

Stroke Rehabilitation Care Pathway Informed by Time-Driven Activity-Based Costing

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Research Article

Keywords: Stroke, costs, value, telerehabilitation, TDABC, home care, rehabilitation, adults

Posted Date: September 30th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-10834227/v1>

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Additional Declarations: No competing interests reported.

Abstract

Background: Stroke is still the leading global cause of mortality and morbidity. To address its social and financial burden, the Early Supported Discharge Program (ESD) can be an effective in addition to telerehabilitation. While evidence supports this approach, limited knowledge exists regarding the cost of such interventions relative to the potential benefits. Leveraging the principles of value-based healthcare, Time-Driven Activity-Based costing (TDABC) is a method used to estimate the costs of healthcare resources. The aim of this study was to use the TDABC in estimating the costs of the ESD program, before and after the introduction of virtual healthcare during the COVID-19 pandemic.

Methods: Participants in this pre-post study included patients and the interdisciplinary clinical team. The TDABC approach was used through five key steps: 1) mapping of care pathways, 2) estimating the duration of interventions, 3) determining clinicians' practical capacity, 4) estimating the unit costs, and 4) determining the overall and per patient cost of care pathway. Data sources included administrative data on clinical teams' salaries, indirect costs, clinical data and dashboard data. Descriptive data analysis of sociodemographic, clinical characteristics and estimation of costs per patient and trajectory were conducted.

Results: In total, 108 patients, predominantly men (51%), aged 76 and over (46%), received rehabilitation services in 2019–2021. A large proportion of participants sustained an ischemic stroke (84%). Virtual healthcare represented 48 % of care from total direct services in 2020-2021. The average total time of interventions per patient increased from 4,299.8 minutes in 2019/2020 to 7,115.3 minutes in 2020/2021, leading to a direct cost per patient of \$4,048.96 and \$6511.68, respectively. The total cost of the ESD program was higher in 2020/2021 (\$7,301.03) compared 2019/2020 (\$4,782.78). Across the two time periods, the average age at admission increased, whereas patients' level of independence at admission declined.

Conclusions: TDABC is an informative and feasible cost modelling methodology for programs such as ESD within a continuum of care integrating telerehabilitation. As a value-based healthcare approach, its application provides a framework to identify process improvements for rehabilitation services in ESD programs.

BACKGROUND

Stroke is among the leading causes of mortality and long-term disability worldwide. Each year, approximately 12 million people experience a new stroke worldwide, and the economic burden of stroke exceeds USD \$721 billion annually, representing approximately 0.66% of global GDP.^{1–5} The access to stroke rehabilitation services remains disproportionately distributed, with stroke-related inequalities persisting over time.^{6, 7} For instance, over half of Canadians with a disability who require rehabilitation care cannot access the health and social services they need.⁸ The social and financial burden of stroke is substantial, especially for women, older adults, individuals living in rural and remote areas, and people

from ethnic and racial minorities.^{7, 9–12} The stroke burden is expected to increase due to demographic and epidemiological changes related to aging and comorbidities¹³. Stroke survivors often experience activity limitations, impairments and restrictions that adversely impact their quality of life and well-being, leading to an increased demand for rehabilitation services¹⁴ and for substantial support and time from informal caregivers.¹⁵

According to the global estimates for rehabilitation needs, approximately one in three people could benefit from rehabilitation at least once during their illness or injury.¹⁴ Addressing the complex care needs of individuals with stroke conditions and the suboptimal access to rehabilitation requires interdisciplinary collaboration,^{16, 17} as well as innovative approaches to optimize healthcare and rehabilitation services^{18, 23} and to enhance patients' value while maintaining or minimizing costs.¹⁹ Effective and timely access to rehabilitation can be achieved through community-based rehabilitation,²⁰ home-based rehabilitation care,^{20, 21} integrated rehabilitation care,¹⁹ and digital health services such as telerehabilitation^{22, 23}. The approaches promote evidence-based practices and patient-centred care^{24–26} by improving quality of care and addressing individual needs early, thereby reducing treatment delays, hospitalization duration, and readmissions, as well as improving patient-reported outcomes.^{27–29}

The Clinical pathways (CPWs) are structured to meet individual needs,³⁰ ensuring the right intensity of rehabilitation is provided at the right time and place.^{31, 32} The COVID-19 pandemic has accelerated the adoption of telehealth and the integration of telerehabilitation in CPWs.^{6, 33} These pathways are usually initiated at the time of admission and ended when the patient is discharged or transferred to another setting.³⁴ CPWs can also improve the efficiency of discharge planning, resulting in many indirect and opportunity costs savings.³⁴ Indeed, early supported discharge (ESD) post-stroke provides intensive rehabilitation to stroke survivors at home or within the community.^{35, 30, 36} Authors of Cochrane reviews on ESD have reported improvements in patients' recovery, including reduced hospital stays length, decreased long-term dependency, and lower admission rates to institutional care,^{20, 37} while also increasing patients' satisfaction and quality of life.^{20, 37} However, evidence regarding the cost-effectiveness of CPWs³⁸ and the ESD post-stroke is inconsistent,³⁷ resulting in a major challenge for its implementation and sustainability.

There is limited evidence demonstrating the costs associated with delivering ESD rehabilitation to stroke survivors via telerehabilitation.^{39, 40} Traditional economic analyses, such as activity-based financing (ABF),⁴¹ patient oriented financing,⁴² or cost-minimization, cost-benefit, cost-utility, and cost-effectiveness analyses,^{43, 44, 45, 46, 44, 47} have been found to be relevant but insufficient to provide accurate insights on the care pathway-related costs; consequently, such analyses are inadequate to support decision-making for care pathway optimization.^{48, 49}

To address this challenge, Kaplan and Anderson⁵⁰ introduced the Time-Driven Activity-Based Costing (TDABC) approach, which aims to maximize the value of care delivered to patients.^{48, 49} The use of this

method of estimating both direct and indirect healthcare costs provides an opportunity to obtain precise information on the costs and benefits of healthcare services^{51, 52,53} and, consequently, to explore optimum resource allocation strategies.^{54, 55} TDABC can be used to accurately describe the costs associated with the management of a patient with a specific disease, while supporting the process of controlling these costs. This method is used for estimating resource utilization and costs associated with different implementation strategies and their individual components.⁵⁶ It can be particularly useful for comparing the cost of a trajectory for a profile of patients with a given pathology,⁵⁷ the costs of two treatments for the same disease, or to calculate the cost of services associated with a given health sector or department.⁵⁸ By simplifying the calculation of the cost of care trajectories, TDABC enables healthcare professionals to better understand these trajectories and the costs of the inherent activities.^{59, 60} Some research has been carried out on the use of TDABC in hospitals or for specific pathologies.^{51, 53, 61, 62} The authors of a literature review on the use of TDABC in healthcare⁶¹ have indicated that TDABC had mainly been used in surgical and cancerology departments.^{54, 63}

However, there is limited literature on the implementation of TDABC in rehabilitation. In a study carried out in France on the application of the TDABC method to the trajectory of stroke patients, the authors confirmed the relevance of this method for the care of chronic diseases such as ischemic stroke.⁵⁷ The authors noted the importance of strong collaboration between the different healthcare professionals involved throughout the CPW, and the complexity of applying TDABC in a context of heterogeneous user profiles and multiple care pathways.⁵⁷ Another study that adopted the TDABC method for ambulatory patients showed a discrepancy between the different disciplines⁶⁴ in the costs of rehabilitation activities for these patients. For example, the cost of occupational therapy (OT) services was higher than that of speech therapy services.⁶⁴ The authors concluded that TDABC, by considering the diversity of human resources and potential variations in costs, could help to identify cost patterns, improve the efficient management of services, and ensure the provision of affordable rehabilitation services.

