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Cost and cost-effectiveness of early inpatient rehabilitation after stroke varies with initial disability: the Czech Republic perspective

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The purpose of this prospective study was to determine whether the cost and cost-effectiveness of early rehabilitation after stroke are associated with the degree of initial disability. The data for cost calculations were collected by the bottom-up (micro-costing) method alongside the standard inpatient care. The total sample included 87 patients who were transferred from acute care to early rehabilitation unit of three participating stroke centers at the median time poststroke of 11 days (range 4–69 days). The study was pragmatic so that all hospitals followed their standard therapeutic procedures. For each patient, the staff recorded each procedure and the associated time over the hospital stay. The cost and cost-effectiveness were compared between four disability categories. The average cost of the entire hospitalization was CZK 114 489 (EUR 4348) with the daily average of CZK 5103 (EUR 194). The cost was 2.4 times higher for the immobile category (CZK/EU: 167 530/6363) than the self-sufficient category (CZK/EUR: 68 825/2614), and the main driver of the increase was the cost of nursing. The motor status had a much greater influence than cognitive status. We conclude that the cost and cost-effectiveness of early rehabilitation after stroke are positively associated with the degree of the motor but not cognitive disability. To justify the cost of rehabilitation and monitor its effectiveness, it is recommended to systematically record the elements of care provided and perform functional assessments on admission and discharge. ***International Journal of Rehabilitation Research*** **43: 376–382 Copyright © 2020 The Author(s). Published by Wolters Kluwer Health, Inc.**

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Introduction

Stroke treatment has changed remarkably in the last decade with the application of novel neurosurgical and neurological procedures and the establishment of specialized (comprehensive) stroke units that also include early rehabilitation (Hamann *et al.*, 2016; Škoda *et al.*, 2016; Powers *et al.*, 2018; Pross *et al.*, 2018; de Sousa *et al.*, 2019). There is a general agreement that early rehabilitation is beneficial after stroke (Bernhardt *et al.*, 2015b; Hamann *et al.*, 2016; Coleman *et al.*, 2017; Langhorne *et al.*, 2017; Powers *et al.*, 2018). Next to clinical evidence, this is supported by the results of animal experiments indicating that a narrow window of opportunity for reactive neurobiological recovery and repair may exist, and the optimum period for change could be early after stroke (Murphy and Corbett, 2009; Krakauer *et al.*, 2012; Teasell and Hussein, 2016). The high-intensity rehabilitation therapy within the first 90 days is reported to be associated with a lower mortality risk than the low-intensity therapy among patients with mild to moderate stroke severity (Hsieh *et al.*, 2018). However, the percentage of patients referred to early inpatient rehabilitation is still low (Chen *et al.*, 2020).

The definition of 'early rehabilitation' differs; however, the 2008 European stroke treatment guidelines consider early rehabilitation when administered 20 or even 30 days after stroke (Hacke *et al.*, 2008; Quinn *et al.*, 2009), but already 6 years later, it decreased to 7 days after stroke (Lynch *et al.*, 2014). Moreover, the A Very Early Rehabilitation Trial after stroke (AVERT) clinical trial investigated the efficacy of a 'very early mobilization' within 24 h of stroke onset (Bernhardt *et al.*, 2015b; Langhorne *et al.*, 2017). A comprehensive overview of this problem was published by Bernhardt *et al.* (2019).

While the clinical aspects of the early rehabilitation have been quite frequently discussed, compare, for example,

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the reviews (Bernhardt *et al.*, 2015a; Coleman *et al.*, 2017; Langhorne *et al.*, 2017) or the guidelines (Winstein *et al.*, 2016; Küçükdeveci *et al.*, 2018; Powers *et al.*, 2018), little is known about its cost and cost-effectiveness. The limited information was collected mainly during the AVERT trials (Tay-Teo *et al.*, 2008; Sheppard *et al.*, 2016; Gao *et al.*, 2019). Simultaneously, several systematic reviews covering economic evaluations of the rehabilitation after stroke have been published (Brady *et al.*, 2005; Tummers *et al.*, 2012; Chen *et al.*, 2020). Chen *et al.* (2020) suggest that the rehabilitation ward is cost-effective in comparison with other options (rehabilitation without transfer to the rehabilitation ward, or no rehabilitation). Although Tummers *et al.* (2012) recommended performing a cost analysis across different severities of stroke almost a decade ago, this information is still missing.

