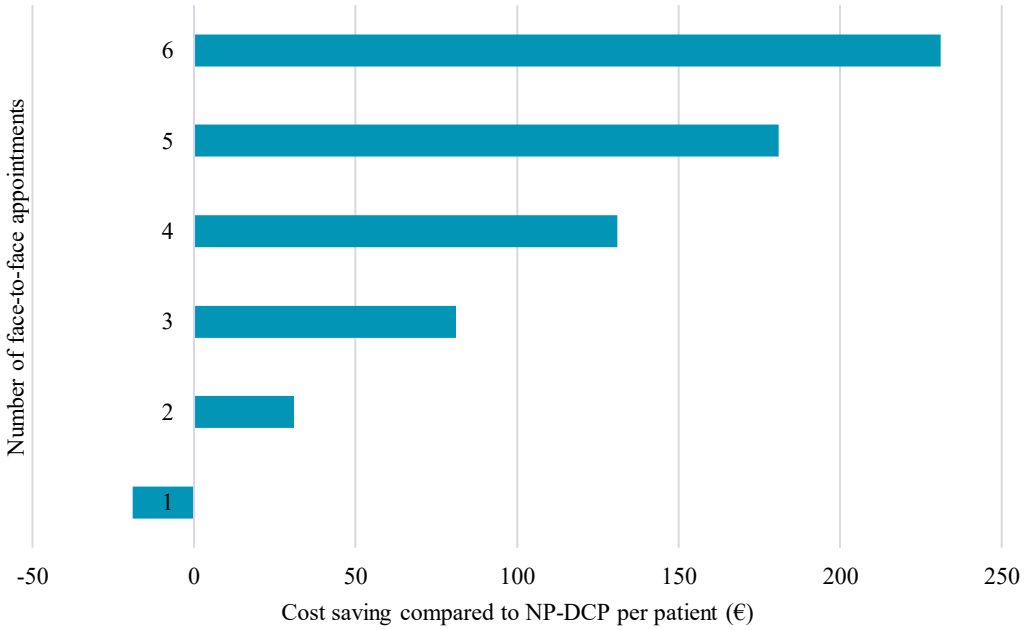


Figure 4.1. Cost difference between interventions per patient, based on the number of face-to-face appointments.

To demonstrate the effect of potential changes in the continuous costs of the NP-DCP, cost increases by percentage are presented in table 4.2. The increase in cost could reflect work regarding management and development of the product, increased costs of IT services, increase of salaries or additional clinician time spent supporting patients on the digital care pathway. If all cost categories increased to 200% the total cost per patient would be 138 €, which is still lower than 299 € for the corresponding face-to-face intervention. The NP-DCP could, in fact, remain cost beneficial until the point of its costs increasing to 200%, even if the number of corresponding face-to-face appointments were reduced to three per patient (150 €). However, in this scenario, to provide an equivalent amount of psychoeducation in three appointments could be challenging.

Table 4.2. The effect of percentage changes in the continuous costs of the NP-DCP per patient.

	Product management	IT-support	Clinician time	Total costs
100 %	9,00 €	32,00 €	28,00 €	69,00 €
110 %	9,90 €	35,20 €	30,80 €	75,90 €
120 %	10,80 €	38,40 €	33,60 €	82,80 €
130 %	11,70 €	41,60 €	36,40 €	89,70 €
140 %	12,60 €	44,80 €	39,20 €	96,60 €
150 %	13,50 €	48,00 €	42,00 €	103,50 €
160 %	14,40 €	51,20 €	44,80 €	110,40 €
170 %	15,30 €	54,40 €	47,60 €	117,30 €
180 %	16,20 €	57,60 €	50,40 €	124,20 €
190 %	17,10 €	60,80 €	53,20 €	131,10 €
200 %	18,00 €	64,00 €	56,00 €	138,00 €

4.1.5. Annual cost estimates

In 2024, with 100 patients completing the NP-DCP, the cost difference was 299 € for face-to-face rehabilitation compared with 69 € for the NP-CDP, resulting in a difference of 230 € per patient. To estimate the annual cost saving in 2024, this difference was multiplied by the 100 patients who completed the NP-DCP that year. This yields an estimation of 23 000 € annual savings when the NP-DCP is used with suitable patients, replacing traditional face-to-face rehabilitation appointments.