To our knowledge, TDABC has not yet been used to analyze the costs of an ESD program within a stroke continuum. In addressing this gap, this study aims to use TDABC in estimating the costs of an ESD program care pathway, applied both before and after the introduction of telerehabilitation (Hybrid approach) during the COVID-2019 pandemic. More specifically, this study has three objectives:

1. Describe the sociodemographic profile of the clientele receiving services within the ESD program (before and after the integration of telerehabilitation);
2. Analyze the applicability of the TDABC method in this program for cost modelling;
3. Compare the costs of the care trajectory with and without telerehabilitation, as well as the average costs of a patient before and during the COVID-19 pandemic.

Adequate knowledge of the costs of the care trajectory using TDABC will inform whether and at what level, rehabilitation care can be optimized, and to analyze its impacts on patient care through better management of time.^{59, 65}

1. Methods

2.1 Settings

This study was conducted in an ESD program in a Quebec healthcare region.⁶⁶ The program serves adults with a diagnosis of mild to moderate stroke, living within the health region territory. Rehabilitation care is delivered by an interdisciplinary team working in coordination with the hospital environment, community programs and other rehabilitation centres..⁶⁷ The ESD program targets patients with mild or moderate disability and includes an average of four weeks functional intensive rehabilitation at home.

The ESD program is designed to reduce hospital readmissions, facilitate professional referrals, and enhance communication and coordination among clinical teams. In addition, its implementation required a shared commitment to rehabilitation outcomes and adherence to evidence-based practices.

Health professions in the program include Nursing, Physical therapy (PT), Occupational therapy (OT), Social work, Speech language pathologists, and Special care counsellor. The team also includes a clinical coordinator, clinical team manager who oversees several other clinical programs, and an administrative agent. During the COVID-19 pandemic, virtual healthcare was introduced into the ESD program to ensure access and continuity of rehabilitation care.

2.2 Study design

This study uses a pre-post, prospective and comparative design. We evaluated costs of care related to the provision of ESD rehabilitation services between April 2019 and March 2021. Hybrid modality, the provision of in-person care and telerehabilitation, was implemented in April 2020 until March 2021. This economic assessment was performed from a health system point of view. This means that costs incurred by patients were not considered. Moreover, the costs associated with the technology used were assumed by the healthcare settings.

2.3 Data collection

Participants

Patients receiving care in the ESD program, and clinicians and managers delivering that care.

Data sources: The databases included: i) administrative with data from the financial department on clinical teams' salaries ; ii) clinical administrative data coding therapeutic interventions (direct in the presence of patients, and indirect in the absence of patients); non-therapeutic interventions (e.g., clinical meetings, training hours). Since the clinical coordinator was an occupational therapist, responsible for both therapeutic activities and coordinating roles, all intervention time was recorded under OT.; iii) other expenses such as travel costs, equipment and supplies; and iv) dashboard data collected in excel from the clinical teams, including patient sociodemographic data, and patients' clinical profiles such as

Functional Independence Measure (FIM), best practices indicators,⁷¹ length of stay, and referral to other community programs.

TDABC to the ESD program

According to the TDABC approach, the execution time to perform each of clinical activities and the identification of human resources (e.g., health professionals, clinical coordinator) who execute them as well as the indirect costs are all relevant to document. Indirect costs include expenses related to travel, training and supplies. In previous work there has been inconsistency in the steps used to apply TDABC.^{72–75}, and there is not a consensus on the optimal approach. In this study, five steps were performed

1. Mapping of patients' care pathways: This step included planning the patient's care process and reporting all the activities the patient must go through to complete the care trajectory. Then it was necessary to break each activity down into tasks or sub-activities and to identify the various resource groups needed to execute each activity. The mapping was codesigned with the clinical team. The manager and the clinical coordinator also identified the resources responsible for each of the trajectory's activities and sub-activities.
2. Estimating the duration of interventions: Information on the duration of interventions was provided by the ESD program's manager and the clinical coordinator. Health professionals used predefined codes to indicate the nature of clinical activities performed and the duration of their interventions for each patient. Direct clinical services are those offered in the presence of the patient. Indirect clinical services include activities offered in the patient's absence and any activities contributing to the quality of care, travelling and home visits without the patient, record keeping and interdisciplinary team intervention planning, case discussion and communication related to the patient..
3. Determining average cost per clinician and per patient, including an estimation of the total cost of the various human resource groups; also, estimating each human resource group's practical capacity, or the actual time required to execute activities, and an estimation of the unit cost of each human resource group, calculated by dividing total costs by total practical capacity.
4. Assessing clinicians' practical capacity. Given the challenges to efficiently determine the time spent on the mapped trajectory activities, we used the time spent by each clinician and the number of patients treated to determine the average time per trajectory for each group of clinicians.
5. Calculating cost of the trajectory/ESD program, including the costs of other personnel who do not work directly on the care trajectories but are needed to execute the activities (e.g., administrative agent). Costs for medical supplies needed to deliver activities were also included in the cost of the trajectory. Estimating the cost per minute per patient per clinician is an important step in the TDABC process. Given the difficulty of determining the exact cost per patient of the services offered by each clinician, we have used an average of the weighting or practical capacity.

The coding of these activities was carried out in a more global way, and the mapping activities were often grouped together under a single code in the program database. We therefore had to regroup the mapping activities in the aforementioned five steps. The advantage of the coding system is the opportunity or ease of calculating the costs associated with each patient in the program and comparing them with the average cost of the mapping activities.

2.4 Data analysis

We carried out a descriptive analysis of data for three periods from 2019–2021: 1 April 2019 to 31 March 2021; 1 April 2019 to 31 March 2020; and 1 April 2020 to 31 March 2021. We described patients' sociodemographic and clinical process profiles using frequencies, proportions and average with standard deviation (Objective 1).

For objectives 2 and 3 (TDABC approach), data analysis included:

1. Mapping of activities: The mapping distinguishes between activities carried out both remotely, using telerehabilitation, and in-person activities. As the activities for both modes of intervention remain the same, with a temporal modification due to the need to travel, we have illustrated a single mapping. However, the duration of activities is spread over two different periods, from 1 April 2019 to 31 March 2020, and from 1 April 2020 to 31 March 2021.
2. Determination of frequencies by type of activity, as well as the number of minutes to perform each activity by health professionals after the first step on mapping of activities.
3. Calculating the cost per minute of human resources requires identifying the individuals working in the various groups and extracting their annual salary. This includes all benefits and payroll taxes paid by the facility. It was also possible to extract from the system the time worked by human resources, without overtime, and to deduct break times.
4. Clinician's practical ability: this step generally requires multiplying the average time for each of the mapped activities by the cost per minute of human resources. Since it was impossible to efficiently determine the time spent, we used the time spent by each of the health professional and the number of patients treated to determine the average time per trajectory for each type of health professionals.

Cost of ESD program with or without telerehabilitation: we considered different elements such as direct and indirect costs per patients. For the remaining staff working within the ESD program, who are more responsible for indirect tasks within the care trajectory, i.e. management, the total indirect salary, including benefits and social charges, was divided by the number of patients. As for travel, telecommunication, equipment and supply costs for all resources, the total amount was distributed over all patients in the trajectory.