Early rehabilitation after stroke did not exist in the Czech Republic until 2015 when the stroke units were officially established (Ministry of Health of the Czech Republic, 2015). At present, there are 13 comprehensive cerebrovascular centers (consisting of neurosurgical, radiological, neurological and early rehabilitation units) and 32 stroke centers (neurological and early rehabilitation units). Patients are typically transferred to early rehabilitation units between 7 and 14 days after stroke, where they receive 3–4 h of multidisciplinary rehabilitation per day.

Our 2017 tri-center study determined the average costs of early rehabilitation after stroke to be CZK 114 489 (EUR 4348) for the entire hospitalization or CZK 5103 (EUR 194) per day (unpublished to date). To expand on this, the goal of this study is to determine whether the cost and cost-effectiveness of early rehabilitation are associated with the degree of initial disability. Such information is expected to be useful for hospital managers to decide about the content and organization of early rehabilitation after stroke, and for negotiating reimbursement with the regulators. On a broader scale, our approach and results would be informative for international comparisons of cost-effectiveness and organization of early rehabilitation after stroke.

Participants and methods

The data used here come from a national pragmatic study carried out in three hospitals (General University Hospital in Prague, Department of Rehabilitation Medicine; Masaryk Hospital in Ústí nad Labem, Rehabilitation Department; and University Hospital Ostrava, Clinic of Rehabilitation and Physical Medicine) from April to November 2017. The study was approved by the ethics committee of the General University Hospital in Prague. The inclusion criteria were stroke diagnosis (ischemic or hemorrhagic), hospitalization between 4 and 90 days, and no interruption in the early rehabilitation stay unless the treatment for complications occurred in the same hospital. A total of 87 patients were included in this study, and they were admitted to the early rehabilitation unit less than 70 days after stroke. The hospitals listed above contributed 29, 31 and 27 patients, respectively.

Data for cost calculation were collected by the bottom-up (micro-costing) method alongside standard patient care. The study was pragmatic so that all hospitals followed their standard therapeutic procedures. The staff recorded each procedure and the number of therapeutic units or time spent continuously with a patient on 10 treatment forms. The recorded data were transferred to 10 economic forms where each therapeutic unit or time spent was multiplied by the respective cost. Standard statistical analyses were performed using MS Excel and R applications.

Personal and clinical data were recorded on eight clinical forms and captured basic demographics, relevant dates (stroke onset, admission, transfer to the early rehabilitation unit and discharge), physician's evaluation of functional abilities and categorization (see below), functional tests carried out by trained therapists (starting on day 3 of admission to the rehabilitation unit and then every 2 weeks). In this study, outcomes were assessed by the following functional tests: the Barthel Index (Mahoney and Barthel, 1965), Extended Barthel Index (EBI) (Prosiegel *et al.*, 1996; Katona *et al.*, 2015) and the functional independence measure (FIM) divided into the motor and cognitive subscales (Chumney *et al.*, 2010). The EBI was developed to widen the utility of this scale by adding six cognitive items. Although some authors used the abbreviation EBI when referring to all 16 items together (Maritz *et al.*, 2019), it is recommended to designate with EBI only the six cognitive items (DIMDI, 2018). To avoid any confusion, we use Barthel Index+EBI to denote the combined 16-item scale.

The above-mentioned categorization (hereinafter referred to as disability category) is on the basis of the Czech reimbursement scheme, Section 6 of the Czech Republic Decree No. 134/1998 Coll. (1998), and it applies to all inpatient facilities. The five disability categories are as follows: (1) self-sufficient, (2) partly self-sufficient, (3) requires an enhanced level of supervision, (4) immobile and (5) unconscious. Staff routinely assigns patients to these categories and can be assumed to have rich experience with this classification. The disability category was used as the independent variable to measure the degree of initial disability.

