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Costs during the first year after stroke by degree of functional disability: A societal perspective

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Abstract

Introduction: The aim of this study was to estimate societal costs during the first year after stroke by degree of functional disability.

Patients and methods: Descriptive study of the cumulative costs incurred during 1-year follow-up of a cohort of patients with stroke in Catalonia (Spain) participating in a multicentre, population-based, cluster-randomised trial (RACECAT). Patients were recruited between September 2017 and January 2019. Costs were collected for each patient from stroke onset to 1-year follow-up through hospital accounting records, electronic healthcare records and structured telephone-based interviews at 6 and 12-months follow-up. Disability was assessed using the 90-day modified Rankin Scale (mRS). Healthcare, community care, and patient/family costs were included. We used complete data from 567 eligible participants. Cost data were analysed using generalised linear models (GLMs) with gamma distributions and log link functions. For variables with >10% zero values, two-part models were applied. We performed sensitivity analyses modifying unit costs for patient/family costs.

Results: Of the 567 patients included, 53% had ischaemic large vessel oclusion (LVO) stroke, 24% intracranial haemorrhage and 23% ischaemic non-LVO stroke. Mean cost per patient during the first year after stroke was €29,673 ± 28,632, and increased with degree of disability (mRS 0–2: €18,568 ± 12,244; mRS 3: €38,214 ± 28,172; mRS 4–5: €52,859 ± 36,383). Healthcare costs represented the highest proportion of total costs (63%; €18,724/patient) across all disability levels, with index hospitalisation being the highest (€12,319 ± 17,675); however, community care and patient/family costs represented over 40% of total cost in patients with higher disability levels.

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Discussion and conclusion: Our results are in line with other studies; the costs during the first year after stroke are high and increase with disability. These results are valuable for calculating the cost of severe stroke cases.

Keywords
Modified Rankin scale, mRS, informal care, hospitalisation

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Introduction

Stroke has a significant impact on a person's physical, cognitive and functional capacity. Disability due to stroke can affect work productivity and result in a need for care and support.[1] Consequently, there is a substantial economic burden on individuals, families, and society as a whole.[2]

Most studies focus on healthcare costs, but a few take a societal perspective emphasising the importance of the burden stroke poses on patient/family costs, especially for those patients with high disability, and among younger adults due to productivity loss.[3,4] In 2017, the cost of stroke was estimated at a total of €60bn, of which, €27bn were healthcare costs, €5bn were community costs, and €28bn were patient/family costs (of these, €16bn were caregiving and €12bn were patient productivity loss) in 32 European countries.[5] In 2016, a Spanish study concluded that the mean cost per patient was €27,711 during the first year, of which more than two-thirds corresponded to patient/family costs (mainly caregiving).[6]

The modified Rankin Scale (mRS) at 90 days is considered the main tool to assess functional disability post-stroke.[7] Cost estimates relating to 90-day mRS categories may be valuable for healthcare economic evaluations of stroke.[8,9]

The aim of this study was to estimate costs during the first year after stroke by the degree of functional disability measured by 90-day mRS, from a societal perspective in a cohort of patients in Catalonia (Spain).

Methods

Study context and population

We assessed a sub-cohort of patients recruited in the RACECAT trial (ClinicalTrials.gov NCT02795962). RACECAT was a multicentre, population-based, cluster-randomised trial involving patients in Catalonia (Spain), with suspected large vessel occlusion (LVO) stroke attended by emergency medical services (EMS) in areas where the closest local stroke centre was not capable of performing thrombectomy. Details of the RACECAT trial are reported elsewhere.[10,11]

We included all consecutive patients between September 2017 and January 2019 ($n = 629$). We included 567 patients after excluding stroke mimics ($n = 42$), transient ischaemic attacks (TIAs; $n = 14$) and six patients lost to follow-up (i.e. patients who did not answer 6- and 12-month follow-up questionnaires as they could not be located; Figure 1). Loss to follow-up patients did not show significant differences in sex, age, mRS at 90 days and diagnosis, compared to included patients.

Data collection

We collected data during 12 months from stroke onset. Data were obtained from: (1) hospital accounting records; (2) electronic healthcare records; and (3) structured telephone-based interviews with the patient and/or caregiver or close relative. Interviews were conducted at 90 days to assess the mRS, and at 6 and 12 months after stroke to retrospectively collect data on use of community care and patient/family resources used since the stroke and up to 1-year. For patients who died between follow up periods, interviews were not conducted and thus community and patient/family resource consumptions during survival within these periods could not be assessed. With the exception of the six patients lost to follow-up (excluded), the database had no missing information.