3. Results

3.1 Patients' sociodemographic and clinical process profiles

As shown in Table 1, clinicians in the ESD program provided rehabilitation services to 108 patients for 110 events over the years 2019–2021 (54 events in 2019/2020 and 56 events in 2020/2021), with two patients having more than one admission to the program. Patients in this sample were predominantly aged 76 and over (2019/2020, 43%; 2020/2021, 50%), and approximately the same number of females (50% 2019/2020, 2020/2021, 48%). A large proportion of participants had experienced an ischemic stroke (2019/2020, 91%; 2020/2021, 78%), and some had a previous history of stroke (2019/2020, 28%; 2020/2021, 11%). Almost all respondents had a family caregiver (2019/2020, 98%; 2020/2021, 93%), often a criterion for admission to the ESD program. Many were discharged from the ESD program to the Adult Ambulatory Rehabilitation Services (SARCA) or rehabilitation services oriented toward the Social Integration (RAIS) program (2019/2020, 44%; 2020/2021, 48%).

Table 1
Patients' sociodemographic and clinical process characteristics per year

Variables	n (%)		
	All	2019–2020	2020–2021
Number of events	110	54	56
Number of patients	108	54	54
Age group at admission			
18 to 55	15 (14%)	7 (13%)	8 (14%)
56 to 75	44 (40%)	24 (44%)	20 (36%)
≥ 76	51 (46%)	23 (43%)	28 (50%)
Sex			
Female	54 (49%)	27 (50%)	27 (48%)
Male	56 (51%)	27 (50%)	29 (52%)
Language spoken			
English	67 (61%)	32 (59%)	35 (63%)
French	37 (34%)	16 (30%)	21 (37%)
Spanish	1 (1%)	1 (2%)	0 (0%)
Other	5 (4%)	5 (9%)	0 (0%)
Family support at home (e.g. Caregiver)			
Yes	105 (96%)	53 (98%)	52 (93%)
No	5 (4%)	1 (2%)	4 (7%)
Reported diagnosis			
Hemorrhagic stroke	15 (14%)	4 (7%)	11 (20%)
Ischemic stroke	93 (84%)	49 (91%)	44 (78%)
Subarachnoid hemorrhage	2 (2%)	1 (2%)	1 (2%)
Previous stroke			
Yes	21 (19%)	15 (28%)	6 (11%)
*SARCA- Service ambulatoire de réadaptation pour la clientèle adulte: Adult Ambulatory Rehabilitation Services;			
RAIS- Réadaptation axée sur l'intégration sociale (RAIS): Social Integration			

Variables	n (%)		
	All	2019–2020	2020–2021
No	89 (81%)	39 (72%)	50 (89%)
Goals at discharge			
Continuity of occupational work	3 (3%)	2 (4%)	1 (2%)
SARCA*/RAIS*	51 (46%)	24 (44%)	27 (48%)
SARCA/RAIS and part-time work	3 (3%)	0 (0%)	3 (5%)
SARCA/RAIS and school/education	1 (1%)	0 (0%)	1 (2%)
Other	52 (47%)	28 (52%)	24 (43%)
*SARCA- Service ambulatoire de réadaptation pour la clientèle adulte: Adult Ambulatory Rehabilitation Services;			
RAIS- Réadaptation axée sur l'intégration sociale (RAIS): Social Integration			

Average FIM scores (a standardised measure of disability) at admission and discharge were similar during both time periods (Table 2). The average number of emergency visits per participant was similar for the two periods (0.13 vs. 0.16). In 2020/2021, however, the average time between discharge from hospital and initial care at the ESD program was higher (2.5 days) compared to 2019/2020 (1.8 days). The average length of stay in the ESD program (less than 28 days) in both years was as recommended within the best practices.⁷¹ The average time before from the onset of stroke to receiving the first service (including the hospitalization time) was 15 days (2019/2021). However, this best practice was higher in 2020/2021 compared with 2019/2020 (17.4 vs. 12.8 days).

Table 2
Best practice indicators and clinical characteristics of ESD
participants, 2019–2020

Variables	All	2019–2020	2020–2021
Time between hospital center/regional hospital <center discharge and request (days)			
N	110	54	56
Mean (SD)	-0.21 (1.67)	-0.48 (1.61)	0.05 (1.69)
Time to ESD program (days) target 2 days			
N	110	54	56
Mean (SD)	2.1 (2.7)	1.8 (1.3)	2.5 (3.5)
ESD program length of stay (days) target < 28 days			
N	110	54	56
Mean (SD)	27.4 (7.8)	27.3 (6.8)	27.5 (8.6)
Number of emergency visits during ESD length of stay			
N	110	54	56
Mean (SD)	0.15 (0.40)	0.13 (0.34)	0.16 (0.46)
Time between stroke and first ESD program service (days)			
N	110	54	56
Mean (SD)	15.1 (12.1)	12.8 (10.4)	17.4 (13.3)
FIM total at admission			
N	106	54	52
Mean (SD)	98.9 (16.8)	101.6 (14.9)	96.1 (18.2)
FIM total at discharge			
N	104	54	50
Mean (SD)	110.2 (15.6)	111.4 (14.7)	108.9 (16.7)

Variables	All	2019–2020	2020–2021
Time between hospital center/regional hospital <center discharge and request (days)			
Delay between ESD discharge and SARCA programs (days) target 7 days			
N	32	18	14
Mean (SD)	29.8 (38.9)	11.6 (12.5)	53.3 (48.4)

Table 3A: Therapeutic and non-therapeutic (clinical) services (n=110 patients/events)

Variables	All	2019-2020	2020-2021
Clinical Activities			
Therapeutic services			
Number of services (%)	16,160 (100%)	6,452 (40%)	9,708 (60%)
Total time in minutes (%)	490,056 (100%)	192,501 (39%)	297,555 (61%)
Non-therapeutic services			
Number of services (%)	1,544 (100%)	566 (37%)	978 (63%)
Total time in minutes (%)	140,600 (100%)	39,690 (28%)	100,910 (72%)
Total of clinical activities	17,704 (100%)	7,018 (40%)	10,686 (60%)
Total time of clinical activities	630,656 (100%)	232,191 (37%)	398,465 (63%)
Clinicians involved in clinical activities, n (%)			
All clinicians	21 (100%)	16 (100%)	14 (100%)
Occupational Therapists	6 (28%)	5 (31%)	4 (29%)
Physiotherapists	5 (24%)	5 (31%)	3 (21%)
Nurses	3 (14%)	1 (6%)	3 (21%)
Speech language pathologists	2 (10%)	2 (13%)	2 (14%)
Social workers	4 (19%)	2 (13%)	2 (14%)
Special care counsellor	1 (5%)	1 (6%)	0 (0%)
Number of services by clinicians involved in clinical activities, n (%)			
All clinicians	16,160 (100%)	6,452 (100%)	9,708 (100%)
Occupational Therapists	5,406 (34%)	2,391 (37%)	3,015 (31%)
Physiotherapists	4,842 (30%)	2,313 (36%)	2,529 (26%)
Nurses	2,185 (14%)	452 (7%)	1,733 (18%)
Speech language pathologists	3,113 (19%)	1,111 (17%)	2,002 (21%)
Social workers	551 (3%)	122 (2%)	429 (4%)
Special care counsellor	63 (0%)	63 (1%)	0 (0%)
Total time in minutes by clinicians involved			

Variables	All	2019-2020	2020-2021
in clinical activities, n (%)			
All clinicians	490,056 (100%)	192,501 (100%)	297,555 (100%)
Occupational Therapists	170,300 (35%)	74,605 (39%)	95,695 (32%)
Physiotherapists	135,192 (28%)	61,690 (32%)	73,502 (25%)
Nurses	59,718 (12%)	14,390 (7%)	45,328 (15%)
Speech language pathologists	104,660 (21%)	35,600 (19%)	69,060 (23%)
Social workers	17,625 (4%)	3,655 (2%)	13,970 (5%)
Special care counsellor	2,561 (0%)	2,561 (1%)	0 (0%)