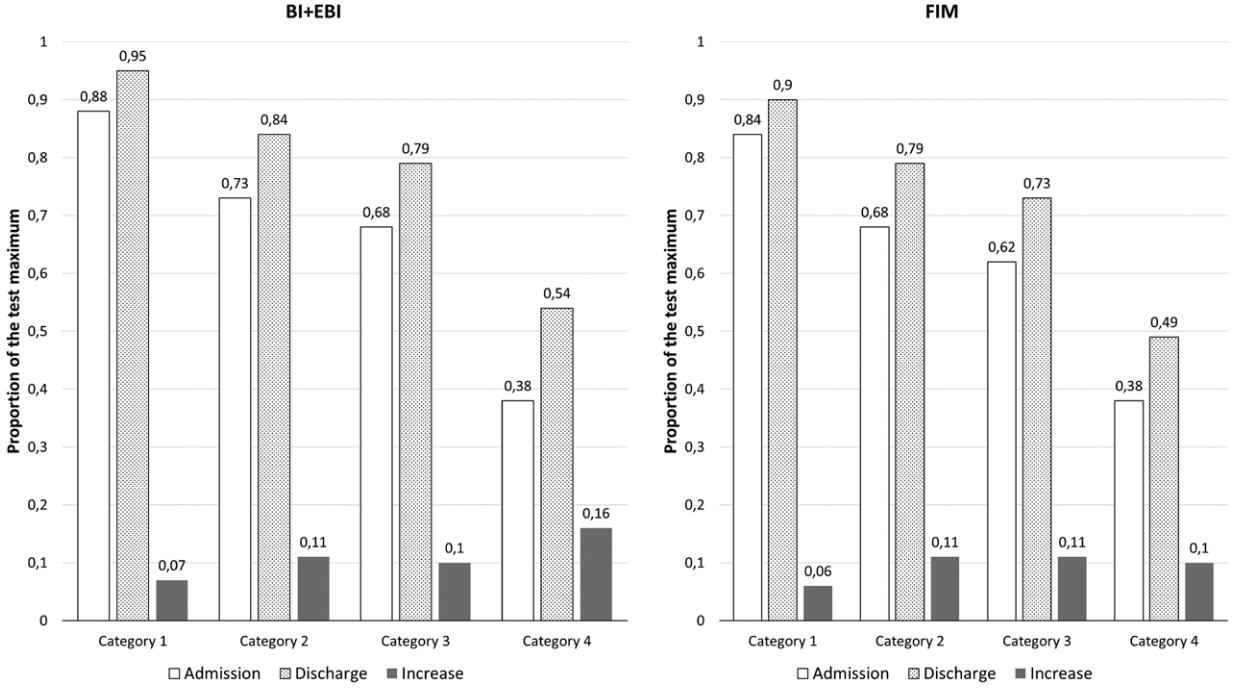
All cost data are given in Czech crowns (CZK) and Euro (EUR) using the 2017 Czech National Bank average exchange rate of EUR 1 = CZK 26.330. The costs were calculated by the micro-costing (bottom-up) method (detailed methodology to be published in a separate article, unpublished to date). The cost-effectiveness ratios were calculated individually for each disability category as the average total cost of the hospitalization in the rehabilitation unit divided by the average incremental change in the outcome (end – beginning). This was done separately for Barthel Index, EBI, Barthel Index+EBI, total FIM, motor FIM and cognitive FIM, yielding six sets of cost-effectiveness values per each disability category.

Table 1 Distribution of patients across the four disability categories and their characteristics at the beginning of rehabilitation

Disability category	1	2	3	4	Average
Number of patients	15	27	24	21	87
Average age (years)	65.7 (45–88)	71.5 (31–90)	71.9 (49–93)	71.0 (41–91)	70.5 (31–93)
Average length of hospitalization on rehabilitation (days)	16.4 (9–40)	19.1 (4–59)	24.6 (11–50)	27.5 (4–45)	22.2 (4–59)
Average time from stroke onset to translation to rehabilitation unit (days)	10.5 (4–22)	12.6 (4–30)	14.3 (6–34)	27.1 (9–69)	11 (4–69)
Barthel Index beginning	88.7 (65–100)	65.9 (15–100)	57.1 (5–90)	23.8 (0–65)	57.3 (0–100)
Barthel Index end	96.7 (80–100)	82.6 (40–100)	72.9 (20–100)	44.5 (5–95)	73.2 (5–100)
EBI beginning	78.0 (40–90)	72.4 (15–90)	72.5 (20–90)	48.8 (20–90)	67.7 (15–90)
EBI end	83.7 (65–90)	76.1 (25–90)	76.3 (15–90)	57.6 (25–90)	73 (15–90)
Barthel Index + EBI beginning	166.7 (125–190)	138.3 (40–185)	129.6 (40–180)	72.6 (25–155)	124.9 (25–190)
Barthel Index + EBI end	180.3 (160–190)	158.7 (65–190)	149.2 (60–190)	102.1 (50–180)	146.2 (50–190)
FIM beginning	105.3 (83–123)	86.0 (26–120)	78.5 (21–114)	48.3 (20–96)	78.2 (20–123)
FIM end	113.2 (92–125)	100.1 (45–126)	92.3 (28–122)	61.3 (22–114)	90.9 (22–126)
FIM – Motor beginning	76.6 (55–91)	58.7 (20–86)	50.0 (14–80)	28.9 (13–72)	52.2 (13–91)
FIM – Motor end	83.1 (69–91)	71.5 (29–91)	62.8 (16–90)	39.5 (15–85)	63.4 (15–91)
FIM – Cognitive beginning	28.7 (15–35)	27.3 (5–35)	28.5 (7–35)	19.4 (6–34)	26 (5–35)
FIM – Cognitive end	30.1 (16–35)	28.6 (6–35)	29.5 (10–35)	21.8 (7–34)	27.5 (6–35)