Variables

Modified Rankin Scale (mRS) at 90 days. The mRS assesses the level of disability in people after stroke.[12] Outcome assessors assign a score from 0 (no symptoms) to 6 (death), with each score representing a different level of disability or functional impairment. We categorised the

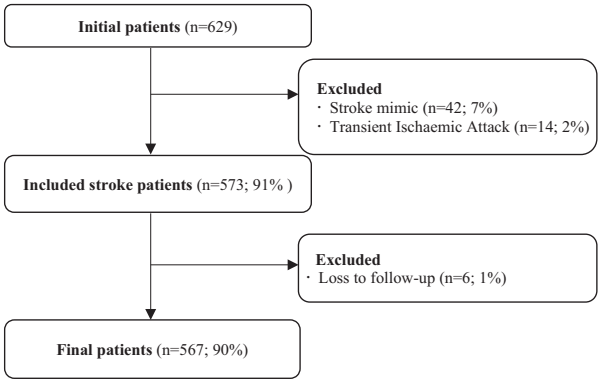

Figure 1. Study flowchart.
LVO: large vessel occlusion.

mRS at 90 days post-stroke into 4 levels according to clinical criteria[13,14]: 0–2 (no disability or slight disability), 3 (moderate disability), 4–5 (severe disability) and 6 (death).

Costs

No discount rate was applied because the cost description[15] had a 1-year follow-up period. All costs are expressed in euros (€) for the reference year 2023. Cost classifications followed Drummond et al. and ESO Health Economics recommendations.[9,15]

Healthcare costs. *Acute phase* included the Emergency Medical Service (EMS) and the index hospitalisation. *EMS costs* for transport for the stroke episode were obtained from accounting records, which take into account the availability of resources in each healthcare region, that is, the cost of each EMS service is lower [on average] in regions were the number of ambulances per capita is higher. *Index hospitalisation costs* were estimated from hospital accounting records through a micro-costing approach (detailed in Supplemental Material 1), including admission days to the emergency ward, general ward, stroke unit or intensive care unit, hospital medication and procedures. Costs were updated to 2023 using the Spanish Health-specific Consumer Price Index (CPI).[16]

The follow-up phase captured the use of healthcare resources from hospital discharge to 12 months, including new hospitalisations (acute and intermediate care), outpatient rehabilitation, mental healthcare, minor outpatient surgery and other medical services. Data were obtained from the Catalan Health Surveillance System, an electronic health record system that tracks public health service utilisation and costs, weighted by Adjusted Morbidity Groups (AMG).[17] Since these data were provided in aggregated form, it was not possible to directly separate stroke-related and unrelated healthcare costs. To address this and minimise any potential inflation, a percentage was attributed to each cost category based on a previous study,[18] and these percentages were validated through consensus with clinical experts (Supplemental Table 1). Costs were calculated for the reference year 2023.

Nursing home use was assessed via telephone interviews, with costs derived from the published 2023 tariffs of the Catalan Government.[19]

Community care costs. Use and costs of General Practitioner clinics, community medication and outpatient consultations were obtained from the Catalan Health Surveillance System[17] for 2023. These costs included both stroke-related and unrelated costs, to which we applied the same percentage allocation approach to avoid cost inflation, as done for all costs derived from the Catalan Health Surveillance System.

Use of telecare, home-care (public, private and home resident caregiver) and home modifications or adaptations were obtained from interviews. Telecare and public home healthcare costs were obtained from the published Catalan tariffs for the year 2023.[20] The unit cost for private home healthcare and home resident caregivers was the minimum wage in Spain for caregivers for the year 2023.[21] Home modifications and adaptation costs were obtained from standard quotes for 2018 of the Centre for Personal Autonomy (Centre de Vida Independent), a return-home pilot programme in Catalonia that included the costs for the adaptations and home modifications.[22] Home modifications and adaptations are one-off costs that can benefit the patient for many years. Therefore, considering that our sample had an average age of 74 years, and survival data after stroke suggest 5–10 years as a critical survival period,[23] as well as the additional years of staying at home before requiring institutional care in older adults with some degree of physical disability is estimated to be 5–10 years,[24] a functional lifespan of 10 years was estimated for these modifications. The total cost was then divided by this period to obtain the annual cost. These costs were updated to 2023 using the Spanish CPI.[25]