Table 3A: Therapeutic and non-therapeutic (clinical) services (n=110 patients/events) – Cont.1

Variables	All	2019-2020	2020-2021
Total time in minutes – Direct services* only by clinicians involved in clinical activities, n (%)			
All clinicians	200,803 (100%)	88,896 (100%)	111,907 (100%)
Occupational Therapists	69,850 (35%)	34,205 (39%)	35,645 (32%)
Physiotherapists	61,086 (30%)	29,615 (33%)	31,471 (28%)
Nurses	22,381 (11%)	6,855 (8%)	15,526 (14%)
Speech language pathologists	40,995 (20%)	15,890 (18%)	25,105 (22%)
Social workers	5,235 (3%)	1,075 (1%)	4,160 (4%)
Special care counsellor	1,256 (1%)	1,256 (1%)	0 (0%)
Total time in minutes – Indirect services* only, by clinicians involved in clinical activities, n (%)			
All clinicians	289,523 (100%)	103,605 (100%)	185,648 (100%)
Occupational Therapists	100,450 (35%)	40,400 (39%)	60,050 (32%)
Physiotherapists	74,106 (26%)	32,075 (31%)	42,031 (23%)
Nurses	37,337 (13%)	7,535 (7%)	29,802 (16%)
Speech language pathologists	63,665 (22%)	19,710 (19%)	43,955 (24%)
Social workers	12,390 (4%)	2,580 (3%)	9,810 (5%)
Special care counsellor	1,305 (0%)	1,305 (1%)	0 (0%)
Clinicians involved in Non-therapeutic activities, n (%)			
All clinicians	8 (100%)	5 (100%)	6 (100%)
Occupational Therapists	2 (25%)	1 (20%)	2 (33%)
Physiotherapists	1 (12%)	0 (0%)	1 (17%)
Nurses	1 (12%)	0 (0%)	1 (17%)
Speech language pathologists	1 (12%)	2 (40%)	1 (17%)
Social workers	3 (38%)	2 (40%)	1 (17%)
Special care counsellor	0 (0%)	0 (0%)	0 (0%)
Number of non-therapeutic activities, by clinicians involved in clinical activities, n (%)			
All clinicians	1,544 (100%)	566 (100%)	978 (100%)
Occupational Therapists	926 (60%)	516 (91%)	410 (42%)
Physiotherapists	159 (10%)	0 (0%)	159 (16%)

Nurses	240 (16%)	0 (0%)	240 (25%)
Speech language pathologists	155 (10%)	13 (2%)	142 (14%)
Social workers	64 (4%)	37 (7%)	27 (3%)
Special care counsellor	0 (0%)	0 (0%)	0 (0%)
Non-therapeutic total time in minutes, by clinicians involved in clinical activities, n (%)			
All clinicians	140,600 (100%)	39,690 (100%)	100,910 (100%)
Occupational Therapists	88,760 (63%)	38,360 (97%)	50,400 (50%)
Physiotherapists	9,595 (7%)	0 (0%)	9,595 (10%)
Nurses	28,055 (20%)	0 (0%)	28,055 (28%)
Speech language pathologists	12,125 (9%)	490 (1%)	11,635 (11%)
Social workers	2,065 (1%)	840 (2%)	1,225 (1%)
<i>Special care counsellor</i>	<i>0 (0%)</i>	<i>0 (0%)</i>	<i>0 (0%)</i>

**Direct= in the presence of the patient; Indirect= done when the patient is not present.*

Table 3B: Type of Therapeutical (Direct and Indirect) and non-therapeutical services (n=110 events)

Fiscal year of travel record	Number of interventions/services (total number of minutes)		
	All	2019-2020	2020-2021
Direct interventions			
Evaluation / Treatment / Follow-up / Home Visit (in person interventions)	2,212 (145,150)	1,333 (86,665)	879 (58,485)
Virtual visits	691 (39,930)	0 (0)	691 (39,930)
Telephone interventions	306 (8,220)	0 (0)	306 (8,220)
Other direct interventions ^β	273 (7,503)	75 (2,231)	198 (5,272)
Total direct interventions	3,482 (200,803)	1,408 (88,896)	2,074 (111,907)
Indirect services			
Home Visit without Patient + Travel / Travel to Home Visit	1,975 (70,820)	1,198 (41,805)	777 (29,015)
Record Keeping / Interdisciplinary Team Without Patient + Interdisciplinary Intervention Plan + Treatment/Intervention Preparation	7,412 (166,993)	2,733 (48,250)	4,679 (118,743)
Communication + Telephone Follow-up / Communication Related to Patient	646 (8,945)	412 (4,145)	234 (4,800)
Interdisciplinary Discussion / Case Discussion	2,532 (39,775)	680 (8,960)	1,852 (30,815)
Other indirect services [¥]	113 (2,720)	21 (445)	92 (2,275)
Total indirect services	12,678 (289,253)	5,044 (103,605)	7,634 (185,648)
Total Direct and Indirect	16,160 (490,056)	6,452 (192,501)	9,708 (297,555)
Non-therapeutic activities			
Training (given and received)	40 (4,625)	6 (1,130)	34 (3,495)
Teaching and supervision of interns	25(1,465)	2 (75)	23 (1,390)
Research	87 (15,645)	0 (0)	87 (15,645)
Administrative activities	903 (61,170)	296 (14,870)	607 (46,300)

Other non-therapeutic activities [£]	489 (57,695)	262 (23,615)	227 (34,080)
Total non-therapeutic activities	1,544 (140,600)	566 (39,690)	978 (100,910)

^ß Dysphagia and communication with caregivers (with or without patient's presence).

[¥] Adaptation/Orthosis/Equipment, forms and pre-admission process.

[£] Case management, support professional practice, CIUSSS meetings and events, travelling to other site and health break.

Table 3A presents the duration of clinical/therapeutical (direct and indirect) services provided to patients by year and by type of clinicians as well as non-therapeutic activities. Overall 21 clinicians provided clinical services. This number varied between 2019/2020 (n = 16) and 2020/2021 (n = 14). Overall, the number of clinicians providing rehabilitation care declined across both periods except for nurses (1 nurse in 2019/2020 versus 3 nurses in 2020/2021). Direct clinical services are those offered in the presence of the patient. Indirect clinical services include activities offered in the patient's absence and any other activities contributing to the quality of care, for instance travelling and home visits record keeping and interdisciplinary team intervention planning, case discussion and communication related to the patient. The amount of services increased from 6,452 in 2019–2020 to 9,708 in 2020–2021, representing 40% and 60%, respectively, of the total service volume across the two-year period. This observation aligns with the total clinical time from 192,501 minutes (39%) to 297,555 minutes (61%) between 2019/2020 and 2020/2021. For all clinicians, the total duration of clinical visits increased between 2019/2020 and 2020/2021, except for OTs and PTs (39% to 32% and 32% to 25%). A similar observation is reported for direct (39% to 32% and 33% to 28% and indirect (39% to 32% and 31% to 23%) services regarding both clinicians. There was no comparison between the two time periods for the special care counsellor since during 2020–2021, this clinician left the team for a maternity leave. Across all therapeutic (direct and indirect) and non-therapeutic services, occupational therapists (OTs) provided more services compared to the other professional groups. However, the proportion of nurses increased, rising from 6% in 2019–2020 to 21% in 2020–2021. Similarly, the proportion of services delivered by nurses increased (from 7% to 16%) between the two periods. A comparable pattern was observed for total time allocation to services. A similar overall trend was observed when examining time devoted to direct and indirect therapeutic services. Total direct care time increased from 88,896 to 111,907 minutes (26%), while indirect care time increased from 103,605 to 185,648 minutes (79%).