EBI, Extended Barthel Index; FIM, functional independence measure.

Fig. 1



Average scores of Barthel Index+EBI and total FIM in the beginning and at the end of inpatient rehabilitation with the average improvement across the four disability categories. EBI, Extended Barthel Index; FIM, functional independence measure.

Results

The age of 87 included patients was between 31 and 95 years (mean 70.5). Sixty-four patients (73.5%) were between 60 and 90 years, almost equally distributed in decades. The laterality in hemiparesis was balanced (left-side in 41 patients, right-side in 41 patients and no or unrecorded in 5 patients). The average length of hospitalization was 22.2 days.

The disability category (see Patients and Methods for the definition) was determined by the physician during the admission interview/examination. No patient was assigned to the unconscious category. Table 1 shows basic baseline data characterizing patient distribution to the categories and the respective initial and final average scores for Barthel Index and FIM. While the age was independent of the categories, both the length of hospitalization in the rehabilitation unit and the number of days between stroke onset and transfer to the rehabilitation unit grew from less to more disabled categories. Also, the scores of Barthel Index and motor FIM were associated with the categories, which was not found for EBI and cognitive FIM (only the patients in the fourth category showed visibly worse results).

Table 2 Average costs across disability categories

Category	Number of patients	Costs per one patient-CZK (EUR)		Total costs per one patient – index (relation to the average costs in the first category)							
		Total	One-day	Total	Personnel	Nursing	Therapeutic	Materials	Devices and aids	Drugs	Complement
1	15	68825 (2614)	4283 (162.67)	1	1	1	1	1	1	1	1
2	27	85263 (3238)	4513 (171.40)	1.239	1.100	1.313	0.943	1.817	1.123	4.942	4.010
3	24	129498 (4918)	5352 (203.27)	1.882	2.441	3.993	1.302	7.269	1.278	3.797	2.064
4	21	167530 (6363)	6165 (234.14)	2.434	3.514	6.178	1.559	14.732	1.399	5.163	2.237

Table 3 Cost-effectiveness ratios across disability categories and outcome measures

Disability category	1		2		3		4	
	68825		85263		129498		167530	
C-Average cost (CZK)	E	C/E	E	C/E	E	C/E	E	C/E
Barthel Index	8.0	8603	16.7	5116	15.8	8179	20.7	8088
EBI	5.7	12075	3.7	23044	3.8	34078	8.8	19038
Barthel Index+EBI	13.7	5024	20.4	4180	19.6	6607	29.5	5679
FIM motor	6.5	10588	12.8	6661	12.8	10117	10.6	15805
FIM cognitive	1.4	49161	1.3	65587	1.0	129498	2.4	69804
FIM	7.9	8712	14.1	6047	13.8	9384	13.0	12887

C/E values are comparable only in lines, not between different outcomes.
C, average cost for the disability category; C/E, cost-effectiveness ratio for the respective outcome; E, effect, i.e. outcome value; EBI, Extended Barthel Index; FIM, functional independence measure.

Figure 1 illustrates the average improvements in different categories in terms of Barthel Index+EBI and FIM. The same proportional change is representative of the increase in Barthel Index and motor FIM, whereas their cognitive parts did not differentiate between categories 1, 2 and 3). Both the initial and final scores were lower in more disabled categories. Thus, the disability categories as defined by the Czech reimbursement scheme proved valid for grouping patients according to the level of disability, which justifies their use as the independent variable in this study.

For the calculation of cost-effectiveness, we first examined the dependence of the costs and their components on the disability category. The cost data are presented in Table 2.