Patient and family costs. Patient and family costs included paid and unpaid patient productivity loss, paid and unpaid caregiver productivity loss and additional caregiving hours not considered productivity loss by the caregiver. These were collected retrospectively at 6 and 12 months, and we used the human capital approach to calculate productivity losses.[6,26]

Patients' paid productivity loss was counted as the number of hours they reduced work or stopped working due to stroke. The patients' unpaid productivity loss was counted as the number of hours the patient stopped performing other unpaid activities due to stroke, such as caring for children or grandchildren, doing household chores, shopping, tending to a garden or orchard, caring for another person, volunteering or, if unemployed, looking for a job, participating in continuing education courses or engaging in employment programmes. Patients' productivity losses were set to a maximum of 8 h per day for 238 annual working days (5 days/week, minus 22 annual paid vacation days) up to 1904 h/year. Additionally, for patients who died during the study period at an age below the mean life expectancy of Spain in 2023 (men: 80.3 years; women: 85.8 years),[27] productivity losses were calculated depending on the age of the patient. For them, we considered productivity losses as paid hours for those patients who were of working age (<65) and unpaid hours for those who were retired ($\geqslant 65$). In both cases, we used the mean working hours annually from the OECD for Spain in 2023,[28] adjusted for the number of days the patient was no longer alive during the study period.

The caregivers' loss of paid and unpaid productivity was collected following the same procedure. Caregiving hours

Table 1. Unit costs.

Cost category	Unit cost (€) in 2023	Source
Healthcare costs		
Acute phase		
Emergency Medical Services (includes transport)	Accounting records[c]	EMS accounting records
Hospitalisation	Accounting records[c]	Hospital accounting records (see Supplemental Material 1)
Follow-up phase		
Hospitalisation (per episode)	€1828.27 to €36,160.08	Catalan Health Surveillance System (CHSS) accounting records[17]
Intermediate care centre[a] (per day)	€247.77	CHSS accounting records[17]
Emergency service (per consultation)	€125.99	CHSS accounting records[17]
Outpatient consulting/minor outpatient surgery (per consultation)	€ 237.74	CHSS accounting records[17]
Outpatient rehabilitation (per consultation)	€17.31€ to €1271.43	CHSS accounting records[17]
Mental healthcare (per consultation)	€69.18	CHSS accounting records[17]
Other Medical services[b] (per use)	€0.15 to €118,641.34	CHSS accounting records[17]
Nursing home (per day)	€65.84	Portal Jurídic de Catalunya[19]
Community care costs		
Primary care centre (per consultation)	€55.02 to €88.04	CHSS accounting records[17]
Community medication	Public price of each product	CHSS accounting records[17]
External consultation (per consultation)	€68.07	CHSS accounting records[17]
Public home healthcare (per hour)	€18.00	Diputació de Barcelona[20]
Private home healthcare (per hour)	€8.45	Ministerio de Trabajo y Economía Social[21]
Private home resident caregiver (per hour)	€8.45	Ministerio de Trabajo y Economía Social[21]
Telecare (annual service, price per month)	€14.04	Diputació de Barcelona[20]
Home modifications		Centre for Independent Living[22]
Small (e.g. shower bars or chair)	€990.68	
Moderate (e.g. shower bars plus handrails or ramps)	€1613.42	
Major (e.g. crane installation)	€4128.65	
Home adaptation		Centre for Independent Living[22]
Shower/bath replacement	€3182.42	
Full bathroom renovation and/or other rooms	€4821.39	
Patient/family costs		
Informal care hours (per hour)	€18.00	Diputació de Barcelona[20]
Informal caregiver productivity loss		
Lost paid hours (per hour)		
Mean gross salary (men)	€10.52	Instituto Nacional de Estadística[29]
Mean gross salary (women)	€8.72	Instituto Nacional de Estadística[29]
Lost unpaid hours (per hour)	€4.50	Ministerio de Trabajo y Economía Social[21]
Patient productivity loss		
Lost paid hours (per hour)		
Mean gross salary (men)	€10.52	Instituto Nacional de Estadística[29]
Mean gross salary (women)	€8.72	Instituto Nacional de Estadística[29]
Lost unpaid hours (per hour)	€4.50	Ministerio de Trabajo y Economía Social[21]

[a]Intermediate care centres include the so-called long-stay socio-health centres, social and healthcare centres, mid-stay and convalescence, Functional Interdisciplinary Socio-Sanitary Units (UFISS), home support equipment (PADES) and day hospital.
[b]Other medical services: individual non-urgent healthcare transport service, home respiratory therapy, dialysis and other mental health services. The lowest price is a home respiratory oxygen cylinder and the highest is a heart transplant.
[c]Different values were calculated through the analytical accounting system.

were collected as the number of hours per day spent caring for the patient post-stroke. Based on previous recommendations we set a maximum possible of 16 h a day,[1] however the actual reported range was 0–11.2 h/day. To avoid double counting, paid and unpaid productivity loss hours were subtracted from total reported caregiving hours, as there were hours the person spent caring but not considered lost productivity. Therefore, the variable of *caregiving hours*

refers to additional hours dedicated to care, but not considered as lost productivity by the caregiver.