Overall, fewer clinicians were involved in non-therapeutic activities than in therapeutic services across all study periods (8 versus 21 in 2019/2021 with 5 versus 16 in 2019/2020, and 6 versus 14 in 2020/2021), although their numbers varied across professional groups. Over time, the number of SLPs and social workers involved in non-therapeutic activities decreased (2 to 1 clinicians), whereas the number of OTs, PTs, and nurses increased (0 to 1, 0 to 1 and 1 to 2 clinicians). However, workforce size did not

consistently correspond to the volume of non-therapeutic services delivered or the time allocated to these activities. For example, although the number of OTs increased from one in 2019/2020 to two in 2020/2021, their relative contribution declined substantially. OTs accounted for 91% of non-therapeutic activities and 97% of the allocated time in 2019/2020, compared with only 42% and 50%, respectively, in 2020/2021. In contrast, despite a reduction in the number of SLPs involved during the same period, their contribution increased markedly, rising from 2% to 14% of activities and from 1% to 11% of allocated time. Similar shifts were observed among other professional groups. Nurses and PTs, who did not participate in non-therapeutic activities in 2019/2020, became substantial contributors in 2020/2021, accounting for 14% and 29% of activities and 15% and 19% of allocated time, respectively. Meanwhile, in 2019/2020, although two social workers participated in non-therapeutic activities, they collectively contributed only 7% of activities and 2% of the allocated time.

In Table 3B, the number of services and duration by types of direct and indirect services is presented for the whole period and by fiscal year. Overall, evaluation, treatment, follow-up and home visits decreased from 2019/2020 to 2020/2021 (1,333 to 879 for direct interventions and 1,198 to 777 for indirect activities). In direct interventions, all telehealth interventions were done in the second year (2020–2021). Regarding the virtual health care interventions, they represented 48.1% (997/2,074) of the total direct interventions in 2020/2021. Video health interventions were mostly provided by OTs (35%), SPLs (29%) and PTs (27%), where phone health interventions were offered by nurses (33%), OTs (24%) and PTs (21%). These virtual health care interventions represented 10% of all direct and indirect interventions in 2020–2021.

Regarding indirect services, record keeping, interdisciplinary team intervention plan and treatment/intervention preparation, and interdisciplinary discussion/case discussion and their time allocated were higher in the second comparatively to the first year (up 71% for number of services and up 146% for time). The difference in services and time spent on interdisciplinary and case discussion is even bigger in the second year with 2.7 times more services and 3.4 times more minutes compared to the first year. On the other end, there were less communication and telephone follow-up related to patient services in the 2020–2021 but more time was spent for each of these services (average time of 10 minutes in 2019–2020 and 21 minutes in 2020–2021). The number of indirect services represent 3.6 times the number of direct services over both years (2019/2021) and stable in each year (3.6 in 2019/2020 and 3.7 in 2020/2021). However, this trend is not similar for time allocated that represents 1.4 time over both years (2019/2021); 1.2 in 2019/2020 and 1.7 in 2020/2021.

For non-therapeutic activities, we see the same trend. Clinicians were involved in more training, teaching, students supervision, research and administrative activities from 2019/2020 to 2020/2021.

3.2 TDABC approach results

3.2.1 Mapping the care trajectory within the ESD program

Figure 1 maps the details of the TDABC approach, co-developed with the ESD program’s manager, and clinical coordinator.

3.2.2 Calculating duration of interventions, cost per minute and practical ability

Table 4 summarizes the average length of interventions per patient for each group of health professionals, for the pre- and post-pandemic periods. The average duration of therapeutic and non-therapeutic services increased between the two years. Specifically, the duration doubled for speech language therapists' services (659.2 mn to 1,233.2 mn) and quadrupled for nurses' (266.5 mn to 809.4 mn) and social workers' services (67.7 mn to 249.4 mn). Regarding the average duration of non-therapeutic services, it increased by almost 2.5 times for all services except for OT (710.4 mn to 900.0 mn). The average total time increased from 4,299.8 mn in 2019/2020 to 7,115.3 mn in 2020/2021.

Table 4
Duration of therapeutic and non-therapeutic services, by discipline and year

Average length of trajectory in 2019–2020			
Resource groups	Average duration of therapeutic services (mn)	Average duration of non-therapeutic services (mn)	Average total time (mn)
Occupational therapists (OT)	1,381.6	710.4	2,092.0
Physiotherapists (PT)	1,142.4	-	1,142.4
Nurses (RN)	266.5	-	266.5
Speech language pathologists (SLP)	659.2	9.1	668.3
Social workers (SW)	67.7	15.5	83.2
Specialized educational technician (TES)	47.4	-	47.4
Total	3,564.8	735.0	4,299.8
Total average trajectory duration in 2020–2021			
Resource groups	Average duration of therapeutic services (mn)	Average duration of non-therapeutic services (mn)	Average total time (mn)
Occupational therapists (OT)	1,708.8	900.0	2,608.8
Physiotherapists (PT)	1,312.5	171.3	1,483.8
Nurses (RN)	809.4	501.0	1,310.4
Speech language pathologists (SLP)	1233.2	207.8	1,441.0
Social workers (SW)	249.4	21.9	271.3
Specialized educational technicians (TES)	-	-	-
Total	5,313.3	1802.0	7,115.3
<i>In 2019–2020, the average duration of therapeutic services was calculated by dividing the total time spent on therapeutic clinical activities by the number of events (n = 54). Similarly, the average duration of non-therapeutic services was calculated by dividing the total time of these activities by the number of events (n = 56).</i>			

3.2.3. Calculation of the average direct and indirect costs per patient, and cost of ESD program with or without telerehabilitation

Table 5 presents the costs of human resources. Table 6 shows the average costs per patient and for the ESD program for three different periods: i) the 24-month period from 1 April 2019 to 31 March 2021; ii) the 12-month period from 1 April 2019 to 31 March 2020 and; iii) the 12-month period from 1 April 2020 to 31 March 2021.

Table 5

Per-minute cost of human resources/clinicians for the care pathway for the 24-month period from April 1^{er} 2019 to March 31 2021

Human resources	Salary and benefits	Practical capacity (in minutes)	Cost per minute	Weight of practical capacity in total
Occupational therapists	693 039\$	690 915	1,00\$	0,364
Physiotherapists	410 883\$	414 990	0,99\$	0,219
Nurses	212 307\$	235 618	0.90 \$	0.124
Speech language pathologists	291 839\$	405 450	0,72\$	0.214
Social workers	31 243\$	38 910	0,80\$	0,021
Specialized educational technicians	88 657\$	109 273	0,81\$	0,05
Weighted average cost per minute of resources: \$0.912				
<i>Weighted average cost per minute was calculated using unrounded values; therefore, the reported total may not exactly correspond to calculations based on the rounded values presented in the table</i>				

Table 6
Average cost per patient and cost of ESD program by year and discipline

Clinicians	Average total time per patient (in minutes)	Average cost per minute	Cost of human resources per patient: Direct costs	Indirect expenses: Indirect costs	Total cost per patient
24-month period from April 1 ^{er} 2019 to March 31 2021					
Occupational therapists	2,355.1	\$1.00	\$2,355.10	\$212.41	\$2,567.51
Physiotherapists	1,316.2	\$0.99	\$1,303.04	\$139.01	\$1,442.05
Nurses	797.9	\$0.90	\$718.11	\$40.37	\$758.48
Speech language pathologists	1,061.7	\$0.72	\$764.42	\$61.80	\$826.22
Social workers	179.0	\$0.80	\$143.20	\$17.61	\$160.81
Specialized educational technicians	23.3	\$0.81	\$18.87	\$46.24	\$65.11
Management	N/A	N/A	N/A	\$232.95	\$232.95
Total	5,733.2	N/A	\$5,302.74	\$750.39	\$6,053.13
12-month period from April 1 ^{er} 2019 to March 31 2020					
Occupational therapists	2,092.0	\$1.00	\$2,092.00	\$192.05	\$2,284.05
Physiotherapists	1,142.4	\$0.99	\$1,130.98	\$138.07	\$1,269.05
Nurses	266.5	\$0.90	\$239.85	\$33.02	\$272.87

Table 6
Average cost per patient and cost of ESD program by year and discipline- Cont.