To reach the patient volume at which the NP-DCP becomes cost-favourable, only 16 suitable patients would need to be referred to the digital care pathway instead of face-to-face

rehabilitation. Sensitivity analysis was used to estimate how the annual cost difference changes across different plausible patient volumes. The results are shown in figure 4.2. If reaching 500 patients per year in the NP-DCP, the annual cost saving is estimated to be 131 288 €. The cumulative cost saving estimates by growing patient volume are presented in figure 4.3.

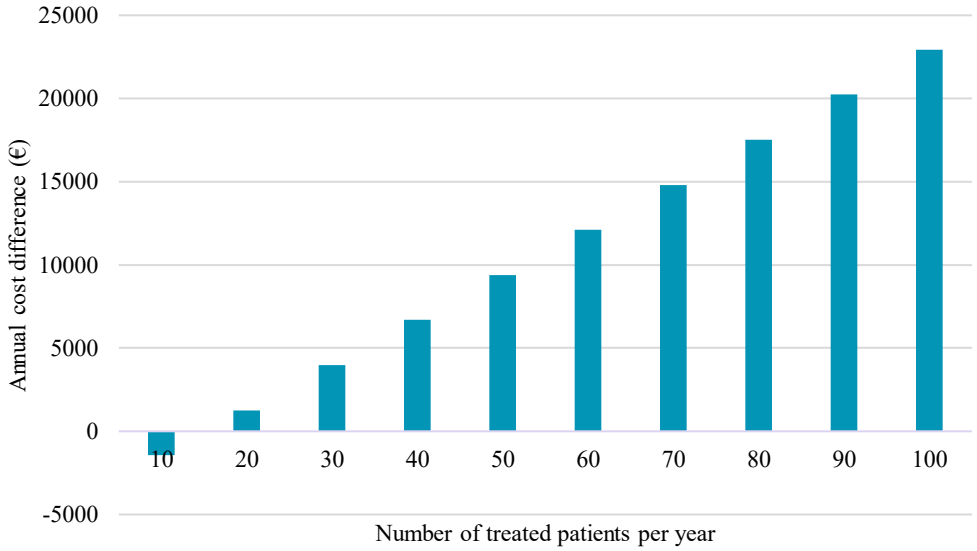


Figure 4.2. Annual cost difference when treating patients through the NP-DCP compared with the corresponding face-to-face intervention, by number of treated patients.

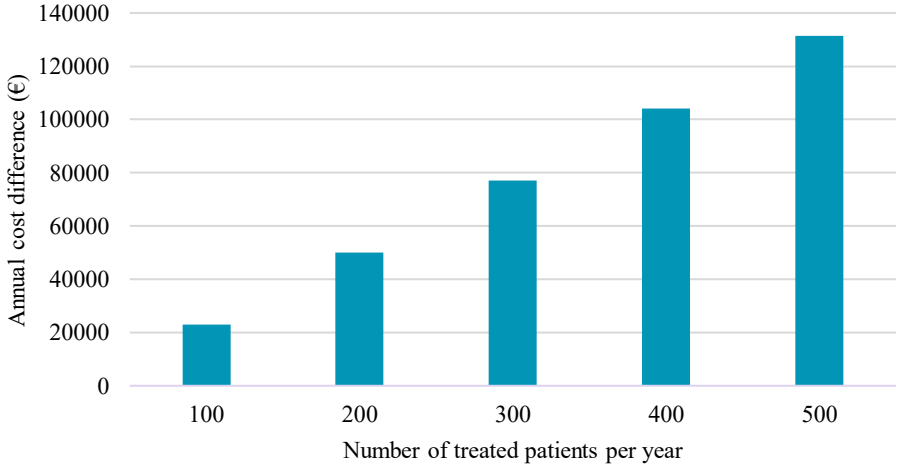


Figure 4.3. Annual cost difference when treating patients through the NP-DCP compared with the corresponding face-to-face intervention, by number of treated patients. Possible growth in patient numbers demonstrated.