For lost paid hours in both patients and caregivers, the unit cost was the mean gross salary in Spain for the year 2022 by sex,[29] updated to 2023 with the Spanish CPI,[25] for unpaid lost hours we used the minimum gross wage[21] and for caregiving hours variable we used the public home-care workers tariff as unit cost.[20] Table 1 shows unit costs used in this study.

Minor out-of-pocket expenses (e.g. hospital parking fees, fuel costs for hospital visits) were not included due to the risk of recall bias, as this information was gathered retrospectively during the 6- and 12-month follow-up interviews, covering the preceding 6 months in each interview and to avoid overburdening patients with an already lengthy questionnaire.

Statistical analysis

Baseline characteristics were described and compared by mRS using the chi-square test for categorical variables and ANOVA for continuous variables. To analyse resource utilisation, generalised linear models (GLMs) were applied. Continuous variables were modelled using a GLM with a gamma distribution and log link function, while categorical variables were analysed with a generalised logistic model using a binomial distribution and logit link. Cost data were also modelled using a GLM with a gamma distribution and log link. For both resource utilisation and cost variables with more than 10% zero values, two-part models with a gamma distribution and log link were employed, except for discrete variables such as telecare and nursing home utilisation, which were modelled using a Poisson distribution with a log link. Model fit was assessed using the Akaike and Bayesian Information Criterion (AIC and BIC).

Because there remains no consensus regarding the best calculation method for patient/family costs,[1] we performed three sensitivity analyses to address the potential variability in our assumptions: we estimated the total cost (1) considering the mean salary by sex in Spain; (2) the minimum wage in Spain; and (3) the private home healthcare minimum wage; as unit costs for informal care hours (not productivity losses).

All analyses were performed using Stata Statistical Software, version 17 (Stata Corp LLC, College Station, TX, USA).

Results

We included 567 patients in the study. The mean age was 74 years, with 59% being male. Among the patients, 53% had ischaemic LVO stroke, followed by 24% with intracranial haemorrhage and 23% with ischaemic non-LVO stroke (Table 2).

Total costs per patient are described in Table 3. All costs increased with mRS score, with healthcare costs being higher than community and patient/family costs across all mRS groups (Figure 2).

Costs by diagnosis, use of resources and costs by mRS categories are shown in Supplemental Tables 2–4. In all sensitivity scenarios (Supplemental Table 5), estimated costs were similar.

Discussion

Our results demonstrate a strong relationship between functional disability measured with mRS and costs after acute stroke, in line with previous literature.[7,30,31] Each mRS category was associated with a different average length of hospital stay in the acute phase of stroke recovery,[31] and with different rehabilitation needs and nursing home care in the chronic phase,[30] increasing as mRS increased.

Studies examining stroke costs often focus on ischaemic stroke.[1,18,32] In contrast, our study provides a comprehensive analysis encompassing various stroke subtypes, including LVO ischaemic stroke (53%), non-LVO ischaemic stroke (23%), and haemorrhagic stroke (24%). Compared to the recent Spanish study by Lucas-Noll et al.,[33] which reported a mean cost of €22,605.66, our study found higher overall mean costs. This discrepancy is likely attributable to our cohort's composition, characterised by a high proportion of severe LVO strokes, in contrast to their inclusion of TIAs, which generally incur lower costs.[33]

Although 60% of costs across all mRS categories were healthcare costs, the highest proportion being index hospitalisation (M=€12,319),[18] patient/family costs represented a considerable burden, ranging from €4394 to €17,552, including caregiving (from €755 to 12,392€)[1,6] and productivity losses. Patients' mean paid productivity loss was €2388, being higher for mRS 0–2 (M=€3,316/patient), probably because there were more active workers pre-stroke in this group with lower mean age.