For calculating the cost-effectiveness ratios, we divided the average costs of early rehabilitation hospitalization by the average increase in Barthel Index, EBI, Barthel Index+EBI, total FIM, motor FIM and cognitive FIM from admission to discharge. Thus, the resulting cost-effectiveness ratio can be interpreted as the incremental cost-effectiveness ratio, which provides a standard comparison of the spent money effectiveness over the disability categories. All cost-effectiveness data are presented in Table 3. Since the cognition scores (EBI and FIM-cognitive) had only a small effect on the total results, we focused on the respective motor scores (Barthel Index and motor FIM) and the total scores (Barthel Index+EBI and total FIM). Figure 2 shows the cost-effectiveness ratio dependent on the disability categories for Barthel Index and FIM, indicating the same pattern for FIM and Barthel Index scores. Finally, Fig. 3 provides the breakdown of the cost-effectiveness results across different Barthel Index and FIM scores, expressed as the ratio to the category average.

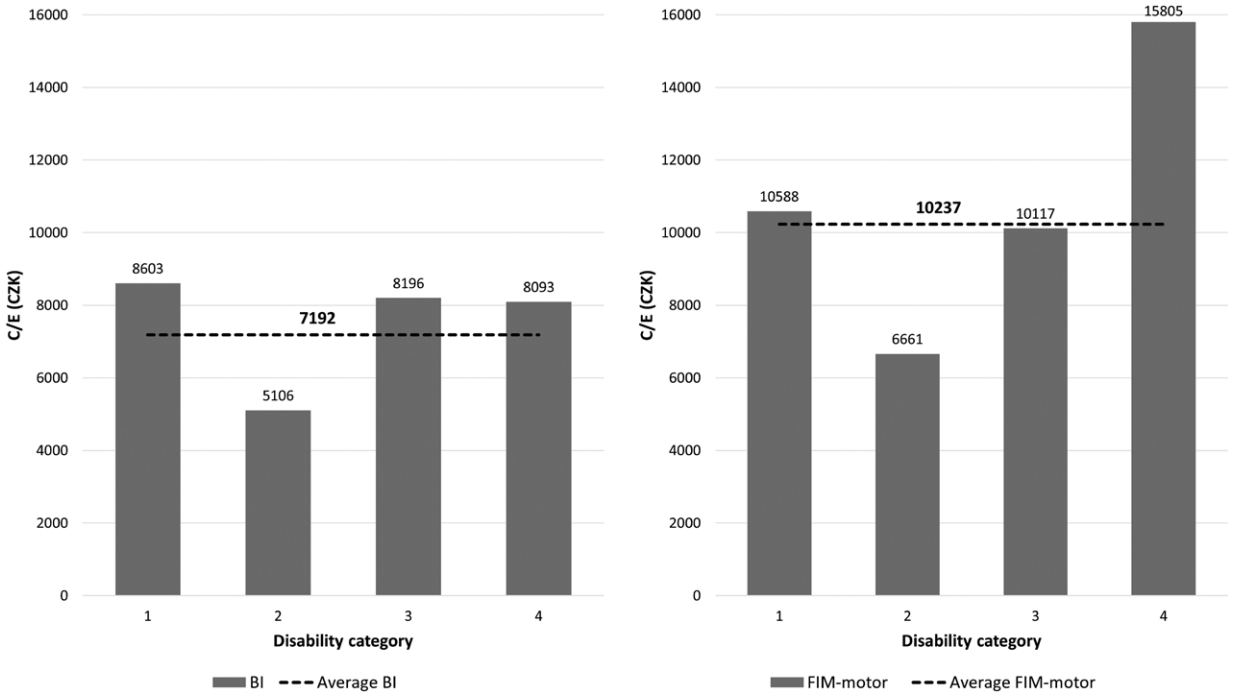
The greatest cost-effectiveness (the smallest expense for achieving a one-point improvement in the functional score) was most often found in category 2 (partly self-sufficient) (i.e. the lowest value across four categories for all outcomes but EBI). The cost-effectiveness based on Barthel Index was similar for categories 1, 3 and 4, while increasing FIM by one point was the most expensive in category 4 (Table 3, last row last column).

Discussion

The idea behind our research was that the costs grow with the degree of disability, which proved true; depending on the disability category, the cost increase was between 56 and 143% (Table 2). This does not fully project into cost-effectiveness figures. The inpatient rehabilitation proved to be most effective for partly self-sufficient patients (disability category 2), although it is closely effective also for self-sufficient patients (category 1) and those that require an enhanced level of supervision (category 3) (Fig. 2).