Clinicians	Average total time per patient (in minutes)	Average cost per minute	Cost of human resources per patient: Direct costs	Indirect expenses: Indirect costs	Total cost per patient
12-month period from April 1 ^{er} 2019 to March 31 2020					
Speech language pathologists	668.3	\$0.72	\$481.18	\$83.75	\$564.93
Social workers	83.2	\$0.80	\$66.56	\$0.47	\$67.03
Specialized educational technicians	47.4	\$0.81	\$38.39	\$95.09	\$133.48
Management	N/A	N/A	N/A	\$191.37	\$191,37
Total	4,299.8	N/A	\$4,048.96	\$733.82	\$4,782.78
12-month period from April 1 ^{er} 2020 to March 31 2021					
Occupational therapists	2,608.8	\$1.00	\$2,608.80	\$231.69	\$2,840.49
Physiotherapists	1,483.8	\$0.99	\$1,468.96	\$139.90	\$1,608.86
Nurses	1,310.4	\$0.90	\$1,179.36	\$47.31	\$1,226.67
Speech language pathologists	1,441.0	\$0.72	\$1,037.52	\$41.03	\$1,078.55
Social workers	271.3	\$0.80	\$217.04	\$33.83	\$250.87
Specialized educational technicians	-	\$0.81	\$ -	\$ -	\$ -
Management	N/A	N/A	N/A	\$295.59	\$295.59

The direct cost and the average time per patient were higher in 2020/2021 (\$6,511.68 / 7,115.3 mn) than in 2019/2020 (\$4,048.96 / 4,299.8 mn) and higher than in the overall period 2019–2021 (\$5,302.74 / 5,733.2 mn), across disciplines. For the two consecutive years and overall, the average total time per patient was greater for OTs and PTs services. However, the cost of nurse services went up (5 fold) in the second year (\$1,179.36 in 2020–2021 vs \$239.85 in 2019–2020), similarly for SLPs services (\$1,037.52 in 2020–2021 vs \$481.18 in 2019–2020). The higher costs reflects that there were more staff available for services to CPA patients in the second year.

Regarding the indirect costs per patient, the amount is almost similar between the three periods: \$750.39 in 2019–2021, \$733.82 in 2019/2020, and \$789.35 in 2020/2021. Again here, the indirect costs

vary across disciplines with higher amounts for OTs, PTs and SLPs services in 2019/2020 and 2019–2021. However, the higher costs were for OTs, PTs and nursing services in 2020/2021. Note that there was a special care counsellor working in 2019–2020 but not in 2020–2021.

The total cost per patient included direct and indirect (e.g., transportation, telecommunication, supplies, infrastructure, charting and administrative agent) costs. The costs of transportation were not significantly different (\$542.45 in 2019/2020, \$493.76 in 2020/2021, and \$517.44 in 2019–2021).

The total cost of the ESD program varied with the integration of telerehabilitation. It was higher in 2020/2021 (\$7,301.03) compared to 2019–2021 (\$6,053.13) and the first year before the pandemic in 2019/2020 (\$4,782.78).

4. Discussion

The aim of this study was to use TDABC in estimating the costs of the ESD program care pathway, before and after the introduction of virtual healthcare during the COVID pandemic. The results demonstrate the applicability of the TDABC approach in rehabilitation for adult stroke survivors, highlighting its potential to provide valuable information that can be used to optimize services. Our study results highlighted significant changes associated to the integration of telerehabilitation within the ESD program during the COVID-19 pandemic, including changes the intensity of services, the average cost per patient and the overall cost of the program. Over the two periods (2019/2021), clinicians delivered 17,704 clinical activities (therapeutic and non-therapeutic) to an average of 110 patients/events, for a total of 630,656 minutes (10,510 hours), at an average cost of CAD 5,733.2 per patient. In 2020/2021, both the duration of therapeutic (direct and indirect) and non-therapeutic services were higher overall and across disciplines compared to 2019–2020. The direct cost and the average time per patient were higher in 2020/2021 (\$6,511.68 / 7,115.3 mn) than in 2019/2020 (\$4,048.96 / 4,299.8 mn). Regarding the indirect costs per patient, and the cost of transportation, the amounts were not significantly different. However, the total cost of the ESD program varied with the integration of telerehabilitation. It was higher in 2020/2021 (\$7,301.03) compared to the first year before the pandemic in 2019/2020 (\$4,782.78).

A surprising result was the increased time for rehabilitation services, which could be in part attributed to telerehabilitation. Given that it was the first time for several health professionals and patients in adopting telehealth during the pandemic, it was expected it would take them more time to integrate this new practice. While the ESD program is intended to deliver intensive rehabilitation, our results indicate a notable intensification for the duration of therapeutic (direct and indirect activities) services with the integration of telerehabilitation. As expected, the higher intensity of practices could result in higher costs per patients and for home-based telerehabilitation. The integration of telerehabilitation, pushed during the COVID-19 pandemic, was a cultural change in organizational and clinical practices⁷⁶ implemented to ensure continuity of services.^{40,70} In Quebec, there were many reforms in the healthcare system leading to a reorganization of policies, structures, work climate, and service offerings,⁷⁷ with an unprecedented transition to virtual healthcare. While this acceleration was necessary to ensure continuity of care, the

adjustment in clinical practices was not possible for all patients. The reasons were varied and were explained by a lack of familiarity with the technological tools, despite their availability and the availability of training modules for patients and their caregivers. In addition, patient's health status could require a home visit to ensure the continuity of care based on patients' realities and preferences. Taken together, the increase in service volume and time allocation during COVID – 19 pandemic despite fewer clinicians suggests possible work intensification, expanded scopes of practice, and a more interdisciplinary model of care delivery. Furthermore, the marked expansion of indirect and non-therapeutic activities likely reflects growing system complexity, coordination demands, and organizational changes.