Limitations

Our sample represented a more severe illness profile compared to the general population, which limits the generalisability of overall results. Data obtained from the Catalan Health Surveillance System were provided in aggregated form, thus it was not possible to directly separate stroke-related and unrelated costs. To address this, we attributed a percentage of each cost category to stroke based on previous studies[18] and expert consensus. Estimations of productivity losses for deceased patients were limited due to missing follow-up questionnaire data, therefore assumptions were made based on age and life expectancy. Minor family/patient out-of-pocket expenses were not included due to the potential recall bias and the length of the questionnaire, which could slightly underestimate the costs.

Table 2. Baseline characteristics of patients and caregivers by 90 days mRS and overall.

Characteristics	90-days mRS										
	Overall (*n* = 567)		0–2 (*n* = 159)		3 (*n* = 92)		4–5 (*n* = 154)		Death (*n* = 162)		*p*-Value[b]
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Days from stroke to death (m, SD)	45.03	5.33	285	-[c]	262.25	41.28	170.79	12.60	15.72	1.63	<0.001
Age (m, SD)	74.08	0.53	68.67	0.92	73.23	1.32	74.20	1.08	79.79	0.80	<0.001
Sex											<0.001
Male	332	58.55	109	68.55	57	61.96	74	48.05	92	56.79	
Female	235	41.45	50	31.45	35	38.04	80	51.95	70	43.21	
Diagnosis											<0.001
Intracranial haemorrhage	135	23.81	17	10.69	15	16.30	48	31.17	55	33.95	
Ischaemic LVO stroke	299	52.73	91	57.23	51	55.43	80	51.95	77	47.53	
Ischaemic non-LVO stroke	133	23.46	51	32.08	26	28.26	26	16.88	30	18.52	
Medical history											
Hypertension	420	74.07	106	66.67	67	72.83	119	77.27	128	79.01	0.058
Dyslipidaemia	279	49.21	71	44.65	50	54.35	78	50.65	80	49.38	0.490
Diabetes	149	26.28	32	20.13	31	33.70	40	25.97	46	28.40	0.107
Coronary heart disease	73	12.87	22	13.84	12	13.04	17	11.04	22	13.58	0.881
Heart failure	56	9.88	12	7.55	6	6.52	15	9.74	23	14.20	0.137
Peripheral vasculopathy	25	4.41	4	2.52	4	4.35	5	3.25	12	7.41	0.151
Ischaemic stroke/TIA	82	14.46	21	13.21	16	17.39	24	15.58	21	12.96	0.731
Atrial fibrillation	165	29.10	44	27.67	23	25.00	40	25.97	58	35.80	0.160
Pre-stroke anticoagulation treatment	116	20.46	28	17.61	20	21.74	29	18.83	39	24.07	0.487
Smoking	80	14.11	30	18.87	16	17.39	20	12.99	14	8.64	0.047
Level of studies[a]											
No studies	49	8.64	15	9.43	11	12.09	23	15.13	0	0.00	<0.001
Incomplete primary	43	7.58	13	8.18	13	14.29	17	11.18	0	0.00	
Complete primary (up to 14 years)	148	26.10	62	38.99	36	39.56	50	32.89	0	0.00	
Secondary (up to 18 years)	70	12.35	30	18.87	17	18.68	23	15.13	0	0.00	
University or above	61	10.76	35	22.01	9	9.89	17	11.18	0	0.00	
Not Reported	196	34.57	4	2.52	6	6.52	24	15.58	162	100.00	
Pre-stroke Labour situation[a]											
Working (paid job)	82	14.46	44	27.67	15	16.48	23	15.13	0	0.00	<0.001
Unpaid job (e.g. working age homemakers)	4	0.71	1	0.63	2	2.20	1	0.66	0	0.00	
Unemployed	10	1.76	4	2.52	3	3.30	3	1.97	0	0.00	
Retired	272	47.97	103	64.78	63	69.23	106	69.74	0	0.00	
Sick leave	6	1.06	2	1.26	2	2.20	2	1.32	0	0.00	
Not Reported	193	34.04	5	3.14	6	6.59	17	11.18	162	100.00	
Caregiver pre-stroke labour situation[a]											<0.001
Not working	277	48.85	152	95.60	44	47.83	81	52.60	0	0.00	
Unemployed, seeking a full-time job	61	10.76	3	1.89	26	28.26	32	20.78	0	0.00	
Unemployed, seeking a part-time job	2	0.35	0	0.00	0	0.00	2	1.30	0	0.00	
Working (paid job)	62	10.93	4	2.52	21	22.83	37	24.03	0	0.00	
Not reported	165	29.10	0	0.00	1	1.09	2	1.30	162	100.00	
Caregiver after-stroke labour situation[a]											
Still working	36	6.35	1	0.63	17	18.48	18	11.69	0	0.00	<0.001
Stopped working	13	2.29	2	1.26	2	2.17	9	5.84	0	0.00	
Left partially	12	2.12	1	0.63	2	2.17	9	5.84	0	0.00	
Not Reported/Not applicable	506	89.24	155	97.48	71	77.17	118	76.62	162	100.00	