4.2. Organizational readiness

4.2.1. Current limitations

The data collection phase and further discussions with representatives revealed several limitations in the availability and structure of organizational data. This currently prevents the production of fully reliable and real-time cost calculations at the level of specific interventions.

A significant data gap concerned clinicians' total time used per patient on different interventions. Cost of clinician's time has a significant role in defining the cost of an intervention and is required when conducting a comparison of total costs. According to clinicians, the neuropsychology unit has a standardized practice of registering only the time spent directly with a patient to the electronic health record system. The total time used outside the appointment, like preparing and writing reports, is not included. Regarding the digital care pathways, clinician time is not recorded in any form. Although it is technically possible to register the total time used per patient in the electronic health record system, clinical practices seem to limit the collection of real time accurate cost data. Since this information was not routinely registered in clinical practice, a sample data was collected specifically for this study to get an estimation of total clinician time per intervention.

In routine clinical work, cost information can however be a distant topic. Clinicians must focus on clinical decision making and to help the patient in best possible way, while the financial consequences of care are managed elsewhere. Based on the discussions with clinicians, practices in registering work are often learned informally by colleagues, rules may be interpreted differently across units, and the purpose of structured documentation is not fully communicated. If clinicians and managers have no deeper understanding on who uses the data, in what way it affects funding, planning, and monitoring, registering can become a minimal compliance task.

To conduct a true cost analysis would require including all relevant costs regarding the interventions. Cost per unit -information was accessible through the financial department, consisting of estimated costs for intervention types based on a costing model used in the organization. However, the original numbers of allocated resources could not be separated from the costing model to specify or compare partial costs. Further discussions with the financial representatives clarified that some fixed costs, like facility and administrative costs, have been

allocated evenly across interventions through the costing model. A more detailed breakdown of for example facility costs would require defining all the facility utilisation and estimating how much time a single patient contact uses in a specific space, which is not realistic in this context. Registering the total time used by a clinician was considered also helpful in allocating other partial costs more precisely. It was concluded, however, that given the size of the organisation, a more granular allocation of costs would likely require changes to existing information systems.

The total investment costs for the NP-DCP also turned out to be challenging to obtain. Typically, investment costs would be essential to include in a cost analysis to estimate when the programme becomes profitable and the investment is recovered. However, the NP-DCP is part of a much broader digital platform and innovation, internally developed within the public sector. Discussions with the product managers and financial representatives revealed, that separating costs at the level of a single digital care pathway has not been considered necessary in this organizational context. Since the digital care pathway platform is a previously developed national service, the IT-related development work is included in a continuous annual payment to the IT-department based on the number of digital care pathways in use in the clinical unit. In this case the one-time payment investment costs remain marginal, which supports the decision to not routinely register them as a separate cost in the financial department. The specific formula used for allocating the annual IT-service payment to clinical units could not be obtained, limiting also the accuracy of fixed cost allocation.

Overall, these limitations demonstrate a gap in precise intervention-level cost data and highlight the need to develop more systematic practices. Limitations hinder the inclusion of total cost per unit in comparative analyses, since the cost structure can't be explicitly understood or transparently presented.

4.2.2. Future suggestions

To enable more precise and intervention-specific cost analyses in the future, improvements in data availability and organizational practices would be needed. Suggestions for practices, but also for adopting a culture of cost awareness are presented and gathered in table 4.3.

First, routine registering of the total clinician time use per patient should be implemented to the daily practice. Clinician time is a key driver of variable costs in comparative analyses

and one of the largest components of total service expenditure in this practice. The electronic health record already includes a technical functionality to register time used, and there's a routine of registering in the clinical practice. Regarding face-to-face appointments, the change required would be to register the total time used including preparing and reporting outside the appointment, instead of only the minutes spent with the patient. For the NP-DCP, this routine would need to be added, possibly leading to additional administrative work for the clinicians. The main barrier can be related to breaking routinely used processes when implementing changes to clinical practice, facing possible resistance to change. Another barrier was brought up by the financial representatives. A change in registering would also require adapting calculations in the financial practices, to note the change in practices when conducting annual comparisons. In conclusion, supported by clear guidelines enabling integration into daily workflows and in communication with the financial department, time registering could provide a basis for comparing true costs per intervention. This serves as an effective management tool, enabling closer examination of operations.