Cost analysis of the ESD program, particularly with the integration of telerehabilitation, as with intensive home-based telerehabilitation targeting stroke survivors, indicates higher average costs per patient and in the overall program compared to home-based rehabilitation. The average cost per patient rose from \$4,782.78 in 2019/2020 to \$7,301.03 in 2020/2021, which is a substantial total increase of \$2,518.25 (53%). Patients presented a similar sociodemographic profile with a slightly higher age distribution and lower FIM at admission in the second year compared to the first year

Overall, the number of patients was comparable across the two study periods, although the number of clinical events differed. Compared with the 2019–2020 period, two patients in 2020–2021 required two additional consultations.. There were more patients aged 76 and over was slightly higher in 2020/2021 (50%) than in 2019/2020 (43%). The average FIM scores at admission and discharge were 101.6 and 111.4 respectively in 2019–2020 compared with 96.1 and 108.9 for patients in 2020–2021, which suggests that patients were, on average, less functionally independent.. A substantial change between these both periods was the number of nursing and SLP hours.. A notable difference between the two periods was the increased nursing and SLP service hours in 2020–2021. Furthermore, pandemic-related restrictions disrupted the implementation of best practices, including delays in conducting initial assessments, delays in hospital referrals (i.e., patients had already been home for several days before rehabilitation care could begin), delays in implementing telerehabilitation due to limited resources (e.g., Zoom licences and clinical guidelines), and delays in implementing infection prevention and control (IPC) guidelines. Together with the older profile and higher dependence of the patients, and the new mode of service delivery requiring two-way adaptation on the part of seniors and their families as well as clinicians, may explain the differences in costs observed.

Previous studies in the literature reported mixed results regarding the cost-effectiveness of telerehabilitation compared to home-based rehabilitation.^{79–85} According to a systematic review on cost-effectiveness of home-based telerehabilitation and telerehabilitation,^{80, 86} home-based telerehabilitation costs were similar or lower as compared to in-person rehabilitation at home or at a care centre.⁸⁰ Cost savings related to telerehabilitation could be attributed to decreases in the costs of staff and transportation,⁸⁰ or to a significant reduction in the number of hospitalizations and emergency visits as well as shorter hospital stays.^{81, 82, 86} Similarly, in one study conducted in a pediatric care setting before and after the COVID-19 pandemic, costs went down with the introduction of telehealth.⁸⁷

Other studies reported there was limited evidence to support the cost-effectiveness of telerehabilitation,^{84, 85} and some studies reported increased costs with the implementation of telerehabilitation. In a study on the economic assessment of home telemonitoring of people with chronic diseases, the authors reported a similar unexpected result after system deployment such as higher costs with telemonitoring,⁸¹ in large part due to the case managers' lack of experience with that approach.⁸¹ We also note that several healthcare professionals experienced an increase in the average working time in 2020/2021, albeit with variability between professionals, highlighting the needs for these services by stroke survivors, as reported in another study in rehabilitation.⁶⁴

Another study that applied TDABC to calculate the marginal costs of OT assessment in patients with strokes did not find a reduction of costs with virtual healthcare.⁸³ This could be explained by the difference in the nature of economic analysis and the type of direct or indirect costs used, the target population and the settings of intervention, the healthcare professionals involved, and ultimately the methodological challenges with the application of TDABC,^{72–75} including the interactions among these reasons. Our result is consistent with those of a scoping review where authors reported that implementing telehealth should be motivated by benefits such as clinical productivity, positive patients benefits and by improving accessibility, mostly for people who had limited or no access to care who can now access services. Further, by improving the convenience of access, there is potential for excess use. Furthermore, the potential for telehealth to become adjunctive to traditional in-person care (rather than substitutive) also increases the potential for increasing use and associated costs. This is in line with recent evidence that suggests that telehealth does not routinely reduce the cost of care delivery⁷⁸.

The TDABC steps, as well as setting and care pathways, vary across all studies including this one. Mapping of tasks and activities is fundamental when adopting TDABC; it could be conducted using administrative data, interviews with clinical teams or observation of their tasks.⁵⁷ In our study, we used administrative data, which provides reliable details on real-world clinical interventions. Reviews of the application of TDABC in hospital departments^{53,62} have reported methodological heterogeneity for cost estimation and the types of activities and costs considered. Domingo et al. (2018)⁵⁷ reported on strategies used to simplify operationalizing the TDABC for stroke, given the diversity of possible pathways (323 pathways for 889 patients) for the same pathology. It is possible to consider a typical patient and to apply TDABC throughout the care pathway, from the first point of contact to the diagnosis and treatment plan.

In addition, some authors have reported on the positive impacts of applying the TDABC costing method on the efficiency of the healthcare system; they cite better training of professionals in patient-centred care through their involvement in the design of the patient's care pathway, the redesign and optimization of clinical and administrative activities, and the allocation of resources.^{53, 88} However, the lack of standardized principles guiding the implementation of TDABC (particularly for indirect costs) due to institutional and regional differences in healthcare systems can create variations in its application. Differences in the definition, estimation and reporting of costs make it difficult to achieve consistency of

results in studies adopting the TDABC costing method,⁶² highlighting the crucial competency needed to apply this method and its stages.^{61, 89}

Implications for practice

This study demonstrated the practical utility of TDABC in analyzing and optimizing care pathway costs within an ESD program for stroke patients, including those who received telerehabilitation. The findings underscore the importance of TDABC in offering a precise breakdown of costs, which is crucial for informed decision-making in resource allocation and program management. The observed increase of costs during the COVID-19 pandemic highlights the need for adaptive costing models like TDABC that can respond to evolving healthcare environments. Moving forward, the integration of TDABC into routine practice could serve as a cornerstone for continuous quality improvement in rehabilitation, provided there is ongoing support and engagement from clinical teams.

Implications for research and quality improvement

The application of TDABC in this study provided valuable insights into the cost dynamics of an ESD program for stroke patients, including those engaged in telerehabilitation. The results highlight the importance of a collaborative, team-based approach to cost analysis, where the active participation of clinical teams is crucial for achieving accurate and actionable insights. The increase in service intensity and associated costs during the COVID-19 pandemic illustrates the complex challenges faced by healthcare providers and the need for flexible and responsive costing methods like TDABC. By fostering collaboration among healthcare professionals, TDABC can contribute to more effective resource allocation and quality improvement.

Furthermore, this study highlights the strategic value of implementing TDABC in healthcare, specifically within an ESD program for stroke patients. The results reveal that TDABC not only enhances the granularity of cost analysis but also provides a strategic framework for improving the efficiency and effectiveness of care pathways. The increased costs associated with the intensified services during the COVID-19 pandemic point to the need for dynamic and adaptable costing methods in healthcare. By fostering a collaborative approach to cost management, TDABC can drive significant improvements in the quality of care.

5. STRENGTHS AND LIMITATIONS

This study has several strengths and limitations. As to strengths, firstly, the TDABC costing method was used to analyze the costing of the care pathway for stroke patients in an ESD program, with or without integrating telerehabilitation, over two time periods. Secondly, the TDABC method offers a framework in the value-based healthcare lens to better understand the cost components of the care pathway by highlighting the average time of care trajectories, which increased during the COVID-19 pandemic. These

calculations, together with trajectory mapping, can help program managers to identify resource reallocation and cost-saving opportunities.⁵³ Thirdly, this cost-analysis approach considers various data sources including activities and time of interventions. Some authors have reported that the application of TDABC usually considers only direct costs.⁶¹ Cost analysis based on direct services gives limited information suggesting reduction of average costs per patient; it does not allow for service optimization including costs avoided or adequate decision-making in terms of quality improvement. As demonstrated by Keel et al. (2017),⁶¹ it's not unusual for research on TDABC to omit some or all indirect costs, which are those not directly controlled by programs or departments, resulting in little interest in their consideration. The present study therefore provides a new approach to applying TDABC, by calculating pathway cost and average cost per patient, beyond the usual observational or interview approaches to determining a typical patient and applying TDABC to it.⁴¹