LVO: large vessel occlusion; TIA: transient ischaemic attack.
[a]Variable collected at 6-month follow-up.
[b]Chi square test was used for categorical variables, and ANOVA for continuous variables.
[c]The standard deviation was not calculated as there was only one observation in this category.

Table 3. Mean and median costs per patient during the first-year post-stroke by 90-days mRS.

90-days mRS													
Costs (€)	Overall (*n* = 567)		0–2 (*n* = 159)		3 (*n* = 92)		*p*-Value[b]	4–5 (*n* = 154)		*p*-Value[b]	Death (*n* = 162)		*p*-Value[b]
	Mean (SD)	Median (p25-p75)	Mean (SD)	Median (p25-p75)	Mean (SD)	Median (p25-p75)		Mean (SD)	Median (p25-p75)		Mean (SD)	Median (p25-p75)	
Healthcare costs													
Acute phase													
Emergency Medical Service	397 (541)	213 (179–426)	414 (593)	213 (179–426)	433 (578)	259 (179–435)	0.803	355 (457)	213 (179–389)	0.324	400 (543)	259 (179–426)	0.821
Hospitalisation	12,319 (17,675)	9555 (3868–15,536)	10,141 (7867)	9109 (4904–12,571)	14,203 (15,311)	11,356 (6300–18,316)	0.026	17,877 (28,894)	13,014 (4748–21,786)	<0.001	8043 (7297)	6207 (2142–12,255)	0.073
Total acute cost	12,716 (17,751)	9981 (4073–15,902)	10,556 (7985)	9398 (5160–13,293)	14,636 (15,591)	11,825 (6637–18,658)	0.027	18,233 (28,914)	13,261 (5050–21,949)	<0.001	8443 (7435)	6501 (2436–12,550)	0.078
Follow-up													
Hospitalisation	936 (2030)	0 (0–0)	1104 (2387)	0 (0–1911)	1294 (2178)	0 (0–2394)	0.912	1324 (2140)	0 (0–2101)	0.346	199 (1031)	0 (0–0)	0.535
Intermediate care centre	3540 (6422)	302 (0–5056)	685 (1743)	0 (0–57)	3864 (5255)	388 (0–6173)	<0.001	9419 (8853)	8574 (302–13,415)	<0.001	568 (1355)	0 (0–302)	0.003
Emergency service	88 (153)	0 (0–163)	113 (161)	81 (0–163)	131 (200)	81 (0–163)	0.456	121 (157)	81 (0–163)	0.893	8 (38)	0 (0–0)	0.302
Outpatient consultation/ outpatient surgery	299 (1294)	0 (0–0)	90 (288)	0 (0–145)	624 (1699)	0 (0–151)	<0.001	632 (2020)	0 (0–145)	<0.001	4 (33)	0 (0–0)	0.876
Outpatient rehabilitation and mental healthcare	68 (305)	0 (0–0)	68 (198)	0 (0–0)	103 (267)	0 (0–0)	0.419	114 (503)	0 (0–0)	0.004	3 (24)	0 (0–0)	0.021
Other Medical services[a]	524 (1620)	0 (0–0)	649 (2063)	0 (0–0)	585 (1471)	0 (0–18)	0.409	659 (1747)	0 (0–61)	0.342	237 (896)	0 (0–0)	0.001
Nursing home	845 (3071)	0 (0–0)	75 (950)	0 (0–0)	912 (3195)	0 (0–0)	1.000	2490 (4878)	0 (0–0)	1.000	0 (0)	0 (0–0)	-
Total follow-up healthcare costs	6299 (9114)	2348 (0–9304)	2785 (4601)	384 (0–4225)	7511 (7622)	5240 (587–11,964)	<0.001	14,759 (11,471)	13,105 (6501–20,470)	<0.001	1018 (1950)	0 (0–605)	<0.001

(Continued)

Table 3. (Continued)