To support accurate documentation as part of good clinical practice, cost awareness could be strengthened by making the cost logic of clinical work more transparent with concrete educational sessions with the clinicians and managers. Targeted education could cover what is recorded, where it is recorded, and how these data are later used by finance teams, operational management, and service planners in this organizational context. Clinicians could then continue to receive annual summaries of key activity and cost indicators presented in a way that is understandable and clinically meaningful, accompanied with clarifying the registering guidelines and resolving recurring problems. Over time, integrating these practices can help establish cost awareness as a normal part of service development, rather than as a separate financial exercise.

Second, costing model transparency could be developed in the financial department to ensure that fixed costs, such as IT-service payments, administrative expenses and facility costs, can be traced. A more specific allocation model would allow more accurate evaluation of cost differences between digital and traditional interventions. The latter, however, could require massive changes to information systems and clinical registering practices.

Third, investment-related costs should be estimated and identifiable also retrospectively, staying transparent to the paying clinical units. This would require implementing a transparent

method for recording and distributing investment expenses in the IT-department, such as development work and platform updates together with depreciation schedules. Including depreciation in cost calculations is relevant, as it enables evaluations of when an intervention becomes cost-neutral and this way allows to better assess the long-term financial effects of the digital care pathway.

Together, these improvements would strengthen cost awareness and the organization's readiness for real-time cost monitoring. Change require effort and investing time but could create a better foundation for future economic evaluations for digital interventions.

Table 4.3. Suggestions for organizational improvements

Development suggestion	Benefit
Implement routine registration of total clinician time use per patient (including preparation and reporting) for both interventions.	Provides a more accurate basis for intervention-specific cost comparisons, because clinician time is a major component of total service expenditure.
Strengthen cost awareness by making the cost logic of clinical work transparent (e.g., targeted educational sessions on what is recorded, where, and how the data is used).	Improves documentation quality and consistency by helping clinicians understand the purpose and use of registered data, supporting cost awareness as part of service development.
Increase transparency in the costing model so fixed costs (e.g., IT payments, administrative and facility costs) can be traced and allocated more specifically.	Enables more accurate evaluation of cost differences between interventions by making fixed cost components identifiable and traceable.
Make IT costs identifiable retrospectively and transparent to clinical units (including a method for recording investment, development and platform update costs, with depreciation schedules).	Supports long-term financial evaluation by including depreciation and clarifying the long-term effects of development costs.

5. Conclusion

5.1. Discussion

The primary purpose of this mixed-evidence case study was to conduct a cost analysis demonstrating the cost-efficiency of the NP-DCP, a web-based rehabilitation programme for stroke patients with mild-to-moderate cognitive difficulties. The results showed that the web-based programme is highly cost-efficient for the health care provider. This aligns with expectations based on prior literature, where telerehabilitation has been recognized as a cost-effective and even cost-saving approach for large populations across various clinical conditions (Baffert et al., 2023; Del Pino et al., 2022; Grigorovich et al., 2022). The findings can be used to inform organizational decision-making by supporting budgeting and resource planning, highlighting the factors that drive costs, and helping to prioritise development efforts.

With current patient numbers, the total cost difference per patient compared with corresponding six face-to-face appointments was 230 €. This yielded an estimated annual saving of 23 000 € when the NP-DCP replaces traditional face-to-face rehabilitation for suitable patients. In continuous costs, the NP-DCP becomes cost-favourable with only 16 suitable patients treated per year. The estimates were presented without depreciations because in this organizational context one time investment costs for the digital care pathway were marginal.