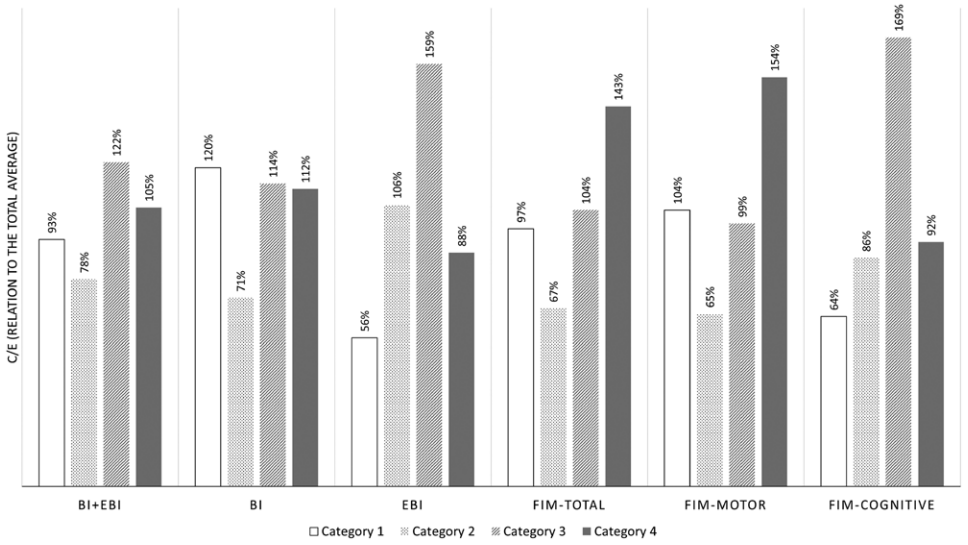
On the other hand, inpatient rehabilitation appears to be the least effective for the most severely disabled patients (disability category four), who are greatly dependent on others in activities of daily living. Not surprisingly, the worse the initial disability, the longer the time to improve to the point of plateau. They also have a lot of comorbidities and need more medication, more aids and sometimes

Fig. 2



Cost-effectiveness based on the Barthel Index and motor FIM across disability categories. FIM, functional independence measure.

Fig. 3



Cost-effectiveness as a percentage of the overall total average cost for different disability categories and outcome measures.

more therapists and nurses to assist with mobility. Some of them remain severely disabled, showing little to no improvement, and we have no reliable predictive markers to see it early after stroke (Winters *et al.*,2018). On the other hand, even a small improvement may mean a great difference in the quality of life for this group.

Our results also revealed which disability scales are the most suitable for economic analyses. The scales assessing motor skills (Barthel Index and motor FIM) are much more sensitive than cognitive counterparts (EBI and cognitive FIM). This is not surprising because, after stroke, motor impairments tend to be more common and

profound than cognitive impairments, they also recover faster and more, and, by the design, the motor scales cover more functional items and are more sensitive than the cognitive scales. The patient categorization for the Czech reimbursement scheme, based mostly on mobility and motor deficits causing the biggest burden on nursing support and material expenses, appeared to be adequate for both grouping patients into different disability categories and cost-effectiveness analysis.

In our study, the average cost of hospitalization was about one-third of the AVERT costs. The AVERT trial cost was calculated from phase II (Tay-Teo *et al.*, 2008) and phase III (Gao *et al.*, 2019) data. These costs are slightly higher than the Taiwan costs described recently by Chen *et al.* (2020). According to Gao *et al.* (2019), their very early mobilization and usual care were associated with comparable costs and outcomes [measured by the modified Rankin Scale and Quality Adjusted Life Years (QALY) gains]. Due to the differences in the purchase power parity (or alternatively, GDP per capita), a direct comparison of costs is not meaningful. Of more interest is the relative cost comparing different cost components or costs under different circumstances.

Limitations and future directions

This study was limited in time (1 year) and research capacity. The main limitations are the relatively small sample from three (although main) Czech hospitals, the sample inhomogeneity (different types and locations of strokes), and no control sample. Finally, this study examined the outcomes of inpatient rehabilitation that do not adequately correspond to the long-time goals and quality of life measures (e.g. QALY gains).

Conclusion

The results indicate that the total and per day costs of early inpatient rehabilitation after stroke increases with increasing disability. On the basis of our disability classification, the difference in the costs between the least costly group (self-sufficient) and the most costly group (immobile) was about 2.4-fold. In absolute values, the main driver of the difference was the personnel costs, above all nursing costs. Monitoring trends in cost and cost-effectiveness of rehabilitation is warranted for the judicious allocation of available resources.

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Conflicts of interest

There are no conflicts of interest.

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