90-days mRS

Costs (€)	Overall ($n=567$)		0–2 ($n=159$)		3 ($n=92$)		p-Value[b]	4–5 ($n=154$)		p-Value[b]	Death ($n=162$)		p-Value[b]
	Mean (SD)	Median (p25-p75)	Mean (SD)	Median (p25-p75)	Mean (SD)	Median (p25-p75)		Mean (SD)	Median (p25-p75)		Mean (SD)	Median (p25-p75)	
Community costs													
Primary care centre	211 (227)	160 (16–337)	296 (196)	270 (153–391)	327 (215)	284 (174–431)	0.434	261 (251)	196 (49–398)	0.449	16 (34)	2 (0–16)	<0.001
Community medication	249 (990)	87 (0–255)	292 (679)	165 (57–309)	275 (588)	165 (77–317)	0.770	430 (1695)	135 (38–299)	0.194	16 (103)	0 (0–1)	0.001
External consultation	154 (270)	89 (0–209)	251 (290)	179 (90–328)	239 (194)	179 (104–358)	0.607	162 (349)	89 (30–209)	0.097	4 (22)	0 (0–0)	0.019
Public home care	40 (697)	0 (0–0)	20 (257)	0 (0–0)	17 (129)	0 (0–0)	0.224	116 (1313)	0 (0–0)	0.387	0 (0)	0 (0–0)	-
Private home care	737 (4396)	0 (0–0)	247 (2031)	0 (0–0)	2013 (7179)	0 (0–0)	0.097	1272 (5908)	0 (0–0)	0.113	0 (0)	0 (0–0)	-
Private home resident caregiver	127 (2549)	0 (0–0)	0 (0)	0 (0–0)	0 (0)	0 (0–0)	-	336 (4145)	0 (0–0)	-	0 (0)	0 (0–0)	-
Telecare	5 (28)	0 (0–0)	5 (29)	0 (0–0)	13 (45)	0 (0–0)	1.000	4 (27)	0 (0–0)	1.000	0 (0)	0 (0–0)	-
Home modifications	36 (88)	0 (0–0)	12 (34)	0 (0–0)	48 (67)	0 (0–99)	0.653	113 (150)	99 (0–161)	<0.001	0 (0)	0 (0–0)	-
Home adaptation	26 (97)	0 (0–0)	14 (73)	0 (0–0)	35 (104)	0 (0–0)	0.341	72 (156)	0 (0–0)	0.665	0 (0)	0 (0–0)	-
Patient/family costs													
Caregiving[a]	5048 (11,313)	0 (0–1224)	755 (3624)	0 (0–0)	9269 (12,166)	3024 (0–17,712)	0.012	12,392 (16,231)	3240 (0–21,816)	<0.001	0 (0)	0 (0–0)	-
Caregiver paid productivity loss	225 (1609)	0 (0–0)	44 (557)	0 (0–0)	489 (2762)	0 (0–0)	0.417	491 (2125)	0 (0–0)	0.743	0 (0)	0 (0–0)	-
Caregiver unpaid productivity loss	124 (896)	0 (0–0)	0 (0)	0 (0–0)	158 (1055)	0 (0–0)	Ref.	363 (1490)	0 (0–0)	0.354	0 (0)	0 (0–0)	-
Patient paid productivity loss	2388 (5859)	0 (0–0)	3316 (6454)	0 (0–3366)	2451 (6195)	0 (0–0)	0.046	2424 (6200)	0 (0–0)	0.036	1406 (4446)	0 (0–0)	0.109
Patient unpaid productivity loss	1770 (2480)	270 (0–2646)	335 (803)	0 (0–1764)	1248 (1655)	882 (0–1764)	0.002	2281 (1786)	2633 (882–3528)	<0.001	2988 (3533)	0 (0–7211)	<0.001
Total costs	29,673 (28,632)	21,434 (11,891–40,753)	18,568 (12,244)	15,782 (10,592–24,558)	38,214 (28,172)	32,416 (18,968–51,187)	<0.001	52,859 (36,383)	51,210 (30,371–64,556)	<0.001	13,681 (9659)	12,913 (6942–18,875)	<0.001

[a]Excluding hours reported as paid and/or unpaid productivity losses.
[b]The reference category was 90-days mRS 0–2, except when all values were 0; in such cases, the lowest mRS category with non-zero values was used as the reference. A GLM with gamma family and log link was used for acute phase and total costs. All other variables, which had >10% zero values, were modelled using two-part models with gamma family and log link, except for discrete variables (telecare, nursing home), which used Poisson with log link. Model fit was assessed using the Bayesian Information Criterion (BIC). p-Values were not calculated for variables where all observations were zero.