The estimated cost difference between interventions is markable. A web-based psychoeducational programme as an intervention type has advantages compared with many other remote therapies, strengthening the potential to achieve cost-efficiency. The largest difference in cost appears to be the clinician time per patient, as the programme relies strongly on patients' independent but supported learning. This study indicated the clinician time difference to be 50 minutes for the NP-DCP compared to 528 minutes for a traditional face-to-face intervention. In addition, as a web-based programme does not require additional devices for either the clinician or the patient, hardware expenditures are minimized while maintaining accessibility and scalability.

The more patients are referred to the NP-DCP instead of traditional rehabilitation, the more cost-efficient the programme becomes. If the NP-DCP reaches 500 patients per year, the cost saving is estimated to be 131 288 € annually. Increasing the volume could enable additional savings to the health care provider, for example if some clinicians have enough NP-DCP

patients to work remotely part of the week, allowing more efficient use of hospital facilities. Given that the NP-DCP is a nationwide service in Finland, broader adoption across regions and clinical units is possible. Ongoing attempts to productise the NP-DCP for wider use across Finland may increase referrals in regions where digital pathways are currently underutilised, bring additional income, and help to develop service capacity. Tailored pathways could also enable expansions for other patient groups, such as MS or brain tumour patients, to deliver efficient rehabilitation.

It is relevant to note that the threshold for referring patients to digital care pathways may be lower than for traditional care, which can increase the overall number of patients treated. Increased accessibility can therefore increase service utilization and raise short-term costs (Snoswell et al., 2021). However, without the NP-DCP, patients would remain on waiting lists for longer and could not receive timely support due to limited clinical capacity. According to the product manager, this was the situation before implementation of the digital care pathway. It is now possible to treat a larger number of patients with the same resources, whereas treating all patients through face-to-face appointments would not be feasible. By enabling neuropsychologists to support patients efficiently through the NP-DCP, earlier and more scalable support can improve patients' daily functioning and support recovery. This, in turn, can translate into improved efficiency from a broader societal perspective via reduced subsequent health care service utilization and improved work ability.

In web-based programmes, there is always a risk of patient dropout, even if adherence to the NP-DCP is comparable or higher than in similar programmes (Vuori et al., 2025). Not all referred patients complete the digital care pathway, which can affect cost-effectiveness. On the other hand, clinician time use is also lower when a patient does not proceed on the pathway. Potential reasons for dropout may include the patient no longer feeling a need for support, finding the digital care pathway difficult to use, or not experiencing the content as helpful. This highlights the need for targeted referral to the NP-DCP. The current programme has been developed for stroke patients with mild-to-moderate cognitive difficulties in the subacute stage of recovery. This means that the usability may be reduced for patients with more severe cognitive symptoms, and for other aetiologies the content might feel less relevant or off target. Also, the patient's motivation is crucial since the programme requires independent initiating and learning.

A registry study has shown that some patients are referred to both the NP-DCP and face-to-face rehabilitation (Vuori et al., 2025). However, these patients had the highest dropout rate, suggesting that the two methods may be experienced as overlapping. When the effectiveness of the interventions is considered equivalent, it is not cost-effective to use the NP-DCP as additive to traditional rehabilitation. In practice, before making a referral, clinicians should carefully weigh whether the patient is likely to benefit sufficiently from the NP-DCP or whether traditional rehabilitation is needed instead, in order to choose between the two. Better targeting overall could reduce the dropout rate and strengthen cost-effectiveness.

An avenue for further development is whether additional parts of the NP-DCP could be automated through rule-based functions or AI-assisted responses. Routine tasks, such as registering to the electronic health record system and responding to frequently asked questions may be partly suitable to automation, improving efficiency. Tasks requiring clinical judgement should remain with the clinician, as a key driver of the NP-DCP's effectiveness is that it enables a direct connection to a clinician, allowing patients to communicate with a psychologist and receive personalised support. Safe automation could reduce marginal clinician time per patient and alter the cost structure, whereas AI solutions may markedly increase fixed costs related to development, validation and monitoring. From a provider perspective, these trade-offs should be considered in future cost evaluations.