Nevertheless, this research has certain limitations. Firstly, we have not considered the cost of capital assets in care pathways. In a hospital environment where many capital assets have been acquired in different ways (through donations from certain foundations, funding from different levels of government, etc.), determining the exact cost of a capital asset acquired or built several years ago is not an easy task. However, most of the CPWs' costs remains devoted to human resources.⁹⁰ In the light of the information available, particularly the fact that the program under study did not require the acquisition of capital assets for its implementation, the analysis focused on human resources as direct costs and indirect costs. However, given the lack of consideration to other costs during all time periods, the comparison is still sound. In addition, this approach is optimal comparatively to other types of data analysis that consider only direct costs⁷⁹ and costs of intervention sessions,⁸³ which could lead to an underestimation. An additional limitation is the absence of time identification of activities and sub-activities from the mapping pathway, corroborating the complexity of TDABC application in a group of patients with diverse profiles and varied care pathways,⁵⁷ given the flexible applicability of the TDABC approach.^{53, 90, 91} Usually, the TDABC model uses two basic parameters: 1) the unit cost of resource input and 2) the time and quantity of resources required for an activity.⁹¹ Mapping is often arduous and time-consuming, blurred and unstable, with several services performed on different patients in the same day,⁵⁷ and it requires regular updating. The main reason for this difficulty is the complexity of determining these times. In fact, the healthcare environment is often complex and different from environments such as manufacturing or sales. Healthcare professionals work in interdisciplinary teams and simultaneously on several patients, which makes it difficult to accurately estimate the duration of a task relating to a particular patient. Instead, we chose an alternative, rigorous and precise method based on the program's administrative data, which includes codes for each activity or service provided and the duration of that clinical intervention. Although a code could cover several sub-activities, it would still be impossible to determine the cost of each sub-activity individually to calculate the overall cost of care pathways. The clinical activities of the clinical coordinator, and OT could not be counted distinctively from other OTs. Finally, our results are not generalizable to a rehabilitation centre that does not have an ESD program, or one that has an ESD program located in a rural setting, as transportation costs in the

pre-pandemic year may be more significant. Another limitation of this study is the lack of consideration of patient health outcomes, such the impact of intensity of services on patients' experiences, which are important components of value-based healthcare;⁹² likewise, there was no control group to evaluate these effects. The above limitations point beyond the scope of this study, which focused on pathway costs and healthcare cost optimization.

6. Conclusion

This study investigated the application of TDABC to analyze patient care pathway costs in an ESD program for stroke patients who have integrated telerehabilitation. The results demonstrate that TDABC is not only a feasible method for cost analysis but also a powerful tool for optimizing costs in an ESD program. It provides a detailed and nuanced understanding of the care pathway costs, particularly in the context of service intensification and increased costs observed during the COVID-19 pandemic. However, the TDABC method offers significant insights, it is inherently time-consuming and require the active commitment and mobilization of clinical teams to achieve meaningful quality improvements. This study opens prospects for the application of TDABC in rehabilitation, highlighting the potential for its use in driving cost-effective and high-quality patient care. However, further research is essential to refine its implementation and maximise its benefits. Future studies should considerer incorporating qualitative research methods, such as interviews with key stakeholders' to gain a deeper understanding of the opportunities and challenges associates with quality improvement of rehabilitation services. This holistic approach will be crucial in enhancing the effectiveness and sustainability of TDABC as a tool for healthcare cost optimization and quality enhancement.

Declarations

Acknowledgment: We would like to thank the interdisciplinary clinical team for their invaluable support in obtaining and interpreting the data. A special thanks to Marie-France Valois for her support with data analysis.

Authors' contribution: This project has been conducted during Dr Talla' postdoctoral fellowship. PKT, SA and VP have conceptualized the study. PKT has drafted the manuscript. All authors (PKT, SA, VP, VN, ML, MB, IG, NC) have substantiallu reviewed the manuscript and they agreed with this version.

Funding: This study was supported by FSISSS-MeDTEQ and BRLLIANT grants.

Availability of data and materials: The datasets used and/or analysed can be made available from the corresponding author upon request.

Ethics approval and consent to participate

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. The study was reviewed and approved by the Research Ethics Board of the Centre for

Interdisciplinary Research in Rehabilitation (CRIR) (ethics approval number CRIR-1453-0719). Informed consent to participate was obtained from all participants prior to their participation in the study.

Consent to publication: Not applicable.

Competing interests: The authors declare no competing interests.

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Figures

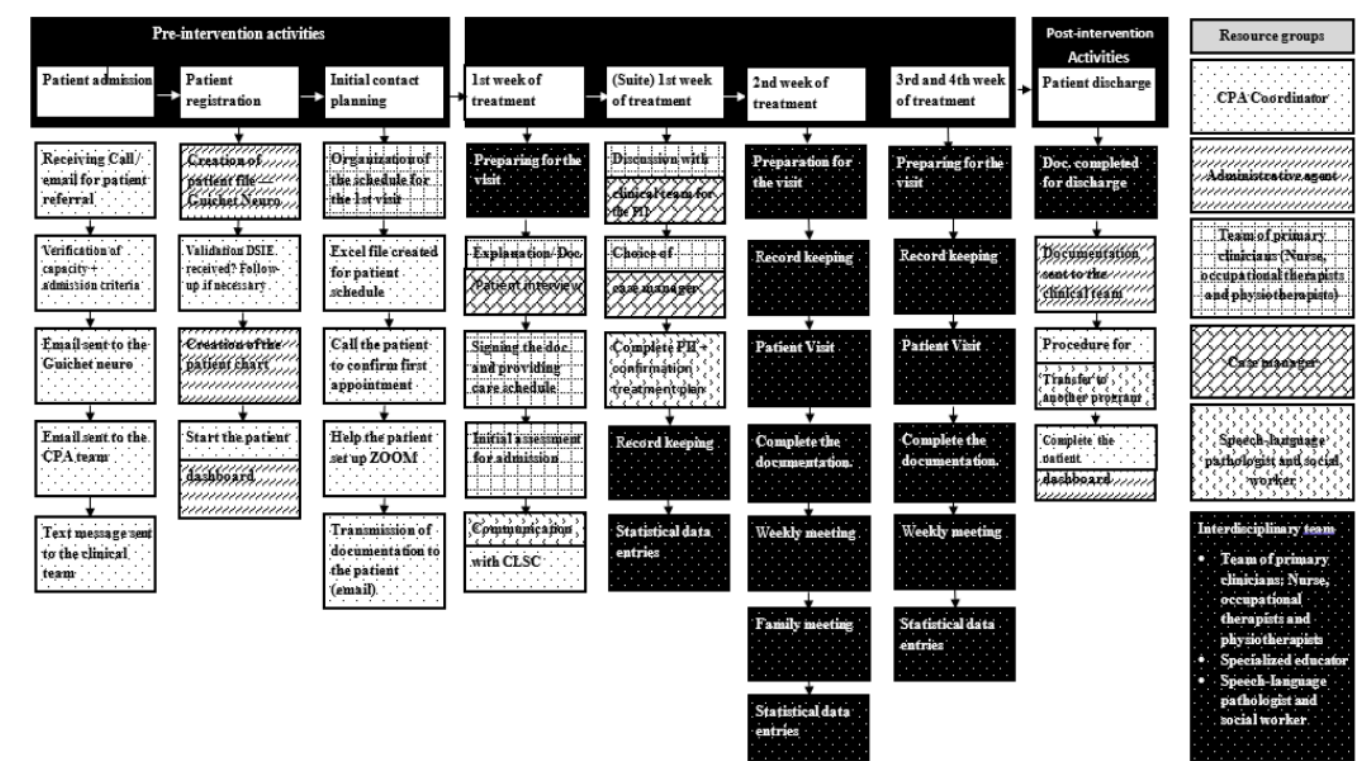


Figure 1

Stroke-ESD program and TDABC approach, co-developed with the ESD program managers.