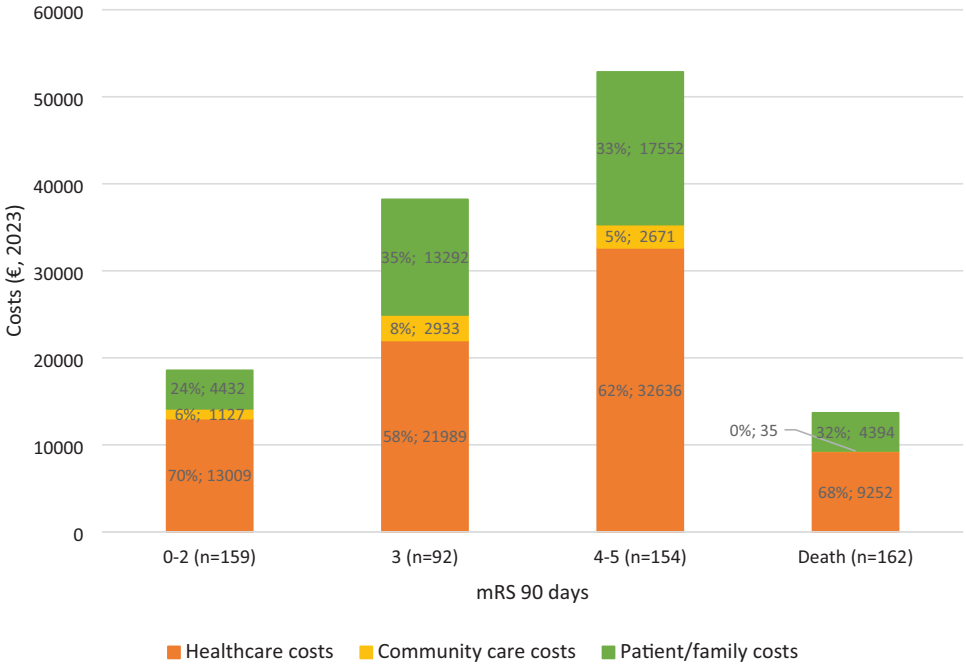

Figure 2. Mean costs per patient by type of resource and 90-day mRS group.
Overall: healthcare €18,724 (63%); community care €1527 (5%); patient/family costs €9422 (32%).

Moreover, as loss of leisure time of patients or caregivers was not directly collected, those costs could be underestimated. Finally, as some data were self-reported by patients, recall and/or comprehension bias cannot be excluded (e.g. unpaid productivity loss could be underestimated, since it can be difficult for caregivers to report this).

Implications for practice and research

Calculating stroke costs by incorporating healthcare, community and patient/family expenses enhances disease cost estimation, and facilitates the formulation of targeted measures and policies. These data indicate the need for healthcare and social policies aimed at caregiver support. Data on stroke costs also aids in refining future economic modelling frameworks, such as Markov or microsimulation models, thus facilitating more precise long-term economic forecasting and evaluation of intervention cost-effectiveness.

Conclusion

Our findings underscore the established association between functional disability and increased costs, with our sample exhibiting an overrepresentation of LVO strokes. Nonetheless, by quantifying the economic impact of severe strokes and taking into account healthcare, community, and patient/family expenses, we provide policymakers and healthcare providers valuable insights to improve resource allocation and service delivery. Moreover, investing in the acute treatment of patients with suspected LVO not only improves clinical outcomes but also reduces overall societal costs in the longer term.

Abbreviations

Modified Rankin scale (mRS), Large Vessel Occlusion (LVO), Transient Ischaemic Attack (TIA), Emergency Medical Services (EMS), Generalised Linear Model (GLM).

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Ethical approval

Ethical approval for this study was obtained from the Ethical Committee for Clinical Research with Medications of the Vall d'Hebron University Hospital (PR(AG)229/2017).

Informed consent

Written informed consent was obtained from all patients or surrogates before the study.

Guarantor

AR

Contributorship

MSF wrote the first draft of the manuscript. AR, MSP, LVG, ASB, NP, MR and SA were involved in the study conception. AR obtained fuding. MSF, ARS, IAL, ASV, JS, EV were involved in the data analysis. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

Data availability

The datasets used during the current study are available from the corresponding author on reasonable request.

Trial registration

RACECAT trial was registered at ClinicalTrials.gob: NCT02795962.

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Supplemental material

Supplemental material for this article is available online.

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