5.2. Limitations

The analysis has limitations related to the retrospective and organisation-specific nature of the data. Some relevant cost drivers could not be traced at a sufficiently detailed level, which reduced the precision of the unit-cost estimates because not all cost components could be included. In addition, some one-time investment costs could not be quantified, meaning that the case may underestimate implementation costs. Sensitivity analyses were used to illustrate to some extent, how conclusions depend on changing factors and assumptions. Qualitative information used for the development suggestions was synthesised descriptively from discussions without a formal coding protocol, which limits reproducibility but fits the pragmatic purpose of the qualitative component in this case study.

Several constraints were identified in the organization regarding the availability of cost data during data collection and later discussions with organisational representatives. The additional

purpose of this study was to describe the constraints limiting the cost calculations and provide suggestions for the future. In particular, clinicians' total time per patient was not fully registered to the electronic health record system, which is why sample data was collected for the analysis. The sample remained quite small, limiting the accuracy of the estimates. In addition, the original costs of all allocated resources could not be separated within the costing model used by the financial department, limiting the ability to specify or compare partial costs. Finally, IT-related development work was included in a continuous annual payment, from which specific costs could not be separated and communicated to the paying units. Collectively, these limitations demonstrate a gap in precise intervention-level cost data and highlight the need to develop more systematic practices. As a result, suggestions related to clinician practices and strengthening a culture of cost awareness to improve the accuracy of time data were presented, as well as recommendations to increase specificity and transparency of the costing model.

The study is a costs-only analysis from the health care provider's perspective and therefore does not constitute a full economic evaluation (Gomes et al., 2022). The analysis examines resource use and costs, but does not include broader benefits for the patient, such as clinical outcomes, quality of life, patient time and travel costs, or wider system-level consequences, such as effects on capacity and waiting times. This means that the findings are interpreted as a description of the cost structure rather than as evidence of overall value for money. If the NP-DCP brings additional benefits, a costs-only comparison may underestimate its net value. On the other hand, if effectiveness differs between intervention types, cost results alone can overestimate value.

As a cost-minimization analysis, the comparison is based on the assumption that clinical outcomes for suitable patients are broadly comparable between the NP-DCP and face-to-face rehabilitation. The NP-DCP has been reported to be accepted and usable among stroke patients, and adherence to the programme was comparable or higher than in other web-based interventions (Vuori et al., 2025). Also, the effectiveness of HUS-iCBT programmes delivered on the same platform for psychiatric disorders has already been plausibly demonstrated (Ritola et al., 2022; Rosenström et al., 2025; Stenberg et al., 2022). Even with plausible evidence from similar interventions supporting the assumption of equal outcomes, it remains uncertain whether the consequences are truly identical between the interventions in question. Could patients benefit more from personalized face-to-face rehabilitation, or might the NP-DCP in fact provide more information and options to work with? An ongoing project at HUS is studying

the effectiveness of the NP-DCP to address these questions. If effectiveness, adherence, or patient selection differ in practice, differences in cost alone are not sufficient to determine value and a full cost-effectiveness approach would be needed.

The cost difference calculated in this study reflects a context in which the digital care pathway was built on an existing platform and supported internally by the IT-department. Typically, in digital interventions the cost profile consists of relatively high fixed development and implementation costs, but low costs for additional users. Consequently, average costs decrease and potential efficiency improve as utilisation and scale increase (Gomes et al., 2022). In settings where such infrastructure is not yet available, investment costs and required technical capacity would need to be carefully evaluated before implementation to determine the cost-efficiency of a similar programme in that specific context.

In conclusion, the NP-DCP can be considered an original programme in its category, and to date there are no studies on costs of corresponding interventions (Vuori et al., 2023). This study lays the groundwork and can serve as an initial reference point for subsequent research. Beyond the case organisation, the results provide a practical template and baseline assumptions of similar digital interventions. However, further comparative research on effectiveness is needed. With robust evidence on clinical outcomes and better availability of cost data, it would be possible to conduct a full cost-effectiveness or cost-utility analysis and determine the true value of digital care pathways in neuropsychological rehabilitation.

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